

**The Entomological Society of India**  
**New Delhi, 110 012**

**Application for ESI- BEST Ph.D. THESIS AWARD 2021**

|    |                                            |                                                                                                                                                                                                     |
|----|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Name of the applicant :                    | Dr. Ramya N                                                                                                                                                                                         |
| 2. | Year of the award :                        | 2021                                                                                                                                                                                                |
| 3. | Date of birth :                            | 25/04/1992                                                                                                                                                                                          |
| 4. | Field of specialization :                  | Entomology (Insect Biosystematics)                                                                                                                                                                  |
| 5. | Mode of award collection :                 | In person                                                                                                                                                                                           |
| 6. | Postal address (with Phone/Fax/Email etc.) | Ramya N<br>C/O Padala Vinod Kumar<br>Scientist, ICAR- Research Centre for Makhana,<br>Delli More, Near New Bus stand<br>Darbhanga, Bihar-846004<br>Ph.No. 7701980974<br>Email- ramyanento@gmail.com |

7. Educational qualifications beginning with the first-degree or equivalent (in a tabular form)

| S.No. | Degree                 | Institution                                                      | Year |
|-------|------------------------|------------------------------------------------------------------|------|
| i.    | B.Sc.<br>(Sericulture) | College of Sericulture, Chintamani, UAS,<br>Bengaluru, Karnataka | 2014 |
| ii.   | M.Sc.<br>(Entomology)  | ICAR-Indian Agricultural Research Institute,<br>New Delhi        | 2016 |
| iii.  | Ph.D.<br>(Entomology)  | ICAR-Indian Agricultural Research Institute,<br>New Delhi        | 2020 |

|     |                                                                                      |                  |
|-----|--------------------------------------------------------------------------------------|------------------|
| 8.  | Date on which qualifying examination passed :                                        | 02 April 2019    |
| 9.  | Transcript of the course work done, if any, as part of the Ph.D. degree programme. : | Enclosed         |
| 10. | Was the thesis submitted in partial fulfillment of the requirement of the Degree? :  | Yes              |
| 11. | Date on which successfully completed thesis viva voce examination :                  | 03 July 2020     |
| 12. | Date of the Degree/provisional certificate :                                         | 12 February 2021 |

|     |                                                |    |
|-----|------------------------------------------------|----|
|     |                                                |    |
| 13. | Have you received best thesis award earlier? : | No |

#### 14. Details of the thesis:

|      |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| i.   | Title of the thesis :                                                                        | Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea) from India                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| ii.  | Department/Division/Institution :                                                            | Division of Entomology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| iii. | Institution/University to which thesis was submitted as a part of the Ph.D. degree programme | IARI, New Delhi                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| iv   | Name and designation of the thesis supervisor                                                | Dr. Naresh Manohar Meshram<br>Senior Scientist<br>ICAR-Central Citrus Research Institute, Nagpur<br>email: <a href="mailto:nmmeshram_ento@iari.res.in">nmmeshram_ento@iari.res.in</a> ;<br><a href="mailto:nmmeshram@gmail.com">nmmeshram@gmail.com</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| v    | Rationale of Research problem :                                                              | <p>Delphacidae is one of most specious families in the order Hemiptera which comprises of approximately 416 genera and 2214 species worldwide. It is the most economically important group, which includes at least 55 species that feed on economically important crops. They are vectors for more than 30 plant viruses. Delphacids are known for their complexity, which include cryptic nature, sexual dimorphism, wing polymorphism, occurrence of different morphs of same species which hinders their identification.</p> <p>In spite of delphacids being notorious pests, there was no consolidated effort from India on taxonomy of this group. Except for few publications of isolated species descriptions and lists of faunistics, there had been no concerted attempts to characterize this family and place them on the updated classifications as per the world trends.</p> <p>As there was very less representation of delphacids from India (51 previously described species). A new study on Indian Delphacidae may lead to discovery of many</p> |

|    |                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                        | species causing change in higher classification of Delphacidae. In this backdrop, the present study was an effort to explore delphacid fauna from India and to develop integrative protocol which will help in establishment of correct identity and phylogenetic relationship.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| vi | Material and methods : | <p><b>Source of Specimens for study</b></p> <p>Extensive collections of Delphacid specimens were made from 26 different localities of 9 states using sweep net, light trap (Mercury vapour lamp) and aspirator collections.</p> <p><b>Morphological studies:</b></p> <p>The collected specimens were processed and identified to species level using literature, which later confirmed with the help of experts.</p> <p>Photographs were taken with Leica DFC 425C digital camera mounted on the Leica 19205FA stereo zoom automontage microscope. These were processed by using Adobe Photoshop CS3 and plates were prepared with Microsoft publisher document for each species.</p> <p><b>Phylogenetic studies:</b></p> <p>DNA was extracted from whole specimen according to the manufacturer protocol, DNASure Tissue Mini Kit</p> <p>The DNA extractions were amplified for PCR products for genes viz., mitochondrial cytochrome oxidase (mtCOI), Histone (H3), 28S ribosomal gene (28S rDNA; D2 AND D9-10 region).</p> <p>Combined ML analysis (28S D2, 28S D9-D10, H3 and COI) were performed in IQtree v1.6.12 using the best-fit substitution model automatically selected by the software according to the Bayesian information criterion scores and weights (BIC) with partitions. An ultrafast bootstrap (UFB) with 10000 replicates and the SH-like approximate likelihood ratio test (SH-aLRT) were used in the analysis to</p> |

|     |                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     |                       | assess branch support.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| vii | Significant results : | <p>The work describes the Indian delphacids along with key, checklist, photographic illustrations and molecular characterization.</p> <p>Survey and collections were conducted in 26 localities of 9 Indian states by using standard methods of collection yielded 39 species of delphacids from Delphacini and Tropidocephalini of Delphacinae, which were described with photographic illustrations. For the description, all the characters were studied with emphasis was given to male genitalia variation. Both macropterous and brachypterous of habitus, male genitalia and female genitalia illustrations were included for description.</p> <p>The complete annotated checklist was provided for 4 subfamilies, 5 tribes, 36 genera, and 73 species of Indian fauna. It comprises of species valid name, synonyms, details of type species, Indian distribution, type locality and type deposition. Along with this illustrative keys were provided for subfamily, tribe, genera and species of Delphacidae.</p> <p>Illustrative diagnostic keys were developed for identification of 12 most commonly occurring delphacids in rice agro ecosystems of India, which helps in authentic and rapid identification.</p> <p>DNA barcodes were generated and phylogenetic analysis was carried out based on four gene regions mtCOI, 28srDNA (D2 region and D9-10 region) and histone to understand the relationship among the various taxa, which yielded a well resolved phylogram indicating the paraphyletic nature of Delphacinae.</p> <p>The study contributed description 9 new species to world delphacid fauna, 9 generic new report and 13 species new</p> |



|      |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      |                                                                                          | report to Indian delphacid fauna. The morphological and molecular characterization data was integrated to avoid ambiguity in identification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| viii | In what way these results have made an original contribution to science and have impact: | <p>Indian delphacids fauna was least investigated, accounting only 51 described species in comparison to 2214 species worldwide. Most of the previous studies were exclusively based on the morpho taxonomy with illustrations via line diagrams and there was no comprehensive work.</p> <p>The present study was aimed at a comprehensive work on Delphacidae which include describing the Indian delphacids along with key, checklist, photographic illustrations and molecular characterization.</p> <p>Described <b>9 new species</b> of Delphacidae, <b>9 genus new record to India</b> and <b>13 species new record to India</b> which results in Indian delphacids account rise from 51 previously described species to 73 described species. We also provided the illustrative diagnostic key for identification of 12 most commonly occurring <b>delphacids in rice agro ecosystems of India</b>, which helps in authentic and rapid identification.</p> <p>DNA barcodes were generated for 22 species and phylogenetic analysis was carried out based on four gene regions mtCOI, 28srDNA (D2 region and D9-10 region) and histone to understand the relationship among the various taxa, which yielded a well resolved phylogram indicating the paraphyletic nature of Delphacinae. This was first study of on phylogeny of Delphacidae from India.</p> <p>The study was consolidated efforts to improve the identification and biosystematics of Indian Delphacidae which help species identification.</p> |
| ix.  | Patents obtained/applied:                                                                | Nil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| x.   | A concise statement (about 150 words) highlighting the most                              | The study “Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea) from India” was a consolidated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

|  |                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | significant aspects of the research work done that you would like to see in your citation of award, if chosen. | <p>effort to update the taxonomic studies on India Delphacidae fauna as per world trend. This resulted in the following contributions.</p> <ul style="list-style-type: none"> <li>✓ Contributed <b>9 new species</b> of Delphacidae to world fauna, <b>9 genus new record</b> and <b>13 species new record to India</b>.</li> <li>✓ Photographic Illustrations to diagnostic keys helps in easy and authentic species identification.</li> <li>✓ Illustrative diagnostic key for identification of 12 most commonly occurring <b>delphacids in rice agro ecosystems of India</b> is provided which helps in authentic and rapid identification.</li> <li>✓ DNA barcodes were generated for 22 species and phylogenetic analysis was carried out based on four gene regions yielded a well resolved phylogram indicating the paraphyletic nature of Delphacinae. This will serve as base for future studies on Delphacidae.</li> </ul> |
|--|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### xi. Publications:

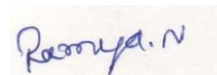
| S.No | Research paper                                                                                                                                                                                                                                               | NAAS/Impact Factor   |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| 1.   | Ramya, N., Bartlett, C. and Meshram, N.M .2020. Two new planthopper species from India (Hemiptera: Auchenorrhyncha: Delphacidae) with first report of genus <i>Parasogata</i> and molecular data. <i>European journal of taxonomy</i> , <b>724</b> : 93-108. | 1.37 (Impact Factor) |
| 2.   | Ramya, N. and Meshram, N. M. 2019. New record of the genus <i>Bambusiphaga</i> (Hemiptera: Delphacidae: Tropidocephalini) from India with description of a new species. <i>Zootaxa</i> , <b>4658</b> (1): 197–200.                                           | 6.00                 |
| 3.   | Ramya, N. and Meshram, N. M. 2019. New Report of small brown planthopper <i>Laodelphax striatellus</i> (Delphacidae: Hemiptera) from Delhi. <i>Indian Journal of Entomology</i> , <b>81</b> (3): 532-535.                                                    | 5.08                 |
| 4.   | Naresh, M. Meshram., Stuti, Rai., Rajgopal, N. N. and <b>Ramya, N.</b>                                                                                                                                                                                       | 6.00                 |

|   |                                                                                                                                                                                                                                                                                             |  |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|   | 2017. Two New species of tribe Agallini (Hemiptera: Cicadellidae: Megophthalminae). Zootaxa, <b>4378</b> (3): 442-450.                                                                                                                                                                      |  |
|   | <b>Seminars/ Symposium</b>                                                                                                                                                                                                                                                                  |  |
| 1 | <b>Ramya N</b> , Naresh M Meshram (2019). Delphacid planthopper complex in rice: Ambiguity in identification. In: Oral presentation IXV Agricultural Science Congress, National Agriculture Science Complex, New Delhi, India, 20-23 February 2019.                                         |  |
| 2 | <b>Ramya, N</b> and Naresh M. Meshram. Barcoding and Phylogenetic analysis of delphacid planthopper complex in rice. In: Oral presentation XIX International Plant Protection Congress (IPPC), Hyderabad, India, 10-14 November 2019.                                                       |  |
| 3 | <b>Ramya, N</b> and Naresh M. Meshram. New report of Small Brown Planthopper <i>Laodelphax striatellus</i> (Delphacidae: Hemiptera) from Delhi - National Capital Region. National Symposium on Entomology 2018: Advances and Challenges, 10th-12th Dec 2018, Hyderabad, India, pp 215-216. |  |

xiii. Professional recognition, awards, fellowships received (In a separate sheet give full particulars such as the agency/ organization which gave the award, purpose, the nature of the award, etc.):

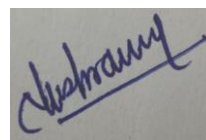
|    |                                                                                                                                                                                                              |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Awarded with <b>NAHEP-CAAST International Fellowship</b> 2019 for International Training at Dr. Charles Bartlett's Lab, Department of Entomology and Wild Life Ecology, University Of Delaware, Newark, USA. |
| 2. | Awarded with <b>NAHEP-CAAST Research grant</b> for Ph.D. Research                                                                                                                                            |
| 3. | 1st Rank in ICAR-JRF 2014 Agricultural Entomology group                                                                                                                                                      |
| 4  | 4 <sup>th</sup> Rank in ICAR - IARI Ph.D. Entrance exam and awarded with IARI Ph.D. fellowship                                                                                                               |

I, Ramya N, hereby declare that all the information submitted by me in the application form is correct, true and valid.



(Ramya N)  
Ph.D (Entomology)

I, Naresh M. Meshram, supervisor for Ph.D program of Ramy N and the information submitted by Ramya N has been verified and found correct.



Signature  
(Naresh M. Meshram)

**Enclosers:**

1. Ph.D Degree certificate
2. Ph.D Transcript
3. First page of publications
4. Seminars/Conference abstracts/certificate
5. Professional recognition, awards, fellowships received
6. SSC marks sheet for age proof
7. Passport size photograph (separate attachment in mail)
8. Thesis (separate attachment in mail)



# INDIAN AGRICULTURAL RESEARCH INSTITUTE



**NEW DELHI**

प्रमाणित किया जाता है कि

सुश्री रम्या एन

को

डॉक्टर ऑफ फिलॉसफी

की उपाधि

कीट विज्ञान

में

इस संस्थान के 59वें दीक्षांत समारोह में  
12 फरवरी, 2021 को प्रदान की गई

*This is to certify that*

**Ms. Ramya N**

*has been admitted to the degree of*

**Doctor of Philosophy**

*in the discipline of*

**Entomology**

*at the 59<sup>th</sup> Convocation of this Institute*

*held on February 12, 2021*

*Self attested  
Ramya.N*

*[Signature]*

रश्मि अग्रवाल / Rashmi Aggarwal  
अधिष्ठाता / Dean

*[Signature]*

अशोक कुमार सिंह / A. K. Singh  
निदेशक / Director





**POST GRADUATE SCHOOL**  
**INDIAN AGRICULTURAL RESEARCH INSTITUTE**  
**NEW DELHI - 110012**

**Ph.D. TRANSCRIPT**

1. Name : Ms. RAMYA N
2. Roll Number : 10789
3. Father's Name : NAGARAJU
4. Permanent Home Address : PO- K T HALLI  
TH-PAVAGADA, DIST-TUMKUR-572116  
KARNATAKA
5. Date of Birth : 25 April 1992
6. Date of Admission at IARI : 29 July 2016
7. Subject : ENTOMOLOGY  
Major : INSECT BIOSYSTEMATICS  
Minor(s) : MOLECULAR BIOLOGY AND BIOTECHNOLOGY  
ENVIRONMENTAL SCIENCES
8. Date of Passing the Qualifying  
Viva-voce Examination : 02 April 2019
9. Title of Thesis : BIOSYSTEMATIC STUDIES OF FAMILY  
DELPHACIDAE (HEMIPTERA: FULGOROIDEA)  
FROM INDIA
10. Date of Submission of Thesis : 25 January 2020
11. Date of Passing the Thesis  
Viva-voce Examination : 03 July 2020
12. Details of Course Credit : Reverse
13. Overall Grade Point Average : 7.76/10.00  
SEVEN POINT SEVEN-SIX OUT OF TEN

New Delhi  
08 July 2020

self attested  
Ramya . N



NAME: Ms. RAMYA N

ROLL NO:10789

DISCIPLINE: ENTOMOLOGY

**Details of Course Work and Overall Grade Point Average**

| TRIME-<br>STER | COURSE<br>CODE | TITLE                                                                  | CREDIT | GRADE |
|----------------|----------------|------------------------------------------------------------------------|--------|-------|
| I              | ENT502         | PEST MANAGEMENT IN FIELD CROPS                                         | 3      | 8.31  |
|                | ENT606         | INSECT BIOCHEMISTRY                                                    | 3      | 7.85  |
|                | ENT691         | SEMINAR                                                                | 1      | 8.97  |
|                | MBB501         | PRINCIPLES OF BIOTECHNOLOGY                                            | 4      | 7.29  |
| II             | ENT608         | ADVANCES IN INSECT PHYSIOLOGY                                          | 3      | 7.38  |
|                | ENT691         | SEMINAR                                                                | 1      | 9.23  |
|                | ES503          | GLOBAL CLIMATE CHANGE AND AGRICULTURE                                  | 3      | 7.17  |
|                | MBB602         | GENOMICS AND PROTEOMICS                                                | 3      | 6.30  |
|                | PGS503         | INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE                | 1      | 8.80  |
|                | PGS505         | AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMES | 1      | 9.07  |
| III            | ENT605         | ADVANCES IN INSECT TOXICOLOGY                                          | 3      | 7.40  |
|                | ENT609         | RECENT TRENDS IN ENTOMOLOGY                                            | 3      | 8.55  |
|                | MBB506         | BIOSAFETY, IPR AND BIOETHICS                                           | 2      | 7.26  |
| IV             | ES500          | INTRODUCTION TO ENVIRONMENTAL SCIENCES                                 | 3      | 8.08  |
|                | ES601          | BIODIVERSITY                                                           | 2      | 8.01  |
|                | ES691          | SEMINAR                                                                | 1      | 8.80  |
| V              | ENT691         | SEMINAR                                                                | 1      | 8.52  |
| IX             | QVVE           | QUALIFYING EXAMINATION                                                 | 2      | 7.06  |

Total Credits: 40

O.G.P.A.: 7.76/10.00

SEVEN POINT SEVEN-SIX OUT OF TEN

Remarks:

Note:

| OGPA            | Description of Performance                                                                                                 |                                                                                              |
|-----------------|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| (1) 9.0 to 10.0 | (90 to 100%) 1st Class with distinction                                                                                    | (2) O.G.P.A. = $\frac{\text{Total points earned}}{\text{Total credits taken}}$               |
| 8.0 to 8.99     | (80 to 89%) 1st Class                                                                                                      |                                                                                              |
| 7.0 to 7.99     | (70 to 79%) 2nd Class                                                                                                      |                                                                                              |
| 6.0 to 6.99     | (60 to 69%) Pass                                                                                                           | (3) One hour lecture or three hours practical per week for 12 weeks carries one credit hour. |
| Below 6.00      | (Less than 60%) Fail                                                                                                       |                                                                                              |
| Incomplete      |                                                                                                                            |                                                                                              |
| (4)             | The date of Final Viva-voce Examination may be treated as the date of completion of the degree programme for all purposes. |                                                                                              |

Prepared &amp; Checked by:

Self attested  
Ramya . N

Registrar  
रत्नेश कुमार / Ratnesh Kumar  
कुलसचिव / Registrar  
स्नातकोत्तर विद्यालय / Post Grad  
भारतीय कृषि अनुसंधान  
Indian Agricultural Resea  
नई दिल्ली / New Delhi

## Research article

urn:lsid:zoobank.org:pub:EAA06FE6-F8CA-4494-9191-414ED0F4BC3C

**Two new species of planthoppers from India  
(Hemiptera: Auchenorrhyncha: Delphacidae)  
in the genera *Parasogata* and *Eoeurysa***

Ramya N.<sup>1</sup>, Charles BARTLETT<sup>2</sup> & Naresh M. MESHRAM<sup>3,\*</sup>

<sup>1,3</sup> Indian Council of Agricultural Research - Indian Agricultural Research Institute,  
New Delhi 110012, India.

<sup>2</sup> Department of Entomology and Wild Life Ecology, College of Agriculture and Natural Resources,  
University of Delaware, Newark DE 19716, USA.

\* Corresponding author: [nmmeshram@gmail.com](mailto:nmmeshram@gmail.com)

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<sup>1</sup> urn:lsid:zoobank.org:author:064ACDA0-ECAF-42E2-91D5-85DE937B8EEA

<sup>2</sup> urn:lsid:zoobank.org:author:47CE21C6-6289-4AD4-90EB-3F03DE1D9BF3

<sup>3</sup> urn:lsid:zoobank.org:author:3B0F30C0-3391-4143-9169-5F996531AE72

**Abstract.** The genus *Parasogata* Zhou, Yang & Chen, 2018 is here reported from India represented by the new species *Parasogata sexpartita* sp. nov. collected in a recent exploration and survey of delphacids from Nagaland in northeastern India. A second species of *Eoeurysa* Muir, 1913 from India, the new species *Eoeurysa sagittaria* sp. nov., was found in Rampur, Una, Himachal Pradesh. Both new species are described with illustrations, and a molecular identification is given with the mtCOI gene sequence. A modified key to species of the genera is also provided.

**Keywords.** Planthopper, morphology, distribution, identification, taxonomy.

Ramya N., Bartlett C. & Meshram N.M. 2020. Two new species of planthoppers from India (Hemiptera: Auchenorrhyncha: Delphacidae) in the genera *Parasogata* and *Eoeurysa*. *European Journal of Taxonomy* 724: 93–108. <https://doi.org/10.5852/ejt.2020.724.1161>

## Introduction

The delphacid fauna of India remains incompletely investigated. Delphacidae Leach, 1815 is the second most speciose family of Fulgoromorpha Evans, 1946 with 2214 extant described species worldwide (after Cixiidae Spinola, 1839, with 2520 species) (Bourgoin 2019). The Indian fauna of Delphacidae includes 52 published species records (Distant 1906; Muir 1921; Joseph 1961, 1964; Mammen & Menon 1972; Sharma & Singh 1980, 1982; Kalode 1983; Asche 1985, 1990; Rao & Chalam 2006; Nimisha 2008; Ramya & Meshram 2019), plus an additional 13 species published in a PhD thesis (Mammen 1971).





## New record of the genus *Bambusiphaga* (Hemiptera: Delphacidae: Tropidocephalini) from India with description of a new species

RAMYA, N.<sup>1</sup> & NARESH M. MESHRAM<sup>1, 2</sup>

<sup>1</sup>Division of Entomology, Indian Council of Agricultural Research—Indian Agricultural Research Institute, New Delhi 110012, India

<sup>2</sup>Corresponding author. E-mail: [nmmeshram@gmail.com](mailto:nmmeshram@gmail.com)

### Abstract

The genus *Bambusiphaga* Huang & Ding is recorded from India for the first time and one new species *B. unispina* sp. nov. is described and illustrated. The new species is similar to *B. taiwanensis* (Muir) but can be separated by the male genitalic structure.

**Key words:** Planthopper, morphology, distribution, identification

### Introduction

The delphacid fauna of India remains inadequately studied. The only comprehensive treatment of Indian Delphacidae was that of Distant (1906, 1916) in the fauna of India including Sri Lanka and Burma, which deals with 49 species in 20 genera. Asche (1990) and Liang (2002) recorded the subfamily Vizcayinae in Southern India. Obviously, much taxonomic work on the group is to be carried out.

*Bambusiphaga* is an Oriental bamboo-feeding planthopper genus, belonging to tribe Tropidocephalini under family Delphacidae. It was established by Huang and Ding (1979) with type species *Bambusiphaga nigropunctata*. A total of 25 species were reported from Oriental region, viz., China (23 species), Taiwan (4 species), Singapore (2 species), Malaysia (2 species), Philippines (1 species), and North-Eastern Himalayas (1 species) (Chen and Liang, 2007; Li *et al.* 2018). Species in the genus exhibit morphological diversity in male genitalia. Asche (1983) divided the members of genus *Bambusiphaga* into 4 species groups (*citrocolorata*, *lacticolorata*, *nigropunctata* and *mirostylis*) based on male genitalia characters. Chen and Liang (2007) revised the genus and added 3 new species groups (*fascia*, *maculate* and *wangmoensis*) which led to total 7 groups. Detailed checklist and key for the identification of species in the genus was provided by Yang and Chen (2011) and Li *et al.* (2018). *Bambusiphaga* can be distinguished from other related genera by the following characters: body yellowish-brown, often with brown or black markings; head including eyes narrower than pronotum; scutellum longer at middle line than vertex and pronotum together; aedeagus (phallosome) complex, tubular, with or without phallobase; and segment 10 ring-like, with or without process.

The genus was previously recorded in China, Taiwan, Singapore, Malaysia and Philippines and in this paper it is recorded for the first time from India.

### Material and methods

The terminology followed is after Asche (1985) except anal tube which is referred as “segment 10” and also the ‘Aedeagal complex’ refers to structures viz., phallosome, connective, parameres, and postgenital segments, when these structures have been separated from the pygofer. The ‘Phallosome’ is referred to the fusion of true aedeagus with theca (Bartlett, 2009).

The photographs were taken with a Leica DFC 425C digital camera mounted on a Leica M205FA stereozoom automontage microscope. Male genitalia dissections were carried out as described by Oman (1949) and Knight (1965). Type material is deposited in the National Pusa Collection, Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi, India (NPC).

self attested  
Ramya, N



## NEW RECORD OF SMALL BROWN PLANTHOPPER *LAODELPHAX STRIATELLUS* FROM DELHI

RAMYA, N. AND NARESH M. MESHRAM

Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi 110012

Email: nmmeshram@gmail.com (corresponding author)

### ABSTRACT

The small brown planthopper *Laodelphax striatellus* (Fallen), an important pest as well as vector of rice diseases, is brought out as a new record from the National Capital Region (NCR) Delhi. Recent field surveys in the rice fields of NCR revealed this. A detailed redescription along with illustrations is provided, along with mtCOI analysis enabling its authentic identification. Perusal of >250 mtCOI sequences of *L. striatellus* available in NCBI GenBank reveal that this is the first submission from India. The blast results reveal its 100% similarity with the Chinese samples. The voucher material is deposited in the National Pusa Collection, Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi.

**Key words:** Delphacidae, small brown planthopper, rice, Gramineae, redescription, illustrations, mtCOI, BLAST analysis

Delphacid planthoppers constitute important sucking pests of rice and other graminaceous plants. Some are major pests causing economic damage by feeding and transmitting the viral and mycoplasma diseases. One such destructive pest is the small brown plant hopper *Laodelphax striatellus* Fallen. It is polyphagous feeding on rice, maize, oats, oatgrass, wheat and barley and is a vector of *Rice Stripe Virus* (RSV), *Rice Black-Streaked Dwarf Virus* (RBSDV) and *Barley Yellow Stripe Mosaic Virus* (BYSMV) (Falk and Tsai, 1998), which cause epidemics in temperate and subtropical regions (Sanada-Morimura et al., 2015). The planthopper is widespread in Palearctic and Indo-Malayan region.

Delphacids can be identified by hind tibial spur (Calcar). Delphacinae can be identified by the flattened hind tibial spur, with teeth along margin or with a single tooth at the apex. Delphacini tribe can be distinguished by four apical spines on second segment of hind tarsi. *L. striatellus* was first identified and described by Fallen in 1806 with its type species *Delphax striata*; later, several nomenclatural changes led to *L. striatellus* as the most preferred name worldwide. *Laodelphax* was given genus status by Fennah in 1963. From India, it was first reported by Shukla in 1979 from Ludhiana, Punjab. Present study at the Delhi NCR led to its record as a pest on rice. Despite its economic importance, there is inadequate taxonomic account of this pest from India, and the present study provides a taxonomic account with detailed redescription and mtCOI analysis.

### MATERIALS AND METHODS

The terminology followed in description is after Asche and Wilson (1990), but anal tube is referred as "segment10". The 'aedeagal complex' refers to structures viz., phallosome, connective, parameres, and post genital segments, when these structures have been separated from the pygofer. The heading 'genitalia' should be understood to refer to males and include the terminal segments Bartlett et al. (2014). Photographs were taken with a Leica DFC 425C digital camera on the Leica M205FA stereozoom microscope with automontage. Male genitalia dissections were carried out as described by Oman (1949) and Knight (1965). Voucher material is deposited in the National Pusa Collection (NPC), Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi.

For mtCOI analysis, the DNA was extracted from whole specimen according to the manufacturer protocol, Qiagen QIAamp® DNA Kit. The isolated DNA was stored at -20°C until required. The DNA extractions were amplified for PCR products, using universal primers LCO1490: 5'-ggcacaacatacagaatattgg-3'; HCO2198: 5'-taaacttcagggtgacacaaaatca-3' which target the mitochondrial cytochrome oxidase subunit I (mtCOI) gene (Dietrich et al., 1997). The PCR protocol of Folmer et al. (1994) was followed. mtCOI was amplified in 25 µl reactions using DNA polymerase (Fermentas GmbH, St. Leon-Rot, Germany) under the following cycling protocol: 4 min. hot start at 94°C, 35

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Ramya. N



## Two new species of tribe Agalliini (Hemiptera: Cicadellidae: Megophthalminae) with note on intraspecific variations

NARESH M. MESHAM<sup>1,2</sup>, STUTI RAI<sup>1</sup>, N. N. RAJGOPAL<sup>1</sup> & N. RAMYA<sup>1</sup>

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<sup>2</sup>E-mail: nmmeshram@gmail.com

### Abstract

Two new species of leafhoppers, *Durgades sineprocessus* sp. nov. (From Himachal Pradesh: Kalpa) and *Japanagallia dolabra* sp. nov. (From Sikkim: Lachung) from India, are described and illustrated. Photographic illustrations of *Durgades aviana* Viraktamath and a detailed note on intraspecific variation in male genitalia of *Austroagallia sinuata* (Mulsant & Rey) are also provided. Material is deposited in the National Pusa Collection, Division of Entomology, Indian Council of Agricultural Research-Indian Agricultural Research Institute (ICAR-IARI), New Delhi, India.

**Key words:** Auchenorrhyncha, Membracoidea, taxonomy, morphology, distribution

### Introduction

Agalliini is one of the larger tribes belonging to subfamily Megophthalminae with 37 genera and 650 species worldwide (Oman 1949; Viraktamath 2005; Oman et al. 1990; Viraktamath 2011). This group commonly occurs on grassland mixed with broad leaved herbs in the Old World (Viraktamath et al., 2012). About 14 species of this tribe are known to transmit plant pathogenic viruses and phytoplasmas (Nielson 1979; Weintraub & Beanland 2006).

Genus *Durgades* Distant was established by Distant (1912) with type species *Durgades nigropictus* Distant. The cylindrical aedeagal shaft with apical processes bearing primary and secondary branches separate it from other genera of Agalliini (Viraktamath, 2012). Another genus *Japanagallia* Ishihara, was erected with the type-species *Agallia pteridis*. This genus closely resembles *Igerna* but differs in having one or two claval cross veins and dorsal pygofer spines or processes (Viraktamath et al., 2012). *Austroagallia sinuata* (Mulsant & Rey) is a cosmopolitan species found in the southern Palaearctic, Afrotropical and Western Oriental and Neotropical regions (Viraktamath, 2011). It has a wide host range including economically important plants, viz., *Ipomoea pes-caprae* Linn., *Vigna sinensis* (Linn.), *Aristida scensionis* Linn., *Cynodon dactylon*, *Sorghum helepense* (Linn.) Pers., *Arachis hypogaea* Linn., *Fagonia cretica*, *Medicagos ativa*, *Zea mays* Linn., *Solanum tuberosum* Linn., *Spinacea oleracea* Linn., *Beta vulgaris* Linn. var. *rapa* Dum., *Crotalaria juncea* (Linn.) (Viraktamath, 2011). To date, these genera include the following numbers of described species from the Oriental and Australian regions, excluding the species described here: *Austroagallia*, 9 species; *Durgades*, 10 species; *Japanagallia*, 18 species (Viraktamath, 2011).

Recent explorations of the high altitude regions of Himachal Pradesh and Sikkim, India yielded series of specimens of Agalliini. This led to discovery of two new species *Durgades sineprocessus* sp. nov. and *Japanagallia dolabra* sp. nov., described here, along with photographic illustrations of the previously described *D. aviana* Viraktamath and notes on the intraspecific variation in *A. sinuata*.

### Material and methods

The terminology follows Viraktamath (2011). Photographs were taken with a Leica DFC 425C digital camera on the Leica M205FA stereozoom automontage microscope. Male genitalia dissections were carried out as described

Self attested  
Ramya. N

## Theme 4: Plant Protection

### Technical Session 2: Detection, Diagnostics, Epidemiology and Forecasting Advances in Protection Sciences

#### Delphacid Plant Hopper Complex in Rice: Ambiguity in Identification



Ramya N, NN Meshram

Indian Agricultural Research Institute, New Delhi, India

ramyanent24@gmail.com

Planthoppers are the group of phloem-feeding insects belonging to 14 different families of Fulgoroidea superfamily. Delphacidae is the largest family of this superfamily and most economically important group the members of which feeds on graminaceous plants. The Delphacids can easily be distinguished by the presence of a large, movable spur (the 'calcar') on the apex of the hind tibiae. Rice is the staple food crop which is also infested by many insect pests and diseases. The Delphacid planthoppers constitute the major pests as well as vectors of rice plant diseases. In rice the major pests viz., Brown planthopper *Nilaparvata lugens* (vector of grassy stunt and ragged stunt viral diseases); Small brown planthopper, *Laodelphax striatellus* (Fallen) (vector of rice stripe and black streaked dwarf); White-backed planthopper like *Sogatella furcifera*, *S. kolophon*, *S. vibix*, and minor pests *Toya propinqua*, *Tagosodes pusanus*, *Coronacella sinhalana*, *Sardia rostrata*, *Peregrinus maidis*, *Nycheuma cognatum*, *cemus sauteri* etc. These species are known for their complexity like cryptic species, sexual dimorphism, wing polymorphism etc. These complexities lead to miss-identification of these planthoppers many times. Although these are different species causing the different state of damage and transmission of diseases there is a lack of field level identification key guide. To confront this we have developed an identification guide for all these species with detailed description comprising the ratios and photographic illustration of characters for each species male, female, brachypterous forms. This will serve the purpose of identification and easy information retrieval.

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#### O25-5. Museum data validates change of crabronid wasp diversity at Delhi

Varun Saini<sup>2</sup>, Amrender Kumar and Debjani Dey<sup>1</sup>

<sup>1</sup>Division of Entomology, <sup>2</sup>AKMU, ICAR- Indian Agricultural Research Institute, New Delhi, India.

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Crabronidae (Hymenoptera: Sphecoidea) includes over 200 genera and 9000 species worldwide. Subfamily Crabroninae, the most diverse group of family Crabronidae, includes around 100 genera and 9,000 species around the world. However, the Indian fauna is poorly known. During the current global warming, collection data of museums have proved to be valuable sources of information indicating changes in diversity and distribution of species. As isotherms shift away from a particular location, warming at the location may occur, but the spatial context of temperature change will influence the regional setting of species diversity change. This study focuses on the effect of climatic variables on species diversity. Long term annual and monthly trends for maximum and minimum temperature of North West Region of India were used for trend analysis with Sen's slope estimator and Mann-Kendall Statistics for assessing differences, if any. Intensive surveys for collecting these wasps were made during 2017 to 2018 at IARI, New Delhi. The current data were compared with the collection data of 1959 to 1960 housed at National Pusa Collection. Changes in abiotic conditions affected the diversity of species. Maximum temperature showed significant increasing trends during the months of February, April, August, November and December while minimum temperature showed significant negative trends in January and June. In response the crabronid wasps shifted their time of occurrence from summer to winter, which might be due to the presence of optimum temperature. Thus museum data can validate observation based species occurrence data.

#### O25-6. Barcoding and Phylogenetic analysis of delphacid plant hopper complex in rice

N Ramya and Naresh M Meshram

<sup>1</sup>Division of Entomology, ICAR- Indian Agricultural Research Institute, New Delhi 110012, India

Email: ramyanento@gmail.com

Delphacid planthoppers constitute the economically important planthopper complex in rice. They cause inevitable damage directly by feeding and indirectly as vectors. Delphacidae is the largest family of the Fulgoroidea superfamily and most economically important group feeds on graminaceous crop plants. The Delphacids are easily distinguished at family level by the presence of a large, movable spur on the apex of the hind tibiae. In rice, the major pests viz., brown planthopper *Nilaparvata lugens* (vector of grassy stunt and ragged stunt viral diseases); small brown planthopper, *Laodelphax striatellus* (Fallen) (vector of rice stripe and black streaked dwarf); white backed planthopper like *Sogatella furcifera*, *S. kolophon*, *S. vibix* and minor pests, viz., *Toya propinqua*, *Tagosodes pusanus*, *Coronacellas inhalana*, *Sardia rostrata*, *Peregrinus maidis*, *Nycheuma cognatum*, *Cemus sauteri*, etc. These species are known for their complexity like cryptic species, wing polymorphism, sexual dimorphism etc, which hinders their identification. The conventional taxonomy combined with molecular tools will give explicit identification. In this regard, we generated DNA barcodes by targeting four gene loci mtCOI, 28srDNA- D2 region, 28srDNA- D9-10 region and Histone gene. The molecular phylogeny analysis has been made to give the evolutionary relationship among these pest species. This will give a comprehensive account on identification, which in turn helps in the survey, monitoring and early warning of the major Delphacid pests of rice.

self attested  
Ramya.N



**National Symposium on  
Entomology 2018: Advances and Challenges  
10-12 December 2018**

PJTSAU, Auditorium, Rajendranagar, Hyderabad-500030.

**Participation**

This is to certify that Dr/Mr/Mrs/Ms. .... *Ramya N.* .....

..... *Ph.D Scholar* .....

from ..... *ICAR - IARI* .....

has participated in the National Symposium on *Entomology 2018: Advances and Challenges* held during 10-12<sup>th</sup> December 2018, Hyderabad and presented a paper which was well appreciated.

**Organising Secretary**

*Self attested  
Ramya.N*

*[Signature]*  
**Chairman**





पादप कार्यिकी विज्ञान संभाग  
भारतीय कृषि अनुसंधान संस्थान, नई दिल्ली-110 012 भारत  
DIVISION OF PLANT PHYSIOLOGY  
Indian Agricultural Research Institute, New Delhi-110 012 (India)



पत्रांक: F.No. 48-14/18-19/NAHEP (71-01)/Intl Training/07

दिनांक: 01-09-2019

डॉ। विश्वनाथन ची

प्रधान वैज्ञानिक & PI, CAAST

**OFFICE ORDER**

Under World Bank-Indian Council of Agricultural Research sponsored NAHEP-Centre for Advanced Agricultural Science and Technology (CAAST) project on "Genomics Assisted Crop Improvement and Management" at ICAR-Indian Agricultural Research Institute, New Delhi-110012, **Ms. Ramya N, Ph.D. Student, Discipline of Entomology, Roll No. 10789** has been selected for undergoing two months training at **University of Delaware, USA**, as approved in the selection committee meeting held on 6-07-2019.

Towards the training, the student is eligible for 1) actual airfare (shortest route in economy class by Air India or code-share flights of Air India), 2) preparatory allowance (VISA fees, travel insurance, etc.), and 3) Fellowship of US Dollar 1500 per month or equivalent as per NAHEP norms. This expenditure will be met from the operation cost of the CAAST project at IARI.

Advance for the training program may be drawn by the Chairperson, Advisory Committee of Ms. Ramya N (Roll No. 10789). The student should complete the training before 31<sup>st</sup> March 2020 and the Chairperson may complete the adjustment of the advance at the earliest after training.

Upon arrival, the student must deliver a seminar and submit a detailed report of the training obtained & work carried out. The student may be asked to contribute in the training programs at IARI under CAAST project. The student must acknowledge the NAHEP-CAAST project in the thesis and publications.

C.V. [Signature] 11/9/19

(Viswanathan Chinnusamy)  
PI, NAHEP-CAAST

**Copy to:**

- ✓ 1) Ms. Ramya N, Ph.D. Student, Discipline of Entomology, Roll No. 10789
- 2) Chairperson of the student
- 3) Professor, Discipline of Entomology, ICAR-IARI, New Delhi-110012
- 4) Head, Division of Entomology, ICAR-IARI, New Delhi-110012
- 5) Dr. T K Behera, Coordinator, Committee for International & National Trainings, short visits & conferences, NAHEP-CAAST, ICAR-IARI, New Delhi-110012
- 6) Dr. Rashmi Aggarwal, Dean & Joint Director (Edu.), ICAR-IARI, New Delhi-110012
- 7) Dr. KM Manjaiah, Associate Dean, ICAR-IARI and Nodal Officer, NAHEP-CAAST project, ICAR-IARI, New Delhi
- 8) AF&AO, Audit-V, Directorate, ICAR-IARI, New Delhi-110012
- 9) AAO, Plant Physiology, ICAR-IARI, New Delhi-110012

self attested  
Ramya N

Dec 19, 2019

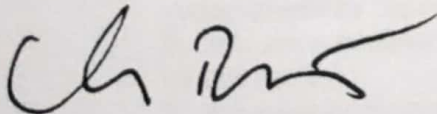
RE: Certificate of Training at University of Delaware

To whom it may concern:

This letter serves to confirm that **Ms. Ramya N, Ph.D.** student of Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi, India-110012, worked as a visiting research scholar in the Department of Entomology and Wildlife Ecology, College of Agriculture and Natural Resources, University of Delaware, USA-19716. She worked here for two months, from *Oct 20, 2019 to Dec 20, 2019* under the student exchange program of Centres for Advanced Agricultural Science and Technology- National Agricultural Higher Education Project, Indian council of Agricultural Research, Ministry of Agriculture and Farmers welfare, Government of India (CAAST-NAHEP). During her stay she worked on a part of her Ph.D. research entitled "Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea) from India." She learned the techniques of classical taxonomy and molecular taxonomy.

Ms. Ramya N. conducted excellent work during her 2-month visit. I provide this certificate for her, as her hosting supervisor. Please feel free to contact me for any further details.

Sincerely



Charles Bartlett, Ph.D.  
University of Delaware  
Department of Entomology and Wildlife Ecology  
250 Townsend Hall  
531 S College Ave  
Newark, DE 19716-2160

self attested  
Ramya. N





डॉ. ए. कुमार, पी.एच.डी  
प्रधान वैज्ञानिक  
**Dr. A. Kumar, Ph.D**  
Principal Scientist



पादप रोग विज्ञान संभाग  
भारतीय कृषि अनुसंधान संस्थान  
नई दिल्ली-110 012 (भारत)  
Division of Plant Pathology  
Indian Agricultural Research Institute  
New Delhi-110 012 (India)

Dear Sir/Madam,

05 Dec 2018

Greetings from CAAST team!

NAHEP-CAAST has invited research proposals from students of IARI for funding part of their research work (as proposed in ORW) in the area of genomics. Students made their presentation on 6-7th Sep 2018. A total of 46 students made presentations and the same was independently evaluated by six Core-team members. Based on merit and several other criteria as laid out by World Bank sponsored NAHEP, a total of 33 students were selected. I am happy to inform that you have been selected for CAAST support for carrying out your thesis project in IARI, **subjected to the following conditions.**

1. You must utilize the fund exclusively for **your thesis project only**
2. You must submit soft copy of progress **report** of your work **on or before 5<sup>th</sup>** of every month. Kindly submit the report **on 4<sup>th</sup> of every month**, if 5<sup>th</sup> is an official holiday. Kindly submit to [kumar@iari.res.in](mailto:kumar@iari.res.in) by email.
3. You must be available for any **CAAST related activities like infrastructure building and all other academic activities** related to CAAST project.
4. You must acknowledge the source of funding (**Part or whole of the thesis project is financially supported by NAHEP-CAAST**). All research publications emerging from your thesis project must indicate this statement.
5. Gene sequence partial/complete, or whole **genome** data and all omics data must be submitted to CAAST for documentation. Separate web options will **be created** soon for this purpose.
6. You must be available for periodical review **meetings** organized by NAHEP-CAAST from time to time.
7. **Submit** your indents to CAAST nodal office at Division of Plant Physiology, ICAR-IARI, New Delhi after due endorsement by the core-member.
8. You are requested to visit <https://nahep.icar.gov.in/> from time to time for any new information on this unique project.
9. You must be participating, assisting and helping **CAAST sponsored training programme** to be organized at IARI at regular interval.
10. Kindly share your active mobile number, and **alternate** emails if any by return mail.

**Fund allocation for your project on *Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea)* from India**

| Name                 | Discipline | Chairman/<br>Chairperson | Result          | 2018-19<br>(Rs. in<br>lakhs) | 2019-20<br>(Rs. in<br>lakhs) | 2020-21<br>(Rs. in<br>lakhs) | Total<br>(Rs. in<br>lakhs) |
|----------------------|------------|--------------------------|-----------------|------------------------------|------------------------------|------------------------------|----------------------------|
| Ms. Ramya N<br>10789 | Entomology | Dr. Naresh M.<br>Meshram | Recomm<br>ended | 3.0                          | 0                            | 0                            | 3.0                        |

Looking forward to your active participation in CAAST project

With best regards,

Yours truly,  
A.Kumar  
Core-Member  
CAAST Project

self attested  
Ramya N



**INDIAN COUNCIL OF AGRICULTURAL RESEARCH  
KRISHI ANUSANDHAN BHAWAN-II, PUSA, NEW DELHI - 110 012  
EDUCATION DIVISION**



025346

F. No. 1(9)/2012-Exam Cell

Date: 19/05/2014

Dear Candidate,

Based on the result of the ICAR's 19<sup>th</sup> All India Entrance Examination (AIEEA-PG-2014), for admission to Master degree programmes in agriculture and allied sciences for 25% seats in Agricultural Universities i.e., SAUs/SVUs, CAU, BHU, AMU, Visva Bharati and Nagaland University, SHIATS and all seats at IARI, VRI, NDRI, and CIFE in the Academic Session 2014-2015, this is to inform that you have qualified for the Counseling. Based on the Counseling, you are likely to be recommended for admission in the subject and the University of your Choice, subject to fulfilling the eligibility conditions of that University and availability of seats at your merit rank and category. The counseling of OBC candidates will be done along with the candidates of General category at their overall merit rank. The SC/ST candidates who do not wish to take admission in their respective reserve category may opt for counseling with General + OBC category.

In order to attend the counseling, it is essential to fill up the Counseling Form provided to the qualified candidates (copy enclosed) and submit the same at the time of counseling, duly filled in and signed along with self-attested photocopies of the required under mentioned certificates to the counseling committee. The counseling form must have clear options for 4 choices of subjects and 6 choices of preferred Universities. In case, all seats in the subject at the university opted for, are exhausted by the time candidate reaches counseling desk, he/she shall have the option to provide fresh choice of subjects/universities wherever seat is available. The preliminary certificate checking for eligibility of candidature based on the submitted photocopies of certificates will be done before counseling. However, their eligibility will be based on final re-checking of documents by the officials of admitting universities at the time of admission during counseling.

Accordingly, you are required to appear for Counseling at A.P. Shinde Symposium Hall, NASC Complex (ICAR), Dev Prakash Shastri (DPS) Marg, Opp. Todapur, Pusa, New Delhi-12 (on the East Patel Nagar to Inder Puri road) as per schedule indicated (Please see the attached Counseling Schedule and location map and also on ICAR website: [www.icar.org.in](http://www.icar.org.in) along with PG result). While reporting for counseling, you must ensure that all the eligibility conditions as specified in the Information Bulletin (IB), are fulfilled in toto including completion of the degree, OGPA/CGPA/percentage marks scored in Bachelor Degree examination etc (Equivalence between OGPA and % marks will not be acceptable). Please note that ICAR/Universities will NOT be held responsible for denial of admission to non-eligible candidates. Please bring the following documents with you (also see IB for other details) along with self-attested photocopy of each certificate:

1. Date of Birth (DOB) certificate/Matriculation Certificate.
2. All Certificates and Mark sheets, grade reports in original, related to Class X and Class XII.
3. Bachelor/UG degree. In case degree has not been awarded, PDC must be produced at the time of Counseling. If these are not available then such candidates reporting for the counseling must have final year/final semester result in hand clearly indicating final OGPA/CGPA or final percentage of marks where grade points are not awarded (refer Information Bulletin page 17 item No. (iii) (c)).
4. In case of candidates from SC, ST and non-creamy layer of OBC categories, original Certificates as per Central Govt. requirements and issued by Competent Authority.
5. Medical certificate in case of Physically Challenged (PC) candidate issued by Medical Officer of any Government Hospital along with description of the kind of disability and the degree of disability.
6. Character Certificate from the Head of the institution last attended.
7. Original copy of the candidate's admit card and counseling call/invitation letter from ICAR.
8. Three recent and clear passport size colour photographs same as pasted on the Application Form.
9. Domicile certificate in cases of candidates from States/Union Territories namely Andaman & Nicobar Islands, Arunachal Pradesh, Dadra & Nagar Haveli, Daman and Diu, Goa, Lakshadweep, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura for UPS categories.
10. Authority letter/undertaking in the prescribed format (Annexure-III of IB) if the candidate is unable to attend the counseling personally.

Registrars of all the associated Universities (as listed on Counseling Proforma) have been invited for your Counseling and granting admission. For confirming the admission you will be required to deposit part admission fee of Rs. 2,000/- (non-refundable) in cash, positively with the Registrar of the concerned University for which receipt will be taken by you. Also, your original certificates will be required to be deposited with the Registrar. In cases of late reporting by the candidates for counseling due to any reasons, he/she will lose claim for admission that was due at his/her rank. However, such candidates may be considered for admission on the same day against left out seats at the time of reporting. No claim/compensation for problems (if any) encountered or cost incurred in attending the Counseling will be entertained by the ICAR/Universities. Candidates with three year U.G. degree may please note that there are only few Universities (see Information Bulletin) that accept three years degree for admission to their Master's degree programmes and the candidates may be required to do the bridge courses and duration of programme will be 2-3 years.

For admission as well as the award of ICAR - JRF (PGS), you must be admitted in a University other than the University from where you have obtained the graduate degree, except at NDRI, as indicated in the Information Bulletin. Ragging in the Universities, in any form, is a criminal offence and has been strictly banned. Please note that this letter is for information to call the candidates for Counseling and does not, in any way, guarantee the admission.

(Controller of Examinations (Edn.))

Phone: 011-25843392, E-mail: [mkagnihotri@icar@nic.in](mailto:mkagnihotri@icar@nic.in)

**Note:** This letter is also being sent separately by post to all candidates qualified for counseling. ICAR will not be held responsible for any postal delay in this regard. The candidates are advised to download the letter from ICAR website which will be acceptable for the purpose of counseling.

Major Subject Group.: 4

Roll Number: 025346

Category: OBC

(For details please see Page No - 2)

Your Counseling date and time :

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ಕರ್ನಾಟಕ ಸರ್ಕಾರ  
GOVERNMENT OF KARNATAKA

471225

0128378067

# ಕರ್ನಾಟಕ ಪ್ರೌಢ ಶಿಕ್ಷಣ ಪರೀಕ್ಷಾ ಮಂಡಳಿ Karnataka Secondary Education Examination Board



ಈ ಕೆಳಗೆ ನಮೂದಿಸಿದ ಅಭ್ಯರ್ಥಿಯು ಎಸ್.ಎಸ್.ಎಲ್.ಸಿ. ಪರೀಕ್ಷೆಯಲ್ಲಿ ಕೆಳಗಿನ ವಿವರಗಳೊಂದಿಗೆ ತೇರ್ಗಡೆಯಾಗಿದ್ದಾನೆ/ದ್ದಾಳೆ ಎಂದು ಪ್ರಮಾಣೀಕರಿಸಲಾಗಿದೆ.

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| ವಿಷಯಗಳು<br>SUBJECTS                           | ಅಂಕಗಳು<br>MARKS |                | ಪಡೆದ<br>ಅಂಕಗಳು<br>MARKS<br>OBTAINED | ಪಡೆದ ದರ್ಜೆ(ಶ್ರೇಣಿ)<br>CLASS OBTAINED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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का जैववर्गिकी अध्ययन**

**Biosystematic studies of family Delphacidae (Hemiptera:  
Fulgoroidea) from India**

**RAMYA. N**

**Roll No. 10789**



**DIVISION OF ENTOMOLOGY**

**ICAR-INDIAN AGRICULTURAL RESEARCH INSTITUTE**

**NEW DELHI-110012**

**2020**



**Biosystematic studies of family Delphacidae (Hemiptera:  
Fulgoroidea) from India**

**A Thesis**

**By**

**RAMYA. N**

**Submitted to the Faculty of the Post-Graduate School,  
ICAR-Indian Agricultural Research Institute, New Delhi,  
In partial fulfillment of the requirements  
for the award of the degree of**

**DOCTOR OF PHILOSOPHY  
IN  
ENTOMOLOGY**

**2020**

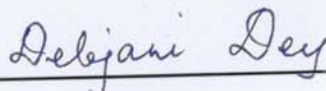
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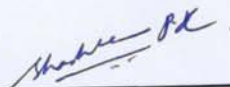
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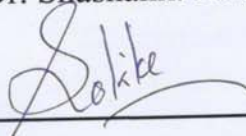
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### **CERTIFICATE**

This is to certify that the thesis entitled, “**Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea) from India**”, submitted to the Faculty of the Post-Graduate School, Indian Agricultural Research Institute, New Delhi, in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY in ENTOMOLOGY** is a record of bona fide research work carried out by **RAMYA. N** under my guidance and supervision, and no part of this thesis has been submitted for any other degree or diploma. It is further certified that all the assistance and help availed during the course of investigation as well as all sources of information have been duly acknowledged by her.

Date:

Place: New Delhi

(Dr. Naresh M. Meshram)  
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---

*I believe the world is one big family, and we need to help each other*

*“The best and fair thing to keep a balance in your life, acknowledge the great powers around us and in us. So, it is essential that I acknowledge the great powers, who paved the way on which I have walked so far. Any accomplishment requires the effect of many people along with the sincere guidance of experienced persons and blessings of God and this work is not different.*

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Dated:

Place: New Delhi

*Ramya. N*  
(RAMYA. N)

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## 1. INTRODUCTION

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Hemiptera is the largest order of hemimetabolous insects, with piercing and sucking type of mouth parts. This order is divided into two suborders Homoptera and Heteroptera, which further grouped into five homophyletic groups. The Homopteran groups are Fulgoromorpha (planthoppers) and Cicadomorpha (leafhoppers, froghoppers and cicadas) belong to Auchenorrhyncha. Three Heteropteran groups (true bugs) are, Sternorrhyncha (plant lice, jumping lice, mealy bugs and scale insects) and Coleorrhyncha (Campbell *et al.*, 1995). The planthoppers having a few large spines on the hind tibiae and the antennae arising below the compound eye which differentiate them from leafhoppers.

Planthopper is a collective term used for the phloem feeding insects belongs to superfamily Fulgoroidea of order Hemiptera (Schaefer and Panizzi, 2000). The name defines their notable analogy with the plantparts and nature of “hop” for quick transportation. These are similar to leafhoppers (Cicadellidae), spittlebugs (Cercopidae) and treehoppers (Membracidae) in the infraorder Cicadomorpha. The superfamily constitutes around twenty families, of these Delphacidae (Hemiptera: Fulgoroidea) is the second most speciose and economically important, which constitutes approximately 2214 described species (Bourgoin, 2019). They are generally small insects less than 5mm except in Stenocraninae and Kelisinae.

Delphacids are easily distinguished from other planthoppers and insect families (*viz.*, the cicadomorphs) by the presence of a large, movable spur (calcar) on the apex of the hind tibiae which helps in jumping. The spur vary in its forms with respect to subfamilies of delphacidae. In primitive groups it is rounded or quadrate in cross-section without the fine teeth. However it is usually flattened and rather curled, with a row of black-tipped teeth along the posterior margin in all other groups. The wings are membranous with black patterns or quite thickened in brachypterous forms and held roof like over the abdomen. They are mostly grass-feeders and vectors of plant diseases, some feed on sedges, rushes, and dicotyledons especially in Asteraceae (Wilson *et al.*, 1994; Nickel, 2003).

### **Economic importance:**

Delphacidae is one of most specious families in the order Hemiptera which comprises of approximately 416 genera and 2214 species worldwide (Bourgoin,

2019). It is the most economically important group, which includes at least 55 species that feed on economically important crops (Wilson and O'Brien, 1987). Delphacids tend to be host-specific, with a majority feeding on phloem sap in monocots such as grasses and sedges (Wilson *et al.*, 1994; Nickel, 2003). In addition to causing mechanical damage by feeding on vascular tissues of plants and cutting slits into plants for oviposition, are vectors of many plant diseases in rice, maize, wheat, barley, sugarcane etc (Wilson, 2005; Hogenhout *et al.*, 2008). They are vectors for more than 30 plant viruses and at least one phytoplasma (Wilson and O'Brien, 1987; Wilson, 2005; Arocha *et al.*, 2005).

### **Complexity in the group:**

Delphacids are known for their complexity, they generally coloured with white and black without fixed patterns, this paved the way to their cryptic nature. The genus level as well as species level crypticity has been recorded in the group. Sexual dimorphism is another important obstacle in the identification, certainly females in some species can not be identified. Wing polymorphism is most common in the group which include macropterous, brachypterous, submacropterous and stenopterous forms. Macropterous wings are membranous and hyaline where as in brachypterous are thickened and dark. In some species the variation in the wing pattern to such an extent that they cannot be identified as brachypterous of certain species unless their genitalia examined carefully (Hamilton, 2011). Another important complexity is different morphs of same species which may be caused by its genetic makeup and environmental conditions.

### **Studies on world fauna:**

Taxonomic work on Delphacidae began from 18<sup>th</sup> century with the description of the genus *Delphax* by Fabricius in 1798. Leach (1815) gave the family rank to the group but it was officially accepted by International Commission on Zoological Nomenclature (1961) with type genus as *Delphax* Fabricius (Hamilton, 2006). Later many workers worldwide described delphacids from different geographical regions, Muir (1916) -Philippine Delphacidae; Fennah (1963) – *Sogatella furcifera* species complex; Fennah (1975) - Delphacid fauna of Ceylon; Fennah (1978) - Fulgoroidea from Vietnam; Chen and Liang (2007) revised the oriental genus *Bambusiphaga*; Hamilton (2006) - genus *Stenocranus* from Canada. Qin and Zhang (2009) revised the

genus *Malaxella* Ding and Hu. Bartlett (2009) gave diversity of new world Stenocraninae. Beiman and Mol (2010) revised the Dutch delphacid fauna. Hu and Ding (2014) described new species of *Neobelocera medogensis* Hu and Ding, along with the keys to genus from China. Karavin *et al.*, (2015) studied the Turkish Delphacid fauna, for which additional notes were given by Karavin and Ozgen (2015). Campodonico (2017) gave the distribution records of Delphacidae from Chile. Della Giustina (2019) studied the delphacid fauna of France.

#### **Studies on Indian fauna:**

Total number of species described from India is very less as compared with world fauna of Delphacidae. Studies on delphacids in India started after 1906. Earlier work on the taxonomy of Indian Delphacidae was carried out by Distant, (1906 and 1916) and published a monograph 'Rhynchota' the fauna of British India, in which 34 species from 15 genera were described. Later, Ishihara and Lowe (1969) reported *Nilaparvata lugens* (Stal), *Sogatella furcifera* (Horvath), *Unkanodas sapparonus* Matsumura, *Sardia rostrata* Melicher, *Nisia atrovenosa* Lethierry and *Eponisia guttula* Matsumura from different rice growing states in India. Mammen and Menon (1972) reported 29 species of delphacids for the first time in India. Mammen and Menon (1974) studied 44 species of delphacids and given a key for separation of 25 genera of Indian delphacids. Kalode (1983) studied the commonly occurring Auchenorrhynchan rice fauna from India, where he reported planthoppers like *N. lugens*, *S. furcifera*, *U. sapparonus* Matsumura, *Laodelphax striatellus* and *Pyrilla perpusilla*. Gunathilagaraj (1999) revised planthoppers associated with rice and he reported 10 species viz., *N. lugens*, *N. bakeri*, *S. furcifera*, *S. vibix*, *Tagosodes pusanus*, *L. striatellus*, *U. sapparonus*, *Eudellana celadon* Fennah, *N. nervosa* and *P. perpusilla* in India. Rao and Chalam (2006) studied biosystematics of planthopper fauna (Homoptera: Fulgoroidea: Delphacidae) in Andhra Pradesh, where he reported 23 species of delphacid planthoppers from south India. Nimisha (2008) studied the Delphacid fauna in agro ecosystems of Karnataka and redescribed the 28 species across 20 genera. The important rice pest *Laodelphax striatellus* Fallen was recorded from Delhi –NCR by Ramya and Meshram (2019). The bamboo feeding genus of the Tropidocephalini, *Bambusiphaga* Huang and Ding, was newly recorded from India along with a new species *Bambusiphaga unispina* by Ramya and Meshram (2019).



## Phylogenetic studies

The family-group classification of Delphacidae has been controversial and seen many changes over the past 50 years. Higher classifications of Delphacidae was proposed by Asche, Emeljanov and Hamilton (Urban *et al.*, 2010). Phylogenetic studies gained momentum with the first cladistics investigation by (1985, 1990). This study recognized the six delphacid clades, divided as paraphyletic subfamily Asiracinae (tribes Asiracini and Ugyopini) and five monophyletic subfamilies (Delphacinae, Kelisiinae, Stenocraninae and Plesiodelphacinae, Vizcayinae) (Asche, 1990). Although there are previous studies based on phenetical grouping and anagenic trends, Asche opined these studies are either for diagnostic purpose or based on artificial system, which lead to perfect confusion (Asche, 1985). Emeljanov (1996) first attempted phylogenetic investigation based on immature stages. There are many significant studies based on external morphology by Yang *et al.*, (1987) and Hamilton (2006). In recent times the phylogenetic studies are based on the molecular data and sometimes combined with morphological data. Dijkstra *et al.*, (2003, 2006) used mitochondrial DNA nucleotide sequence data (mtCOI 504bp) and 12S ribosomal DNA (352bp) data and supported Asiracinae consistently as sister to the remaining subfamilies. Urban *et al.*, (2010) combined the molecular (four genetic loci - 18S rDNA, 28S rDNA, wingless and cytochrome oxidase I) and morphological data (132 coded characters) to study the evolution of Delphacidae along with the host shifts. This study support the host relationships have played a key role in the evolutionary history of Delphacidae.

In spite of delphacids being notorious pests, their taxonomy is shrouded in uncertainty. Except for stray publications of isolated species descriptions and lists of faunistics, there had been no concerted attempts to characterize this family and place them on the updated classifications as per the world trends. As there is very less representation of delphacids from India, this study may lead to discovery of many species causing change in higher classification of Delphacidae. In this backdrop, the present study is an effort to explore and collect delphacids from India and to develop integrative protocol which will help in establishment of correct identity and could also be employed for rapid identification of planthoppers.

**Objectives:**

1. Morphological studies and identification of planthoppers belonging to Delphacidae.
2. To prepare annotated checklist and development of illustrative diagnostic keys.
3. DNA barcoding and phylogenetic analysis of the planthoppers belonging to Delphacidae.

## 2. REVIEW OF LITERATURE

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Delphacidae constitutes one of the largest and economically important family in Fulgoroidea. According to recent estimates delphacids accounts for total 2214 species, (Bourgoin, 2019) grouped under 416 genera and six subfamilies. Taxonomic work on Delphacidae began from 18<sup>th</sup> century with the description of the genus *Delphax* by Fabricius (1798). Leach (1815) gave the family rank to the group in 1815, but it was officially accepted when International Commission on Zoological Nomenclature in 1961 with type genus as *Delphax* Fabricius (Hamilton, 2006). Delphacidae is the monophyletic family with six subfamilies viz., Asiracinae, Delphacinae, Kelisiinae, Plesiodelphacinae, Stenocraninae and Vizcayinae (Asche, 1985, 1990). Delphacinae and Delphacini are the largest subfamily and tribe respectively.

### 2.1 Economic importance of delphacid planthoppers

The Delphacidae is the most diverse and economically important family with worldwide distribution, causing persistent damage to crops. They are well known from tropical and subtropical regions and most of the species recorded as pests of graminaceous crop plants. Worldwide 85 species are known as pests on 25 crops (Wilson and O'Brien, 1987; Wilson, 2005) including 5 of the top 10 major world food commodities. They cause both direct (by feeding) and indirect (by vectoring) damage to plants, resulting effects are hopperburn, phytoxicity and diseases (Memmen, 1971). In June 2008, the International Rice Research Institute (IRRI) in their press release referred planthoppers a “major threat to Asian rice production”.

Delphacids are recorded as important pests of paddy, sugarcane, wheat, barley, maize, oats, colocassia etc. They suck the plant sap from the mesophyll tissues and cause a white stippling on leaves. The chlorophyll content of the plant is greatly reduced intern affect the plant physiology resulting in stunted growth. The toxins produced by these insects causes tissue necrosis and phytoxicity on plant tissue. The honey dew secreted on the leaves became the cause for sooty mould development.

Delphacids are vectors for more than thirty three plant viruses and at least one phytoplasma (Wilson and O'Brien, 1987; Wilson, 2005; Arocha *et al.*, 2005). *Nilaparvata lugens* is a major pest of rice and also transmits *grassy stunt* and *ragged stunt virus* diseases in rice (Reissig *et al.*, 1985). Anjaneyulu (1974) first time

reported the heavy losses in paddy yields due to grassy stunt, which is transmitted by *N. lugens* in Kerala state of India. In rice, planthoppers alone constitute for 20 per cent loss (Dhaliwal, *et al.*, 2004). The long dry spells, followed by short spells of heavy rains of monsoon in 2018 triggered the *N. lugens* outbreak which affected the nine major rice growing states viz., Odisha, Maharashtra, West Bengal, Telangana, Gujarat, Andhra Pradesh, Assam, Tamil Nadu and Rajasthan. (<https://www.downtoearth.org.in/news/climate-change/wipeout-59356>). In 2019 BPH outbreak led the farmers to burn the crop, besides this the pest is resistant to most of the available pesticides.

The sorghum shoot bug *Peregrinus maidis* is also one of the major pest in India, which transmits *freckled yellows of sorghum*, *sorghum chlorosis* and *sorghum mosaic* (Chellaiah and Basheer, 1965). Apart from these reports from India there are many delphacids transmits diseases in sugarcane and other crops which are reported from other countries.

In India many number of delphacids have been reported as pests of cultivated crops. In 1916 a serious outbreak of the rice white backed plant hoppers *Sogatella furcifera* (Horv.) in the central province was investigated by the Indian Agricultural Research Institute, Pusa. Usman (1959) recorded the occurrence of *Tropidocephalus margineounetata* as a pest of sugarcane in Mysore. In 1958 there was a serious outbreak of the brown plant hopper *Nilaparvatha lugens* (Stal) in deep water paddy belt of Kuttanad in Kerala. Chelliah and Basheer (1965) reported the sorghum shoot bug *Perigrinus maidis* Ashmead on sorghum, maize, bajra, and other millets from Hyderabad. Atwal *et al.*, (1967) reported on outbreak of *Sogatella furcifera* (Horv.) in Punjab and studied the biology and control of the pest. In addition to these, the collection data of the specimens in the National Pusa Collection (NPC) revealed that number of delphacid planthoppers have been collected from other crops like orange, guava, cotton, tobacco, moong, soyabean, potato, menthe *etc.* (Mammen, 1971).

Worldwide 57 species of delphacids are recorded as pests of crop plants and some grasses (Wilson and O'Brien, 1987, Wilson 2005), in which 33 species are known as vectors of plant viral and phytoplasma diseases (Wilson, 2005). The economically important pests, crop infested, disease transmission and their distribution in India were updated in Table. 1.



**Table 1. Major pest species of Delphacidae reported from India.**

| Sl no. | Delphacid pest species        | Crop infested                                                                             | Disease transmitted/Association                                                                        | Distribution in world and India                                                            | Reference                                  |
|--------|-------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------|
| 1.     | <i>Eoerysa flavocapitata</i>  | Sugarcane                                                                                 |                                                                                                        | IM<br><b>India:</b> West Bengal, Assam,                                                    | Wilson and O'Brien 1987                    |
| 2.     | <i>Laodelphax striatellus</i> | Barley, citrus, maize, rice, oats, wheat                                                  | Black streak dwarf stripe<br>Yellow striate mosaic<br>Yellow dwarf in rice                             | IM, PA<br><b>India:</b> Punjab, Delhi                                                      | Wilson, 2005; Heong, 2009                  |
| 3.     | <i>Metadelphax propinqua</i>  | Sugarcane, rice barley, barnyard grass, bermuda grass, maize, rice, speargrass, sugarcane | Maize rough dwarf fivirus (MRDV)<br>Barley yellow striate mosaic cytorhabdovirus (BYSMV)               | All India (All states)                                                                     | Wilson, 2005                               |
| 4      | <i>Nilaparvata bakeri</i>     | <i>Leersia</i> , rice                                                                     | Rice grassy stunt tenuivirus (RGSV)<br>Rice ragged stunt oryzavirus                                    | IM<br><b>India :</b> Karnataka: Bengaluru, Mudigere                                        | Wilson, 2005                               |
| 5      | <i>Nilaparvata lugens</i>     | Rice                                                                                      | Rice grassy stunt tenuivirus (RGSV)<br>Rice ragged stunt oryzavirus (RRSV)<br>Hoja blanca, Rice stripe | AP, IM<br><b>India</b> (All states)                                                        | Reissig <i>et al.</i> , 1985; Wilson, 2005 |
| 6      | <i>Peregrinus maidis</i>      | Maize, sorghum                                                                            | Maize stripe virus (MSV)<br>Freckled yellows of sorghum,<br>Sorghum chlorosis<br>Sorghum mosaic        | AF, AP, IM<br><b>India</b> (All states)                                                    | Chellaiah and Basheer, 1965; Wilson, 2005  |
| 7      | <i>Perkinsiella insignis</i>  | Maize, sugarcane                                                                          | Fiji disease<br>Sugarcane yellow leaf phytoplasma (SCYLP)                                              | <b>India:</b> Bihar: Pusa;<br>Maharashtra: Bombay;<br>Karnataka: Bengaluru;<br>West Bengal | Arocha <i>et al.</i> , 2005                |
| 8      | <i>Perkinsiella sinensis</i>  | Maize, sugarcane                                                                          | Fiji disease<br>Sugarcane yellow leaf phytoplasma (SCYLP)                                              | India (In all the states)                                                                  | Wilson, 2005                               |
| 9      | <i>Purohita cervina</i>       | Bamboo                                                                                    |                                                                                                        | IM<br><b>India:</b> West Bengal: Darjiling;<br>Tamil Nadu: Coimbatore                      | Wilson, 2005                               |
| 10     | <i>Purohita taiwanesis</i>    | Bamboo                                                                                    |                                                                                                        | IM<br><b>India:</b> Himachal Pradesh: Nauni, Bilaspur;<br>Delhi: Pusa campus New Delhi.    | Wilson, 2005                               |

|    |                                        |                                                      |                                                                                                                       |                                                                                                                        |                                    |
|----|----------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| 11 | <i>Sogatella furcifera</i>             | Pangola grass, maize, millet, rice                   | Southern Rice Black Streak Dwarf                                                                                      | AP, IM, PA<br><b>India</b> (In all the states)                                                                         | Wilson, 2005                       |
| 12 | <i>Sogatella kolophon</i>              | Barley, carrot, coconut, maize                       | Maize sterile stunt virus (MSSV)                                                                                      | AF, AP, IM, NA, NT<br><b>India:</b> Andhra Pradesh; Karnataka; Maharashtra; Tamil Nadu; Himachal Pradesh; Delhi,       | Wilson, 2005                       |
| 13 | <i>Sogatella vibix</i>                 | Barnyard grass, grass, maize, oats, rice, rye, wheat | Maize sterile stunt virus (MSSV)<br>Maize rough dwarf fivirus (MRSV)<br>Finger millet mosaic nucleorhabdovirus (FMMV) | AP, IM, PA<br><b>India:</b> Andhra Pradesh; Karnataka; Maharashtra; Tamil Nadu; Delhi; Himachal Pradesh.               | Wilson, 2005                       |
| 14 | <i>Tagosodes pusanus</i>               | Rice, sugarcane                                      |                                                                                                                       | IM<br><b>India:</b> Andhra Pradesh; Karnataka: Bengaluru, Makuta, Maharashtra; Tamil Nadu. Pasighat, Arunachal Pradesh | Rao and Chalam, 2007               |
| 15 | <i>Terthron albobittatum</i>           | Barnyard grass, rice                                 | Black streak dwarf Stripe, Rice stripe tenuivirus (RSV)<br>Rice black-streaked dwarf fivirus (RBSDV)                  | IM, PA-E<br><b>India:</b> Andhra Pradesh :Tirupati; Uttarkhand: Hawalbag; Maharastra: Malkhed forest.                  | Wilson, 2005; Rao and Chalam, 2007 |
| 16 | <i>Tropidocephala saccharivorella</i>  | Sugarcane                                            |                                                                                                                       | <b>India:</b> Karnataka: Bengaluru, Mandya                                                                             | Nimisha, 2008                      |
| 17 | <i>Tropidocephalus margineounetata</i> | Sugarcane                                            |                                                                                                                       | India: Karnataka: Mysore                                                                                               | Usman, 1959                        |
| 18 | <i>Unkanodes sapporonus</i>            | Rice                                                 | Northern cereal mosaic virus (NSV)<br>Rice stripe tenuivirus (RSV)<br>Rice black-streaked dwarf fivirus (RBSDV)       | IM, PA-E<br><b>India:</b> Odisha                                                                                       | Wilson, 2005                       |

Biogeographic Region Abbreviations: AF-Afrotropical, AP-Australo-Pacific, IM-Indo Malayan, NA-Nearctic. NT-Neotropical, PA-Palearctic, PA-E-Eastern Palearctic,

## 2.2 Systematics of Delphacidae

The most accepted taxonomic classification of Delphacidae is by Asche, (1990), which divided it into six subfamilies. The tribes under each subfamily are given as Table 3. Many attempts have been made by different workers that divided Delphacidae (Table 2). Urban *et al.*, (2010) studied the evolution of Delphacidae based on the morphology and molecular basis, which supports the higher classification proposed by Asche (1985,1990), Emiljanov(1996) and Hamilton (2006). The world catalogue of Delphacidae in the name of Areopidae was given by Metcalf (1943) using the type genus *Areopus* Spinola 1839, which includes 137 genera and 1114 species.

**Table 2. Major subfamily classification of Delphacidae given by different workers.**

| Metcalf, 1943             | Haupt, 1929                                                    | Wagner, 1963                                                                                                                           | Asche, 1990                                                                                 | Emeljanov, 1996                         |
|---------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------|
| Asiracinae<br>Delphacinae | Asiracinae,<br>Delphacinae<br>Megamelinae<br>Tropidocephalinae | Asiracinae<br>Achorotilinae<br>Chlorioninae<br>Delphacinae<br>Jassidaeinae<br>Kelisiinae<br>Megamelinae<br>Stirominae<br>Stenocraninae | Asiracinae<br>Delphacinae<br>Kelisiinae<br>Plesiodelphacinae<br>Stenocraninae<br>Vizcayinae | Asiracinae,<br>Delphacinae<br>Ugyopinae |

**Table 3. Tribes of Delphacidae. Value in bracket indicate number of genera**

| Asiracinae<br>(No. of genera)                                                                                                        | Vizcayinae    | Plesiodelphacinae    | Kelisiinae    | Stenocraninae     | Delphacinae                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------|---------------|----------------------|---------------|-------------------|-------------------------------------------------------------------|
| Asiracini (6)<br>Eodelphacini (10)<br>Idiosystatini (3)<br>Neopunanini (1)<br>Platysystatini(4)<br>Tetrasteirini (1)<br>Ugyopini (6) | Vizcayini (2) | Plesiodelphacini (2) | Kelisiini (2) | Stenocranini (10) | Saccharosydniini (4)<br>Tropidocephalini (36)<br>Delphacini (307) |

Distant (1906, 1916) had begun the taxonomic work on Indian Delphacid fauna. He referred Delphacidae as subfamily Delphacinae under Fulgoridae and stated ‘the movable spur at the distal end of hind tibia’ as taxonomic character of delphacids. He recorded 51 species under 19 genera, including nine new genera and 15 new species. Distant (1906) provided a key for 11 genera. Distant (1908, 1918)

had done more extensive study and recorded it in '*Rhynchota*' *Fauna of British India series*. Muir (1921) synonymized many genera through nomenclature changes.

Muir (1916) studies on planthoppers, reiterated the importance of male genitalia in complex groups. Divided the family into two subfamilies, Asiracinae and Delphacinae. He also recognized Tropidocephalini and Delphacini tribes under Delphacinae.

Muir (1921) established the new Tropidocephalini genus *Columbisoga* with type species *Columbisoga campbelli* Muir from Nilgiri hills, Tamil Nadu. Along with this he described 2 new species *Tropidocephala indica* and *Tropidocephala butleri*.

Fennah (1956) prepared a key for the genera of Delphacidae of Australia and Pacific islands. Fennah (1963) studied the *Sogatella furcifera* species complex and recognized 23 distinct species. Fennah (1973, 1975) studied the Delphacid fauna of Ceylon and given subfamily classification matching with that of Muir's (1916). All together he dealt with 39 genera and 69 species with their provincial distribution, several recombinations and synonymies. Fennah (1978) dealt with Fulgoroidea from Vietnam including 25 genera and 34 species.

Joseph (1964) described a new species of *Stenocranus*, *S. ajmerensis* Joseph from Ajmer, Rajasthan. Rao (1965) reported *Tropidocephala saccharivorella* Matsumura from India on sugarcane from Bengaluru and Mandya.

Ishihara *et al.*, (1969) reported *Nilaparvata lugens* (Stal), *Sardia rostrata* Melichar, *Sogatella furcifera* (Horvath) and *Unkanodes sapparonus* Matsumura from different rice growing states of India.

Mammen and Menon (1972) reported 29 new species for the first time from India. Mammen and Menon (1974) studied 44 species belongs to 25 genera and given a key for genera of Indian delphacids.

Ding *et al.*, (1983) studied 25 delphacid species in two tribes (Delphacini and Tropidocephalini) and provided the key for separation of nymphs based on the two median keels on the frons and arrangement of sensory pits on the frons, thorax and abdomen. Along with this, provided the key for some economically important species like *Perkinsiella saccharida*, *Laodelphax striatellus* and *N. lugens* are the important species included in the key.



Kalode (1983) documented common Auchenorrhyncha on rice from different geographic locations in India. He reported wide distribution of *N. lugens* (BPH) and *S. furcifera* (WBPH) from different rice growing areas and occurrence of *Unkanodes sapporouns* Matsumura from Odisha.

Wilson (1983) studied the planthoppers and leafhoppers commonly associated with rice in Asia and provided the key for identification, for separating sexes and to distinguish common species based on fifth instar nymphal stage. Among them, important planthoppers studied were, *N. lugens*, *S. furcifera*, *Sogatodes pusanus* and *L. striatellus*. Wilson and Claridge (1985; 1991) reported 25 delphacids on rice in major rice growing areas in the world and gave the generic keys. Wilson and O'Brien (1987) reported 22 delphacids in rice.

While revising Delphacidae of Taiwan Yang (1989), studied Stenocraninae and Delphacinae, also provided the key to genera along with key for identification of nymphs.

Asche and Wilson (1990) reviewed the genus *Sogatella* and related genera associated with rice and provided the keys. They suppressed *Sogatodes* as a junior subjective synonym of *Sogatella* and transferred most of species of *Sogatodes* to *Tagosodes*.

Gunathilagaraj (1999) revised the planthoppers fauna associated with rice and reported 10 species. He also provided synonyms, host plants, distribution, factors responsible for losses, symptoms of damage, biology and management for *N. lugens* and *S. furcifera* and reported *L. striatellus* as occasional pest.

Asche (1985) gave 6 subfamily classification of Delphacidae through phylogeny analysis. He provided a key for the subfamilies and tribes of Delphacidae. Asche (1990) established a new subfamily Vizcayinae with type genus *Vizcaya* Muir along with keys to species. The Oriental genus *Vizcaya* Muir containing four species, among these *V. vindaloo* Asche was from South India. Liang (2002) described a new genus *Neovizcaya* with inclusion of a new species under the subfamily Vizcayinae and also described five new species, in which *V. aschei* Liang was reported from south India.

Rao and Chalam (2007) studied the biodiversity of the planthopper fauna associated with rice and sugarcane crop ecosystems in South India. They surveyed 5

states viz., Andhra Pradesh, Karnataka, Kerala, Maharashtra and Tamil Nadu and 23 species in 17 genera of Delphacinae were identified.

Chen and Liang (2007) revised the oriental genus *Bambusiphaga* Huang and Ding and provided a key to the known species of the genus. Li *et al.*, (2018) added two species to the genus and given the modified key to species.

Hamilton (2006) revised classification of the Delphacidae with two subfamilies Asiracinae and Delphacinae and further Delphacinae classified into four tribes: Vizcayini, Stenocranini, Tropidocephalini and Delphacini. The subfamily Kelisiinae was reduced to the sub-tribe of Stenocranini and Saccharosydmini was placed within Tropidocephalini.

Qin and Zhang (2009) revised the genus *Malaxella* Ding and Hu, of Tropidocephalini from China. Barringer and Bartlett (2011) reviewed the New World Asiracinae; Weglarz, and Bartlett (2011) described the new genus *Akemetopon* of Delphacini with type species *Akemetopon inornatum* and other two new species, *Akemetopon ainigma* and *Akemetopon politum*.

Rossi-Batiz and Remes-Lenicov (2011) described the new genus of Saccharosydmini *Lacertina* with species *Lacertina australis*. Chen and Hou (2012) revised of the planthopper tribe, Eodelphacini, from china with a new genus *Parapunana* and two new species *Parapunana liangi* from Guizhou and *Prolivatis hainanensis* from Hainan. Kennedy *et al.*, (2012) gave annotated checklist of the Florida delphacid planthoppers with description of new species.

Gnanaswaran (2013) reviewed the genus *Harmalia* Fennah from Sri Lanka with description of five recorded species. Fujinuma (2013) revised the *Harmalia* Fennah and *Opiconsiva* Distant, genera of Delphacini from Japan and redescribed 4 species of *Harmalia* and 2 species of *Opiconsiva*.

Paradell *et al.*, (2014) studied Delphacidae diversity associated with vetch plant, *Vicia villosa* in Argentina. Hu and Ding (2014) described new species of *Neobelocera medogensis* Hu and Ding, provided the keys to genus from China.

Karavin *et al.*, (2015) studied the Turkish Delphacid fauna and their distribution, which recorded 64 species across 34 genera from Turkey. Karavin and Ozgen (2015) gave some additional notes on this along with the new record of *Laodelphax striatellus* Fallen and *Sogatella vibix* (Haupt) from Turkey.

Campodonico (2017) gave the distribution records of Delphacidae from Chile. Mariani and Lenicov (2018) described the new species of *Sogatella* Fennah, *Sogatella unidentata* and gave the modified key to the species from Argentina. Zhou *et al.*, (2018) established genus *Parasogata* (Delphacini) with two new species *P. binaria* and *P. furca* from China. Della Giustina (2019) studied the fauna of France. Campodonico and Coccia (2019) described new genus and species *Salinesia atacamensis* from Chile. Ramya and Meshram (2019) recorded the bamboo feeding genus of the Tropidocephalini, *Bambusiphaga* Huang and Ding, from India along with a new species *Bambusiphaga unispina* Ramya and Meshram, 2019.

## **2.2 Subfamily Delphacinae**

The subfamily was erected by Leach (1815). It is the largest subfamily of Delphacidae includes 347 genera in three tribes viz., Delphacini Leach, Saccharosydmini Vilbaste and Tropidocephalini Muir. Members of Delphacinae was easily characterized by the presence of post-tibial spur with or without teeth on hind margin; aedeagus fused with phallobase to form phallotheca, which distinguish this from other subfamilies.

### **Tribe Delphacini Leach**

The tribe, Delphacini was established by Leach (1815) with type genus *Delphax*. Delphacini is the largest tribe of Delphacidae, accounts for 328 genera (Bourgoin 2019) out of which only 27 genera were reported from India (Asche 1985, 1990; Distant 1906; Joseph 1961, 1964; Kalode 1983; Mammen and Menon 1972; Muir 1921; Rao and Chalam 2006; Sharma and Singh, 1980, 1982; Nimisha 2008) constitutes most economically important genera. The post-tibial spur with teeth on hind margin; aedeagus fused with phallobase to form phallotheca are the important tribal characters.

### **Genera of tribe Delphacini**

#### ***Cemus* Fennah**

*Cemus* genus established by Fennah (1964) with its type species *Cemus leviculus* Fennah. Wilson and Claridge (1991) provided the characterization of species by the vertex and mesonotum with variable brown pattern; forewings often marked with granulations on veins. Distant (1916) described *Pundaluoya pulchella* Distant

from Travancore which was later recognized as junior synonym of *Cemus leviculus* Fennah.

### ***Chloriona* Fieber**

This genus was erected by Fieber (1866) with type species *Delphax unicolor* Herrich-Schaffer. It is Widespread in the Palearctic region, Asia, and Africa with 22 recognized species. The genus can be recognized by the converging vertex, parameres reaching the laterodorsal angles of pygofer.

### ***Coronacella* Metcalf**

Metcalf (1950) first stated the genus *Coronacella* with *Kelisia kirkaldyi* Muir as the type species. Later, Wilson and Claridge (1991) described the genus characters, small individuals with black and white patterned, pronotum with white transverse band on posterior three fourth of pronotum and provided the key for identification. First report of occurrence of *C. sinhalana* from India was given by Rao and Chalam (2007) through the survey from different rice eco-systems of Karnataka and given the key for identification.

### ***Eoeurysa* Muir**

The genus *Eoeurysa* was established by Muir (1913) with its type species *Eoeurysa flavocapitata* Muir. It constitutes only three species *E. flavocapitata* Muir (1913), *E. bispina* Menon (1972) and *E. arundina* Kuoh and Ding (1980) till date. The genus characterized by the widened frons, flattened body, segment 10 (anal segment) ring like with or without short latero-apical process, laterodorsal angle of pygofer not produced (Yang, 1989). *E. flavocapitata* is a known as pest of sugarcane worldwide. Chatterjee and Choudhuri (1979) gave the biology of this pest on sugarcane in India.

### ***Falcotoya* Fennah**

Fennah (1969) established the genus with type species, *Falcotoya aurinia* Fennah. The genus constitutes 11 species distributed in Palearctic, New Calodina, China, Taiwan and one species from New World. Members of this genus can be recognized by dark colored habitus with prominent carinae on the thorax and head; the aedeagus strongly downcurved; abdominal segment X bears a pair of processes that tend to be approximated (Fennah, 1969).

### ***Harmalia* Fennah**

The genus was erected by Fennah 1969 with type species *Harmalia thoracica* (Distant, 1916). *Harmalia* was recently subsumed under *Opiconsiva* Distant, by Huang *et al.*, 2017. The genus constitutes 18 species worldwide of which 2 species *Harmalia anacharsis* Fennah, 1969 and *Harmalia thoracica* (Distant, 1916) were known from India. This genus characterized by the expanded lateroapical margin of the pygofer from with inner foldings caudal view, aramature of diaphragm with a process and differently modified shape of parameres (Fennah, 1969).

### ***Laodelphax* Fennah**

*Laodelphax* was raised to genus by Fennah (1963). *Laodelphax striatellus* was described by Fallen (1826) as *Delphax striatella* Fallen. Shukla (1979) first reported *L. striatellus* from Ludhiana, Punjab, then it was reported from Delhi National capital region (NCR) (Ramya and Meshram, 2019). This genus can be differentiated from others in having pygofer in profile with posterior margin acutely incised at middle and tubular aedeagus, laterally compressed, broad at basal half, pointed at apex (Yang, 1989).

### ***Mahmutkashgaria***

*Mahmutkashgaria* is one of least reported genus of Delphacini (Hemiptera: Delphacidae). The genus *Mahmutkashgaria* Kocak and Kemal was earlier placed in the genus *Sulculus* Chen and Ding, with type species *Mahmutkashgaria sulculatus* Ding. Later on shifted to present genus by Kocak and Kemal due to homonymy. Chen and Ding (2002) described genus with two species *Mahmutkashgaria sulculatus* (Ding) and *Mahmutkashgaria liboensis* (Chen) from China. Two long, slender medio-ventral processes of pygofer, dorsal surface of the aedeagus concave with a furrow and subapical lateral process of paramere are unusual characters of this genus which distinguish it from other delphacini genera (Chen and Ding, 2002)

### ***Metadelphax* Wagner**

The genus was erected by Wagner (1963) with type species *Delphax propinqua* Fieber, 1866. *Metadelphax* was synonymized with *Toya* Fennah 1964 (Type species moved to *Toya*), the name restored by Ding 2006 (Gonzon and Bartlett, 2007). Till date the genus constitutes five recognized species worldwide. *Metadelphax propinqua* (Fieber, 1866) is the only species reported as *Toya propinqua* from India



from all most all states in India (Nimisha, 2008). *Metadelphax* more similar to *Toya* in most respects such as habitus size, colour, characters of frons etc. The genera and species are best separated by features of the male genitalia especially expanded dorsal portion of pygofer in caudal view. The genus is known for cryptic species, without males, females cannot be identified to species level (Gonzon and Bartlett, 2007).

### ***Miranus* Chen and Ding**

The genus *Miranus* was erected by Chen and Ding, 2002 with type species *Miranus varians* (Kuoh, 1981). This genus constitutes five species and was earlier reported from China, Fiji and Vietnam. The genus can be distinguished by the extremely long foliaceous lateroapical processes of the segment ten reaching the ventral margin pygofer (Chen and Ding, 2002).

### ***Neunkanodes* Yang**

The genus *Neunkanodes* was established by Yang, 1989 with its type species. *Neunkanodes formosana* Yang. This genus contains three species and was earlier reported from China and Taiwan. The genus can be distinguished by pygofer with or without a medioventral process but with large lamellar expansion medially at caudal margin; aedeagus compressed, with a simple process; parameres long, laterobasal angle with spine-like process.

### ***Nilaparvata* Distant**

Distant (1906) described the genus *Nilaparvata* with *Delphax lugens* (Stål) as the type species. The genus cosmopolitan in distribution with species like *N. lugens* recorded from almost all the states of India. Out of 19 species distributed in the Oriental, Australian and Afrotropical regions, two species were recorded from India viz., *N. lugens* and *N. bakeri* (Nimisha, 2008). Bartlett (2007) revised the genus for the New World and given the key. The genus can be identified by the 1-5 small spines on the inner side of the hind basitarsi (Wilson and Claridge, 1991).

### ***Nycheumna* Fennah**

The genus erected by Fennah (1964) with type species *Dicranotropis cognata* Muir 1917. It is comprises of three species *Nycheumna cognatum* (Muir, 1917), *N. dimorpha* (Matsumura, 1910) and *N. nilotica* (Linnavuori, 1973) in the world. Nimisha (2008) recorded this for the first time from India with the specimens

recovered from Bengaluru, Karnataka. Members of the genus characterized by metatarsal tibial spur with 20 small teeth on lateral margin; pygofer ventral margin with medioventral processes (3 or 1) or absent; aedeagus with 1 long retrose process arising near apex (Xiao *et al.*, 2014).

### ***Opiconsiva* Distant**

The genus described by Distant (1917) with type species *Opiconsiva fuscovaria* Distant. Wilson and Claridge (1991) given genus character as, the tubular aedeagus with dorsal basal extensions. Nimisha (2008) reported the *Opiconsiva* sp. from Karnataka. It can be recognized by shiny black mesonotum carinae not conspicuous. Aedeagus asymmetrical, tubular with basal fold-like extension.

### ***Parasogata* Zhou, Yang and Chen**

*Parasogata* is the recently established genus by Zhou, Yang and Chen (2018) with type species *Parasogata binaria* Zhou. It can be readily recognized by its large size and uninterrupted white fascia extending from vertex to tip of mesonotum, up-curved aedeagus with a row of subapical processes (Zhou *et al.*, 2018). This genus externally similar to *Sogata* Distant but can be separated by the structure of aedeagus (Ding 2006; Zhou *et al.*, 2018). Till date this genus represented by two species.

### ***Peregrinus* (Ashmead)**

The genus *Peregrinus* (Ashmead) was established by Kirkaldy (1904) with *Delphax maidis* Ashmead as the type species. Wilson and Claridge (1991) reviewed along with genus character as the larger species with extremely long aedeagus and absence of the lateroapical process of the segment ten. Rao and Chalam (2007) reported *P. maidis* associated with rice and sugarcane ecosystems. Distant (1916) described *Pundaluoya simplicia* from the Chikkaballapura which later considered it as junior synonym of *P. maidis*.

### ***Perkinsiella* Kirkaldy**

The genus established by Kirkaldy (1903) with its type species *Perkinsiella saccharicida* Kirkaldy. Wilson and Claridge (1991) stated that the genus includes large planthoppers with broad head often with a broad yellow or white stripe from the vertex extending to mesonotum. Distant (1916) described a species *Pundaluoya insignis* Distant from Mumbai which later placed in this genus.

### ***Phyllodinus* Van Duzee**

The genus was established by Van Duzee with type species *Phyllodinus nervatus* Van Duzee, 1897. The genus is characterized by the enlarged femur and tibia of the front and middle legs. Large species, usually brachypterous. According to the current status this genus is probably best restricted to the North American *Phyllodinus nervatus*. The other three species *P. affinis*, *P. aritainoides*, and *P. kotoshonis* treated as species of uncertain status by Yang (1989) and Ding (2006). The review of the genus is needed to confirm current status of the genus.

### ***Sardia* Melicher**

Melichar (1903) established the genus with the type species *Sardia rostrata* Melichar. Distant (1916) described a new species *Sardia pronotalis* Distant from Sri Lanka. Joseph (1961) gave a taxonomic account on *Sardia rostrata* reported from India. The elongate head and overall dark coloration of thorax and the forewings are the diagnostic characters of the genus (Wilson and Claridge, 1991). Muir (1921) described *Sardia campbelli* from South India. *Sardia rostrata* reported from Andhra Pradesh and Karnataka from different rice growing areas (Narayana, 2005).

### ***Shadelphax* Ding**

Ding (2006) erected this monotypic genus with type species *Calligypona eforiae* Dlabola. Later on Chen and Yang (2012) added one more species *S. kashiensis*. Members of the genus recognized by pygofer subequally longer than broad, tubular aedeagus, twisted distally dorsal margin with several teeth, left side with many teeth at central to basal areas (Chen and Yang, 2012).

### ***Sogatella* Fennah**

Horvath (1899) first described the species *furcifera* under *Delphax* later Fennah (1956) established the genus with *Delphax furcifera* Horvath as the type species. Asche and Wilson (1990) reviewed the genus *Sogatella* and provided the keys for 14 species. Along with occurrence of *Sogatella* species from subtropical and tropical regions of the world. The genus includes slender planthoppers with a pale white vitta extending from vertex to mesonotum. They can be distinguished based on male genitalia by the twisted aedeagus with two rows of small teeth (Wilson and Claridge, 1991). Sheng *et al.*, (2000) studied the nymphs of species of *Sogatella* from China.

### ***Tagosodes* Asche and Wilson**

Asche and Wilson (1990) described the genus with its type species *Dicranotropis cubanus* Crawford. They proposed nineteen new combinations and reported *Tagosodes pusanus* (Distant) from India. This genus externally resembles the genus *Sogatella*, but it can be differentiated by the male genitalia (Wilson and Claridge, 1991). Rao and Chalam (2007) reported *T. pusanus* on sugarcane and rice from South India. *T. pusanus* reported from different rice ecosystems of Andhra Pradesh, Karnataka (Narayana, 2005).

### ***Terthron* Fennah**

Kirkaldy (1907) first described *Delphax anemonias* under later Fennah (1965) established the genus with *Delphax anemonias* as its type species. Wilson and Claridge (1991) reviewed the genus and provided the key for identification of *Terthron albovittatum*. In India *T. albovittatum* first reported from Andhra Pradesh by Narayana *et al.*, (2005). Rao and Chalam (2007) reported *T. albovittatum* from different rice eco-systems of South India. This genus can be identified by vertex, pronotum and mesonotum amber coloured with a median stramineous vitta extending from vertex to tip of scutellum; aedeagus tubular and deeply curved are the generic characters.

### ***Toya* Distant**

The genus established by Distant (1906) with type species *Toya attenuata* Distant. This genus can be distinguished from the other genera by the short vertex and armature of the diaphragm wider than long (Wilson and Claridge, 1991; Gonzon and Bartlett, 2007). Usman and Puttarudriah (1955) reported *Delphax propinqua* Fieber from Bengaluru. Rao and Chalam (2007) reported *Toya propinqua* on rice and sugarcane from South India and *Toya bridwelli* from Tamil Nadu.

### ***Unkanodes* Fennah**

Fennah (1956) established the genus with type species, *Unkana sapporona* Matsumura. The genus constitutes 9 species reported from Palearctic and New world. Ishihara and Lowe (1969) reported *U. sapparona* Matsumura from different rice growing states of India. Members of the genus recognized by mesonotum black with offwhite median carinae; laterodorsal angle of pygofer produced; aedeagus tubular with regularly placed spines.

### **Tribe Tropidocephalini Muir**

Tropidocephalini is the second largest tribe of Delphacinae (Hemiptera: Delphacidae) established by Muir (1915). This tribe includes 36 genera till date, with its distribution in Oriental, Palaearctic, Afrotropical, Australian and Pacific regions. Bamboo (Bambusoidea) is the major host of most species of the tribe and some species feed on grasses (Gramineae) (Chen 2003; Chen and Tsai 2009). The tribe is characterized by thick and large post-tibial spur which is concave on inner surface, and lacks teeth along the hind margin.

### **Genera of the tribe Tropidocephalini**

#### ***Arcofacies* Fennah**

The economically important Bamboo delphacid genus *Arcofacies* was established by Muir (1915) with its type species *A. fullawayi* Muir. It can be easily distinguished from other genera of the tribe by the postclypeus at right angle to frons or by white median longitudinal line extending from the apex of the frons to end of the mesonotum, bordered with brown to black stripe. Worldwide ten species have been reported and it is well known from Oriental region (Chen *et al.*, 2007, Li *et al.*, 2019).

#### ***Arcofaciella* Fennah**

The genus *Arcofaciella* was established by Fennah (1956) based on type species *Arcofaciella verrucosa* Fennah, 1956. The genus can be distinguished by the shape of vertex carinae, postclypeus at right angle to frons (in lateral view). Antennae cylindrical in cross-section. Segment ten of male ring-like, without latero-apical process (Fennah, 1956). The genus was represented by two species *Arcofaciella obflexa* Guo and Liang, *Arcofaciella verrucosa* Fennah, 1956 with its distribution in China and Taiwan. The genus first recored from India by Nimisha (2008) from Karnataka.

#### ***Bambusiphaga* Huang and Ding**

The genus *Bambusiphaga* was established by Huang and Ding (1979) with type species *Bambusiphaga nigropunctata*. A total of 25 species were reported from Oriental region (Chen and Liang, 2007; Hong-Xing *et al.*, 2018). Head including eyes



narrower than pronotum, anterior margin of vertex evenly rounded or truncated, pygofer without lateral expansion are the generic characters.

### ***Purohita* Distant**

The genus established by Distant (1906) with type species *Purohita cervina* Distant and also described *Purohita arundinaceae* Distant breeding on bamboo from India. Rao and Chalam (2007) reported *Purohita* sp. on sugarcane from Maharashtra. Nimisha (2008) reported the *Purohita* sp. from Karnataka. Antennae elongate, foliaceous with a median ridge and pedicel of antennae shorter than scape are the diagnostic characters of the genus.

### ***Tropidocephala* Stal**

Stal (1853) established the genus with type species *Tropidocephala flaviceps* Stal. Distant (1916) described *Orchesma signata* from Karnataka which is later placed under the genus *Tropidocephala* and *T. luteola* Distant from West Bengal. Members of the genus recognized by vertex subtriangular and producing in front of eyes. Muir (1921) reported two species, *T. butleri* and *T. indica* Muir from South India. Rao (1965) reported *T. saccharivorella* Matsumura on sugarcane from Karnataka. Nimisha (2008) reported *T. saccharivorella*, *T. serendiba* from different agro-ecosystems in Karnataka.

### **Phylogenetic analysis:**

The family-group classification of Delphacidae was attempted by many workers among them the most pioneers were Metcalf, Haupt, Wagner, Asche, and Emeljanov (Urban *et al.*, 2010). Phylogenetic studies gained momentum with the first cladistics investigation by Asche (1985, 1990).

Haupt (1929) gave the 4 subfamily classification of Delphacidae: Asiracinae, Delphacinae, Megamelinae and Tropidocephalinae; later Metcalf (1943) gave 2 subfamily classification: Asiracinae and Delphacinae; Wagner (1963) gave 9 subfamily classification: Asiracinae, Achorotilinae, Chlorioninae Delphacinae, Jassidaeinae, Kelisiinae, Megamelinae, Stirominae and Stenocraninae.

Asche (1985) gave 5 subfamily classification of Delphacidae viz., Asiracinae, Delphacinae, Kelisiinae, Plesiodelphacinae and Stenocraninae. This study identified the most primitive group is the Asiracinae and most evolved Kelisiinae. There is a

substantial gap between the character display of the most primitive group and rest of the delphacidae.

Yang and his co-workers (1987) studied the phylogeny of Asiracinae and Tropidocephalini from Taiwan. They used the numerical taxonomy techniques, including both phenetics and cladistics. Based on the results of these analysis they have concluded that all the genus except *Tropidocephala* forms the monophyletic group as *non-Tropidocephala* group and joins *Tropidocephala* as sister group.

Asche (1990) investigated the delphacids of Oriental region through which he established the new subfamily Vizcayinae with type genus *Vizcaya* Muir. He found Vizcayinae displaying the important morphological characters between the Asiracinae and rest of the delphacids. He concluded Vizcayinae as an important evolutionary link between Asiracinae and rest of the monophyletic groups of Delphacidae. This study recognized the six delphacid clades, divided as paraphyletic subfamily Asiracinae (tribes Asiracini and Ugyopini) and five monophyletic subfamilies (Delphacinae, Kelisiinae, Stenocraninae and Plesiodelphacinae, Vizcayinae).

Emeljanov (1996) first attempted phylogenetic investigation based on immature stages. He given the detailed terminology to larval (nymphal) structures and used these for phylogenetic evaluation. His analysis gives the phylogenetic scheme for lower Delphacidae to tribal level which complements the Asche's classification.

Hamilton (2006) investigated the *Stenocranus* from Canada. Investigated the phylogeny using delphacids and placed *Stenocranus* species in relation to clearly defined taxa. He concluded classification of Delphacidae based on the synapomorphy results that, subfamily Delphacinae comprises of four tribes viz., Delphacini, Tropidocephalini, Stenocranini and Vizcayini. The subfamily Kelissinae reduced to subtribe of Stenocranini and Saccharosydniini placed within tribe Tropidocephalini.

Till 20<sup>th</sup> century the phylogenetic analysis in Delphacidae were based on the morphological character coding. The molecular phylogeny analysis gained momentum with the work of Dijkstra *et al.*, (2003, 2006). They used mitochondrial DNA nucleotide sequence data (mtCOI 504bp) for phylogenetic analysis of Delphacidae. The results supported Asiracinae consistently as sister to the remaining subfamilies. This fragment of the gene can be used for resolving the wide taxonomic range of Delphacidae except the generic level.

Dijkstra *et al.*, (2006) resolved the phylogenetic relationship from species to subfamily level using 12S ribosomal DNA and 16S ribosomal DNA. The results are in matching with the tree based on morphological data and the contrasting result was Kelissinae and Asiracinae are sister groups. The Molecular evolutionary patterns evidenced that there has been a shift in base composition from T to A during the early evolution of species other than Asiracinae species.

Urban *et al.*, (2010) combined the molecular (four gene loci - 18S rDNA, 28S rDNA, wingless and cytochrome oxidase I) and morphological data (132 coded characters) to study the evolution of Delphacidae along with the host shifts. The phylogenetic analysis results support higher classification of Delphacidae by Asche, Emiljanov and Hamilton. This study concluded the host relationships played a key role in the evolutionary history of Delphacidae.

Huang *et al.*, (2017) investigated phylogeny of the subfamily Delphacinae based on mitochondrial and nuclear ribosomal DNA sequences of four genetic loci (16S rDNA, 28S rDNA, *Cytochrome oxidase I* and *Cytochrome b*). The study supports the monophyly of Delphacinae with its basal branching into three tribes. The tribes Delphacini and Tropidocephalini were sub-divided into three and two clades respectively.

Huang and Qin (2018) given the mitochondrial genome of *Saccharosydne procerus* (Matsumura) of Saccharosydmini and *Sogatella vibix* of Delphacini. The phylogeny of three rice planthoppers viz., BPH, WBPH and SBPH based on the mitochondrial genome sequence was carried out using *Saccharosydne procerus* as outgroup. The ML analysis revealed the two identical topologies one is *Saccharosydne procerus* and other is remaining species of Delphacinae, with *Peregrinus maidis* being sister to the remaining species. The study confirms the relationships of important pests of rice.

### 3. MATERIALS AND METHODS

Studies on biosystematics of family, Delphacidae was undertaken from India. During the present study, 10213 specimens were investigated from various localities in India and comprised 39 species belonging to 26 genera of the subfamily Delphacinae. These are described and illustrated. Molecular phylogeny analysis was done using the genes mtCOI, 28srDNA (D2 region and D9-10 region) and Histone to understand the relationship among the various taxa. The detailed methods adopted during the course of the study are given below.

#### 3.1. Source of Delphacid specimens

Extensive collections of Delphacid specimens were made from 26 different localities of 9 states, namely, Andhra Pradesh, Arunachal Pradesh, Himachal Pradesh, Maharashtra, Nagaland, Karnataka, Kerala, and Union Territory of Delhi and Ladhak. The location of collection are shown on map. (Plate. 4)

**Table: 4. Localities of delphacid specimen collection**

| Sl no. | Location                                                                            | Co-ordinates                  | State             |
|--------|-------------------------------------------------------------------------------------|-------------------------------|-------------------|
| 1      | Indian Agricultural Research Institute, Pusa Campus, New Delhi                      | (28°63'77"N, 77°15'71"E)      | Delhi             |
| 2      | Sunder Nursery, Delhi                                                               | (28°35'43"N 77°14'41" E)      | Delhi             |
| 3      | Leh                                                                                 | (34°09'9.32"N 77°34'37.38" E) | Ladhak            |
| 4      | GBP university, HRC, Pantnagar                                                      | (29°02'29"N 79°48'79" E)      | Uttarakhand       |
| 5      | Chikhaldara forest, Amravati,                                                       | (21°24'25.3"N 77°21'27.2" E)  | Maharashtra       |
| 6      | Malkhed forest, Amravati,                                                           | (20°50'40.7"N 77°40'40.7" E)  | Maharashtra       |
| 7      | Ranichauri - Krishi Vigyan Kendra (KVK)                                             | (27°17'50"N 85°98'15"E)       | Uttarkhand        |
| 8      | Bidar                                                                               | (17°55'16"N 77°29'54" E)      | Karnataka         |
| 9      | Gulbarga                                                                            | (17°32'97"N 76°83'43" E)      | Karnataka         |
| 10.    | Thensa DC                                                                           | (26°99'43.0"N, 95°54'07.0"E)  | Arunachal Pradesh |
| 11     | Khonsa                                                                              | (26°99'29.0"N, 95°50'14.0"E)  | Arunachal Pradesh |
| 12     | Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya (CSK HPKV), Palampur | (32°10'03.0"N, 76°.54'65"0E)  | Himachal Pradesh  |

| Sl no. | Location                                                                                | Co-ordinates                     | State            |
|--------|-----------------------------------------------------------------------------------------|----------------------------------|------------------|
| 13     | Sourabh Van Vihar, Palampur                                                             | (32°13'19.0"N 76°53'35.0"E)      | Himachal Pradesh |
| 14     | Rampur, Una                                                                             | (31°44'92"N 77°62'92"E)          | Himachal Pradesh |
| 15     | Berthin, Bilaspur,                                                                      | (31°21'35.18"N<br>76°39'52.38"E) | Himachal Pradesh |
| 16     | Powari, Kinnaur,                                                                        | (31°31'42.14"N<br>78°16'19.18"E) | Himachal Pradesh |
| 17     | Sharbu, Kinnaur                                                                         | (31°32'14.26"N 78°16'33.08"E)    | Himachal Pradesh |
| 18     | Kalpa, Kinnaur                                                                          | (31°32'11.33"N 78°15'33.98"E)    | Himachal Pradesh |
| 19     | Kasol, Kullu                                                                            | (32°01'00"N, 77°31'50"E)         | Himachal Pradesh |
| 20     | Tirupati                                                                                | (13°62'88"N, 79°41'92" E)        | Andra Pradesh    |
| 21     | Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni campus, Solan. | (30°85'70"N, 77°16'74"E)         | Himachal Pradesh |
| 22     | Forest road, Forest guest house, Solan                                                  | (30°54'29.27"N, 77°6'8.04"E)     | Himachal Pradesh |
| 23     | Hawalbag                                                                                | (29°64'28"N, 79°63'27"E)         | Uttarkhand       |
| 24     | Manali                                                                                  | (32°23'96"N, 77°18'87"E)         | Himachal Pradesh |
| 25     | Jharnapani                                                                              | (25°75'58"N, 93°84'39"E)         | Nagaland         |
| 26     | Nilambur                                                                                | (11°27'94"N, 76°23'98"E)         | Kerala           |

### 3.2. Collection techniques

Delphacids generally found on grasses, sedges, graminaceous crop plants and some are recorded on bamboo too. Collections were made in agro-ecosystems as well as in forest ecosystems. Specimens were collected by sweeping on various vegetation using an insect sweep net, by light traps and by manual collection using aspirator.

a. Sweep net: sweepings were done during the sun shine hours of the morning to till evening. Specimens were collected by multiple sweepings on various vegetation including grasses and crop plants and shrubs. Collected specimens were taken in small polythene bag and they were killed by small quantity of 70% alcohol by impregnating in the cotton.

b. Light trap (Mercury vapour lamp): Light traps were placed in field in the evening hours and power supply will be given to lighten the trap whole night. The



collected insects were killed in the small quantity of ethyl acetate and benzene 100% impregnated in cotton and kept inside the collection vessel of light trap.

c. Aspirator collection: The stable insects were collected by manual sucking into the aspirator. Aspirator Collections were made on vegetation in day collection and near light sources in night collection only in accessible areas. Collected specimens were transferred to a killing bottle charged with ethyl acetate.

After killing the dead specimens were separated based on morphospecies and placed in butter paper covers with pertinent labels which included name of the locality, date of collection, host plant, name of the collector etc. The butter papers are arranged in specimen storing boxes and brought to the laboratory for further processing.

### **3.3. Processing of the specimens:**

Collected specimens were brought to laboratory and dried in hot air oven at 45-50°C for about 4 to 5 hours. The dried specimens of delphacids were identified based hind tibial spur and sorted out from other insect specimens.

#### **3.3.1. Mounting and labelling**

The sorted specimens were pinned singly on trichocards by gluing on the right hand side of the thorax using Fevicol®, to facilitate easy handling and identification. All the specimens were attached with a label having details of place of collection along with coordinates, date of collection and name of the collector. Labelled specimens were placed in cabinet box for further study. Some specimens preserved in plastic vials containing 100% alcohol and stored at 20°C for molecular studies. The alcohol stored specimens were labelled by placing pencil written label inside the vial.

### **3.4. Preparation of genitalia**

Dried, preserved specimens were used to study the genitalia. Dissections were carried out as described by Oman (1949) and Knight (1965). The specimen was gently supported on a china clay on its back. The abdomen was detached from thorax with the help of a thin needle by inserting it at the junction of the thorax and abdomen and gently dragging to detach. The detached abdomen was transferred into a test tube containing 0.5 ml of 10% KOH and boiled for a minute to hasten digestion. The dissections were then rinsed with water to remove the KOH content, dehydrated in

70% ethanol and placed in cavity block containing glycerol. For males, the genital capsule was separated from abdomen. Aedeagal complex (constitutes aedeagus, parameres and segment 10 and 11) was separated from pygofer by gently dragging the connective. The female genitalia was separated from abdomen and then the 3<sup>rd</sup> gonopopysis were separated from pygohore. After studying the genitalia, they were stored in genitalia vials containing a drop of glycerine and the vials were pinned below the respective specimens.

### **3.5. Photographs and plates preparation**

The photographs of male and female (habitus dorsal, lateral, face, Pronotum) and genitalia structures (genital capsule dorsal, lateral, aedeagal complex, aedeagus, parameres, pygofer dorsal, lateral, Segment 10 and 11) were taken with Leica DFC 425C digital camera mounted on the Leica 19205FA stereo zoom automontage microscope. The genitalia images were taken by placing the structures in glycerine filled cavity block. Measurements are taken by calibrating the microscope with ocular and stage micrometer and then the above structures have been measured. The photographs were processed by using Adobe Photoshop CS3 and plates were prepared with Microsoft publisher document for each species.

### **3.6. Identification of specimen**

Identification of subfamily, tribe, genera and species were made using the various available literature from Distant's Rhynchota volumes in the Fauna of British India Series (Distant, 1904a and 1910) to till date. Earlier thesis work on Delphacidae from India were also used as basis for identification. The Chinese literature, Fauna Sinica INSECTA Volume. 45 Homoptera; Delphacidae by Ding Jinhua was also used to identify species as most of the tropical Delphacidae species were illustrated in the literature. A few of the species were identified in consultation with Dr. Charles Bartlett, University of Delaware, USA, expert in planthopper work and hosting the Planthopper website of North-America. The websites such as FLOW, North-American Delphacidae, BugGuide.net were visited to know the terminology, history, synonymy and some images to for identification and confirmation. Those species which did not concur with descriptions and figures of already known species were considered as putative new species identified by comparing with all the available literature on the taxa.

### **3.7. Preparation of keys and checklist**

Keys were prepared for subfamily, tribe, genera and species based on specimens collected in India. In the case of subfamily and tribe earlier recorded from India but not be in the present collections, were included using the characters mentioned in the literature in order to give the more comprehensive keys. Keys to species which were identified in the study were given under the respective genera.

The checklist of Indian Delphacidae was prepared including valid names synonyms, type species, type locality, type repository and distribution in India.

### **3.8. Description**

Diagnostic characters of genera and brief description of species are provided. The species description includes the colouration, description of characters such as head, thorax, abdomen and male genitalia. Ratios of these characters are provided along with photographic illustrations.

### **3.9. Molecular studies**

#### **3.9.1 Extraction and isolation of DNA**

##### **a) Sample preparation for DNA extraction**

Specimens of each species were stored separately in absolute ethanol and kept in refrigerator till it used for extraction. Before starting the extraction a single specimen of each species is taken out from ethanol and shifted in cavity block with absolute ethanol. Preliminary cleaning is done to avoid contamination. Fine Camlin brush (000') was used for this purpose. Then the specimens were placed on tissue paper for 1min to get it dried, it remove traces of ethanol.

##### **b) DNA extraction**

DNA was extracted from whole specimen according to the manufacturer protocol, DNAsure Tissue Mini Kit with slight modification in the procedure.

1. Placed the specimen sample in a centrifuge tube.
2. Added 180µl Buffer LBT (first add 20µl and crush the sample then add 160µl) and 25µl Proteinase. Vortex and Incubated at 56°C overnight.
3. Vortexed the samples. Added 200µl Buffer BT3, vortexed vigorously and incubated at 70°C for 10min. Vortex briefly.

4. Added 210µl absolute ethanol to sample and vortexed vigorously.
5. For each sample Placed DNASure Tissue mini kit column into a Collection Tube. Applied the sample to the column without wetting the rim. Centrifuged for 3 min at 14000x g. Discarded the flow-through and placed the column back into the Collection Tube.
6. Added 50 µl Buffer WBT. Centifuged for 3 min at 14000x g. Discarded the flow-through and placed the column back into the Collection Tube.
7. Added 600 µl Buffer WBT5 to the column and centrifuged for 5 min at 14000x g. Discarded flow-through and placed the column back into the Collection Tube.
8. Placed the DNASure Tissue mini kit column into a centrifuge tube and added 30 µl Prewarmed buffer BET (70°C). Incubated at room temperature for 1 min. centrifuged 3 min at 14000x g.
9. Removed the DNASure Tissue mini kit column from centrifuge tube. Labeled and stored the isolated DNA at –20°C until required.

### 3.9.2. PCR amplification, visualization and sequencing

The DNA extractions were amplified for PCR products for genes viz., mitochondrial cytochrome oxidase (mtCOI), Histone (H3), 28S ribosomal gene (28S rDNA; D2 AND D9-10 region) the primers for the respective genes are given in table 3.

**Table: 5 Primers used for amplification**

| Marker                    |                            | Primers                                                                 | Size  |
|---------------------------|----------------------------|-------------------------------------------------------------------------|-------|
| Mitochondrial DNA markers |                            |                                                                         |       |
| 1                         | Cytochrome oxidase I (COI) | LCO1490 GGTCAACAAATCATAAAGATATTGG<br>HCO2198 TAAACTTCAGGGTGACCAAAAAATCA | 540bp |
| Nuclear markers           |                            |                                                                         |       |
| 1                         | 28SD2                      | 28SD2F AGTCGKGTGCTTGAKAGTGCAG<br>28SD2R TTCGGGTCCCAACGTGTACG            | 450bp |
| 2                         | 28SD9-D10                  | 28SD9-D10F GTAGCCAAATGCCTCGTCA<br>28SD9-D10R CACAATGATAGGAAGAGCC        | 550bp |
| 3                         | Histone H3                 | H3F2 AAGCAGACGGCTCGTAAATC<br>H3R2 ATGATGGTGACYCGYTTGGC                  | 400bp |

During the study, Hashmi *et al.*, (2018) PCR protocol was followed. The concluding volume of the PCR mixture was 25 µl consisting of 12.5 µl of Thermo Scientific maxima hot start PCR master mix, 8.5 µl of molecular grade water, 1 µl each forward primer and 2 µl of genomic DNA. Ventri® 96-well thermal cycler (Applied Biosystems® Life Technologies) was used for the amplification of the samples. Cycling protocol were: 4 min. hot start at 94°, 35 cycles of denaturation for 30 s at 94°, annealing for 60 s at 47°C, elongation for 50 s at 72°C and a final extension 72°C for 8 min in a C1000™ Thermal cycler. (The cycling protocols is same for all 4 genes except the annealing temperature for 28srDNA D9 region, i.e., 54°C).

The products were run in 2% agarose gel with 0.5µg/ml ethidium bromide at 85 V for 30 min. Visualized under UV using Alphaview® software version 1.2.0.1. The amplified products were sequenced at AgriGenome Pvt. Ltd. (Cochin, India). The quality sequences were assembled with BioEdit version 7.0.0 and deposited in NCBI GenBank.

### 3.9.3 Alignment and Phylogenetic Analyses

The dataset sequences used in the current study were obtained from our own study and few of them were retrieved from NCBI (National Center for Biotechnology Information) GenBank. In total dataset consisting 28 species from tribe Delphacini and 8 species from tribe Trophidocephalini and 1 outgroup were used for phylogenetic analysis (Table. 6).

Sequences were aligned with the Clustal W (Jeanmougin *et al.*, 1998) algorithm using default factors in MEGA version 6 (Tamura *et al.*, 2013). In a total matrix length of 2588 bp for the combined DNA sequences was acquired and used for the phylogenetic analysis. Combined ML analysis (28S D2, 28S D9-D10, H3 and COI) were performed in IQtree v1.6.12 (Nguyen *et al.*, 2015) using the best-fit substitution model automatically selected by the software according to the Bayesian information criterion scores and weights (BIC) with partitions. An ultrafast bootstrap (UFB) (Minh *et al.*, 2013) with 10000 replicates and the SH-like approximate likelihood ratio test (SH-aLRT) (Guindon *et al.*, 2010) were used in the analysis to assess branch support.

### 3.10. Terminology (Plate: 1 and 2)

Terms used in the description of the genera and species are those used by Asche (1985) and Bartlett (2009). The terminologies of various parts were briefly described below.

|                         |                                                                                                                                            |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Aedeagus</b>         | : Sperm conducting tube bearing an apical or subapical gonopore, may also bear number of teeth or spines.                                  |
| <b>Anteclypeus</b>      | : Distal Part of clypeus, separated from post clypeus by transclypeal suture.                                                              |
| <b>Diaphragm</b>        | : Modification of phallobase divides the pygofer into anterior and posterior chambers.                                                     |
| <b>Frons</b>            | : Bordered by lateral carinae and separated from the clypeus by the frontoclypeal suture.                                                  |
| <b>Gena</b>             | : Region between the lateral carina of the frons and the compound eye and contains a lateral ocellus.                                      |
| <b>Gonopore</b>         | : Apical or subapical opening of the aedeagus.                                                                                             |
| <b>Lateral carina</b>   | : Lateral longitudinal carina of thorax.                                                                                                   |
| <b>Median carina</b>    | : Dorsal longitudinal carina of thorax.                                                                                                    |
| <b>Paramere</b>         | : Movable paired often modified structures which may bear spines or hooks, attached to the aedeagus by a Y or T-shaped movable connective. |
| <b>Phallobase</b>       | : Base of the penis which is generally fused with the base of aedeagus, act as penis guide.                                                |
| <b>Phallus</b>          | : The median partly sclerotised intromittent coupulatory organ.                                                                            |
| <b>Post clypeus</b>     | : Anterior part of clypeus separated from the anteclypeus by a partial transclypeal suture.                                                |
| <b>Post-tibial spur</b> | : Movable spur at the apex of hind-tibia.                                                                                                  |
| <b>Pronotum</b>         | : Collar-like, structure extends laterally overlapping the reduced pleural sclerites.                                                      |
| <b>Pygofer</b>          | : Ninth abdominal segment forms a partial or complete capsule and contains the stuctures of male genitalia.                                |
| <b>Rostrum</b>          | : Three segmented beak succeeding the clypeus.                                                                                             |
| <b>Scutellum</b>        | : The part of mesothorax forming a posteriorly directed triangle.                                                                          |
| <b>Segment 10</b>       | : Tenth abdominal segment modified to bear segment 11, usually movable but fused to pygofer and mostly having lateroapical process.        |
| <b>Segment 11</b>       | : A movable long process attached with segment 10.                                                                                         |
| <b>Tegula</b>           | : Pad like scleritized structures at the base of forewing.                                                                                 |
| <b>Vertex</b>           | : Dorsal aspect of head nearly triangular, bounded posteriorly by the back of head, laterally by the compound eyes.                        |



### 3.11. Measurements (Plate: 3)

Measurements of various morphological structures were made using Leica Application Suite (LAS) software installed in Leica 19205FA stereo zoom automontage microscope. All measurements are given in millimetres. The abbreviation in paranthesis indicate the way the parts are indicated in (Plate: 3).

|                                                   |                                                                                                                 |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| <b>Total length (TL)</b>                          | : Distance between the anterior most point of head and the posterior tip of forewings along the middorsal line. |
| <b>Length of pronotum (LP)</b>                    | : Distance between the anterior and posterior margins of the pronotum along the middorsal line.                 |
| <b>Length of scutellum (LS)</b>                   | : Distance between posterior margin of pronotum and posterior tip of scutellum along the middorsal line.        |
| <b>Length of vertex (LV)</b>                      | : Distance between the anterior and the posterior margins of vertex along the middorsal line.                   |
| <b>Length of pygofer (LPY)</b>                    | : Length from dorsal margin to ventral margin of pygofer.                                                       |
| <b>Length of Segment 10 and 11(LSE)</b>           | : Length from base of segment 10 to tip of segment 11.                                                          |
| <b>Length of Latero-apical process(LLP)</b>       | : Length of latero-apical process of the segment 10 from base to tip.                                           |
| <b>Length of Paramere (LPA)</b>                   | : Distance between base and tip of the paramere.                                                                |
| <b>Length of Aedeagus (LA)</b>                    | : Distance from the junction of aedeagus and connective to tip of the aedeagus                                  |
| <b>Width across eyes (WE)</b>                     | : Distance between midpoints of the compound eyes where the width is maximum.                                   |
| <b>Width of pronotum (WP)</b>                     | : Distance measured across the posterior angles where the pronotum is with maximum width.                       |
| <b>Width of vertex (WV)</b>                       | : Distance between the lateral carina of vertex at the basal margin.                                            |
| <b>Width of scutellum (WS)</b>                    | : Distance measured across the scutellum where the width is maximum.                                            |
| <b>Width of pygofer (WPY)</b>                     | : Distance across the middle of pygofer where the width is maximum.                                             |
| <b>Width of segment 10 (WSE)</b>                  | : Distance across the segment 10 where width is maximum.                                                        |
| <b>Width of paramere (WPA)</b>                    | : Distance across the paramere where the width is maximum.                                                      |
| <b>Width of aedeagus (WA)</b>                     | : Distance across the aedeagus where the width is maximum.                                                      |
| <b>Width across hind margin of Pronotum (WHP)</b> | : Distance between tip of pronotum on both sides                                                                |

### **3.12. Depositories**

All the material studied was deposited in National Pusa Collection (NPC), Division of Entomology, Indian Agricultural Research Institute, New Delhi, India.

### **3.13. Abbreviation used in the study**

- 1. BMNH** - British Museum of Natural History
- 2. IEGU** - Institute of Entomology, Guizhou University, Guiyang, Guizhou Province, China
- 3. NPC** - National Pusa Collection
- 4. NCR** - National Capital Region
- 5. NCBI** - National Center for Biotechnology Information
- 6. SH-aLRT** - SH-like approximate likelihood ratio test
- 7. UFB** - Ultrafast bootstrap

## 4. RESULTS

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Planthopper is a collective term used for the phloem feeding insects belongs to superfamily Fulgoroidea of order Hemiptera. The name defines their notable analogy with the plantparts and nature of “hop” for quick transportation. Delphacidae is one of most specious families in the order Hemiptera which comprises of approximately 416 genera and 2214 species worldwide (Bourgoin, 2019). It is the most economically important group, which includes at least 55 species that feed on economically important crops. In addition to causing mechanical damage by feeding on vascular tissues of plants and cutting slits into plants for oviposition, are vectors of many plant diseases in rice, maize, wheat, barley, sugarcane *etc.*

Delphacids are known for their complexity, they generally coloured with white and black without fixed patterns, this paved the way to their cryptic nature. The genus level as well as species level crypticity has been recorded in the group. Sexual dimorphism is another important abstacle in the identification, certainly females in some species can not be identified. Wing polymorphism is most common in the group which include macropterous, brachypterous, submacropterous and stenopterous forms. Macropterous wings are membranous and hyaline where as in brachypteous are thickened and dark. In some species the variation in the wing pattern to such an extent that they can not be identified as brachypterous of certain species unless their genitalia examined carefully. The result presented here is an integrative protocol which will help in establishment of correct identity and could also be employed for rapid identification of planthoppers.

Delphacidae constitutes six subfamilies in total, out of which 4 subfamilies (Asiracinae Motschulsky, 1863; Delphacinae Leach, 1815; Stenocraninae Wagner, 1963; Vizcayinae Asche, 1990), 5 tribes (Ugyopini Fennah, 1979; Vizcayini Asche, 1990; Stenocranini Wagner, 1963; Tropidocephalini Muir, 1915; Delphacini Leach, 1815), 36 genera and 73 species (including the new species and new records in the present study) were described from India. A detailed checklist of these described species, including valid name, synonyms, details of type species, Indian distribution, type locality, type deposition is given in the following table. Occurrence in present study stated here will give the details of localities of the species recovered from present study.

#### 4.1. Checklist of Delphacidae species from India

|                                                                                                                 |                                                                                                                           |                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| <b>Subfamily: Asiracinae</b> Motschulsky, 1863: 108                                                             |                                                                                                                           |                                                                                                   |
| <b>Tribe: Ugyopini</b> Fennah, 1979: 116                                                                        |                                                                                                                           |                                                                                                   |
| <b>Genus: <i>Punana</i></b> Muir 1913; Type species: <i>Punana brunnea</i> Muir 1913: 250                       |                                                                                                                           |                                                                                                   |
| <b><i>Punana annulata</i> (Distant)</b><br><i>Onkelos annulatus</i> Distant 1916: 137                           | <b>Type locality:</b> Borneo: Mowong<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station, Honolulu. | <b>Distribution:</b> India: Tamil Nadu: Kodaikanal                                                |
| <b>Subfamily: Vizayinae</b> Ashe, 1990: 154                                                                     |                                                                                                                           |                                                                                                   |
| <b>Genus: <i>Vizcaya</i></b> Muir, 1917; Type species: <i>Vizcaya bakeri</i> Muir 1917: 351                     |                                                                                                                           |                                                                                                   |
| <b><i>Vizcaya aschei</i></b> Liang 2002: 612                                                                    | <b>Type locality:</b> Tamil Nadu: Anamalai Hills: Cinchona, <b>Type deposited:</b> BMNH                                   | <b>Distribution:</b> India: Tamil Nadu: Cinchona, Nilgiri Hills                                   |
| <b><i>Vizcaya vindaloo</i></b> Ashe 1990: 174                                                                   | <b>Type locality:</b> Tamil Nadu: Anamalai Hills: Cinchona, <b>Type deposited:</b> BMNH                                   | <b>Distribution:</b> India: Karnataka: Balehunnur; Kerala: Travancore; Tamil Nadu: Anamalai Hills |
| <b>Subfamily: Stenocraninae</b> Wagner, 1963: 111                                                               |                                                                                                                           |                                                                                                   |
| <b>* Genus: <i>Stenocranus</i></b> Fieber, 1866; Type species: <i>Stenocranus minutus</i> (Fabricius 1917): 262 |                                                                                                                           |                                                                                                   |
| <b><i>Stenocranus ajmerensis</i></b> Joseph 1964: 460                                                           | <b>Type locality:</b> India: Rajasthan: Ajmer<br><br><b>Type deposited:</b> NPC                                           | <b>Distribution:</b> India: Rajasthan: Ajmer                                                      |
| <b>Subfamily: Delphacinae</b> Leach, 1815: 125                                                                  |                                                                                                                           |                                                                                                   |
| <b>Tribe: Tropidocephalini</b> Muir, 1915                                                                       |                                                                                                                           |                                                                                                   |
| <b>*Genus <i>Arcofacies</i></b> Muir Type species: <i>Arcofacies fullawayi</i> Muir 1915: 319                   |                                                                                                                           |                                                                                                   |
| <b>*<i>Arcofacies securisus</i> sp. nov.</b>                                                                    | <b>Type locality:</b> India: Himachal Pradesh : Bilaspur : Berthin<br><br><b>Type deposited:</b> NPC                      | <b>Occurrence in present study:</b> India: Himachal Pradesh : Bilaspur : Berthin                  |

|                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                |                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>* Genus <i>Arcofaciella</i> Fennah, 1956</b> Type species: <i>Arcofaciella verrucosa</i> Fennah, 1956: 467                                                                                                                                                                                                                   |                                                                                                                                                                                                |                                                                                                                                                 |
| <b>* <i>Arcofaciella sinuata</i> sp. nov.</b>                                                                                                                                                                                                                                                                                   | <b>Type locality:</b> India:<br>Himachal Pradesh :<br>Bilaspur : Berthin<br><br><b>Type deposited:</b> NPC                                                                                     | <b>Occurrence in present study:</b><br>India: Himachal Pradesh :<br>Bilaspur : Berthin                                                          |
| <b>* Genus <i>Bambusiphaga</i> Hung and Ding</b> Type species: <i>Bambusiphaga nigripunctata</i> Huang and Ding, 1979:170                                                                                                                                                                                                       |                                                                                                                                                                                                |                                                                                                                                                 |
| <b>* <i>Bambusiphaga unispina</i> Ramya and Meshram, 2019: 197</b>                                                                                                                                                                                                                                                              | <b>Type Locality:</b> India:<br>Palampur<br><br><b>Type deposited:</b> NPC                                                                                                                     | <b>Distribution:</b> India: Himachal Pradesh : Palampur                                                                                         |
| <b>*<i>Bambusiphaga</i> sp. nov.</b>                                                                                                                                                                                                                                                                                            | <b>Type Locality:</b> India:<br>Himachal Pradesh,<br>Berthin, Bilaspur<br><br><b>Type deposited:</b> NPC                                                                                       | <b>Distribution:</b> India: Himachal Pradesh, Berthin, Bilaspur                                                                                 |
| <b>Genus <i>Columbisoga</i> Muir, 1921</b> Type species: <i>Columbisoga campbelli</i> Muir 1921: 483                                                                                                                                                                                                                            |                                                                                                                                                                                                |                                                                                                                                                 |
| <b><i>Columbisoga campbelli</i> Muir 1921: 483</b>                                                                                                                                                                                                                                                                              | <b>Type Locality:</b> India:<br>Karnataka: Dodabetta Hill, Ooty, Nilgiri Hills<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station, Honolulu.<br><br><b>Host:</b> Bamboo | <b>Distribution:</b> India: Tamil Nadu: Nilgiri Hills                                                                                           |
| <b>Genus <i>Tropidocephala</i> stal 1853</b> Type species: <i>Tropidocephala flaviceps</i> 1855:93<br><i>Tropidocephala</i> Stal, 1853: 10: 266.<br><i>Conicoda</i> Matsumura, 1900: 26: 258.<br><i>Orchesma</i> Melichar, 1903:94.<br><i>Ectopiopterygodelphax</i> Kirkaldy, 1906: 412.<br><i>Smara</i> Distant, 1906: 3: 478. |                                                                                                                                                                                                |                                                                                                                                                 |
| <b><i>Tropidocephala butleri</i> Muir 1921: 481</b>                                                                                                                                                                                                                                                                             | <b>Type Locality:</b> India:<br>Tamil Nadu: Kodaikanal<br><br><b>Type deposited:</b> NPC<br><br><b>Host:</b> Bamboo                                                                            | <b>Distribution:</b> India: Tamil Nadu: Kodaikanal                                                                                              |
| <b>*<i>Tropidocephala festiva</i> (Distant)</b><br><i>Smara festiva</i> Distant 1906:478                                                                                                                                                                                                                                        | <b>Type Locality:</b> Sri Lanka : Pundaluoya<br><br><b>Type deposited:</b> NPC                                                                                                                 | <b>Distribution:</b> Tamil Nadu: Coimbatore<br><br><b>Occurrence in present study:</b><br>Andra Pradesh: Tirupati;<br>Arunachal Pradesh: Basar, |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                  |                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Host:</b> Bamboo                                                                                                              | Pasighat; Himachal Pradesh:<br>Ranichauri, Bilaspur.                                                                                                                      |
| <b>*<i>Tropidocephala tuberipennis</i> (Mulsant and Rey)</b><br><i>Delphax tuberipennis</i> Mulsant and Rey, 1855: 197<br><i>Tropidocephala elegans</i> Fieber, 1872                                                                                                                                                                                                                                                                                                                                      | <b>Type Locality:</b> unknown                                                                                                    | <b>Occurrence in present study:</b><br>Andra pradesh: Tirupati;<br>Arunachal Pradesh: Basar,<br>Pasighat; Himachal Pradesh:<br>Ranichauri, Bilaspur ( <b>New record</b> ) |
| <b><i>Tropidocephala saccharivorella</i> Matsumura 1907: 65</b>                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Type Locality:</b> Borneo: Pontianak<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station, Honolulu.     | <b>Distribution:</b> India: Karnataka: Bengaluru, Mandya,                                                                                                                 |
| <b><i>Tropidocephala serendiba</i> (Melichar, 1903): 85</b><br><i>Orchesma signata</i> Distant, 1912 previous combination of <i>Tropidocephala signata</i> (Distant, 1912) according to Muir (1921): 480<br><i>Orchesma serendiba</i> Melichar, 1903 previous combination of <i>Tropidocephala serendiba</i> (Melichar, 1903) according to Metcalf (1943): 98<br><i>Tropidocephala signata</i> (Distant, 1912) synonym of <i>Tropidocephala serendiba</i> (Melichar, 1903) according to Fennah (1975): 85 | <b>Type Locality:</b> Sri Lanka: Peradeniya<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station, Honolulu. | <b>Distribution:</b> India: Karnataka: Bengaluru, Dharwad, Mandya.                                                                                                        |
| <b><i>Tropidocephala indica</i> Muir 1921: 482</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Type Locality:</b> India: Kodai Kanal,<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station, Honolulu.   | <b>Distribution:</b> India: Karnataka: Devarayandurga, Tamil Nadu: Kodaikanal                                                                                             |
| <b><i>Tropidocephala luteola</i> Distant 1912: 193</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Type locality:</b> West Bengal: Kolkata<br><br><b>Type deposited:</b> Indian museum                                           | <b>Distribution:</b> India: Bihar: Pusa; West Bengal: Kolkata                                                                                                             |



|                                                                                                       |                                                                                                                                |                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <b>*<i>Tropidocephala sinuosa</i> Yang and Yang, 1986:28</b>                                          | <b>Type locality:</b> Taiwan: Nanhua<br><br><b>Type deposited:</b> Department of Entomology, National Chung Hsing University.  | <b>Occurrence in present study:</b> Andra Pradesh: Tirupati ( <b>New record</b> )                                                 |
| <b><i>Tropidocephala signata</i> (Distant, 1912)</b>                                                  | <b>Type locality:</b> Sri Lanka :Peradeniya<br><br><b>Type deposited:</b> BMNH                                                 | <b>Distribution:</b> India: Karnataka Chikkaballapura; Tamil nadu: Coimbatore                                                     |
| <b>Genus <i>Purohita</i> Distant, 1906</b> Type species: <i>Purohita cervina</i> Distant 1906: 257    |                                                                                                                                |                                                                                                                                   |
| <b><i>Purohita arundinacea</i> Distant, 1907: 10</b>                                                  | <b>Type locality:</b> Darjiling<br><br><b>Type deposited:</b> BMNH<br><br><b>Host:</b> Bamboo                                  | <b>Distribution:</b> India: West Bengal: Darjiling,                                                                               |
| <b><i>Purohita cervina</i> Distant 1906: 257</b>                                                      | <b>Type locality:</b> Sri Lanka<br><br><b>Type deposited:</b> BMNH                                                             | <b>Distribution:</b> India: West Bengal: Darjiling; Tamil Nadu: Coimbatore                                                        |
| <b><i>Purohita punjabensis</i> Sharma and Singh 1982: 23</b>                                          | <b>Type locality:</b> India: Punjab: Sirhind<br><br><b>Type deposited:</b> Department of Zoology, Punjabi University, Patiala. | <b>Distribution:</b> India: Punjab                                                                                                |
| <b>*<i>Purohita taiwanensis</i> Muir, 1914:53</b>                                                     | <b>Type Locality:</b> Taiwan: Formosa<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station, Honolulu.     | <b>Occurrence in present study:</b> India: Himachal Pradesh: Nauni, Bilaspur; Delhi: Pusa campus New delhi. ( <b>New record</b> ) |
| <b>Tribe: Delphacini Leach, 1815</b>                                                                  |                                                                                                                                |                                                                                                                                   |
| <b>Genus: <i>Akilas</i> Distant, 1916</b> Type species: <i>Akilas fasciatus</i> Distant 1916: 248     |                                                                                                                                |                                                                                                                                   |
| <b><i>Akilas fasciatus</i> Distant 1916: 138</b><br><i>Gelastocephalus fasciatus</i> Muir , 1921: 565 | <b>Type Locality:</b> India: Kodai Kanal,<br><br><b>Type deposited:</b> Hawaiian Sugar Planter's Experiment Station,           | <b>Distribution:</b> India: Tamil Nadu: Kodaikanal                                                                                |

|                                                                                                                                                                                                                                                                                       |                                                                                                                                                  |                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                       | Honolulu.                                                                                                                                        |                                                                                                                                                                                        |
| <b>Genus <i>Cemus</i> Fennah, 1964</b> Type species: <i>Cemus leviculus</i> Fennah 1964: 148                                                                                                                                                                                          |                                                                                                                                                  |                                                                                                                                                                                        |
| <b><i>Cemus pulchellus</i> (Distant)</b><br><i>Pundaluoya pulchella</i> Distant<br>1912: 190                                                                                                                                                                                          | <b>Type Locality:</b> Sri Lanka:<br>Peradeniya<br><br><b>Type deposited:</b> BMNH                                                                | <b>Distribution:</b> India: Bihar: Pusa;<br>Kerala: Travancore;<br>Maharashtra: Mumbai                                                                                                 |
| * <b><i>Cemus sauteri</i> (Muir)</b><br><i>Phyllodinus sauteri</i> Muir<br>1917: 319                                                                                                                                                                                                  | <b>Type Locality:</b> Taiwan:<br>Formosa: Daimokko<br><br><b>Type deposited:</b><br>Hawaiian Sugar Planter's<br>Experiment Station,<br>Honolulu. | <b>Occurrence in present study:</b><br>India: Himachal Pradesh:<br>Bilaspur; Karnataka: Raichur,<br>Bidar. <b>(New record)</b>                                                         |
| * <b><i>Cemus zhitus</i> Kuoh, 1981: 423</b>                                                                                                                                                                                                                                          | <b>Type Locality:</b> China:<br>Yunnan and Hainan<br>Provinces<br><br><b>Type deposited:</b> Anhui<br>Agricultural University                    | <b>Occurrence in present study:</b><br>India: Himachal Pradesh:<br>Bilaspur; Karnataka: Raichur,<br>Bidar; Maharastra: Malkhed<br>forest; Uttarkhand: Hawalbagh<br><b>(New record)</b> |
| <b>Genus <i>Coronacella</i> Metcalf, 1950</b> Type species: <i>Kelisia kirkaldyi</i> Metcalf 1950: 59                                                                                                                                                                                 |                                                                                                                                                  |                                                                                                                                                                                        |
| * <b><i>Coronacella sinhalana</i> (Kirkaldy, 1906): 156</b><br><i>Liburnia frontalis</i> Melichar<br>1903:100<br><i>Delphacodes sinhalanus</i><br>Kirkaldy 1906: 156<br><i>Kelisia kirkaldyi</i> Muir 1917:<br>329                                                                    | <b>Type Locality:</b> Sri Lanka<br>: Henarathgoda<br><br><b>Type deposited:</b> Anhui<br>Agricultural University                                 | <b>Distribution:</b> India: Karnataka<br><br><b>Occurrence in present study:</b><br>Andra Pradesh: Tirupati;<br>Maharashtra: Chikhaldara;<br>Delhi: Pusa                               |
| <b>Genus <i>Chloriona</i> Fieber, 1866: 519, Type species: <i>Delphax unicolor</i> Herrich-Schaffer, 1835:66</b>                                                                                                                                                                      |                                                                                                                                                  |                                                                                                                                                                                        |
| * <b><i>Chloriona unicolor</i> (Herrich-Schaffer), 1835: 66</b><br><i>Delphax unicolor</i> Herrich-Schaffer, 1835: 66<br><i>Chloriona oranensis</i><br>Matsumura, 1910: 35<br><i>Chloriona edwardsi</i> Le<br>Quesne, 1960: 15<br><i>Chloriona canariensis</i><br>Lindberg, 1954: 155 | <b>Type Locality:</b><br>Unknown                                                                                                                 | <b>Occurrence in present study:</b><br>India: Leh                                                                                                                                      |
| <b>Genus <i>Eoeuryrsa</i> Muir, 1913</b> Type species: <i>Eoeuryrsa flavocapitata</i> Muir 1913: 249                                                                                                                                                                                  |                                                                                                                                                  |                                                                                                                                                                                        |

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| <b><i>Eoeurysa flavocapitata</i> Muir<br/>1913: 249</b>                                                                                                                        | <b>Type locality :</b> Malayan Peninsula and China<br><br><b>Type deposited:</b><br>Hawaiian Sugar Planter's Experiment Station, Honolulu | <b>Distribution:</b> India: West Bengal; Assam                                                            |
| <b>* <i>Eoeurysa sagitta</i> sp. nov.</b>                                                                                                                                      | <b>Type locality:</b> India: Himachal Pradesh: Una: Rampur<br><br><b>Type deposited:</b> NPC                                              | <b>Occurrence in present study:</b><br>India: Himachal Pradesh: Una: Rampur                               |
| <b>Genus <i>Euides</i> Fieber, 1866: 519.</b> Type species: <i>Euidella basilinea</i> Germar, 1821: 125<br><i>Euidella</i> Puton, 1886: 72<br><i>Epunka</i> Matsumura 1935: 77 |                                                                                                                                           |                                                                                                           |
| <b><i>Euides kashmirensis</i> (Muir, 1922)<br/><i>Euidella kashmirensis</i> Muir 1922 : 351</b>                                                                                | <b>Type locality :</b> India: Darjiling<br><br><b>Type deposited:</b><br>Hawaiian Sugar Planter's Experiment Station, Honolulu.           | <b>Distribution:</b> India: West Bengal: Darjeeling                                                       |
| <b>Genus <i>Falcotoya</i> Fennah, 1975</b> Type species: <i>Falcotoya aurinia</i> Fennah 1969: 40                                                                              |                                                                                                                                           |                                                                                                           |
| <b>* <i>Falcotoya daluoensis</i> Ding, 2006 : 41<br/><i>Coronacella curvipennis</i> Menon 1972</b>                                                                             | <b>Type locality :</b> China: Yunnan<br><br><b>Type deposited:</b> BMNH                                                                   | <b>Occurrence in present study:</b><br>India: Uttarkhand: Ranichauri; Maharastra: Amaravathi, Bramhanwada |
| <b>Genus <i>Harmalia</i> Fennah 1969</b> Type material: <i>Sogata thoracica</i> Distant, 1916: 140                                                                             |                                                                                                                                           |                                                                                                           |
| <b><i>Harmalia anacharsis</i> Fennah, 1969: 38<br/><i>Paracorbulo amplexicaulis</i> Tian and Ding, 1980: 136</b>                                                               | <b>Type locality :</b> New Caledonia: Poindimie<br><br><b>Type deposited:</b> BMNH                                                        | <b>Distribution:</b> India                                                                                |
| <b>*<i>Harmalia</i> sp. nov.</b>                                                                                                                                               | <b>Type locality :</b> INDIA: Karnataka: Bidar<br><br><b>Type deposited:</b> BMNH                                                         | <b>Occurrence in present study:</b><br>India: : Karnataka: Bidar                                          |
| <b>Genus <i>Kartalia</i> Kocak, 1981: 31</b> Type species: <i>Zuleika bengalensis</i> Distant 1916: 181                                                                        |                                                                                                                                           |                                                                                                           |
| <b><i>Kartalia bengalensis</i> (Distant)<br/><i>Zuleika bengalensis</i> Distant 1912 : 194</b>                                                                                 | <b>Type locality :</b> India: Kolkata<br><br><b>Type deposited:</b> BMNH                                                                  | <b>Distribution:</b> India: West Bengal : Kolkata                                                         |

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| <b>Genus <i>Laodelphax</i> Fennah, 1963</b> Type species : <i>Delphax striatella</i> Fallen, 1826: 75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                          |                                                                                                                                                                                                                                                    |
| <p><b>* <i>Laodelphax striatellus</i> (Fallen, 1826)</b><br/> <i>Delphax striatella</i> Fallen, 1826:75<br/> <i>Delphax akashiensis</i> Matsumura, 1900: 266<br/> <i>Delphacodes akashiensis</i> (Matsumura, 1900); comb. by Metcalf (1943: 399)<br/> <i>Delphacodes akashiensis</i> (Matsumura, 1900): 266. synonym by Matsumura and Ishihara (1945: 61)<br/> <i>Liburnia striatella</i> (Fallén, 1826); comb. by Scott (1870: 27)<br/> <i>Achorotile striatella</i> (Fallén, 1826); comb. by Oshanin 1870: 48.<br/> <i>Delphacodes striatella</i> (Fallén, 1826); comb. by Muir (1917: 334); Fennah (1963: 15)<br/> <i>Liburnia devastans</i> Matsumura, 1900: 262; syn. by Horvath, 1903: 558.<br/> <i>Liburnia marginata</i> Haupt, 1935; syn. by Haupt (1935: 142)</p> | Type locality:<br>Unknown                                                                                                                                                                | <p><b>Distribution:</b> India: Delhi: Pusa. Punjab</p> <p><b>Occurrence in Present study:</b><br/> India: Delhi, NCR: Sunder nursery, Pusa Campus.</p>                                                                                             |
| <b>Genus <i>Mahmutkashgaria</i> (Chen and Ding, 2002)</b> Type species: <i>Sulculus sulcatus</i> Ding, 2002: 226<br><i>Sulculus</i> Ding and Chen 2002                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                          |                                                                                                                                                                                                                                                    |
| <p><b>*<i>Mahmutkashgaria liboensis</i> (Chen, 2002)</b><br/> <i>Sulculus liboensis</i> Chen, 2002: 226-229.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p><b>Type locality:</b><br/> China :<br/> Guizhou</p> <p><b>Type deposited:</b><br/> Department of Plant Protection,<br/> Nanjing Agricultural University and Institute,<br/> China</p> | <p><b>Occurrence in present study:</b><br/> Himachal Pradesh: Nauni, Solan</p>                                                                                                                                                                     |
| <b>Genus <i>Metadelphax</i> Wagner, 1963: 176.</b> Type species: <i>Delphax propinqua</i> Fieber, 1866: 525<br><i>Metadelphax</i> Wagner, 1963: 176; syn. with <i>Toya</i> by implication Fennah 1964: 142 (Type species moved to <i>Toya</i> ); Nast 1972: 65, Linnavuori 1973: 107 (generic synonymy listed) ( <i>Metadelphax</i> used as valid in Mitjaev 1971). Name restored by Ding 2006: 511; Gonzon and Bartlett 2008.<br><i>Meadelphax</i> Wagner, 1963: Missp. by Kuoh <i>et al.</i> , 1983: 155.                                                                                                                                                                                                                                                                 |                                                                                                                                                                                          |                                                                                                                                                                                                                                                    |
| <p><b>* <i>Metadelphax propinqua</i> (Fieber)</b><br/> <i>Delphax propinqua</i> Fieber, 1866: 525.<br/> <i>Delphax hamulata</i> Kirschbaum, 1868: 38.<br/> <i>Liburnia propinqua</i> (Fieber, 1866)<br/> <i>Delphacodes propinqua</i> (Fieber, 1866) Muir 1917: 335.<br/> <i>Liburnia terminalis</i> Van Duzee, 1907: 49.<br/> <i>Liburnia tuckeri</i> Van Duzee, 1912: 506.<br/> <i>Delphacodes neopropinqua</i> Muir, 1917: 335.</p>                                                                                                                                                                                                                                                                                                                                      | <p><b>Type locality:</b><br/> Malaga</p> <p><b>Type deposited:</b><br/> Museum<br/> Vienna</p>                                                                                           | <p><b>Distribution:</b> India (All states)</p> <p><b>Occurrence in present study:</b><br/> India: Andra Pradesh: Tirupati;<br/> Delhi: Pusa campus, Sunder nursery; Himachal Pradesh; Nauni, Solan , Palampur, Una, Rampur, Berthin, Bilaspur;</p> |

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| <p><i>Delphacodes subfusca</i> Muir, 1919: 38.<br/> <i>Liburnia albicollis</i> Haupt, 1935 (nec Motschulsky 1863): 144.<br/> <i>Calligypona propinqua</i> (Fieber, 1866) Dlabola 1954: 14.<br/> <i>Delphacodes shirozui</i> Ishihara, 1949: 53-54.<br/> <i>Metadelphax propinqua</i> (Fieber, 1866) Wagner 1963: 170.<br/> <i>Toya propinqua</i> (Fieber, 1866 Fennah 1964: 142.<br/> <i>Calligypona</i> (<i>Metadelphax</i>) <i>propinqua</i> (Fieber, 1866) Linnavuori 1964: 341-342.<br/> <i>Delphacodes proquiqua</i> (Fieber, 1866) Wray 1967.<br/> <i>M[etadelphax] propingua</i> (Fieber, 1866) Mitjaev 1971: 66.<br/> <i>Toya</i> (<i>Calligypona</i>) <i>propinqua</i> (Fieber, 1866) Linnavuori 1973: 107.<br/> <i>Delphax cataniae</i> Matsumura, 1910: 35.<br/> <i>Toya propinqua neopropinqua</i> (Muir, 1917) Kuoh <i>et al.</i>, 1983: 155.<br/> <i>Liburnia marshalli</i> Scott, 1873: 104.<br/> <i>Delphax graminicola</i> Matsamura, 1910: 17.<br/> <i>Metadelphax propinqua</i> (Fieber, 1866) Ding 2006: 511.</p> |                                                                                                                                                                             | <p>Karnataka; Bidar, Raichur;<br/> Kerala: Nilambur; Ladakh: Leh;<br/> Uttarkhand; Ranichauri.</p>                    |
| <p><b>Genus <i>Miranus</i> Chen and Ding, 2001:323</b> Type species: <i>Miranus varians</i> (Kuoh, 1981): 80</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                             |                                                                                                                       |
| <p><b><i>Miranus varians</i> (Kuoh, 1981)</b><br/> <i>Stenocranus varians</i> Kuoh, 1981: 80</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <p><b>Type Locality:</b><br/> China: Yunnan</p> <p><b>Type deposited:</b><br/> Nanjing Agricultural College</p>                                                             | <p><b>Occurrence in present study:</b><br/> India: Arunachal Pradesh: West Siang Basar</p> <p><b>(New record)</b></p> |
| <p><b>Genus <i>Neukanodes</i> Yang, 1989</b> Type species. <i>Neukanodes formosana</i> Yang, 1989: 164</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                             |                                                                                                                       |
| <p><b><i>Neukanodes unispinatus</i> Hou, Yang and Chen</b><br/> <i>Neukanodes unispinatus</i> Hou, Yang and Chen 2014: 180</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <p><b>Type Locality:</b><br/> China: Yunnan Province: Pianma</p> <p><b>Type deposited:</b><br/> Institute of Entomology, Guizhou University, Guiyang, Guizhou Province,</p> | <p><b>Occurrence in present study:</b><br/> Uttarkhand: Ranichauri</p> <p><b>(New record)</b></p>                     |

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| <b>Genus <i>Nilaparvata</i> Distant, 1906</b> Type species: <i>Nilaparavata greeni</i> Distant, 1906: 473<br><i>Delphax lugens</i> Stal, 1854: 63<br><i>Kalpa</i> Distant, 1906 (Type species <i>Kalpa aculeata</i> Distant 1906); syn. by Muir 1919: 7-8)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                     |
| <p><b>* <i>Nilaparvata lugens</i> (Stal)</b><br/> <i>Delphax lugens</i> Stal, 1854: 246, original combination.<br/> <i>Delphax sordescens</i> De Motschulsky, 1863: 109; synonym by Melichar, 1903: 102, 225; Muir and Giffard (1924)<br/> <i>Nilaparvata greeni</i> Distant, 1906: 473; synonym according to Muir (1919: 7, 1922: 350); Muir and Giffard (1924)<br/> <i>Kalpa aculeata</i> Distant, 1906: 474; synonym according to Muir (1919: 8, 1922: 350); Muir and Giffard (1924)<br/> <i>Delphax parysatis</i> Kirkaldy, 1907: 153; synonym according to Muir and Giffard (1924).<br/> <i>Delphax ordovix</i> Kirkaldy, 1907: 152; synonym according to Muir and Giffard (1924).<br/> <i>Liburnia sordescens</i> (De Motschulsky, 1863); comb. by Melichar, 1903: 102, 225.<br/> <i>Dicranotropis anderita</i> Kirkaldy, 1907: 133; syn. by Muir 1919: 7.<br/> <i>Delphacodes anderita</i> (Kirkaldy, 1907); comb. by Muir, 1917: 311.<br/> <i>Delphacodes parysatis</i> (Kirkaldy, 1907); comb. by Muir, 1917: 333.<br/> <i>Delphacodes ordovix</i> (Kirkaldy, 1907), comb. by Muir 1917: 333.<br/> <i>Delphacodes sordescens</i> (De Motschulsky, 1863); comb. by Muir, 1919: 8 (transfer implicit).<br/> <i>Nilaparvata sordescens</i> (De Motschulsky, 1863); comb. by Muir, 1922: 350.</p> | <p><b>Type</b><br/> <b>Locality:</b><br/> Indonesia:<br/> Java<br/> <br/> <b>Type deposited:</b><br/> Hawaiian<br/> Sugar Planter's<br/> Experiment<br/> Station,<br/> Honolulu.</p>        | <p><b>Distribution:</b> India (All states)<br/> <br/> <b>Occurrence in present study:</b><br/> India: Andra Pradesh: Tirupati;<br/> Delhi: Pusa campus, Sunder<br/> nursery; Himachal Pradesh;<br/> Nauni, Solan, Palampur, Una,<br/> Rampur, Berthin, Bilaspur;<br/> Karnataka: Bidar, Raichur;<br/> Ladakh: Leh; Uttarkhand:<br/> Ranichauri.</p> |
| <p><b><i>Nilaparvata bakeri</i> (Muir)</b><br/> <i>Delphacodes bakeri</i> Muir, 1917: 336</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <p><b>Type</b><br/> <b>Locality:</b><br/> Philippines :<br/> Los Bonos<br/> <br/> <b>Type deposited:</b><br/> Hawaiian<br/> Sugar Planter's<br/> Experiment<br/> Station,<br/> Honolulu</p> | <p><b>Distribution:</b> India: Karnataka:<br/> Bengaluru, Mudigere.</p>                                                                                                                                                                                                                                                                             |



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| <b>Genus <i>Nothokalpa</i> Fennah, 1975</b> Type species: <i>Nothokalpa salome</i> Fennah 1975: 102                                                                                                                                                                                                                                                                                                                                                                            |                                                                                           |                                                                                                                                                                           |
| <b><i>Nothokalpa salome</i> Fennah 1975: 102</b>                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Type Locality:</b> Sri Lanka                                                           | <b>Distribution:</b> India: Karnataka: Bengaluru.                                                                                                                         |
| <b>Genus <i>Nycheuma</i> Fennah, 1964</b> Type species: <i>Dicranotropis capensis</i>                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                           |                                                                                                                                                                           |
| <b>* <i>Nycheuma nilotica</i> Linnavuori, 1973 : 105</b><br><i>Neycheuma coctum</i> Yang, 1989: 98<br><i>Neycheuma coctum</i> Ding, 2006: 247                                                                                                                                                                                                                                                                                                                                  | <b>Type Locality:</b> Taiwan                                                              | <b>Distribution:</b> India: Karnataka: Bengaluru.<br><br><b>Occurrence in present study:</b> Uttarkhand: Hawalbagh                                                        |
| <b>Genus <i>Opiconsiva</i> Distant, 1917</b> Type species: <i>Opiconsiva fuscovaria</i> Distant 1917: 301<br><i>Corbulo</i> Fennah, 1965: 68 was made a junior synonym of <i>Opiconsiva</i> by Asche (1988: 197).<br><i>Harmalia</i> Fennah, 1969 synonym of <i>Opiconsiva</i> Distant, 1917 by Huang <i>et al.</i> , (2017): 175<br><i>Paracorbulo</i> Tian and Ding, 1980 synonym of <i>Harmalia</i> Fennah, 1969 by Yang (1989: 198.)                                       |                                                                                           |                                                                                                                                                                           |
| <b>* <i>Opiconsiva tangira</i> (Matsumura, 1910)</b><br><i>Delphax tangira</i> Matsumura 1910: 30<br><i>Toya tangira</i> (Matsumura 1910); comb. by Nast 1975: 6.<br><i>Corbulo tangira</i> (Matsumura 1910); comb. by Kwon 1982: 7<br><i>Opiconsiva tangira</i> (Matsumura 1910); comb. by Asche 1988: 197.<br><i>Chloriona (Sogatella) paludum</i> (Kirkaldy, 1910); syn by Fennah 1958: 490.<br><i>Opicosiva nigra</i> Ding and Tian, 1980: 39; syn by Fujinama, 1913: 348. | <b>Type Locality:</b> Unknown                                                             | <b>Occurrence in present study:</b> India: Himachal Pradesh: Nauni; Delhi NCR: Sunder nursery.                                                                            |
| <b>* Genus <i>Parasogata</i> Zhou, Yang and Chen</b> Type species: <i>Parasogata binaria</i> Zhou, Yang and Chen, 2018: 77                                                                                                                                                                                                                                                                                                                                                     |                                                                                           |                                                                                                                                                                           |
| <b>* <i>Parasogata sexpartita</i> sp. nov.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Type Locality:</b> INDIA: Nagaland: Jharnapani<br><br><b>Type deposited:</b> NPC       | <b>Occurrence in present study:</b> INDIA: Nagaland: Jharnapani                                                                                                           |
| <b>Genus <i>Peregrinus</i> Kirkaldy, 1904</b> Type species: <i>Delphax maidis</i> Ashmead 1890: 323<br><i>Hagamiella</i> Fennah, 1958 synonym of <i>Peregrinus</i> Kirkaldy, 1904 according to Fennah (1969: 35)<br><i>Perigrinus</i> Muir, 1915 wrong spelling of <i>Peregrinus</i> Kirkaldy, 1904                                                                                                                                                                            |                                                                                           |                                                                                                                                                                           |
| <b>* <i>Peregrinus maidis</i> (Ashmead)</b><br><i>Delphax maidis</i> Ashmead 1890: 323<br><i>Dicranotropis maidis</i> (Ashmead, 1890), comb. by Van Duzee (1897: 227, 240), Kirkaldy (1904: 176).<br><i>Delphax psylliodes</i> Lethierry, 1903 (original combination), syn. by Kirkaldy 1907: 132.<br><i>Liburnia psylloides</i> (Lethierry, 1903) comb. by Melichar (1903: 101); synonym by Kirkaldy (1907: 132).<br><i>Pundaluoya simplicia</i> Distant, 1906                | <b>Type Locality:</b> Florida<br><br><b>Type deposited:</b> Harvard University, Museum of | <b>Distribution:</b> India: (All states)<br><br><b>Occurrence in present study:</b> Delhi: Pusa campus; Himachal Pradesh: Rampur Una, Bilaspur; Karnataka: Raichur, Bidar |

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| <p>synonym by Kirkaldy (1907: 132); also Muir, 1917: 147).<br/> <i>Megamelus teapae albinotatus</i> Crawford, 1914, original combination of <i>Delphacodes albinotata</i> (Crawford, 1914) by Muir and Giffard (1924)<br/> <i>Delphacodes albinotata</i> (Crawford, 1914) synonym by Beamer (1948: 106).</p> | Comparative Zoology.                                                                                                   |                                                                                                                                                                                               |
| <p><b>Genus <i>Perkinsiella</i> Kirkaldy, 1903</b> Type species: <i>Perkinsiella saccharicida</i> Kirkaldy 1903: 179<br/> <i>Araeopides</i> Ribaut, 1948: 13</p>                                                                                                                                             |                                                                                                                        |                                                                                                                                                                                               |
| <p><b><i>Perkinsiella facialis</i> (Distant)</b><br/> <i>Pundaluoya facialis</i> Distant 1912: 191<br/> <i>Perkinsiella facialis</i> (Distant); comb. by Muir 1919.<br/> <i>Perkinsiella fascialis</i> (Distant); missp. by Usman, 1954: 648.</p>                                                            | <p><b>Type Locality:</b><br/> India: West Bengal</p> <p><b>Type deposited:</b><br/> BMNH</p>                           | <p><b>Distribution:</b> India: Karnataka: Bengaluru; West Bengal: Chapra</p>                                                                                                                  |
| <p><b>*<i>Perkinsiella insignis</i> (Distant)</b><br/> <i>Pundaluoya insignis</i> Distant 1912: 190<br/> <i>Perkinsiella taiwana</i> Yang, 1989 (Taiwan); syn. of <i>P. bigemina</i> Ding, 1980</p>                                                                                                          | <p><b>Type Locality:</b><br/> India: Bengal</p> <p><b>Type deposited:</b><br/> BMNH</p>                                | <p><b>Distribution:</b> India: Bihar: Pusa; Maharashtra: Mumbai; Karnataka: Bengaluru; West Bengal.</p> <p><b>Occurrence in present study:</b><br/> India: Karnataka: Bidar; Delhi: Pusa,</p> |
| <p><b>* <i>Perkinsiella sinensis</i> Kirkaldy, 1907: 138</b><br/> <i>Perkinsiella taiwana</i> Yang, 1989: 88 (Taiwan); syn. of <i>P. bigemina</i> Ding, 1980: 108</p>                                                                                                                                        | <p><b>Type Locality:</b> Sri Lanka : Henarathgoda</p> <p><b>Type deposited:</b><br/> Anhui Agricultural University</p> | <p><b>Distribution:</b> India (In all the states)</p> <p><b>Occurrence in present study:</b><br/> India: Karnataka: Bidar</p>                                                                 |
| <p><b>*Genus <i>Phyllodinus</i> Van Duzee</b> Type species: <i>Phyllodinus nervatus</i> Van Duzee, 1897: 240</p>                                                                                                                                                                                             |                                                                                                                        |                                                                                                                                                                                               |

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| <b>*Phyllodinus sp. nov.</b>                                                                       | <b>Type Locality:</b><br>India:<br>Uttarkhand:<br>Hawalbagh<br><br><b>Type deposited:</b><br>NPC                                                                 | <b>Occurrence in present study:</b><br>India: Uttarkhand: Hawalbagh                                                                                                         |
| <b>Genus <i>Platypareia</i> Muir, 1934</b> Type species: <i>Platypareia albipes</i> Muir 1934: 579 |                                                                                                                                                                  |                                                                                                                                                                             |
| <b><i>Platypareia albipes</i> Muir 1934: 579</b>                                                   | <b>Type Locality:</b><br>India:<br>Darjeeling<br><br><b>Type deposited:</b><br>Hawaiian<br>Sugar Planter's<br>Experiment<br>Station,<br>Honolulu.                | <b>Distribution:</b> India: Dajiling                                                                                                                                        |
| <b>Genus <i>Sardia</i> Melichar, 1903</b> Type species: <i>Sardia rostrata</i> Melichar 1903: 96   |                                                                                                                                                                  |                                                                                                                                                                             |
| <b><i>Sardia campbelli</i> Muir 1921: 485</b>                                                      | <b>Type Locality:</b><br>India:<br>Coonoor,<br>Nilgiri Hills<br><br><b>Type deposited:</b><br>Hawaiian<br>Sugar Planter's<br>Experiment<br>Station,<br>Honolulu. | <b>Distribution:</b> India: Tamil Nadu: Nilgiri Hills                                                                                                                       |
| <b>*<i>Sardia rostrata</i> Melichar 1903: 96</b>                                                   | <b>Type Locality:</b> Sri Lanka :<br>Henarathgoda<br><br><b>Type deposited:</b>                                                                                  | <b>Distribution:</b> India: Maharastra: Mumbai; Kerala; West Bengal.<br><br><b>Occurrence in present study:</b><br>Andra Pradesh: Tirupati;<br>Arunachal Pradesh: Pasighat. |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Anhui<br>Agricultural<br>University                                                                                               |                                                                                                                                                                                                                                                                                                                             |
| <b>Genus <i>Shadelphax</i> Ding, 2006:</b> 625. Type species: <i>Calligypona eforiae</i> Dlabola, 1961: 314                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |                                                                                                                                                                                                                                                                                                                             |
| <b>* <i>Shadelphax eforiae</i> (Dlabola, 1961)</b><br><i>Calligypona eforiae</i> Dlabola, 1961:314<br><i>Calligypona kirghisica</i> Dubovsky, 1966:71<br><i>Delphacodes eforiae</i> Mitjaev, 1971:66<br><i>Javesella eforiae</i> Nast, 1972:67<br><i>Unkanodes eforiae</i> Dlabola, 1974:34<br><i>Herbalima eforiae</i> Emeljanov, 1977:117<br><i>Herbalima (Pherancyra) eforiae</i> Emeljanov, 1982:73<br><i>Shadelphax eforiae</i> Ding, 2006:625             | <b>Type Locality:</b><br>Kazakhstan                                                                                               | <b>Occurrence in present study:</b><br>India: Leh                                                                                                                                                                                                                                                                           |
| <b>*Genus <i>Sogata</i> Distant, 1906</b> Type species: <i>Sogata dohertyi</i> Distant, 1906: 471                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                   |                                                                                                                                                                                                                                                                                                                             |
| <b>*<i>Sogata</i> sp. nov.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Type Locality:</b><br>India: Delhi<br>NCR: Sunder nursery<br><br><b>Type deposited:</b><br>Anhui<br>Agricultural<br>University | <b>Occurrence in present study:</b><br>India: Delhi NCR: Sunder nursery                                                                                                                                                                                                                                                     |
| <b>Genus <i>Sogatella</i> Fennah 1956</b> Type species: <i>Delphax furcifera</i> Horvath 1899: 372.<br><i>Chloriona (Sogatella)</i> Fennah, 1956: 471; Type <i>Delphax furcifera</i> Horvath, 1899: 372.<br><i>Sogatodes</i> Fennah, 1963: 71; Type species (by subsequent designation by Fennah, 1963: 166), <i>Sogatodes molinus</i> Fennah, 1963: 72. Syn. by Asche and Wilson 1990: 5.<br><i>Sogatella</i> Fennah, 1956; status (genus) by Fennah 1963: 48. |                                                                                                                                   |                                                                                                                                                                                                                                                                                                                             |
| <b>*<i>Sogatella furcifera</i> (Horvath)</b><br><i>Delphax furcifera</i> Horvath 1899: 372<br><i>Sogata distincta</i> Distant 1912: 191<br><i>Sogata pallescens</i> Distant 1912: 192<br><i>Sogata kyusyuensis</i> Matsumura and Ishihara 1945: 65<br><i>Sogata tandojamensis</i> Qadri and Mirza 1960 : 115                                                                                                                                                    | <b>Type locality:</b><br>Unknown                                                                                                  | <b>Distribution:</b> India (In all the states)<br><b>Occurrence in present study:</b><br>India: Andra Pradesh: Tirupati;<br>Delhi: Pusa campus, Sunder nursery; Himachal Pradesh: Nauni, Solan, Palampur, Una, Rampur, Berthin, Bilaspur; Karnataka; Bidar, Raichur; Kerala: Nilambur; Ladakh: Leh; Uttarkhand: Ranichauri. |

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| <p>* <b><i>Sogatella kolophon</i> (Kirkaldy)</b><br/> <i>Delphax kolophon</i> Kirkaldy 1907 : 157<br/> <i>Delphacodes elegantissima</i> Ishihara 1952: 45<br/> <i>Opiconsiva insularis</i> Distant 1917: 303<br/> <i>Opiconsiva balteata</i> Distant 1917: 302<br/> <i>Opiconsiva derelicta</i> Distant 1917: 303<br/> <i>Sogatella balteata</i> Fennah 1963: 64<br/> <i>Sogatella chenhea</i> Kuoh 1977: 440<br/> <i>Sogatella derelicta</i> Fennah 1963: 62<br/> <i>Sogatella elegantissima</i> Fennah 1963 : 76<br/> <i>Sogatella kolophon atlantica</i> Fennah 1963: 58<br/> <i>Sogatella kolophon insularis</i> Fennah 1963: 59<br/> <i>Sogatella kolophon meridiana</i> Fennah 1963: 59<br/> <i>Sogata meridiana</i> Beamer 1952: 111<br/> <i>Sogatella nebris</i> Fennah 1963 : 67</p> | Literature unavailable                                                                                                | <p><b>Distribution:</b> India: Andhra Pradesh; Karnataka : Bengaluru,Chinthamani, Doddaballapura, Devanahalli, Mandya; Maharashtra; Tamil Nadu.</p> <p><b>Occurrence in present study:</b> Himachal Pradesh: Kinnaur, Bilaspur, Palampur, Rampur Una, Nauni, Solan; Delhi NCR: Pusa campus, Sunder nursery.</p> |
| <p>* <b><i>Sogatella vibix</i> (Haupt)</b><br/> <i>Delphacodes dogensis</i> Ishihara 1952: 47<br/> <i>Delphacodes longifurcifera</i> Eskai and Ishihara 1943: 41<br/> <i>Delphacodes panicola</i> Ishihara 1949: 51<br/> <i>Liburnia matsumurana</i> Metcalf 1943: 364<br/> <i>Liburnia vibix</i> Haupt 1927 : 13<br/> <i>Sogatella catoptron</i> Fennah 1963 : 54<br/> <i>Sogatella diachenhea</i> Kuoh 1977 : 441<br/> <i>Sogatella longifurcifera</i> Fennah 1963 : 53<br/> <i>Sogatella matsumurana</i> Nast 1975:2<br/> <i>Sogatella panicola</i> Fennah 1963 : 76<br/> <i>Sogatella parakolophon</i> Linnavuori 1973 : 108<br/> <i>Sogatella suezensis</i> Linnavuori 1964: 341</p>                                                                                                     | <p><b>Type locality:</b> Unknown</p>                                                                                  | <p><b>Distribution:</b> India: Andhra Pradesh; Karnataka : Chinthamani, Doddaballapura, Mudigere; Maharashtra; Tamil Nadu.</p> <p><b>Occurrence in present study:</b> Delhi: Pusa campus, Sunder nursery; Himachal Pradesh: Sharbu, Kinnaur.</p>                                                                |
| <p><b>Genus <i>Syndelphax</i> Fennah 1963</b> Type species: <i>Syndelphax matanitu</i> Fennah 1963: 16</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                       |                                                                                                                                                                                                                                                                                                                 |
| <p><b><i>Syndelphax euroclydon</i> Fennah 1975 : 111</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <p><b>Type locality:</b> Sri Lanka: Trincomalee</p> <p><b>Type deposited:</b> Zoological Museum, Lund University.</p> | <p><b>Distribution:</b> India: Karnataka : Bengaluru</p>                                                                                                                                                                                                                                                        |
| <p><b>Genus <i>Tagosodes</i> Asche and Wilson 1990: 32</b>, Type species: <i>Dicranotropis cubanus</i> Crawford 1914: 595</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                       |                                                                                                                                                                                                                                                                                                                 |
| <p>* <b><i>Tagosodes pusanus</i> (Distant)</b><br/> <i>Himeunka chibana</i> Tian and Kuoh 1981: 193 in Kouh et al., 1981: 193<br/> <i>Sogatodes assimilis</i> Yang 1989: 178<br/> <i>Sogata pusana</i> Distant 1912: 191<br/> <i>Sogata striatus</i> Qadri and Mirza 1960: 117<br/> <i>Unkana formosella</i> Matsumura 1935: 72<br/> <i>Tagosodes pusanus</i> (Distant); comb.by</p>                                                                                                                                                                                                                                                                                                                                                                                                          | <p><b>Type locality:</b> Kwantung</p> <p><b>Type deposited:</b> Anhui Agricultural</p>                                | <p><b>Distribution:</b> India: Andhra Pradesh; Karnataka: Bengaluru, Makuta; Maharashtra; Tamil Nadu.</p> <p><b>Occurrence in present study:</b> Delhi: Pusa campus, Sunder</p>                                                                                                                                 |

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| Asche and Wilson 1990: 34.<br><i>Sogatodes assimilis</i> Yang 1989: 178                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | University                                                                           | nursery; Arunachal Pradesh:<br>Pasighat                                                                                                                                    |
| <b>Genus <i>Terthron</i> Fennah 1965: 55</b> Type species: <i>Delphax anemonias</i> Kirkaldy 1907:159                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                      |                                                                                                                                                                            |
| <b>*<i>Terthron albobittatum</i> (Matsumura)</b><br><i>Dicranotropis albobittata</i> (Matsumura)<br>1900: 269<br><i>Liburnia albobittata</i> , Matsumura 1931: 269<br><i>Sogota albobittata</i> Esaki, 1932: 2241                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Type locality:</b><br>Japan                                                       | <b>Distribution:</b> India: Andhra Pradesh<br><br><b>Occurrence in present study:</b><br>Andhra Pradesh: Tirupati;<br>Maharastra: Malkhed forest;<br>Uttarkhand: Hawalbagh |
| <b>Genus <i>Toya</i> Distant 1906</b> Type species: <i>Toya attenuata</i> Distant 1906: 417<br><i>Himeunka</i> Matsumura and Ishihara 1945 (Type species <i>Unkana kushiana</i> Matsumura, 1945 in Matsumura and Ishihara 1945: 70): Synonymy made by Anufriev 1977: 865. Removed from synonymy by Kuoh <i>et al.</i> , 1981: 190.<br><i>Metadelphax</i> Wagner, 1963 (type species <i>Delphax propinqua</i> Fieber, 1866): Synonymy made by Fennah 1964: 142 (by implication; type species moved to <i>Toya</i> ); Nast 1972: 65, Linnavuori 1973: 107 (generic synonymy listed). Removed from synonymy by Ding 2006: 511; Gonzon and Bartlett 2007.                                                                                                                                                                                                                                                                                                                                                                    |                                                                                      |                                                                                                                                                                            |
| <b>*<i>Toya nigra</i> (Crawford, 1914)</b><br><i>Megamelus erectus</i> Crawford, 1914: 624.<br><i>Delphacodes axonopi</i> Fennah, 1945: 434<br><i>Delphacodes nigra</i> (Crawford, 1914), new combination and emendation by Muir and Giffard, 1924: 32.<br><i>Delphacodes axonopi</i> Fennah, 1945: 434-435, fig. 107-110, synonymy by Gonzon and Bartlett 2007: 224.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Type locality:</b><br>Mexico: Jalapa                                              | <b>Occurrence in present study:</b><br>India: Maharastra: Malkhed forest; Uttarkhand: Hawalbagh                                                                            |
| <b>*<i>Toya tuberculosa</i> (Distant, 1916)</b><br><i>Liburnia varia</i> Hesse, 1925 previous combination of <i>Delphacodes varia</i> (Hesse, 1925) according to Muir (1929): 220<br><i>Delphacodes varia</i> (Hesse, 1925) previous combination of <i>Toya varia</i> (Hesse, 1925) according to Fennah (1964): 142<br><i>Toya terryi</i> (Muir, 1917) synonym of <i>Toya tuberculosa</i> (Distant, 1916) according to Fennah (1975): 117<br><i>Liburnia tuberculosa</i> Distant, 1916 previous combination of <i>Toya tuberculosa</i> (Distant, 1916) according to Fennah (1976): 269<br><i>Toya varia</i> (Hesse, 1925) synonym of <i>Toya tuberculosa</i> (Distant, 1916) according to Fennah (1976): 269<br><i>Toya hispijimensa</i> Asche, 1980 synonym of <i>Toya tuberculosa</i> (Distant, 1916) according to Asche (1988): 224<br><i>Toya terryi</i> (Muir, 1917) status revivisco according to Ding (2006): 506<br><i>Delphacodes terryi</i> Muir, 1917 previous combination of <i>Toya terryi</i> (Muir, 1917) | <b>Type locality:</b><br>Sri Lanka:<br>Hakgala<br><br><b>Type deposited:</b><br>BMNH | <b>Occurrence in present study:</b><br>India: Karnataka: Bidar                                                                                                             |
| <b>Genus <i>Unkanodes</i> Fennah, 1956</b> Type species: <i>Unkana sapporona</i> Matsumura 1935: 74<br><i>Elymodelphax</i> Wagner, 1963: 167 (type <i>Liburnia excisa</i> Melichar, 1898); Synonymy by Dlabola 1965: 86.<br><i>Chilodelphax</i> Vilbaste, 1968: 26 (subgenus; type species ' <i>Unkanodes silvatica</i> ' Vilbaste, 1968: 26); status revised to genus by Kwon (1982), returned to subgenus by Anufriev and Emeljanov 1988: 409.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                      |                                                                                                                                                                            |

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| <i>Uncanodes</i> Fennah, 1956; Missp. By Dlabola, 1965: 86.                                        |                                                                                                     |                                                                                                |
| * <i>Unkanodes latespinosa</i> (Dlabola, 1957)<br><i>Calligypona latespinosa</i> Dlabola, 1957: 33 | <b>Type locality:</b><br>Afghanistan<br><br><b>Type deposited:</b><br>National<br>museum,<br>Prague | <b>Occurrence in present study:</b><br>India: Himachal Pradesh:<br>Kalpa, Kinnaur; Ladakh: Leh |

\* Species and genera included in the present study

## 4.2. Keys to Delphacidae

### 4.2.1 Key to the subfamilies of the Indian Delphacidae

1. Hind tibial spur quadrangular/rounded in cross section, with row of short bristles on edge, without teeth on inner margin.....**Asiracinae: Ugyopini**
- Hind tibial spur flattened, dilated, foliaceous with or without teeth on inner margin.....**2**
2. Antennae elongate with pedicel almost twice as long as scape.....**Vizcayinae: Vizcayini**
- Antennae terete, not elongate, if elongated and foliaceous, pedicel shorter than scape.....**3**
3. Hind tibial spur with or without teeth on hind margin, if without teeth well developed penis guide present.....**Delphacinae**
- Hind tibial spur with numerous teeth on hind margin, aedeagus with well developed phallobase, aedeagus slender freely movable within phallobase, phallobase shorter than aedeagus and bearing 1-2 apical ventral hook.....**Stenocraninae**

### 4.2.2 Key to the Tribes of Delphacinae of India

1. Post-tibial spur without teeth on hind margin.....**Tropidocephalini**
- Post-tibial spur with teeth on hind margin.....**Delphacini**

#### Tribe Delphacini

### 4.2.3 Key to the genera of the tribe Delphacini

1. Hind basitarsomere with 1-5 teeth (Plate 1C)..... **Nilaparvata** Distant
- Hind basitarsomere without teeth.....**2**
2. Median carina forked beyond base of frons (Fig. 14E, 14F, 14G).....**3**
- Median carina not forked, or forked before frons (Fig. 13C, 13D).....**10**
3. Antennal scape triangular (Fig. 14F, 14G)..... **Perkinsiella** Kirkaldy
- Antennal scape not triangular (Fig. 13I, 14F).....**4**
4. Black species, forewings with prominent black granules, antennal scape black (Fig. 1A-E, 2B-C, 3K-L, 7A-B, 7H 7F).....**5**
- Forewing veins not granulated/granules not prominent, antennal scape not black (Fig. 1K, 2K-L, 3E-F, 7H, 8B, 8F).....**8**
5. Fore and middle femur and tibia enlarged (8H, 14H), hindlegs long without enlargement, mesonotum triangular (Fig. 11H)..... **Phyllodinus** Van Duzee
- Fore and middle femur and tibia not enlarged, antennal scape fuscous, mesonotal disc tumid in dorsal view (Fig. 1A-E, 2A-B, 7A-B, 7H).....**7**
7. Larger species of 4.5- 5mm long (Fig. 2B-C, 7I), ventral margin of the pygofer with a pair of long median processes (Fig. 24D) ..... **Mahmutkashgaria** (Ding and Chen)
- Small species of 3.5-3.8mm long (Fig. 1A-E, 7A-B); Ventral margin of pygofer without any process (Fig. 16D, 17E)..... **Cemus** Fennah
8. Size >4mm (Fig. 3E-F); pygofer without any process (Fig. 32E) and anal tube/segment 10 without spine-like processes (Fig. 32B)..... **Peregrinus** Kirkaldy



- Size 3.5 mm; basal abdominal notum with circular yellow patch (Fig. 1K, 2K-L), pygofer with or without process (Fig. 20C, 28E) and segment 10 with latero-apical process (Fig. 21F, 29C).....**9**
- 9. Frons, genae, clypeus and thorax stramineous, abdomen black (Fig. 1K, 2K-L), segment 10 with short ventrall directed spine-like process (Fig. 29C).....**Neycheuma Fennah**
- Frons, genae, clypeus, mesonotum except tip, abdomen black (Fig. 1K); segment 10 with sinuate latero-apica processes (Fig. 21F).....**Falcotoya Fennah**
- 10. Vertex pointed apically, extending beyond compound eyes (Fig. 10C, 10E, 11I).....**11**  
 Vertex blunt apically and not extending beyond compound eyes (Fig. 10L, 10L, 11D).....**13**
- 11. Vertex long, apically pointed and extending beyond compound eyes; median carina raised at base (Fig. 11I).....**Sardia Melichar**
- Vertex long, broad and progressively converging not pointed as above; median carina not raised, frons broad and widest at apex (Fig. 10C, 10E).....**12**
- 12. Creamy white to pale yellow (Fig. 11I-J); forewings hyaline with black bordered apical margin, abdomen creamy white in basal half and black in distal half (Fig. 7E), aedeagus with or without basal process (Fig. 20C).....**Eoeurysa Muir**
- Hyaline to testaceous; forewings hyaline without any markings, abdomen black (Fig. 1F-G), diaphragm medially modified into a thickened broad arch (Fig. 18G); parameres margins parallel, reaching to laterodorsal angles of pygofer (Fig. 18A, 18F).....**Chloriona Fieber**
- 13. Mesonotum with a longitudinal white vitta (Fig. 10K, 10L, 11D, 11L, 12A-D).....**14**  
 - Mesonotum without longitudinal white vitta (Fig. 10D, 10H, 11C, 11J, 12E).....**20**
- 14. Latero-apical processes of segment ten long, expanded to reach near or medio-ventral margin of pygofer (26A, 27H).....**15**  
 - Latero-apical processes of segment ten short, not reaching the medio-ventral margin (31G, 38D, 39C, 40C, 41C, 42C, 43C).....**16**
- 15. Aedeagus long tubular with acute apex; without basal process (Fig. 26C). **Miranus Chen and Ding**  
 - Aedeagus short, curved ventrally; with basal process (Fig. 27B)..... **Neukanodes Yang**
- 16. Aedeagus twisted with rows of teeth (Fig. 39B, 40B, 41B)..... **Sogatella Fennah**  
 - Aedeagus tubular with or without teeth (Fig. 38B, 40B).....**16**
- 16. Large species (4.2- 5mm) (Fig. 3D, 4D-E), light yellow to stramineous with white longitudinal stripe along median carina of frons to scutellum tip (Fig. 11D, 11K).....**17**  
 - Medium to small species (3.5-3.7mm) (Fig. 4L, 5A, 5B, 5E), thoracic notum black to brown with stramineous intercarinal area (Fig. 12C, 12D, 12G).....**18**
- 17. Aedeagus tubular, apical third sharply turned down without teeth (Fig. 38B), paramere long with truncate or tapering apex (Fig. 38C), .....**Sogata Distant**  
 - Aedeagus tubular, up-curved with a row of subapical processes (Fig. 31B, 31C).....**Parasogata Zhou et al.,**
- 18. Armature of diaphragm arched like inverted V shaped (Fig. 42D), parameres forked at apical end (Fig. 42E) .....**Tagosodes Acshe and Wilson**  
 - Armature of diaphragm expanded V shaped (Fig. 43E, 44E) parameres not forked at apical end (Fig. 41D, 42D).....**19**
- 19. Aedeagus long tubular, upturned to an elbow shape (Fig. 46B), paramere flattened with deeply curved apex (Fig. 47D) .....**Unkanodes Fennah**  
 - Aedeagus deeply curved inside (Fig. 43B), paramere not deeply curved apex (Fig. 43D).....**Terthron Fennah**
- 20. Mesonotum completely black except tip of scutellum (Fig. 10D, 11C, 11J). .....**21**  
 - Mesonotum may or may not black (Fig. 10G, 10J, 12E-F).....**24**
- 21. Wings without claval pterostigma (Fig. 4C); armature of diaphragm convex (Fig. 37C), Parameres blunt without modified.....**Shadelphax Ding**  
 Wings with claval pterostigma (Fig. 1H, 2A, 3B), armature of diaphragm sinuate (Fig. 19D, 23C, 30D), parameres modified differently.....**22**
- 22. Parameres bilobed (Fig. 30G), aedeagus with a basal fold like extension (Fig. 30B).....**Opiconsiva Distant**  
 - Parameres not bilobed (Fig. 19E, 23F), aedeagus with basal extension but not foldlike (Fig. 19B, 23B).....**23**
- 23. White broad transverse band towards posterior margin of pronotum, basal margin black (Fig. 10D), median carina of frons black, lateral carina with distinctive white suffusion (Fig. 13D).....**Coronacella Metcalf**

- Pronotum white with distinct black fascia behind compound eyes (Fig. 11H); median carina of frons white along with lateral carina (Fig. 13H) ..... **Laodelphax Fennah**
- 24. Latero-dorsal angle of the pygofer expanded in caudal view with apices inflected ventromedially (Fig. 22D, 25D) ..... **25**
- Latero-dorsal angle of the pygofer not expanded as above, if expanded not inflected, armature margin wavy (Fig. 44D, 45D)..... **Toya Wagner**
- 25. Armature of diaphragm bilobed or trilobed (Fig. 25D) ..... **Metadelphax Wagner**
- Armature of diaphragm single lobed (Fig. 22D)..... **Harmalia Fennah**

#### 4.2.4 Key to the genera of the tribe Tropidocephalini

1. Antennae elongate, foliaceous with a median ridge, pedicel of antennae shorter than scape (Fig. 12L, 15L)..... **Purohita Distant**
- Antennae short, not foliaceous (Fig. 12H, 12I, 12J, 12K, 12M, 12N)..... **2**
2. Head distinctly narrower than pronotum, basal compartment of vertex triangular, antennae not elongated (Fig. 12L, 12M, 12N)..... **Tropidocephala Stal**
- Head almost as broad as pronotum; vertex quadrate or nearly so (Fig. 12H, 12I, 12J)..... **3**
3. Postclypeus in profile strongly bent at right angle to frons (Fig. 9H, 9I) ..... **4**
- Postclypeus in profile in the same plane as frons, or curved caudad but not at right angle to frons (Fig. 8G), anterior margin of vertex evenly rounded or truncated (Fig. 12J, 12K) ..... **Bambusiphaga Huang and Ding**
4. Longitudinal whitish stripe bordered with blackish brown bordered, extend along midline from apex of postclypeus to end of mesonotum (Fig. 12H), frons in midline more than 2X wider than maximum width (Fig. 15H) ..... **Arcofacies Muir**
- Longitudinal whitish stripe absent (Fig. 12I), frons in midline about 1.4 times wider than maximum width (Fig. 15I)..... **Arcofaciella Fennah**

#### Key to the delphacids complex in rice agroecosystem in India.

The delphacid complex is huge in agroecosystem, in rice ecosystem itself, around 65 species will occur. Among them Delphacini genera *Nilaparvata*, *Sogatella*, and *Laodelphax* are most economically important as pest and vectors of rice diseases (Heong, 2009). Here we gave the key for 12 species of delphacids that commonly occurring in rice fields of India.

1. Hind basitarsomere with 1-5 teeth (Plate. 1C) ..... **2**
- Hind basitarsomere without teeth ..... **3**
2. Diaphragm without median process (Fig. 28E); aedeagus upturned (Fig. 28B) ..... **Nilaparvata lugens (Stal)**
- Diaphragm with median process; aedeagus asymmetrical with two rows of lateral marginal teeth ..... **Nilaparvata bakeri (Muir)**
3. Median carina forked beyond base of frons (Fig. 14E, 14F, 14G) ..... **4**
- Median carina not forked, or forked before frons (Fig. 13D, 13H)..... **5**
4. Antennal scape triangular (Fig. 14F), medioventral margin of pygofer with broad ventral processes (Fig. 33D), lateroapical processes segment 10 long (Fig. 33C)..... **Perkinsiella insignis (Distant)**
- Antennal scape not triangular (Fig. 14E), medioventral margin of pygofer without ventral processes (Fig. 32E), lateroapical processes of the segment 10 absent (Fig. 32B)..... **Peregrinus maidis (Ashmaed)**
5. Pronotum white to stramineous with black fascia behind compound eyes, mesonotum completely black except at tip of scutellum (Fig. 10D, 10H) ..... **6**
- Pronotum with or without transverse white band if present, mesonotum with a longitudinal white vitta (Fig. 10J, 11L, 12A, 12B, 12C, 12D) ..... **7**
6. White broad transverse band towards posterior margin of pronotum, basal margin black (Fig. 10D), median carina of frons black, lateral carina with distinctive white suffusion (Fig. 13D)..... **Coronacella sinhalana (Kirkaldy)**
- Pronotum white with distinct black fascia behind compound eyes (Fig. 10H), frons black with distinct white median and lateral carina (Fig. 13H)..... **Laodelphax striatellus (Fallen)**
7. Mesonotum without a longitudinal white median band (Fig. 10J), forewing without any marking towards apical margin (Fig. 7J) ..... **Metadelphax propinqua (Fieber)**

- Mesonotum with a longitudinal white median band (Fig. 11L, 12A, 12B, 12C, 12D), aedeagus twisted with rows of teeth or tubular with teeth towards the apex (Fig. 39B, 42B, 43B).....**8**
- 8. Lateral area of thoracic notum dark (Fig. 12C, 12D), aedeagus may or may not tubular with few spines (Fig. 43B, 42B) .....**9**
- Lateral area of thoracic notum light to dark (Fig. 11L, 12A, 12B), aedeagus twisted with rows of teeth (Fig. 39B, 40B, 41B) .....**10**
- 9. Aedeagus tubular and tapering towards apex, dorsally curved (Fig. 42B), wing with claval pterostigma (Fig. 4L)..... ***Tagosodes Pusanus (Distant)***
- Aedeagus deeply curved to form longer and shorter lobe distally (Fig. 43B), wing without claval pterostigma (Fig. 5B) .....***Terthron albobittatum (Matsumura)***
- 10. Forewing hyaline with distinct claval pterostigma (Fig. 4F); Frons, genae and clypeus black (Fig. 14L); Pygofer with a stout process on ventral margin (Fig. 39D).....***Sogatella furcifera (Horvath)***
- Forewings without claval pterostigma (Fig. 4H, 4J); pygofer ventral margin without distinct process (Fig. 40C, 41C) .....**11**
- 11. Frons, genae and clypeus stramineous (Fig. 15A); forewing with a light brown suffusion at the anal margin (Fig. 9A) .....***Sogatella kolophon (Kirkaldy)***
- Frons and clypeus pallid stramineous with dark fuscous genae (Fig. 15B); forewing hyaline without any markings (Fig. 9B)..... ***Sogatella vibix (Haupt)***

### 4.3. Description

#### Genus *Cemus* Fennah

Type species: *Cemus leviculus* Fennah, 1964: 147

**Amended diagnosis:** Black. Head including compound eyes as wide as pronotum. Lateral carinae shallowly convex. Frons longer than broad, widest at level of ocelli. Rostrum reaching hind coxae. Antennal scape longer than broad, second segment almost 2x as long as first segment. Thorax tricarinate, fuscous except carinae, mesothorax raised. Lateral carinae of pronotum not reaching hind margin. Legs fuscous, post-tibial spur with toothed hind margin pale compared to other segments. Male pygofer ventrally long, caudal margin truncate with median lobe-like projection. Diaphragm with a V shaped excavation medially. Parameres narrow not broad. Aedeagus elongate, asymmetrical.

**Remarks:** The genus can be easily distinguished by the dark grey to black habitus, wings veins ornamented with prominent black granules and asymmetrical aedeagus. Externally very similar to the genus *Mahmutkashgaria* (Ding and Chen), however the earlier can be differentiated by the smaller habitus and absence of median process of the pygofer.

#### Key to the species of *Cemus* Fennah

1. Subapical outer angle parameres greatly produced to form a convex apical curve (Fig. 16F). Aedeagus tubular with paired lobe-like subapical process; left process hooklike apically (Fig. 16B) .....***Cemus sauteri (Muir, 1971)***
- Parameres flattened, sinuate with outer mesal margin deeply curved (Fig. 17F). Aedeagus tubular with paired lobe-like subapical process with basal finger like projection on ventral margin (Fig. 17D), .....***Cemus zhitus Kuoh, 1981***

***Cemus sauteri* (Muir, 1917) [Fig. 1A, 1B, 1C, 7A, 10A, 13A, 16A-F, 55A-D] (New record)**

*Phyllodinus sauteri* Muir 1917:319

Dark grey to black; vertex black; frons dark fuscous with prominent carinae, white spots on intercarinal areas; eyes, pronotum mesonotum, and abdominal tergites darker than remaining. Antenna dark fuscous. Thorax black with light carina; lateral angle of pronotum off white. Tegulae creamy white; Fore wings hyaline, dark claval pterostigma, apically light U shaped brown suffusion; veins with regularly placed granules. Brachypterous similar in appearance to macropterous except in sclerotization of wing (Fig. 1A, 1B, 1C, 7A, 10A, 13A).

Head including eyes 1.2x width of pronotum; in dorsal view slightly concave in front, crown length 0.2x width across eyes (Fig. 1A, 10A). Frons widest medially, median carinae forked far below frons. (Fig. 13A). Fastigium round in lateral view. Pronotum 5.2x wider than long; lateral carinae not reaching hind margin, scutellum 1.2x wider than long. (Fig. 7A).

**Male genitalia [Fig. 16A-F]:** Pygofer 1.2x longer than wide (Fig. 16E) diaphragm well developed with median V shaped excavation (Fig. 16D). Segment ten and eleven 1.1x longer than wide with 0.3x spine like short lateroapical processes; segment eleven short (Fig. 16C). Parameres 5.8x longer than wide; subapical outer angle greatly produced into convex apical curve (Fig. 16F). Aedeagus 1.8x longer than wide; tubular, with paired lobe-like subapical process; left process hooklike apically; gonopore apical. (Fig. 16A, B).

**Female genitalia (Fig. 55A-D):** Valvulae I in lateral view (Fig. 55A, B), dorsal sculptured area extending from middle portion to apex of blade; ventral apical 1/4th area even and translucent. Valvulae II (Fig. 55C, D), in lateral view, dorsal margin concave, distal half with serrations terminating into stout spine apically; ventral margin translucent with sculptured apical teeth.

**Measurements (mm).** Male 3.7 long, 0.7 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.9 long, 0.7 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied.** INDIA: Himachal Pradesh: 8♂, 10♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Karnataka: 9♂,

14♀, Bidar (17°55'16"N 77°29'54" E) 08.x.2018 Shashank P. R (NPC). Uttarkhand: 29♂, 45♀ Hawalbagh (29°64'28"N 79°63'27"E) 25.xii.2018 Sunil (NPC).

**Remarks:** *Cemus sauteri* is externally similar to *C. zhitus* but can be differentiated by aedeagus subapical process without basal finger like projection on ventral margin. This species is new record to India, earlier it was recorded from China, Japan, Fiji, Srilanka and Australia.

***Cemus zhitus* Kuoh, 1981 [Fig. 1D, 1E, 7B, 10B, 13B, 17A-F, 55E-H] (New record)**

*Cemus zhitus* Kuoh, 1981 : 423

Dark grey to black; vertex black; frons dark fuscous with prominent carinae, white spots on intercarinal areas. Eyes, pronotum, mesonotum, and abdominal tergites darker than remaining. Antenna dark fuscous. Thorax black with light carina. Lateral angle of pronotum off white. Tegulae creamy white. Fore wings hyaline, with dark claval pterostigma, apical light U shaped brown suffusion; veins with granules. Abdomen black. (Fig. 1D, 1E, 7B, 10B, 13B)

Head including eyes 1.2x width of pronotum, in dorsal view slightly concave in front, crown length 0.2x width across eyes (Fig. 1D, 10B). Frons widest medially, median carinae forked far below frons (Fig. 13B). Fastigium round in lateral view (Fig. 7B). Pronotum 5.2x wider than long; lateral carinae not reaching hind margin. Scutellum 1.2x wider than long; carina light (Fig. 10B).

**Male genitalia (Fig. 17A-F):** Pygofer 1.3x longer than wide with well developed diaphragm with median V shaped slit (Fig. 17E). Segment ten and including segment eleven 1.6x longer than wide along with 0.4x spine like lateroapical processes; segment eleven short (Fig. 17C). Parameres 5.6x longer than wide; flattened, sinuate with outer mesal margin deeply curved (Fig. 17F). Aedeagus 1.6x longer than wide; tubular with well developed paired lobe-like subapical process along with basal finger like projection on ventral margin, gonopore apical. (Fig. 17A, D).

**Female genitalia (Fig. 55E-H):** Valvulae I (Fig. 55E, F) in lateral view, broader, dorsal sculptured area extending from sub-basal portion to apex of blade; ventral area membranous and translucent. Valvulae II (Fig. 55G, H), in lateral view, dorsal margin basally concave, distal half with serrations, apex acute with ventral-lateral serrations; ventral margin translucent.

**Measurements (mm).** Male 3.8 long, 0.8 wide across eyes, 0.6 wide across hind margin of pronotum. Male 3.9 long, 0.8 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material studied.** INDIA: Himachal Pradesh: 8♂, 11♀ Palampur, CSK-HPKV, (32°10'03.0"N, 76°54'65.0"E) 10.viii.2018, Sweep net Coll. Niranjana (NPC); 7♂ 5♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC).

**Remarks:** *Cemus zhitus* is morphologically similar to *C. sauteri* but the earlier can be differentiated by the aedeagus tubular with well developed paired lobe-like subapical process along with basal finger like projection on ventral margin; parameres flattened, sinuate with outer mesal margin deeply curved. This species is new record to India, earlier it was recorded from China.

***Chloriona* Fieber, 1866 (New record)**

Type species: *Chloriona unicolor* (Herrich-Schäffer, 1835): 66

**Amended diagnosis:** Stramineous to green. Head including eyes narrower than pronotum. Vertex projected in front, as long as wide at base. Frons tricarinate, broad, widest at distal end, median carina forked before frons. Gena, clypeus concoloured with frons. Rostrum reaching to meso-trochanters. Antennae cylindrical, basal segment longer than wide, shorter than second segment. Thorax concoloured with body, carina evanescent. Forewings hyaline without any markings. Pygofer very short, opening wider than long, without medioventral process, diaphragm arched medially. Parameres slender, divergent, both margins parallel, reaching to laterodorsal angles of pygofer. Segment 10 ring-like, lateroapical processes absent. Aedeagus short, tubular, armed with teeth.

**Remarks:** The genus is new record to India, collected from Leh region of Ladakh, earlier it was recorded from Southern palearctic countries except India. The genus *Chloriona* is closely associated with genus *Sogata* Distant can be differentiated by the converging vertex, parameres reaching the laterodorsal angles of pygofer.

***Chloriona unicolor* (Herrich-schäffer, 1835) [Fig. 1F, 1G, 7C, 10C, 13C, 18A-G, 55I-L]**

*Delphax unicolor* Herrich-Schäffer, 1835: 66

*Chloriona oranensis* Matsumura, 1910: 629

*Chloriona edwardsi* Le Quesne, 1960: synonym noted Nast 1987: 629

*Chloriona canariensis* Lindberg, 1954: synonym by Asche 1982: 137

Yellow to stramineous. Vertex stramineous. Frons pale yellow with light carina. Gena, clypeus concolourous with frons; rostrum stramineous. Antenna pale yellow with black hairs. Thorax stramineous with light carina. Pronotum tricarinate, lateral carina not reaching hindmargin. Forewings hyaline with regularly placed hairs on veins. Abdomen black mosaic with yellow strips on tergum (Fig. 1F, 1G, 7C, 10C, 13C).

Head including eyes 0.8x width of pronotum; triangular in front. Vertex length 0.4x width across eyes; converging anteriorly (Fig. 1F, 1G, 10C). Frons broad, subapically widest; median carina forked at frons. Clypeus as wide as frons basally, rostrum surpassing mesocoxae not attaining hindcoxae. Antenna terete (Fig. 13C). Fastigium rounded in lateral view (Fig. 7C). Pronotum 4.3x wider than long; evanescent carina, lateral carinae diverging not reaching hind margin. Scutellum 1.1x wider than long; carina not conspicuous (Fig. 10C).

**Male genitalia (Fig. 18A-G):** Pygofer 0.6x wider than long; diaphragm arched medially (Fig. 18G). Segment ten and including segment eleven as long as wide lateroapical sinuate processes; segment elevenshort and inconspicuous (Fig. 18D). Parameres 4x longer than wide; slender, divergent, both margins parallel, reaching to laterodorsal angles of pygofer (Fig. 18F). Aedeagus 3.5x longer than wide; flattened, ornamented with subapical spines at base of gonopore; dorso-apical gonopore (Fig. 18B, 18C).

**Female genitalia (Fig. 55I-L):** Valvulae I in lateral view (Fig. 55I, J) broader basally, apically sharper; ventral area membranous and translucent. Valvulae II (Fig. 55K, L)) in lateral view, with irregular sculpturing in distal 2/3rd also bearing dorsal teeth (35-37) apical 2/3rd except basally

**Measurements (mm).** Male 4.9 long, 0.6 wide across eyes, 0.7 wide across hind margin of pronotum. Female 5.1 long, 0.7 wide across eyes, 0.8 wide across hind margin of pronotum.

**Material studied.** INDIA: Ladakh; 8♂ 9♀ Leh, (34°09'9.32"N 77°34'37.38" E) 15.viii.2018, Sweep net Coll. Naresh Meshram (NPC).

**Remarks:** *Chloriona unicolor* is recorded first time from India earlier this species was recorded from China, Europe, Russia and Middle East. It can be easily distinguish by other species of the genus by the larger, testaceous habitus; parameres



slender, both margins parallel, reaching to laterodorsal angles of pygofer; aedeagus ornamented with subapical spines at base of gonopore.

**Genus *Coronacella* Metcalf**

Type species: *Kelisia kirkaldyi* Muir 1917: 329

**Amended diagnosis:** Black. Head including compound eyes slightly narrower than pronotum. Vertex as long as wide with black intercarinal areas. Frons, gena black with keeled median carinae. Clypeus off white, rostrum attaining mid-coxae. Antenna stramineous with second segment longer than first. Thorax with white longitudinal band on posterior 3/4<sup>th</sup> of pronotum, mesonotum black except at scutellum tip. Forewings hyaline with distinct claval pterostigma. Pygofer short with well developed diaphragm; Aedeagus tubular with broad base.

**Remarks:** The genus *Coronacella* externally similar to *Laodelphax* Fennah. The genus with black species and cryptic in nature. It can be differentiated by the tubular, broad based aedeagus and short pygofer with well developed diaphragm.

***Coronacella sinhalana* (Kirkaldy) [Fig. 1H, 7D, 10D, 13D, 19A-E]**

*Liburnia frontalis* Melichar 1903:100

*Delphacodes sinhalanus* Kirkaldy 1906: 156

*Kelisia kirkaldyi* Muir 1917: 329

White and black; vertex off-white with black intercarinal area. Frons and gena black with white teral carinae with suffusion on inner side; median carina black; clypeus off-white. Pronotum creamy white, with black fasciae, mesothorax dark brown except at hind margin of scutellum. Tegulae creamy white to black. Fore wings hyaline with dark claval pterostigma (Fig. 1H, 7D, 10D, 13D)

Head including eyes 0.8x width of pronotum, in dorsal view nearly quadrate with emarginate carinae. Vertex length 3.1x width across eyes, median carina forked before frons (Fig. 1H, 10D). Frontoclypeus broad, frontal suture extending onto vertex. Frons equal width throughout, median carina black and lateral carina with white suffusion (Fig. 13D). Fastigium nearly round in lateral view (Fig. 7D). Pronotum 3.6x wider than long; scutellum 1.4x wider than long (Fig. 10D).

**Male genitalia (Fig. 19A-E):** Pygofer 1.5x longer than wide with well defined ventral margin, diaphragm conspicuous (Fig. 19D). Segment ten and eleven combinedly short with 0.5x slightly curved lateroapical processes; segment eleven moderately long (Fig. 19C). Parameres 4.7x longer than wide; convergent apically with medially curved

inner margins (Fig. 19E). Aedeagus 4.5x longer than wide; tubular with broad base and three spines on dorsoapical end; gonopore apical (Fig. 19A, B).

**Material studied:** India: Andra Pradesh; 5♂ Tirupati, (13°62'88"N, 79°41'92" E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC). Delhi, NCR; New Delhi: 30 ♂ Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, and Pusa Campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Maharashtra; 7♂ Chikhaldara forest (21°24'16.8"N 77°20'39.0"E), 19.xii.2017, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC).

**Measurements (mm):** Male 2.7 long, 0.5 wide across eyes, 0.4 wide across hind margin of pronotum.

**Remarks:** This species externally similar to *Laodelphax stiatellus* in appearance and can be differentiated by the black median carinae of frons, aedeagus tubular with broad base with three spines on dorsoapical end.

### **Genus *Eoeurysa* Muir 1913**

Type species: *Eoeurysa flavocapitata* Muir, 1913: 249

**Amended diagnosis:** Habitus black to white. Head including eyes narrower than pronotum. Vertex as long as wide at base, Y-shaped carina distinct, apically converging with rounded margin. Frons slightly elongate medially, widest at apex, flattened, median carina prominent and forked before frons. Clypeus at base as wide as apex of frons. Rostrum reaching to meso-coxae. Antennae terete, surpassing frontoclypeal suture. Pronotum with lateral carinae attaining hind margin. Segment 10 (anal segment) ring like with or without short latero-apical processes. Pygofer with laterodorsal angle not produced, in posterior view opening wider than long, medioventral process absent; diaphragm moderately wide, dorsal margin protruding into a plate to connect base of suspensorium. Aedeagus tubular. Suspensorium elongate quadrate, circular at ventral half.

**Remarks:** The genus can be distinguished by the apically converging vertex and forewings held roof like over the body. Pygofer in posterior view with opening wider than long, medioventral process absent; diaphragm moderately wide. Aedeagus tubular with or without a basal process

***Eoeurysa sagitta* sp. nov. 1 [Fig. 1I, 1J, 7E, 10E, 13E, 20A-H, 55 M-P]**

Creamy white to pale yellow. Vertex, frons, gena and clypeus concolorous with thorax. Frontal carina prominent. Antennal monochrome with vertex. Thorax creamy white with light yellow carina. Pronotum and mesonotum with light stripes and carina. Tegulae with thoracic notum. Forewings hyaline, apical margin black. Abdomen creamy white in basal half and black in distal half (Fig. 1I, 1J, 7E, 10E, 13E).

Head including eyes 0.9x width of pronotum, slightly narrower than pronotum. Vertex length 0.4x width across eyes, Y shaped carina distinct (Fig. 1J, 10E). Frons longer than wide, progressively widening to widest at apex, median carina forked before frons. Clypeus base as wide as apex of frons, rostrum reaching meso-coxae, antennal terete, scape shorter than pedicel (Fig. 13E). Fastigium subtriangular in lateral view (Fig. 7E). Pronotum 3.1x wider than long; light carina. Scutellum 1.1x wider than long; light carina (Fig. 10E).

**Male genitalia (Fig. 20A-H):** Pygofer 1.2x longer than wide; pygofer broad without any lateral expansion, medioventral processes absent, diaphragm moderately wide, dorsal margin protruding into a plate to connect base of suspensorium (Fig. 20C, 20H). Segment ten and eleven combinedly as long as wide, ring like with short processes; segment eleven moderately long (Fig. 20E). Parameres 8x longer than wide; sinuate with acute apex in dorsal view, with mediolateral processes in lateral view (Fig. 20F, G). Aedeagus 7.2x longer than wide; recurved subapically with round arrow head apex, basally ornamented with 1.8x long curved spinose process. Suspensorium very large, ventral two-thirds ring-like (Fig. 20A, 20D).

**Female genitalia (Fig. 55 M-P)** Valvulae I (Fig. 55M, N) curved medially, pointed, with strigate sculpturing throughout. Valvulae II (Fig. 55O, P) shallowly curved, denticulate area confined to distal 3/4, denticles prominent, gradually becoming smaller distally, apex pointed, with serrations on ventral margin.

**Material Examined:** INDIA: Himachal Pradesh; 5♂ 7♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, coll. Sunil, Niranjana (NPC)

**Measurements (mm).** Male 3.7 long, 0.6 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.9 long, 0.7 wide across eyes, 0.5 wide across hind margin of pronotum.

**Remarks:** *Eoeurysa sagitta* sp. nov. 1 is closely related to *E. arundina* Kuoh and Ding, especially based on the basal process of aedeagus, and can be differentiated by flattened body, progressively broadening frons and aedeagus recurved subapically with round arrowhead apex, basally ornamented with long curved spinose process.

***Falcotoya* Fennah, 1969**

Type species: *Falcotoya aurinia* Fennah, 1969: 40

**Amended diagnosis:** Black. Head including eyes narrower than pronotum. Vertex stramineous, as long as wide, not projected in front of eyes. Frons rectangular, same width throughout, median carina forked far below frons. Antenna stramineous, cylindrical, second segment longer than first. Pronotum stramineous with prominent carinae. Mesonotum black. Forewings hyaline. Male pygofer with produced laterodorsal angle; diaphragm well developed with median lobe. Aedeagus tubular, sickle-shaped, ornamented with many teeth.

**Remarks :** The genus is new record to India, it was earlier recorded from China. It contains small, black species, which are cryptic with other delphacids and it can be identified based on approximately sickle shaped aedeagus ornamented with small teeth on ventral margin

***Falcotoya daluoensis* Ding (Fig. 1K, 7F, 10F, 13F, 21A-G)**

*Falcotoya daluoensis* Ding, 2006: 41

Black; vertex stramineous. Frons, clypeus and gena black with yellow carinae. Pronotum stramineous with black fascia behind compound eyes. Mesonotum black with concolourous carinae. Tegulae stramineous. Abdomen black with yellow circular vitta at abdominal base. Fore wings hyaline with claval pterostigma (Fig. 1K, 7F, 10F, 13F).

Head including eyes narrower than pronotum. Vertex length 0.1x width across eyes; as long as wide (Fig. 1K, 10F). Frons rectangular; median carina forked at midlength of eyes. Antenna stramineous (Fig. 13F). Fastigium rounded in lateral view (Fig. 7F). Pronotum 3.1x wider than long; tricarinate, lateral carinae reaching to hind margin. Scutellum 1.4x wider than long; carinae not conspicuous (Fig. 10F).

**Male genitalia (Fig. 21A-G):** Pygofer 1.1x longer than wide with well developed diaphragm having sinuate median process; laterodorsal angle slightly produced (Fig. 21C, E). Segment ten along with segment eleven 1.4x longer than wide along with

0.04x lateroapical processes; segment eleven short (Fig. 21F). Parameres rectangular, 3x longer than wide, sinuate inner margin with basal extension, flattened apex (Fig. 21G). Aedeagus 2.3x longer than wide; tubular, sickle shaped with rows of spines; gonopore apical with basal few spines (Fig. 21A, B).

**Measurements (mm).** Male 1.7 long, 0.3 wide across eyes, 0.3 wide across hind margin of pronotum.

**Material studied.** INDIA: Maharashtra: 5♂, Amaravati (20°93'20" N, 77°75'23"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Akash (NPC); 10♂, Bramhanwada (19°34'31"N, 74°03'44"E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Akash (NPC). Uttarkhand; 9♂, Ranichauri-KVK. (27°17'50"N 85° 98'15"E) 07.x.2017, Sweep net Coll. Akash (NPC).

**Remarks:** The species is new record to India and it was earlier described from China. This species externally similar to *Laodelphax striatellus*, but can be distinguished by the bifurcated median carina at base of frons and tubular aedeagus sickle shaped with rows of spines.

#### **Genus *Harmalia* Fennah**

Type species: *Harmalia thoracica* (Distant, 1916): 140

**Amended diagnosis:** Dark brown to vermillion. Head distinctly narrower than pronotum. Vertex longer than broad at base, Y-shaped carina present, median carina emerginate, lateral carinae concave; apex pointed. Frons tricarinate, longer in middle than width at widest margin, median carina simple, intercarinal areas dark fuscous. Rostrum passing middle coxae and not reaching hind coxae. Thoracic notum tricarinate, lateral carina of prothorax not reaching hind margin. Pygofer slightly ventrally longer than dorsally, lateroapical angles produced and folded deeply. Segment ten with lateroapical process and segment eleven moderately. Parameres long and broadest at about basal half, apically bilobed or curved, Aedeagus cylindrical, moderately long.

**Remarks:** This genus closely associated with *Metadelphax* Wagner but can be differentiated by the extremely expanded lateroapical margin of the pygofer with inner foldings, armature of diaphragm longer than wide and aedeagus tubular, laterally compressed, broad at basal half, pointed at apex.

***Harmalia* sp. nov. 2 [Fig. 1L, 7G, 10G, 13G, 22A-E]**

Yellowish orange. Vertex dull yellow. Frons, gena and clypeus yellowish with black basal area of frons. Antenna starmineous. Thorax yellowish brown. Pronotum yellowish brown with light posterior band across. Mesonotum monochrome with thorax, scutellum tip light yellow. Tegulae basally concolours with thorax, bordered with black. Forewings hyaline with concolours veins. Abdomen black with yellowish circular patch at notum base (Fig. 1L, 7G, 10G, 13G).

Head including eyes as wide as width of pronotum. Vertex length 0.2x width across eyes; truncate in front (Fig. 1L, 10G). Frons longer than wide with median carina forked before frons. Clypeus as wide as apex of frons, rostrum attaining hindcoxae. Antenna terete, second segment longer than first (Fig. 13G). Fastigium rounded in lateral view (Fig. 7G). Pronotum 4.7x wider than long; light carina, lateral carina nearly attaining hind margin. Scutellum 1.2x wider than long; carina inconspicuous (Fig. 10G).

**Male genitalia (Fig. 22A-E):** Pygofer 1.3x longer than wide; characteristically expanded dorsal portion in caudal view with apices inflected, diaphragm (armature) well developed, longer than wide with a stout medioventral process (Fig. 22D). Segment ten and eleven combinedly 1.7x longer than wide with 0.5x lateroapical processes, slender and upcurved; segment elevenshort (Fig. 22C). Parameres 5x longer than wide; broad, basal half broadly expanded with deeply incised subapical inner margin, expanded acute apex (Fig. 22E). Aedeagus 5.1x longer than wide; straight tubular, broad basally and narrowed medially, without teeth; gonopore latero-apical (Fig. 22A, B).

**Measurements (mm).** Male 2.7 long, 0.6 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied.** INDIA: Karnataka: 1♂, Bidar (17°55'16"N 77°29'54" E) 08.x.2018 Shashank P. R (NPC).

**Remarks:** Placement of this species in the *Harmalia* Fennah is based on pygofer with expanded dorsal portion in caudal view, armature of the diaphragm longer than wide. Current species can be distinguished by congeners by the yellowish orange habitus, tubular aedeagus with basal extension, armature of diaphragm with a stout process and hook like parameres. The complete literature survey on the genus distinguished the present species from all other described species.

### Genus *Laodelphax* Fennah

Type species: *Delphax striatella* Fallen, 1826: 75

Black. Head including eyes narrower than pronotum. Vertex quadrate, apical margin transverse, lateral carinae straight, submedian carinae uniting just before frons. Frons longer in middle line than wide at widest part, widest below level of ocelli. Rostrum surpassing meso-coxae. Ocelli present. Antennae cylindrical, basal segment longer than wide. Pronotum with lateral carinae diverging and not attaining hind margin. Segment 10 of male ring-like with spinose lateroapical process. Pygofer slitely longer than wide, in posterior view lateral margins strongly produced. Aedeagus tubular, lateral compressed, broad at basal half, pointed at apex. Suspensorium ring-like with two relatively long arms at dorsal margin, directed dorsocephalad. Diaphragm very broad. Parameres simple, short.

**Remarks:** This genus was recorded by Shukla (1979) from Ludhiana, Punjab, India but unreported till we collected it from Delhi and NCR region of India. This genus very similar to *Coronacella*, however it can be differentiated by the white median carinae of frons. Aedeagus tubular, lateral compressed, broad at basal half, pointed at apex.

### *Laodelphax striatellus* (Fallen) [Fig. 2A, 7H, 10H, 13H, 23A-F]

*Delphax striatella* Fallen, 1826: 75

*Liburnia akashiensis* (Matsumura, 1900): comb. by Oshanin (1907): 330

*Delphax akashiensis* (Matsumura, 1900) comb. by Oshanin 1907: 330

*Delphacodes akashiensis* (Matsumura, 1900) comb. by Metcalf (1943: 399)

*Delphacodes akashiensis* (Matsumura, 1900) syn. by Matsumura and Ishihara, 1945: 61

*Liburnia striatella* (Fallén, 1826); comb. by Scott 1870: 27

*Achorotile striatella* (Fallén, 1826); comb. by Oshanin 1870: 48.

*Delphacodes striatella* (Fallén, 1826); comb. by Muir 1917: 334; Fennah 1963: 15

*Liburnia devastans* Matsumura, 1900: 262; syn. by Horvath, 1903: 558.

*Liburnia marginata* Haupt, 1935; syn. by Haupt 1935: 142

Stramineous to white and black; vertex stramineous and face fuscous with white carinae. Eyes, mesonotum, and abdominal tergites darker than remaining. Prothorax creamy white with dark brown fasciae, below posterior margin of compound eyes, mesothorax dark brown except the hind margin of scutellum. Tegulae characteristically creamy white. Fore wings are hyaline, have a dark claval pterostigma with light brown suffusion beyond clavus. (Fig. 2A, 7H, 10H, 13H)

Head including eyes 0.8x width of pronotum, in dorsal view obliquely rounded in front, crown length 0.2x width across eyes (Fig. 2A, 10H). Frontoclypeus broad, frontal suture extending onto vertex. Median carina of vertex forked before frons (Fig.



13H). Fastigium extended in lateral view. Frons having equal width throughout, median carina conspicuous with white suffusion, divided at lower level of eyes (Fig. 7H). Pronotum 0.2x longer than wide and 0.3x length of scutellum (Fig. 10H).

**Male genitalia (Fig. 23A-F):** Pygofer 1.2x longer than wide; with mediolateral expansion (Fig. 23C). Segment 10 broader than long with short with latero apical processes; segment elevenshort (Fig. 23D). Paramere divergent apically are 2.2x longer than its width, duck head shaped with serration laterad of apex (Fig. 23F). Aedeagus 4x longer than wide, broad at base and ventrally bent with tube like structure extending from midlength to gonopore, followed by an extended process with acute tip (Fig. 23A, B).

**Measurements (mm):** Male 3.2 long, 0.6 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material examined:** INDIA: Delhi, NCR: 22♂, New Delhi: Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, and 38♂ Pusa Campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Meshram (NPC).

**Remarks:** Externally this species closely resembles *Coronacella sinhalana* but differs in having vertex stramineous and median carinae of frons with white suffusion. Aedeagus with broad base and ventrally bent tube like structure extending from midlength to gonopore, followed extended process with acute tip. Duck-head shaped parameres divergent apicaly. This species is economically very important pest in East Asian countries such as China, Korea and Japan, transmitting Rice Stripe Virus (RSV) (Otuka, 2013). But till date there are no record of this disease in India.

**Genus *Mahmutkashgaria* (Ding and Chen 2002) (New record)**

Type species: *Sulculus* Ding and Chen 2002: 226

**Amended diagnosis:** Dark brown to black, legs and face stramineous; forewing with a prominent black granules and fuscous crescent shaped marking apically. Vertex as wide as long, or slightly wider; carinae distinct, median carina forked beyond base of frons. Head rounded at apex in lateral view. Pronotal lateral carinae obscure, median carina, reaching posterior margin; Mesonotal carinae distinct. Male pygofer with well developed diaphragm, dorsal margin weakly concave; armature round, ventral margin with two long median processes (midventral processes). Aedeagus broad in dorsal and ventral view with well developed phallobase.

**Remarks.** Larger species and externally very similar to *Cemus* Fennah. However the size of habitus, midventral processes of pygofer and subapical lateral process of paramere are unique characters of this genus which distinguish it from other delphacini genera.

***Mahmutkashgaria liboensis* (Chen) [Fig. 2B, 2C, 7I, 10I, 13I, 24A-G, 56A-D] (New record)**

*Sulculus liboensis* Chen, 2002: 226-229, figs 13-23.

Body dull black to grey. Face, genae, clypeus, sternum of thorax including legs stramineous. Hind coxae with oval shaped dark spot laterally. Posterior compartments of vertex paler than anterior compartments. Carinae of frons and lateral margins of the frons prominent brown. Antennae dark brown proximally, shading distally paler to yellow. Mesonotum slightly paler between lateral carinae. Pygofer dark brown with paler margins. (Fig. 2B, 2C, 7I, 10I, 13I).

Head including eyes 1.1x width of pronotum. Head broadly rounded in front, crown length 0.88x shorter than width between eyes (Fig. 2B, 10I). Anteclypeus apically not exceeding facial margin. Frontoclypeus longer than wide. Antennae situated just below the middle margin of eyes in facial view (Fig. 13I). Hind margin of pronotum shorter than width of scutellum. Pronotum length 0.24x as long as wide and 0.28x length of scutellum (Fig. 10I).

**Male Genitalia (Fig. 24A-G).** Pygofer 1.41x longer than wide, midventral processes with common tumid base stalk at base, diverged apically and 0.25x length of pygofer (Fig. 24D). Segment ten and eleven combinedly 1.72x longer than wide (Fig. 24G). Paramere dumbbell shaped flattened 3.55x longer than wide; with subapical laterally projected spine 0.15x length of paramere (Fig. 24E, F). Aedeagus in lateral view, curved at base with blunt apex with gonopore. Dorsal margin of gonopore opening with projection, which asymmetrically diverged from its midlength, the broader projection notched at its end and slender projection with blunt end (Fig. 24A, B, C)..

**Female genitalia (Fig. 56A-D).** Valvulae I in lateral view (Fig. 56A, B) dorsally concave, dorsal and ventral margin smooth without sculptured area. Valvulae II (Fig. 56C, D) in lateral view, dorsal margin concave, distal half with serrations increasing in size gradually, apex acute; ventral margin translucent.

**Measurements (mm).** Male 4.5 long, 0.9 wide across eyes, 0.9 wide across hind margin of pronotum. Female 5.3 long, 0.9 wide across eyes, 0.9 wide across hind margin of pronotum.

**Material Examined.** INDIA: Himachal Pradesh: 1♂, 1♀, Nauni (30.74°N, 76.80°E, 16.iii.2016) at light trap, Ramya (NPC).

**Remarks.** *M. liboensis* (Chen) closely resembles *M. sulcatus* (Ding) but can be distinguished by the pygofer midventral processes with common tumid stock at base, diverged at apex. Aedeagal shaft in lateral view with two dorsal asymmetrical projection, broader projection notched at its end and slender projection with blunt end.

**Genus *Metadelphax* Wagner, 1963**

Type species: *Delphax propinqua* Fieber, 1866: 525

**Amended diagnosis:** Yellowish. Head including eyes subequal to pronotum. Vertex yellowish with distinct Y shaped carina, sinuate anteriorly. Frons longer than broad, narrow at base and widest at middle, median carina forked basally. Clypeus as wide as apex of frons. Rostrum attaining metacoxae. Antennae terete. Thorax tricarinate, lateral carina of pronotum not reaching hind margin. Mesonotum homogeneous. Forewings hyaline with concolorous veins. Pygofer dorsal portion expanded in caudal view with apices inflected (usually medially or ventromedially directed). Diaphragm (armature) well developed, longer than wide. Aedeagus straight to slightly downcurved with apical teeth.

**Remarks:** This genus was restored by Ding (2006). The genus is closely related to *Toya*, can be differentiated by pygofer dorsal portion expanded in caudal view with inflected apices (usually medially or ventromedially directed). Armature of the diaphragm well developed, longer than wide.

***Metadelphax propinqua* (Fieber, 1866) [Fig. 2D, 2E, 2F, 7J, 10J, 13J, 25A-F, 56E-H]**

- Delphax propinqua* Fieber, 1866: 525.
- Delphax hamulata* Kirschbaum, 1868: 38.
- Delphacodes propinqua* (Fieber, 1866) Muir 1917: 335.
- Liburnia terminalis* Van Duzee, 1907: 49.
- Liburnia tuckeri* Van Duzee, 1912a: 506.
- Delphacodes neopropinqua* Muir, 1917: 335.
- Delphacodes subfusca* Muir, 1919: 38.
- Liburnia albicollis* Haupt, 1935 (Motschulsky 1863): 144.
- Calligypona propinqua* (Fieber, 1866) Dlabola 1954: 14.
- Delphacodes shirozui* Ishihara, 1949: 53-54.
- Metadelphax propinqua* (Fieber, 1866) Wagner 1963: 170.
- Toya propinqua* (Fieber, 1866) Fennah 1964: 142.

*Calligypona (Metadelphax) propinqua* (Fieber, 1866) Linnavuori 1964: 341-342.  
*Metadelphax propinqua* (Fieber, 1866) Mitjaev 1971: 66.  
*Toya (Calligypona) propinqua* (Fieber, 1866) Linnavuori 1973: 107.  
*Delphax cataniae* Matsumura, 1910: 35.  
*Toya propinqua neopropinqua* (Muir, 1917) Kuoh *et al.*, 1983: 155.  
*Liburnia marshalli* Scott, 1873: 104.  
*Delphax graminicola* Matsumura, 1910: 17.  
*Metadelphax propinqua* (Fieber, 1866) Ding 2006: 511.

Yellowish. Vertex stramineous. Frons, gena and clypeus fuscous with yellowish tinges, carina white. Antenna stramineous. Thorax black. Pronotum yellowish to light with light carinae. Mesonotum yellowish monochrome, light yellow carina. Tegulae concolours with thorax. Forewings hyaline with concolours veins. Abdomen black with yellowish circular patch at notum base. Brachypterous with reduced wings and exposed genitalia capsule (Fig. 2D, 2E, 2F, 7J, 10J, 13J)

Head including eyes as wide as pronotum. Vertex length 0.2x width across eyes; sinuate in front (Fig. 2D, 10J). Frons longer than wide with median carina forked basally. Clypeus as wide as apex of frons, rostrum attaining hindcoxae. Antenna terete, second segment longer than first (Fig. 13J). Fastigium rounded in lateral view (Fig. 7J). Pronotum 4.7x wider than long; light carina, lateral carina not reaching hind margin. Scutellum 1.2x wider than long; carina not conspicuous (Fig. 10J).

**Male genitalia (Fig. 25A-F):** Pygofer 1.3x longer than wide; diaphragm well developed, longer than wide with symmetrical medioventral processes (Fig. 25D). Segment ten and eleven combinedly 1.7x longer than wide with 0.5x lateroapical processes; segment eleven moderately long (Fig. 25E). Parameres 5x longer than wide; broad, basally bulged outer margin, apically two lobed with notched inner lobe (Fig. 25F). Aedeagus 5.1x longer than wide; straight tubular, ornamented with subapical dorsal and ventral teeth; dorso- apical gonopore (Fig. 25B, 25C).

**Female genitalia (Fig. 56E-H):** Valvulae I in lateral view (Fig. 56E, F), dorsal sculptured area extending from middle portion to apex of blade; ventral margin even with apical 1/4th area sloped. Valvulae II in lateral view (Fig. 56G, H), distal half of dorsal margin with blunt serrations decreasing in size gradually; with small serrations at apex; ventral margin membranous and translucent.

**Measurements (mm).** Male 2.7 long, 0.6 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.3 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 27♂, 35♀, IARI Pusa campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramya and 65 ♂, 86♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh; 6♂ 10♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Mercury vapour light trap Coll. Ramya (NPC); 3♂ 3♀ Forest road, Forest guest house, (30°54'29.27"N, 77°6'8.04"E) 15.vii.2017, Mercury vapour light trap Coll. Ramya (NPC); 8♂, 11♀ Palampur, CSK-HPKV, (32°10'03.0"N, 76°54'65.0"E) 10.viii.2018, Sweep net Coll. Niranjana (NPC); 9♂ 13♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, Coll. Sunil, Niranjana (NPC); 13♂, 18♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018, mercury vapour light trap Akash, Niranjana (NPC). Karnataka; 3♂ 2♀ Bidar (17°55'16"N 77°29' 54" E) 23.viii.2017, Mercury vapour light trap, Shashank, P. R. (NPC). Uttarkhand; 12♂ 15♀ Ranichauri-KVK. (27°17'50"N 85° 98'15"E) 07.x.2017, Sweep net Coll. Akash (NPC). Ladakh; 8♂ 9♀ Leh, (34°09'9.32"N 77°34'37.38" E) 15.viii.2018, Sweep net Coll. Naresh Meshram (NPC). Andhra Pradesh; 5♂ 8♀ Tirupati, (13°62'88"N, 79°41'92" E) 28.ii.2018, Mercury vapour light trap Coll. Rajagopal (NPC).

**Remarks:** *Metadelphax propinqua* similar to *Toya tuberculosa* (Distant) but can be differentiated by the smaller, yellowish to tan habitus; expanded pygofer; diaphragm longer than wide, with symmetrical medioventral processes. Straight tubular aedeagus with subapical spines.

**Genus *Miranus* Chen and Ding, 2001 (New record)**

Type species: *Miranus varians* (Kuoh, 1981): 75

**Amended diagnosis:** Stramineous to ochraceous. Head including compound eyes distinctly narrower than pronotum. Vertex longer medially than broad at base with distinct or feeble Y-shaped carina, broader at base than apex. Frons longer than broad, wider at apex than base, tricarinate, with simple median carinae. Frontoclypeal suture arcuate. White median band running from tip of the clypeus to end of scutellum and continues upto half of forewings forming a characteristic vitta. Thorax tricarinate, lateral carinae of prothorax almost reaching the hind margin. Wings hyaline, with

concolours veins without claval pterostigma. Post-tibial spur lamellate with numerous teeth on hind margin. Aedeagus flattened tubular with acute tip. Parameres symmetrical with tip bifurcated. Segment ten with lateroapical processes extremely long reaching the ventral margin pygofer. Pygofer longer than broad with latero-basal angle expanded.

**Remarks:** *Miranus* is newly recorded from India with single species *Miranus varians* (Kuoh) before the genus was recored from China, Fiji and Vietnam. The species of this can be recognized by the extremely long foliaceous lateroapical processes of the segment ten reaching the ventral margin pygofer.

***Miranus varians* (Kuoh, 1981) [Fig. 2G, 7K, 10K, 13K, 26A-E] (New record)**

*Stenocranus varians* Kuoh, 1981

Taupe to stramineous. Vertex grey with median white band. Frons black with white median carina. Gena and clypeus stramineous with white median carina. Ocelli black. Antenna stramineous. Thorax stramineous taupe with light carina. Pronotum and mesonotum with white median vitta along median carina in continuation with vertex white band. Fore wings hyaline with grey band extend from anal base to apical base. Abdomen stramineous taupe. (Fig. 2G, 7K, 10K, 13K)

Head including eyes 0.8x width of pronotum. Vertex length 0.4x width across eyes, slitley projected in front of eyes, Y shaped carina feeble (Fig. 2G, 10K). Frons medially longer than wide, widest at apex, median carina forked before frons. Clypeus base wider than apex of frons, rostrum reaching meta-coxae. Antennal terete, pedicel longer than scape (Fig. 13K). Fastigium subtriangular in lateral view (Fig. 7K). Pronotum 3x wider than long; light carina, lateral carina distinct and reaching hind margin. Scutellum 1.1x wider than long; light carina (Fig. 10K).

**Male genitalia (Fig. 26A-E):** Pygofer 1.5x longer than wide; ventrally longer, medioventral processes absent, diaphragm narrow without any processes (Fig. 26D); laterobasal angle with humped expansion laterally (Fig. 26B). Segment ten and eleven combinedly 11 1.5x longer than wide, lateroapical processes modified as long foliaceous structure with acute apex, ventrally curved to reach ventral margin pygofer; segment elevenablong (Fig. 26A). Parameres 6x longer than wide; tapering towards with apex diverging and bifurcated apicaly (Fig. 26E). Aedeagus 10x longer than wide; deeply upcurved dorsally, tapering with acute apex; gonopore subapical (Fig. 26A, C).

**Material studied.** INDIA: Arunachal Pradesh; 1♂ West Siang Basar, (27°59'34"N 94°42'15"E) 30.xi.2018, Sweep net Coll. Stuti (NPC).

**Measurements (mm).** Male 4.8 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum. Female 5.2 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum.

**Remarks:** *Miranus varians* is closely related to *Neunkanodes unispinatus* Hou, Yang and Chen but can be differentiated by the habitus colour and characters male genitalia like pygofer with humped expansion of laterobasal angle; extremely long foliaceous lateroapical processes of the segment ten and aedeagus without any process.

**Genus *Neunkanodes* Yang, 1989 (New record)**

Type species: *Neunkanodes formosana* Yang, 1989: 164

**Amended diagnosis:** Stramineous to ochraceous. Head including compound eyes distinctly narrower than pronotum. Vertex longer medially broader basally with distinct or feeble Y-shaped carina. Frons longer than broad, wider at apex than base, tricarinate, with simple median carinae. Frontoclypeal suture arcuate. White median band running from clypeus tip to scutellum end and continues upto half of forewings forming a characteristic vitta. Thorax tricarinate, lateral carinae of prothorax almost reaching the hind margin. Forewings hyaline, with concolours veins without claval pterostigma. Post-tibial spur lamellate with numerous teeth on hind margin. Aedeagus asymmetrical with a process from base extended over the aedeagus. Pygofer with a lamellar process produced at mediolaterally from lateral view; medioventral margin present or absent. Segment ten with a pair of long lateroapical processes. Parameres slender and diverging.

**Remarks:** The genus includes the larger species externally similar to *Sogata* and *Parasogata* species. This genus can be distinguished by the character of male genitalia like pygofer with a lamellar process produced at mediolaterally from lateral view and aedeagus with a process from basal region.

***Neunkanodes unispinatus* Hou, Yang and Chen [Fig. 2H, 7L, 10L, 13L, 27A-H]**

Vermilion to ochraceous. Vertex stramineous with median white band. Frons black with white median carina. Gena and clypeus stramineous. Ocelli black. Antenna stramineous. Thorax stramineous with faded orange intercarinal area, carina light. Pronotum and mesonotum with white median vitta along median carina. Fore wings

hyaline with concolorous veins and white anal margin unite to forms a median band continues with thoracic vitta. Abdomen yellowish orange. (Fig. 2H, 7L, 10L, 13L)

Head including eyes 0.9x width of pronotum, subequal to pronotum. Vertex length 0.4x width across eyes, Y-shaped carina indistinct (Fig. 2H, 10L.). Frons medially longer than wide, widest at apex, median carina forked before frons. Clypeus base slightly wider than apex of frons, rostrum reaching meso-coxae. Antennal terete, pedicel longer than scape (Fig. 13L). Fastigium rounded in lateral view with slightly keeled lateral carina (Fig. 7L). Pronotum 2.9x wider than long; light carina, lateral carina reaching hind margin. Scutellum 1.2x wider than long; light carina (Fig. 10L).

**Male genitalia (Fig. 27A-H):** Pygofer 1.3x longer than wide; ventrally longer, diaphragm well developed without any armature; lamellar process produced mediolaterally; ventral margin of posterior opening curved with long prominent medioventral processes (Fig. 27C, D, F). Segment ten and eleven combinedly 1.5x longer than wide, distinctly long lateroapical processes reaching the middle of pygofer, bifurcated apically; segment elevenshort (Fig. 27H). Parameres 5.6x longer than wide; tapering towards apex with branched spine on basolateral angle (Fig. 27G). Aedeagus 5x longer than wide; deeply decurved with subacute apex, ventrally articulated with small spines, similar basal process arised from base of aedeagus and suspensorium (Fig. 27B).

**Material studied.** Uttarkhand; 5♂ Ranichauri-KVK. (27°17'50"N 85° 98'15"E) 07.x.2017, Sweep net Coll. Akash (NPC).

**Measurements (mm).** Male 4.6 long, 0.7 wide across eyes, 0.8 wide across hind margin of pronotum. Female 5.1 long, 0.7 wide across eyes, 0.8 wide across hind margin of pronotum.

**Remarks:** *Neunkanodes unispinatus* Hou, Yang and Chen externally similar to *N. bispinatus*. Hou, Yang and Chen. However this species can be easily identified by pygofer with lamellar process produced at mediolaterally from lateral view; ventral margin of posterior opening curved with long prominent medioventral processes and aedeagus with a similar basal process arised from base of aedeagus and suspensorium.

### **Genus *Nilaparvata* Distant**

Type species: *Nilaparavata greeni* Distant, 1906: 473, a junior synonym of *Delphax lugens* Stal, 1854.



**Amended diagnosis:** Stramineous to dark brown. Head including compound eyes narrower than pronotum. Vertex longer than broad at base, Y-shaped carina distinct, lateral carina subrectangularly rounding into frons. Frons in middle line longer than wide at widest part. Lateral carina of prothorax not reaching hind margin. Forewing hyaline with distinct claval pterostigma. Rostrum not reaching hind coxa. Post tibial spur lamellate and concave on inner side, hind basitarsomere with one to five spines. Shape of pygofer, aedeagus, paramere varying with species, diaphragm well developed.

**Remarks:** Genus *Nilaparvata* can be distinguished from other genera by the hind basitarsomere with one to five spines. Two species, *N. lugens* (Stal) and *N. bakeri* (Muir) were reported from India.

***Nilaparvata lugens* (Stal) [Fig. 2I, 2J, 8A, 11A, 14A, 28A-G, 56I-L]**

*Delphax lugens* Stal, 1854: 246, original combination.

*Delphax sordescens* De Motschulsky, 1863: 109; synonym by Melichar, 1903: 102, 225; Muir and Giffard (1924)

*Nilaparvata greeni* Distant, 1906: 473; synonym according to Muir (1919: 7, 1922: 350); Muir and Giffard (1924)

*Kalpa aculeata* Distant, 1906: 474; synonym according to Muir (1919: 8, 1922: 350); Muir and Giffard (1924)

*Delphax parysatis* Kirkaldy, 1907: 156; synonym according to Muir and Giffard (1924).

*Delphax ordovix* Kirkaldy, 1907: 152; synonym according to Muir and Giffard (1924).

*Liburnia sordescens* (De Motschulsky, 1863); comb. by Melichar, 1903: 102, 225.

*Dicranotropis anderita* Kirkaldy, 1907: 133; syn. by Muir 1919: 7.

*Delphacodes anderita* (Kirkaldy, 1907); comb. by Muir, 1917: 311.

*Delphacodes parysatis* (Kirkaldy, 1907); comb. by Muir, 1917: 333.

*Delphacodes ordovix* (Kirkaldy, 1907), comb. by Muir 1917: 333.

*Delphacodes sordescens* (De Motschulsky, 1863); comb. by Muir, 1919: 8 (transfer implicit).

*Nilaparvata sordescens* (De Motschulsky, 1863); comb. by Muir, 1922: 350.

Nut-brown to black; vertex and frons taupe with pale carinae. Pronotum pale matching with mesonotum in brown morph and contrast in black morph. Tegulae concolorous with thorax. Fore wings hyaline with dark claval pterostigma. Antenna stramineous, pedicel longer than scape. Legs stramineous. Abdomen black with off-white tip in male (Fig. 2I, 2J, 8A, 11A, 14A).

Head including eyes 0.8x width of pronotum, obliquely rounded in front; vertex length 0.3x width across eyes (Fig. 2I, 11A). Frons nearly rectangular with short clypeus, frontal suture extending onto vertex, median carina of vertex forked before frons (Fig. 14A). Fastigium extended lateral view (Fig. 8A). Pronotum 5.1x wider than long; scutellum 0.6x wider than long (Fig. 11A).

**Male genitalia (Fig. 28A-G):** Pygofer 1.3x longer than wide with well defined ventral margin and oblique dorsal margin (Fig. 28E); posterior margin slightly

produced at middle in lateral view (Fig. 28D). Segment ten and eleven combinedly short with 0.6x long lateroapical processes; segment eleven moderately long (Fig. 28F). Parameres are 3.4x longer than wide; triangular apically (Fig. 28G). Aedeagus 45x longer than wide, broader base progressively sharp and upcurved distally with subapical gonopore (Fig. 28B).

**Female genitalia (Fig. 56I-L):** Valvulae I in lateral view (Fig. 56I, J), dorsal sculptured area extending from basal half to apex of blade; ventral margin evenly translucent. Valvulae II (Fig. K, L), in lateral view, dorsal margin with blunt serrations extending from basal half to apex; with small serrations at apex; ventral margin even with lateral portion.

**Measurements (mm).** Male 3.6 long, 0.7 wide across eyes, 0.7 wide across hind margin of pronotum. Female 4.1 long, 0.8 wide across eyes, 0.7 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 55♂, 85♀, IARI Pusa campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramya (NPC) and 93 ♂, 110♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh; 7♂ 13♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC); 5♂ 6♀ Forest road, Forest guest house, (30°54'29.27"N, 77°6'8.04"E) 15.vii.2017, Mercury vapour light trap Coll. Ramya (NPC); 9♂, 14♀ Palampur, CSK-HPKV, (32°10'03.0"N, 76°54'65.0"E) 10.viii.2018, Sweep net Coll. Niranjana (NPC); 10♂ 13♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, coll. Sunil, Niranjana (NPC); 15♂, 18♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Karnataka; 8♂ 9♀ Bidar (17°55'16"N 77°29' 54" E) 23.viii.2017, Mercury vapour light trap, Shashank, P. R. Uttarkhand; 9♂ 13♀ Ranichauri-KVK. (27°17'50"N 85° 98'15"E) 07.x.2017, Sweep net Coll. Akash (NPC). Ladakh; 7♂ 6♀ Leh, (34°09'9.32"N 77°34'37.38" E) 15.viii.2018, Sweep net Coll. Naresh Meshram (NPC). Andhra Pradesh; 15♂ 19♀ Tirupati, (13°62'88"N, 79°41'92" E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC).

**Remarks:** *Nilaparvata lugens* resembles externally to *N. bakeri* (Muir) can be identified by the 1-5 hind tibial spur and upcurved aedeagus. Also one can be easily

identify this species without dissection by observing triangular apical end of paramere.

### **Genus *Nycheuma* Fennah**

Type species: *Dicranotropis capensis* Muir, 1926: 28

**Amended diagnosis:** Wing dimorphism evident in the genus. Macropterous form stramineous and brachypterous form black. Head including compound eyes as wide as pronotum. Vertex broader than long at base, Y-shaped carina with distinct arm and indistinct median arm. Frons tricarinate, median carina forked just below frons, longer in middle than at base, widest at level of forking of median carina. Thorax tricarinate, lateral carinae of pronotum not reaching hind margin, pronotum shorter than broad at anterior margin between lateral carina. Pygofer short, ventral margin with median and lateral projection at base of caudal margin. Segment 10 with ventrally directed spine-like process, aedeagus compressed.

**Remarks:** The genus similar to *Peregrinus* Kirkaldy in external appearance, but this can be differentiated by the laterally compressed aedeagus and segment 10 with lateroapical processes.

### ***Nycheuma nilotica* Linnavuori [Fig. 2K, 2L, 3A, 8B, 11B, 14B, 29A-F, 56M-P]**

*Nycheuma coctum* Yang, 1989: 98

*Nycheuma coctum* Ding, 2006: 247

Stramineous. Posterolateral basal compartment pallid stramineous. Postclypeus laterad of median carina and anteclypeus fuscous. Rostrum attaining post coxae. Antennal scape cylindrical, longer than broad at apical margin, pedicel longer than scape, brown ring at base of scape and apex of pedicel. Forewing hyaline with claval pterostigma, apical half of forewing with fuscous area on posterior part of claval region. First and second coxae and basal half of post coxae fuscous. Post tibial spur lamellate with teeth on hind margin. Brachypterous with black tegmen wings covering abdomen (Fig. 2K, 2L, 3A, 8B, 11B, 14B).

Head including eyes 1.3x width of pronotum, in dorsal view rounded in front; crown length 0.2x width across eyes (Fig. 2K, 11B). Frons widest at middle, median carinae forked at frons. (Fig. 14B). Fastigium round in lateral view (Fig. 8B). Pronotum 5.1x wider than long; lateral carinae diverging towards hind margin. Scutellum 1.2x wider than long; carina light (Fig. 11B).

**Male genitalia (Fig. 29A-F):** Pygofer 1.1x longer than wide, armature of diaphragm broad U- shaped, ventral margin with paired medioventral process (Fig. 29D, E). Segment ten and eleven combinedly 1.3x longer than wide; lateroapical process small, curved spine like (Fig. 29C). Paramere 5.5x longer than wide, with a mesal stout process at base, a lateral angular projection at midlength, apophysis narrow near apex (Fig. 29F). Aedeagus 5x longer than wide, compressed laterally, gonopore subapical with recurved subapical longer process and a stout lateral process on right side (Fig. 29A, B).

**Female genitalia (Fig. 56M-P).** Valvulae I in lateral view (Fig. 56M, N), dorsal sculptured area extending from basal half to apex of blade; ventral margin even with apical 1/4th area slopped. Valvulae II (Fig. 56O, P) in lateral view, dorsal margin with blunt serrations extending from basal half to apex; with small serrations at apex; ventral margin membranous and translucent.

**Measurements (mm).** Male 3.5 long, 0.70 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.6 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material studied.** INDIA: Uttarkhand: 30♂, 25♀ Hawalbagh (29°64'28"N 79°63'27"E) 25.xii.2018 Sunil (NPC).

**Remarks:** *Nycheuma nilotica* externally similar to *Nycheuma dimorpha* (Matsumura, 1910) but can be distinguished by laterally compressed aedeagus gonopore subapical with recurved subapical longer process and a stout lateral process on right side (two stout process in *Nycheuma dimorpha*).

### **Genus *Opiconsiva* Distant**

Type species: *Opiconsiva fuscovaria* Distant, 1917: 301

**Amended diagnosis:** Brown. Head including eyes narrower than pronotum. Vertex as long as broad. Frons longer than wide, median carina of frons forked at base. Rostrum surpassing mesocoxae not reaching hind margin. Forewing hyaline with distinct claval pterostigma. Pronotum tricarinate, lateral carinae distinct and not reaching hind margin, light fuscous, paler towards hind margin. Mesonotum tricarinate, shiny black, carinae not conspicuous. Aedeagus asymmetrical, tubular with basal fold-like extension.

**Remarks:** The genus *Opiconsiva* closely related to *Shadelphax* Ding in external appearance but can be differentiated by the shiny black mesonotum including tip of scutellum, inconspicuous carinae; aedeagus asymmetrical, tubular with basal fold-like extension.

***Opiconsiva tangira*(Matsumura, 1910) [Fig. 3B, 3C, 8C, 11C, 14C, 30A-G]**

*Delphax tangira* Matsumura 1910: 30

*Toya tangira* (Matsumura 1910); comb. by Nast 1975: 6.

*Corbulo tangira* (Matsumura 1910); comb. by Kwon 1982: 7

*Opiconsiva tangira* (Matsumura 1910); comb. by Asche 1988: 197.

*Chloriona (Sogatella) paludum* (Kirkaldy, 1910); syn by Fennah 1958: 490.

*Opicosiva nigra* Ding and Tian, 1980: 39; syn by Fujinama, 1913: 348.

Black; Vertex stramineous to black. Frons, gena and clypeus black with carinae stramineous. Antenna stramineous. Pronotum tricarinate, stramineous to black. Mesonotum black with off-white tipped scutellum. Tegulae concolourous with body. Fore wings hyaline with claval pterostigma. Abdominal tergum with round yellow marking at base. Brachypterous form is completely black with dark glossy wings (Fig. 3B, 3C, 8C, 11C, 14C).

Head including eyes 0.3x width of pronotum, quadrate in dorsal view, vertex length 0.3x width across eyes; as long as wide (Fig. 3B, 11C). Frons tricarinate with clypeus slightly broader than frons; median suture bifurcated at frons base (Fig. 14C). Fastigium rounded in lateral view (Fig. 8C). Pronotum 5.2x wider than long; scutellum 1.2x wider than long (Fig. 11C).

**Male genitalia (Fig. 30A-G):** Pygofer 1.31x longer than wide; laterodorsal angle extended; Diaphragm well developed with heart shaped median process (Fig. 30D, F). Segment ten and eleven combinedly 1.7x longer than wide with 0.5x long lateroapical processes (Fig. 30E). Parameres 4.3x longer than wide; deeply curved mesal margin, apex bifurcated, inner margin longer than outer margin (Fig. 30G). Aedeagus 3.2x longer than wide; tubular with basal foldings; gonopore apical (Fig. 30A, B).

**Measurements (mm).** Male 2.3 long, 0.4 wide across eyes, 0.4 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 3♂, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh: 6♂, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC).

**Remarks:** This species externally cryptic with other Delphacini species but can be differentiated by the jet black mesonotum and tubular aedeagus with basal foldings. Black brachypterous form species recorded from the study.

**Genus *Parasogata* Zhou, Yang and Chen, 2018 (New record)**

Type species: *Parasogata binaria* Zhou, Yang and Chen, 2018: 77

**Amended diagnosis:** Yellowish white to brown. Vertex, pronotum and mesonotum with an uninterrupted white fascia. Vertex, frons, face, antennae yellowish brown to yellowish white. Pronotum and mesonotum yellowish white. Forewings and hindwings hyaline with prominent veins. Legs yellowish white. Abdomen yellowish orange. Head including eyes narrower than pronotum. Vertex subquadrate, anterior margin arched, submedian carinae uniting at apex. Frons with single median carina, longer medially wider apically. Y-shaped carina feeble. Antennae cylindrical. Pronotum with lateral carinae almost attaining hind margin. Post-tibial spur with 29–32 distinct teeth along hind margin. Pygofer in profile wider ventrally than dorsally, lateral quadrate areas strongly sclerotized, medioventral process absent. Segment 10 collar-shaped, lateroapical angles produced into processes, diaphragm broad. Aedeagus long, tubular, with a row processes at subapically, slightly upward apically. Genital styles simple, widely divergent apically. Suspensorium large.

**Remarks:** This genus is readily recognized by its large size and vertex, pronotum and mesonotum bearing an uninterrupted white fascia. The genus is closely associated with *Sogata* Distant, 1906 but differentiated by the aedeagus being up-curved with a row of subapical processes. Present study record the genus as new record to India, earlier this genus was recorded from China.

***Parasogata sexpartita* sp. nov. 3 [Fig. 3D, 8D, 11D, 14D, 31A-H]**

Yellowish orange to stramineous. Vertex, pronotum and mesonotum with an uninterrupted white fascia. Vertex, frons, face, antennae yellowish brown to pale white. Pronotum and mesonotum dark yellow. Forewings and hindwings yellowish hyaline with prominent black veins. Legs yellowish white. Abdomen yellowish orange (Fig. 3D, 8D, 11D, 14D).

Head including eyes 0.9x width of pronotum. Vertex length 0.3x width across eyes; extended anteriorly (Fig. 3D, 11D). Frons longer than wide, widest at apex, with median carina forked at level of compound eyes. Clypeus as wide as frons basally,

rostrum reaching meso coxae. Antenna terete (Fig. 14D). Fastigium elliptical in lateral view (Fig. 8D). Pronotum 3.2x wider than long; lateral carinae diverging not reaching hind margin. Scutellum 1.1x wider than long; carina not conspicuous (Fig. 11D).

**Male genitalia (Fig. 31A-H):** Pygofer 1.2x longer than wide; diaphragm well developed without any processes (Fig. 31D, F). Segment ten and eleven combinedly, 0.7x longer than wide with two pairs of lateroapical processes; segment eleven long (Fig. 31G). Parameres 6.1x longer than wide; widest subapically, apically acute (Fig. 31H). Aedeagus 8x longer than wide; shallow tubular, dorsobasally concave, subapically ornamented with six radiating spines; apically recurved with dorsal gonopore (Fig. 31A, B, C).

**Measurements (mm).** Male 4.6 long, 0.7 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied.** Holotype ♂ INDIA: Nagaland: Jharnapani, (25°75'58"N, 93°84'39"E), 23.vi.2019, Mercury vapour light trap Coll. Niranjana (NPC). Paratype 3♂ same data as holotype

**Remarks:** *Parasogata sexpartita* sp. nov. can be easily differentiated from its closely related species *P. binari* by the aedeagus subapically ornamented with six radiating spines; apical gonopore.

### **Genus *Peregrinus* Kirkaldy**

Type species: *Peregrinus maidis* (Ashmead, 1890): 323

**Amended diagnosis:** Testaceous. Head including eyes narrower than pronotum. Vertex as long as wide at base, shallowly projected in front. Y-shaped carina distinct. Frons rectangular longer than wide, widest at just above level of ocelli. Median carina forked at frons. Frons, genae, clypeus brown including carina. Rostrum reaching near to hind coxae, not attaining hind coxae. Ocelli present. Antennae terete. Thorax tricarinate, lateral carinae of pronotum diverging, not reaching hind margin. Forewings hyaline with or without markings. Pygofer longer than wide without medioventral process, diaphragm arched medially. Parameres broader. Aedeagus tubular long structure with apical or subapical processes.

**Remarks:** The genus includes the larger species and can be identified by the extremely long aedeagus and absence of the lateroapical process of the segment 10.

***Peregrinus maidis* (Ashmead) [Fig. 3E, 3F, 8E, 11E, 14E, 32A-E, 57A-D]***Delphax maidis* Ashmead 1890: 323*Dicranotropis maidis* (Ashmead, 1890), comb. by Van Duzee (1897: 227, 240), Kirkaldy (1904: 176).*Delphax psylliodes* Lethierry, 1903 (original combination), syn. by Kirkaldy 1907: 132.*Liburnia psyllioides* (Lethierry, 1903) comb. by Melichar (1903: 101); synonym by Kirkaldy (1907: 132).*Pundaluoya simplicia* Distant, 1906 synonym by Kirkaldy (1907: 132); also Muir, 1917e: 147).*Megamelus teapae albinotatus* Crawford, 1914, original combination of*Delphacodes albinotata* (Crawford, 1914) by Muir and Giffard (1924)*Delphacodes albinotata* (Crawford, 1914) synonym by Beamer (1948: 106).

Testaceous to yellow. Vertex stramineous. Frons, gena, clypeus fuscous with light carinae. Antenna stramineous. Thorax off white with fuscous borders, dark band extending from pronotum to mesonotum, on intercarinal areas each. Tegulae concolourous with thorax. Forewings hyaline with distinct claval pterostigma and veins with dark suffusion apically. Abdomen black (Fig. 3E, 3F, 8E, 11E, 14E).

Head including eyes 0.8x width of pronotum. Vertex length 0.5x width across eyes; truncate in front (Fig. 3E, 11E). Frons longer than wide with median carina forked at level of compound eyes. Clypeus as wide as frons basally, rostrum reaching meso coxae. Antenna terete (Fig. 14E). Fastigium elliptical in lateral view (Fig. 8E). Pronotum 4.2x wider than long; evanescent carina, lateral carinae, diverging not reaching hind margin. Scutellum 1.2x wider than long; carina not conspicuous (Fig. 11E).

**Male genitalia (Fig. 32A-E):** Pygofer 0.5x longer than wide; diaphragm well developed without any processes (Fig. 32E). Segment ten and eleven combinedly as long as wide, without lateroapical processes; segment elevenshort (Fig. 32B). Parameres 4x longer than wide; broad, subapically bulged outer margin, apically two lobed with lower lobe having bifurcation (Fig. 32D). Aedeagus 10.5x longer than wide; shallow tubular, ornamented with subapical short and long spine each; apical gonopore (Fig. 32A, C).

**Female genitalia (Fig. 57A-D).** Valvulae I in lateral view (Fig. 57A, B), dorsal sculptured area extending from basal half to apex of blade; ventral margin translucent and even. Valvulae II (Fig. 57C, D), in lateral view, dorsal margin with serrations extending from basal half to apex; with small serrations at apex; ventral margin membranous and translucent.



**Measurements (mm).** Male 4.2 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum. Female 4.5 long, 0.8 wide across eyes, 0.7 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 7♂, 5♀, IARI Pusa campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramya and 6 ♂, 6♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh: 9♂ 13♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, coll. Sunil, Niranjana (NPC); 8♂, 5♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC).

**Remarks:** *Peregrinus maidis* externally similar to *Peregrinus iocasta* (Fennah, 1958) but can be differentiated by the testaceous habitus; fuscous bands on intercarinal areas of thorax, parameres broad; subapically bulged outer margin; apically two lobed with lower lobe having bifurcation. Aedeagus shallow tubular, ornamented with subapical short and long spine each.

### **Genus *Perkinsiella* Kirkaldy**

Type species: *Perkinsiella saccharicida* Kirkaldy, 1903: 179

**Amended diagnosis:** Large planthoppers. Black. Head including eyes as wide as or wider than pronotum. Vertex stramineous, as long as broad at base. Frons rectangular, tricarinate, intercarinal areas patterned with light spots. Intercarinal areas of prothorax and mesothorax creamy white, lateral areas of pro and mesonotum brown to black. Tegulae stramineous. Antennal segments fuscous, scape triangular, pedicel longer than scape. Forewings dark grey to black, veins concolorous and granulose, with or without claval pterostigma, white base of anal margin unite to form a white median line. Pygofer with well developed diaphragm having sclerotised structure medioventrally. Aedeagus tubular. Shape of the aedeagus, paramere and ornamentation at diaphragm variable across species. During this study two species of this genus have been recorded.

**Remarks:** The genus includes the larger dark species. The triangular scape of antenna differentiate it from other genera of delphacidae.

### Key to the species of *Perkinsiella* Kirkaldy of Karnataka

1. Forewings with claval pterostigma (Fig. 3G, 3H); broad based parameres, diverging apically (Fig. 33E), processes of segment 10 extremely long and arises at apex of laterad (Fig. 33C); aedeagus flattened, ventrally curved with pair of symmetrical subapical processes; gonopore apical (Fig. 33A, 33B).....*Perkinsiella insignis* (Distant)
- Forewings without claval pterostigma (Fig. 3I, 3J); parameres broad with three apical lobes (Fig. 34F); processes of segment 10 short and arises at base of laterad (Fig. 34C); aedeagus flattened with a pair of spine sub-dorsally (Fig. 34A, 34B)..... *Perkinsiella sinensis* Kirkaldy

### ***Perkinsiella insignis* (Distant) [Fig. 3G, 3H, 8F, 11F, 14F, 33A-E, 57E-H]**

*Pundaluoya insignis* Distant 1912: 190

*Perkinsiella taiwana* Yang, 1989 (Taiwan); syn. of *P. bigemina* Ding, 1980

Dark brown to black. Vertex stramineous, with basal compartment creamy white, rest fuscous. Frons fuscous with intercarinal white spots; median carinae forked below frons. Compound eyes large with bright ventrobasal band. Clypeus, gena fuscous with stramineous bands. Thorax black with intercarinal areas stramineous. Pronotum tricarinate with stramineous intercarinal areas with black spot each. Mesonotum black with bright stramineous intercarinal area continuous to scutellum tip. Forewings black hyaline, white base of anal margin unite to form a white median line till claval pterostigma. Abdomen black (Fig. 3G, 3H, 8F, 11F, 14F).

Head including eyes same width of pronotum; nearly convex in front. Vertex length 0.2x width across eyes; not produced beyond compound eyes (Fig. 3G, 11F). Frons rectangular; median carina forked before frons. Antenna black, basal segment triangular (Fig. 14F). Fastigium rounded in lateral view (Fig. 8F). Pronotum 4.1x wider than long; tricarinate, lateral carinae short not reaching to hind margin. Scutellum 1.1x wider than long; prominent median carina, lateral carinae evanescent (Fig. 11F).

**Male genitalia (Fig. 33A-E):** Pygofer as long as wide, with thin diaphragm without median process (Fig. 33D). Segment ten and eleven combinedly, 0.5x longer than wide along with 1.8x lateroapical processes; segment eleven moderately long (Fig. 33C). Parameres 2.8x longer than wide; broad at base tapering apically; diverging apically (Fig. 33E). Aedeagus 10x longer than wide; flattened, ventrally curved with pair of symmetrical subapical processes; gonopore apical (Fig. 33A, B).

**Female genitalia (Fig. 57E-H):** Valvulae I in lateral view (Fig. 57E, F), dorsal sculptured area extending from basal half to apex of blade; even ventral margin.

Valvulae II (Fig. 57G, H), in lateral view, dorsal margin with serrations extending from basal half to apex; with small serrations at apex; ventral margin even with medio-basal translucent membrane.

**Measurements (mm).** Male 4.3 long, 0.9 wide across eyes, 0.6 wide across hind margin of pronotum. Female 4.5 long, 1.0 wide across eyes, 0.8 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 8♂, 10♀, IARI Pusa campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramya and 5 ♂, 8♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh: 6♂ 9♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC); 3♂ 3♀, Solan, Forest road, Forest guest house, (30°54'29.27"N, 77°6'8.04"E) 15.vii.2017, Mercury vapour light trap Coll. Ramya (NPC); 4♂ 6♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, coll. Sunil, Niranjana (NPC); 3♂, 7♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Karnataka; 9♂ 12♀ Bidar (17°55'16"N 77°29' 54" E) 23.viii.2017, Mercury vapour light trap, Shashank, P. R.

**Remarks:** *Perkinsiella insignis* similar in appearance to *Perkinsiella* species, it can be differentiated by the black habitus, claval pterostigma of wings, pygofer without medio-ventral processes. Aedeagus flattened, ventrally curved with pair of symmetrical subapical processes.

***Perkinsiella sinensis* Kirkaldy [Fig. 3I, 3J, 8G, 11G, 14G, 34A-E, 57I-L]**

*Perkinsiella taiwana* Yang, 1989 (Taiwan); synonym of *P. bigemina* Ding, 1980: 181

Larger species. Testaceous to brown. Vertex stramineous. Frons testaceous basal half with intercarinal white spots; distal half white concolourous with gena. Clypeus testaceous with rostrum white. Antenna stramineous with black pattern. Thorax dark brown with intercarinal areas stramineous. Pronotum tricarinate with stramineous intercarinal areas having spot on each. Mesonotum dark brown with bright stramineous intercarinal area continuous to scutellum tip. Forewings hyaline with brown band extending from median sector vein to apical margin, without claval pterostigma, white base of anal margin unite to form a white median line. Abdomen white with black mosaic (Fig. Fig. 3I, 3J, 8G, 11G, 14G).

Head including eyes same width of pronotum; nearly convex in front. Vertex length 0.2x width across eyes; truncate beyond compound eyes (Fig. 3I, 11G). Frons rectangular; median carina forked far below frons. Clypeus tricarinate, rostrum reaching hind coxae. Antenna triangular (Fig. 14G). Fastigium rounded in lateral view (Fig. 8G). Pronotum 5.1x wider than long; tricarinate, lateral carinae diverging not reaching hind margin. Scutellum 1.1x wider than long; prominent median carina, lateral carinae evanescent (Fig. 14G).

**Male genitalia (Fig. 34A-F):** Pygofer as long as wide; ventral margin with a pair of median processes (Fig. 34D). Segment ten and eleven combinedly 3x longer than wide along with 0.8x processes arises basally on laterad margin; segment eleven long (Fig. 34C). Parameres 2.5x longer than wide; broad at base tapering apically; diverging apically (Fig. 34F). Aedeagus 4x longer than wide; flattened, aedeagus flattened with a pair of spine sub-dorsally; dorso-apical gonopore (Fig. 34A, B).

**Female genitalia (Fig. 57I-L).** Valvulae I in lateral view (Fig. 57I, J), dorsal sculptured area extending from basal half to apex of blade; even ventral margin. Valvulae II (Fig. 57K, L), in lateral view, dorsal margin with serrations increasing in size, extending from basal half to apex; with minute serrations at apex; ventral margin even with medio-basal translucent membrane.

**Measurements (mm).** Male 4.8 long, 0.9 wide across eyes, 0.7 wide across hind margin of pronotum. Female 5.0 long, 1.1 wide across eyes, 0.9 wide across hind margin of pronotum.

**Material studied.** INDIA: Karnataka; 1♂, 1♀ Bidar (17°55'16"N 77°29' 54" E) 23.viii.2017, Mercury vapour light trap, Shashank, P. R. (NPC)

**Remarks:** *P. sinensis* is a larger species than *P. insignis*. It can be easily recognized by the testaceous colour of habitus, forewings with brown band, pygofer with medio-ventral processes and broad aedeagus with a pair of dorsal sub-apical spines.

**Genus *Phyllodinus* Van Duzee (New record)**

Type species: *Phyllodinus nervatus* Van Duzee, 1897: 240

**Amended diagnosis:** Black. Head including eyes subequal width of pronotum. Vertex less produced in front, as long as wide at base, Y shaped carina indistinct. Frons speckled with white granules. Gena and clypeus black without any markings. Thorax black with light carina. Antenna terete, pedicel much longer than scape.

Femur and tibia of front and middle leg enlarged, hind leg long without any expansion. Pygofer longer than wide. Segment 10 round with or without lateroapical processes. segment eleven moderately long. Adeagus narrow tubular. Parameres shape variable across species of this genus.

**Remarks:** The genus is characterized by the enlarged femur and tibia of front and middle legs. This genus externally closely resembles genus *Cemus* Fennah, but varies based on the enlarged portion of leg. Species of this genus usually brachypterous forms.

***Phyllodinus* sp. nov. 4 [Fig. 3K, 3L, 8H, 11H, 14H, 35A-H, 57M-P]**

Black. Vertex, frons, gena and clypeus concolorous with thorax. Frons black, speckled with off white granules on intercarinal areas, postgena characteristically white. Thorax black with light carina. Pronotum black with stramineous suffusion in middle, dorsolateral extension of pronotum white. Mesonotum black with light carina. Tegulae off white. Forewings hyaline, with closely spaced black granules. Abdomen black with off white anal area (Fig. 3K, 3L, 8H, 11H, 14H).

Head including eyes 0.9x width of pronotum, slightly narrower than pronotum. Vertex length 0.3x width across eyes, Y- shaped carina indistinct (Fig. 3K, 11H). Frons slightly longer than wide, narrowest at base between compound eyes, median carina forked after frons. Clypeus base wider than apex of frons, rostrum reaching meso-coxae. Antennal terete, pedicel much longer than scape (Fig. 14H). Front and middle legs, enlarged with femur and tibia, hind legs long without enlarged femur and tibia. Fastigium rounded in lateral view (Fig. 8H). Pronotum 3.8x wider than long; light carina. Scutellum 1.8x wider than long; light carina (Fig. 11H).

**Male genitalia (Fig. 35A-H)**

Pygofer 1.2x longer than wide; pygofer broad without any lateral expansion, medioventral processes sharp spine like (Fig. 35H), diaphragm thick with v shaped excavation medioventrally (Fig. 35F). Segment ten and eleven combinedly 1.1x longer than wide, lateroapical processes absent; segment eleven moderately long (Fig. 35C). Parameres 5.4x longer than wide; long, subapically deep curved, outer margin with laterally turned apex having stout process directed dorsal (Fig. 35G). Aedeagus 25x longer than wide; decurved with apical gonopore, decurved process of same length with acute apex (Fig. 35A, 35B).

**Female genitalia (Fig. 57M-P).** Valvulae I in lateral view (Fig. 57M, N), dorsal sculptured area extending from basal half to apex of blade; ventral margin translucent. Valvulae II (Fig. 57O, P), in lateral view, distal 1/3<sup>th</sup> dorsal margin with serrations increasing in size gradually; with minute serrations at apex; ventral margin even with medio-basal translucent membrane.

**Measurements (mm).** Male 2.6 long, 0.8 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.2 long, 0.9 wide across eyes, 0.7 wide across hind margin of pronotum.

**Material studied.** INDIA: Uttarkhand: 1♂, 1♀Hawalbagh (29°64'28"N 79°63'27"E) 25.xii.2018 Sunil (NPC).

**Remarks:** *Phyllodinus* sp. nov. is closely related to *P. nervatus* Van Duzee based on external appearance. However this species can be distinguished by pygofer with medioventral sharp spine like processes and aedeagus decurved with apical gonopore, decurved process of same length with acute apex.

### **Genus *Sardia* Melichar**

Type species: *Sardia rostrata* Melichar, 1903: 96

**Amended diagnosis:** Chocolate brown. Head distinctly narrower than pronotum. Vertex narrow, elongated, produced anteriorly between compound eyes. Frons tricarinate, constricted at basal one third or at level of ocelli, broadened towards postclypeous, median carina forked at base of frons. Post-tibial spur with teeth at hind margin. Forewing chocolate brown with well developed claval pterostigma, darker apically. Pygofer long, ventral margin longer than dorsal, dorsal margin of diaphragm with a bilobed process directed caudally.

**Remarks:** This genus closely associated with *Perkinsiella* Kirkaldy and it can be differentiated by long dark, wedge shaped species. The long, apically pointed vertex, extending beyond compound eyes and raised median carina.

### ***Sardia rostrata* Melichar 1903 [Fig. 4A, 4B, 8I, 11I, 14I, 36A-F, 58A-D]**

*Sardia rostrata* Melichar 1903: 96

Black to stramineous; vertex black with pale yellow spots. Frons, clypeus and gena black patterned with stramineous. Pronotum and mesonotum black with stramineous spots; scutellum end margined with off-white; pronotum with strong carina and

mesonotum tricarinate. Tegulae concolourous with body. Fore wings basally hyaline and dark apically (Fig. 4A, 4B, 8I, 11I, 14I).

Head including eyes 0.8x width of pronotum. Vertex length 0.6x width across eyes; elongated with triangular apex formed by strongly keeled Y shaped carinae (Fig. 4A, 11I). Frons elongated basally with broader distal half. Median carina forked at apex (Fig. 14I). Fastigium subtriangular in lateral view (Fig. 8I). Pronotum 3.1x wider than long; scutellum 1.1x wider than long (Fig. 11I).

**Male genitalia (Fig. 36A-F):** Pygofer 1.1x longer than wide with well defined ventral margin having stout median process (Fig. 36B, 36C). Segment ten and eleven combinedly 1.5x longer wide with 0.8x lateroapical processes; segment eleven moderately long (Fig. 36E). Parameres 2.5x longer than wide; sickle shaped with a tooth (Fig. 36F). Aedeagus 3.5x longer than wide; tubular with slitely curved apex; gonopore apical (Fig. 36A, 36D).

**Female genitalia (Fig. 58A-D).** Valvulae I in lateral view (Fig. 58A, B), dorsal sculptured area extending from base to apex of blade; ventral margin even without sculpture. Valvulae II (Fig. 58C, D), in lateral view, dorsal margin with serrations increasing in size, extending from basal half to apex; with minute serrations at apex; ventral margin even with medio-basal translucent membrane.

**Measurements (mm):** Male 2.6 long, 0.2 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.0 long, 0.3 wide across eyes, 0.7 wide across hind margin of pronotum.

**Material studied.** INDIA: Andra Pradesh; 5♂ 2♀ Tirupati, (13°62'88"N, 79°41'92"E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC). Arunachal Pradesh 5♂ 8♀ CAU Pasighat, (28°07'85"N, 95°32'36"E) 28.ii.2018 Mercury vapour light trap coll. Stuti (NPC)

**Remarks:** *Sardia rostrata* can be easily distinguished from other closely related species by black narrow species with apically pointed vertex, curved lateroapical process of segment 10, sickle shaped parameres and the broad tubular aedeagus with 1-3 dorsoapical spines.

**Genus *Shadelphax* Ding, 2006 (New record)**

Type species: *Shadelphax eforiae* (Dlabola, 1961): 314

**Amended diagnosis:** Black. Head including eyes subequal to pronotum. Vertex in middle line as long as wide at base or slightly shorter, rounded anteriorly. Frons longer than broad, widest at middle, median carina forked at base of frons. Clypeus slightly wider at base than frons apex. Rostrum surpassing metacoxae. Antennae terete, reaching postclypeus. Thorax tricarinate. Pronotum creamy white with lateral carinae diverging caudally, not reaching hind margin. Mesonotum as long as vertex and pronotum together, black outercarinal areas on either side. Forewings hyaline in macropterous and tegmen like in brachypterous, reaching 4–6th abdominal segment. Pygofer subequally longer than broad, with well developed diaphragm. Aedeagus tubular, narrowing to apex, distal part slightly twisted and curved ventrally, dorsal margin with several teeth, left side with many teeth at central to basal areas; gonopore subapical on lateral margin.

**Remarks:** This genus is closely associated *Opiconsiva* Distant, but can be differentiated by the pygofer with armature of the diaphragm convex, aedeagus tubular with teeth on dorsal margin, parameres without bifurcation. This genus is newly recorded from India, earlier it was recorded from China, Iran and Mongolia.

***Shadelphax eforiae* (Dlabola) [Fig. 4C, 8J, 11J, 14J, 37A-E] (New record)**

*Calligypona eforiae* Dlabola, 1961:314

*Calligypona kirghisica* Dubovsky, 1966:71

*Delphacodes eforiae* Mitjaev, 1971:65

*Javesella eforiae* Nast, 1972a:67

*Unkanodes eforiae* Dlabola, 1974:34

*Herbalima eforiae* Emeljanov, 1977:117

*Herbalima (Pherancyra) eforiae* Emeljanov, 1982a:73

*Shadelphax eforiae* Ding, 2006a:625

Black to stramineous. Head including eyes subequal to pronotum. Vertex stramineous with Y shaped carina, shallowly projected in front. Frons, gena and clypeus black with stramineous carina, median carina forked before frons. Rostrum surpassing mesocoxae. Antennal scape black with stramineous pedicel. Pronotum black with stramineous mosaic in middle, evanescent tricarina. Mesonotum black with stramineous scutellum tip. Forewings hyaline with concolours veins. (Fig. 4C, 8J, 11J, 14J)

Head including eyes 0.9x width of pronotum; truncate in front. Vertex length 0.3x width across eyes (Fig. 4C, 11J). Frons longer than wide, widest at middle. Antenna terete (Fig. 14J). Fastigium rounded in lateral view (Fig. 8J). Pronotum 4.5x wider



than long; evanescent carina, lateral carinae not reaching hind margin. Scutellum 1.2x wider than long; carina faint (Fig. 11J).

**Male genitalia (Fig. 37A-E):** Pygofer 0.7x longer than wide; diaphragm well developed without any processes (Fig. 37C). Segment ten and eleven combinedly 2.1x longer than wide along with 0.2x lateroapical processes; segment eleven moderately long (Fig. 37E). Parameres 3.4x longer than wide; short, divergent apically with slightly curved inner margin, (Fig. 37D). Aedeagus 8.5x longer than wide; flattened, ornamented with dorsolateral spines from medially to apex; left side with many small teeth at central to basal areas; latero-subapical gonopore (Fig. 37A, 37B).

**Measurements (mm).** Male 3.7 long, 0.3 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material studied.** INDIA: Ladakh; 8♂, Leh, (34°09'9.32"N 77°34'37.38" E) 15.viii.2018, Sweep net Coll. Naresh Meshram (NPC).

**Remarks:** *Shadelphax eforiae* is new record for India recorded from Leh district of Ladakh, earlier recorded from China, Iran, Mongolia. It is similar to *Opiconsiva tangira* (Matsumura), can be differentiated, diverging parameres, pygofer without median process; aedeagus with dorsolateral spines from medially to apex and left side with many small teeth at central to basal areas.

### **Genus *Sogata* Distant, 1906**

Type species: *Sogata dohertyi* Distant, 1906: 471

**Amended diagnosis:** Yellowish tan. Comparatively larger species. Head including eyes narrower than pronotum. Vertex fairly oblong, converging anteriorly. Frons in middle line longer than wide at widest part, widest at apex. Frons and clypeus black with median carina with white suffusion. Clypeus base as wide as apex of frons. Antennae cylindrical, second segment longer than first. Ocelli present. Thorax with white median band running from pronotum to end of scutellum. Pronotum with lateral carinae straight, diverging to hind margin almost attaining hind margin. Fore wings hyaline with thickened veins apically. Pygofer well developed with diaphragm broadly lobed, protruding cephalad, connected end of Aedeagus. Aedeagus tubular, apical third sharply turned down. segment 10 collar like, with lateroapical spinose process and segment eleven long. Parameres long and variously modified.

**Remarks:** This genus closely associated with *Chloriona* Fieber in external appearance but can distinguished by the black intercarinal area of frons, aedeagus ventrally curved without any teeth.

***Sogata* sp. nov. 5 [Fig. 4D, 4E, 8K, 11K, 14K, 38A-E, 58E-H]**

Ochraceous to stramineous. Vertex stramineous. Frons, gena and clypeus black with median carina with white suffusion, postgena concolours with body. Thorax stramineous with white narrow vitta running from pronotum to end of scutellum. Pronotum and mesonotum stramineous light carina. Tegulae stramineous. Forewings hyaline, apical half with dark thickened veins. Abdomen off white with black basal band. (Fig. 4D, 4E, 8K, 11K, 14K)

Head including eyes 0.9x width of pronotum, subequal to pronotum. Vertex length 0.3x width across eyes, Y-shaped carina feeble (Fig. 4D, 11K). Frons medially longer than wide, median carina forked before frons. Clypeus base as wide as apex of frons, rostrum reaching meta-coxae. Antennal cylindrical, pedicel longer than scape (Fig. 14K). Legs with black streaks. Fastigium rounded in lateral view (Fig. 8K). Pronotum 3.6x wider than long; light carina. Scutellum 1.2x wider than long; light carina (Fig. 11K).

**Male genitalia (Fig. 38A-E):** Pygofer 1.1x longer than wide; pygofer broad without any lateral expansion, medioventral processes absent, diaphragm thick uniform throughout and united with armature (Fig. 38E). Segment ten and eleven combinedly 2.5x longer than wide, deeply curved ventral margin gives 0.2x spinose processes; segment eleven moderately long (Fig. 38D). Parameres 3.5x longer than wide; converging apically with sinuate inner margin and humped inner basal angle (Fig. 38C). Aedeagus 5x longer than wide; without any processes or teeth, simple, basally broad with apically sharp decurved apex; basal gonopore (38A, B).

**Female genitalia (Fig. 58E-H).** Valvulae I in lateral view (Fig. 58E, F), dorsal sculptured area extending from distal 1/4<sup>th</sup> to apex of blade; ventral margin even with median ridges. Valvulae II (Fig. 58G, H), in lateral view, dorsal margin with serrations decreasing in size, extending from distal 1/3<sup>rd</sup> to apex; with acute apex; ventral margin even.

**Measurements (mm).** Male 4.1 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum. Female 4.8 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material studied.** INDIA: 5♂, 4♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC).

**Remarks:** *Sogata* sp. nov. is closely related to *Sogata nigrifrons* (Muir) based on external appearance. However this species can be distinguished by deeply curved ventral margin of Segment 10, aedeagus without processes, basally broad with apically sharp decurved apex.

### **Genus *Sogatella* Fennah**

Type species: *Sogatella furcifera* (Horváth, 1899): 372

**Amended diagnosis:** Stramineous to black. Fairly small slender planthoppers. Head including compound eyes narrower than pronotum. Vertex longer than broad at base. Lateral carina of pronotum not reaching hind margin, intercarinal areas of mesothorax including scutellum pale. Claval pterostigma present or absent. Rostrum not reaching meta coxae. Spur foliaceous with folded toothed hind margin. Pygofer with a U-shaped trough on mediodorsal margin; ventral margin longer than dorsal. Segment ten and eleven combinedly short with pair of spine-like lateroapical processes; Segment eleven moderately long. Aedeagus twisted with two rows of teeth.

**Remarks:** The genus can be separated from other delphacini genera by a median stramineous vitta running from vertex to tip of scutellum and twisted aedeagus with two parallel rows of spines on ventral margin. Coloration of vertex, frons, clypeus, thorax and claval pterostigma vary with respect to species. During the study 3 species were recorded from this genus.

### **Key to the species of *Sogatella* Fennah**

1. Forewing hyaline with distinct claval pterostigma (Fig. 4F, 4G); Frons, genae and clypeus black (Fig. 14L); Pygofer with a stout medioventral process (Fig. 39D) ..... *Sogatella furcifera* (Horváth)
- Claval pterostigma absent (Fig. 4H, I, J, K); pygofer without distinct medioventral process (40E, 41E) ..... 2
2. Frons, genae and clypeus stramineous (Fig. 15A); forewing with a light brown suffusion at the anal margin (Fig. 9A) ..... *Sogatella kolophon* (Kirkaldy)
- Frons and clypeus pallid stramineous with dark fuscous genae (Fig. 15B); forewing hyaline without any markings (Fig. 9B) ..... *Sogatella vibix* (Haupt)

***Sogatella furcifera* (Horvath) [Fig. 4F, 4G, 8L, 11L, 14L, 39A-F, 58I-L]***Delphax furcifera* Horvath 1899: 372*Sogata distincta* Distant 1912: 191*Sogata pallescens* Distant 1912: 192*Sogata kyusyuensis* Matsumura and Ishihara 1945: 65*Sogata tandojamensis* Qadri and Mirza 1960 : 115

Creamy white to black; vertex white with black intercarinal areas. Frons straminous to black concolours with gena and clypeus; white conspicuous median and lateral carinae; median carina forked at base of frons. Pronotum creamy white concoloured with tegula. Scutellum black with white median vitta. Fore wings hyaline with dark claval pterostigma and dark curved marking from median vein to anal margin. Antenna stramineous, terete, pedicel longer than scape. Legs stramineous. Abdomen with black notum and white sternum (Fig. 4F, 4G, 8L, 11L, 14L).

Head including eyes 0.6x width of pronotum, in dorsal view slightly projected with obliquely rounded front, vertex length 0.3x width across eyes ((Fig. 4F, 11L). Frons nearly rectangular with short clypeus, frontal suture extending onto vertex. Median carina of vertex forked before frons, (Fig. 14L). Fastigium extended lateral view (Fig. 8L). Pronotum 4.3x wider than long; scutellum 1.2x wider than long (Fig. 11L).

**Male genitalia (Fig. 39A-F):** Pygofer 1.2x longer than wide with well defined ventral margin having stout process and well developed diaphragm; dorsal margin sinuate with median broad U-shaped structure (Fig. 39D, E). Segment ten and eleven combinedly short with 0.2x long lateroapical processes; segment eleven moderately long (Fig. 39C). Parameres are 2.2x longer than wide; bifid apically (Fig. 39F). Aedeagus 8.7x longer than wide; moderately long, twisted with two rows of teeth on both sides; ventro-apical gonopore (Fig. 39A, B).

**Female genitalia (Fig. 58I-L).** Valvulae I in lateral view (Fig. 58I, J), dorsal sculptured area extending from basal 1/3<sup>rd</sup> to apex of blade; ventral margin even without sculpture. Valvulae II (Fig. 58K, L), in lateral view, dorsal margin with median ridge and serrations increasing in size, extending from base of ridge to apex of blade; with minute serrations at apex; ventral margin even with medio-basal translucent membrane.

**Measurements (mm).** Male 3.4 long, 0.6 wide across eyes, 0.6 wide across hind margin of pronotum. Female 4.3 long, 0.7 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 21♂, 30♀, IARI Pusa campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramya and 15♂, 16♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh; 15♂ 18♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC); 3♂ 3♀ Forest road, Forest guest house, (30°54'29.27"N, 77°6'8.04"E) 15.vii.2017, Mercury vapour light trap Coll. Ramya (NPC); 8♂, 11♀ Palampur, CSK-HPKV, (32°10'03.0"N, 76°54'65.0"E) 10.viii.2018, Sweep net Coll. Niranjana (NPC); 15♂ 20♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, coll. Sunil, Niranjana (NPC); 14♂, 19♀, Berthin, Bilaspur, Himachal Pradesh (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Karnataka; 3♂ 2♀ Bidar (17°55'16"N 77°29' 54" E) 23.viii.2017, Mercury vapour light trap, Shashank (NPC).

**Remarks:** This species can be easily distinguished by the other *Sogatella* species by claval pterostigma of wings, twisted aedeagus with two rows of spines and ventral margin of the pygofer with a stout median process.

***Sogatella kolophon* (Kirkaldy) [Fig. 4H, 4I, 9A, 12A, 15A, 40A-F, 58M-P]**

*Delphax kolophon* Kirkaldy 1907 : 154  
*Delphacodes elegantissima* Ishihara 1952: 45  
*Opiconsiva insularis* Distant 1917: 303  
*Opiconsiva balteata* Distant 1917: 302  
*Opiconsiva derelicta* Distant 1917: 303  
*Sogatella balteata* Fennah 1963 : 64  
*Sogatella chenheia* Kuoh 1977: 440  
*Sogatella derelicta* Fennah 1963 : 62  
*Sogatella elegantissima* Fennah 1963 : 76  
*Sogatella kolophon atlantica* Fennah 1963 : 58  
*Sogatella kolophon insularis* Fennah 1963 : 59  
*Sogatella kolophon meridiana* Fennah 1963 : 59  
*Sogata meridiana* Beamer 1952: 111  
*Sogatella nebris* Fennah 1963 : 67

Stramineous to grey; vertex stramineous with light carinae. Frons tawny concolours with gena and clypeus; pale median and lateral carinae; median carina forked at base of frons. Pronotum creamy white concolours with tegula. Scutellum black with off-white to stramineous median vitta. Fore wings hyaline with brown suffusion at the apical margin. Antenna stramineous, terete, pedicel longer than scape. Legs stramineous. Abdomen black with a light notal stripe basally. Male and female cryptic in colour (Fig. 4H, 4I, 9A, 12A, 15A)

Head including eyes 0.8x width of pronotum, obliquely rounded front in dorsal view, vertex length 0.3x width across eyes (Fig. 4H, 12A). Frons nearly rectangular with short clypeus, frontal suture extending onto vertex. Median carina of vertex forked before frons, (Fig. 15A). Fastigium not extended in lateral view (Fig. 9A). Pronotum 3.8x wider than long; scutellum 1.1x wider than long (Fig. 12A).

**Male genitalia (Fig. 40A-F):** Pygofer 1.1x longer than wide with well defined ventral margin with stout process, diaphragm distinct; dorsal margin with median prominent U-shaped structure having produced ends (Fig. 40D, E). Segment ten and eleven combinedly, short with 0.5x long lateroapical processes; segment eleven moderately long (Fig. 40C). Parameres 2.1x longer than wide; bifid apically (Fig. 40F). Aedeagus 7.8x longer than its width; moderately long, twisted with two rows of teeth on both sides; latero-apical gonopore (Fig. 40A, B).

**Female genitalia (Fig. 58M-P).** Valvulae I in lateral view (Fig. 58M, N), dorsal sculptured area extending from basal half to apex of blade; ventral margin even without sculpture. Valvulae II (Fig. 58O, P) in lateral view, dorsal margin with serrations increasing in size, extending from basal half to apex; with minute serrations at apex; ventral margin even with medio-basal translucent membrane.

**Measurements (mm).** Male 3.3 long, 0.5 wide across eyes, 0.4 wide across hind margin of pronotum. Female 3.6 long, 0.6 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied:** INDIA: Delhi, NCR: 19♂: New Delhi: Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, and Pusa Campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh; 8♂ 13♀ Kalpa, Kinnaur (31°32'11.33"N 78°15'33.98"E) 15.viii.2017, Mercury vapour light trap coll. Ramya (NPC). Bilaspur; 16♂ 25♀ Berthin, (31°21'35.18"N 76°39'52.38"E), 08.x.2018, Sweep net Coll. Akash, (NPC); 8♂ 15♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC); 3♂ 11♀ Palampur, CSK-HPKV, (32°10'03.0"N, 76°54'65.0"E) 10.viii.2018, Sweep net Coll. Niranjana (NPC); 3♂ 8♀ Una, Rampur (31°44'92"N 77° 62'92"E) 22.ix.2018, Light trap, coll. Sunil, Niranjana (NPC).

**Remarks:** This species can be distinguished from *S. vibix* and *S. furcifera* by the stramineous face, dark suffusion of wings, absence of claval pterostigma and twisted aedeagus with two parallel rows and lateral gonopore at apex.

***Sogatella vibix* (Haupt) [Fig. 4J, 4K, 9B, 12B, 15B, 41A-F, 59A-D]**

*Delphacodes dogensis* Ishihara 1952: 47  
*Delphacodes longifurcifera* Eskai and Ishihara 1943: 41  
*Delphacodes panicola* Ishihara 1949: 51  
*Liburnia matsumurana* Metcalf 1943: 364  
*Liburnia vibix* Haupt 1927: 13  
*Sogatella catoptron* Fennah 1963: 54  
*Sogatella diachenhea* Kuoh 1977: 441  
*Sogatella longifurcifera* Fennah 1963: 56  
*Sogatella matsumurana* Nast 1975: 2  
*Sogatella panicola* Fennah 1963: 76  
*Sogatella parakolophon* Linnavuori 1973: 108  
*Sogatella suezensis* Linnavuori 1964: 341

Stramineous to light orange; vertex stramineous with light carinae. Frons Stramineous with pale carinae, concolours with clypeus; black to dark fuscous gena; median carina forked at base of frons. Pronotum creamy white concolourous with tegula. Scutellum black with off-white to stramineous median vitta. Fore wings hyaline with or without any markings. Terete Antenna and legs stramineous. Abdomen black with a triangular light vitta with black spot stripe, basally. Male and female cryptic in colour (Fig. 4J, 4K, 9B, 12B, 15B).

Head including eyes 0.8x width of pronotum, obliquely rounded front in dorsal view, vertex length 0.3x width across eyes (Fig. 4J, 12B). Frons nearly rectangular with short clypeus, frontal suture extending onto vertex. Median carina of vertex forked before frons (Fig. 15B). Fastigium rounded in lateral view (Fig. 9B). Pronotum 3.6x wider than long; scutellum 1.2x wider than long (Fig. 12B).

**Male genitalia (Fig. 41A-F):** Pygofer 1.1x longer than its width, with distinct ventral margin having arcuate sclerotized area, diaphragm well developed (Fig. 41D, E). Segment ten and eleven combinedly short with 0.5x long lateroapical processes; segment eleven moderately long (Fig. 41C). Parameres 2.1x longer than wide; bifid apically with outer lobe stouter and divergent than inner lobe (Fig. 41F). Aedeagus 7.9x longer than wide; twisted with two rows of teeth on both sides; latero-apical gonopore (Fig. 41A, B).

**Female genitalia (Fig. 59A-D).** Valvulae I in lateral view (Fig. 59A, B), dorsal sculptured area extending from basal half to apex of blade; ventral margin even without sculpture. Valvulae II (Fig. 59C, D), in lateral view, dorsal margin with median ridge, serrations increasing in size, extending from base of ridge to apex of blade; with minute serrations at apex; ventral margin apex with stout broad spine; even with medio-basal translucent membrane.

**Measurements (mm).** Male 3.2 long, 0.5 wide across eyes, 0.4 wide across hind margin of pronotum. Female 3.4 long, 0.6 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 22♂, 17♀ New Delhi: Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, and Pusa Campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC). Himachal Pradesh; 16♂ 10♀ Kalpa, Kinnaur (31°32'11.33"N 78°15'33.98"E) 15.viii.2017, Mercury vapour light trap coll. Ramya (NPC). Bilaspur; 7♂ 3♀ Berthin, (31°21'35.18"N 76°39'52.38"E), 08.x.2018, Sweep net Coll. Akash, (NPC); 6♂ 9♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC).

**Remarks:** This species can be distinguished from *S. furcifera* and *S. kolophon* by the dark gena contrasting with stramineous frons and clypeus. It may be confused with the genus *Stenocranus* but they are very distinct in male genitalia.

#### **Genus *Tagosodes* Asche and Wilson**

Type species: *Tagosodes cubanus* (Crawford, 1914): 595

**Amended diagnosis:** Stramineous to black. Head narrower than pronotum. Vertex longer than broad at base, projected in front of eyes, lateral carinae parallel. Frons rectangular, broader than wide with prominent median carina, bifurcating at base. Off white to stramineous band extending from base of vertex to scutellum with chocolate brown latero-carinal area. Thorax tricarinate, median carina prominent, lateral carinae reaching hind margin. Forewings hyaline with black markings. Male pygofer ventrally longer than dorsally, diaphragm well developed with median lobe. Aedeagus straight tubular.

**Remarks:** The genus can be identified by the off white to stramineous band extending from base of vertex to scutellum with chocolate brown latero-carinal area, Forewings hyaline with black markings and straight tubular aedeagus.

#### ***Tagosodes pusanus* (Distant) [Fig. 4L, 5A, 9C, 12C, 15C, 42A-E, 59E-H]**

*Himeunka chibana* Tian and Kuoh 1981: 193

*Sogatodes assimilis* Yang 1989: 178

*Sogata pusana* Distant 1912: 191

*Sogata striatus* Qadri and Mirza 1960: 117

*Unkana formosella* Matsumura 1935: 72



Black to stramineous; Vertex stramineous. Frons, clypeus and gena stramineous. Stramineous vitta extending from vertex to scutellum tip. Pronotum and mesonotum black with stramineous vitta. Tegulae concolourous with body. Fore wings hyaline with claval pterostigma and dark apically. (Fig. 4L, 5A, 9C, 12C, 15C)

Head including eyes 0.8x width of pronotum. Vertex length 0.4x width across eyes; elongated with triangular apex (Fig. 4L, 12C). Frons tricarinate, longer than broad; median carina stronger than lateral carinae; median carina forked before frons (Fig. 15C). Fastigium subtriangular in lateral view (Fig. 9C). Pronotum 3.8x wider than long; scutellum 1.4x wider than long (Fig. 12C).

**Male genitalia (Fig. 42A-E):** Pygofer 1.3x longer than wide with well developed diaphragm having stout median process; laterodorsal angle extended (Fig. 42D). Segment ten and eleven combinedly 1.7x longer than wide along with 0.8x lateroapical processes; segment eleven moderately long (Fig. 42C). Parameres 2.7x longer than wide; deeply curved inner margin, apex bifurcated, outer margin longer than inner margin (Fig. 42E). Aedeagus 4x longer than wide; tubular with broad base; few spines on lateral angle; gonopore apical with basal few spines (Fig. 42A, B).

**Female genitalia (Fig. 59E-H):** Valvulae I in lateral view (Fig. 59E, F), dorsal margin even; ventral margin even with membranous medio-basal area. Valvulae II (Fig. 59G, H), in lateral view concave, dorsal margin with serrations slightly increasing in size, extending from basal half to apex of blade; with minute serrations at apex; ventral margin even with medio-basal translucent membrane and a stout serration at apex.

**Measurements (mm).** Male 3.3 long, 0.5 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.3 long, 0.5 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied.** INDIA: Delhi, NCR: 7♂, 5♀, IARI Pusa campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramya and 5♂, 6♀, Sunder nursery (28°35'43"N 17°14'41"E), 10.xiii.2018, Sweep net, Mercury vapour light trap Coll. Naresh Meshram (NPC).

**Remarks:** The species can be distinguished from other species of the genus in having off white to stramineous band extending from base of vertex to scutellum with

chocolate brown latero-carinal area, Forewings hyaline with black markings and straight tubular aedeagus with irregularly placed apical spines.

**Genus *Terthron* Fennah**

Type species: *Terthron anemonias* (Kirkaldy, 1907): 159

**Amended diagnosis:** Umber and black; vertex umber with black intercarinal area (Fig.4). Frons and gena black with light carinae, clypeus umber with light carina. Vertex, Pronotum and mesonotum amber coloured with a median stramineous vitta extending from vertex to tip of scutellum; pronotum with prominent lateral carinae. Fore wings hyaline with dark granules in veins and a dark curving extending from sector of radius to anal vein. Pygohore with triangular median process on ventral margin and aedeagus deeply curved ventally.

**Remarks:** The genus can be easily recognized by the pronotum and mesonotum amber coloured with a median stramineous vitta extending from vertex to tip of scutellum.

***Terthron albovittatum* (Matsumura) [Fig. 5B, 9D, 12D, 15D, 43A-E]**

*Dicranotropis albovittata* (Matsumura) 1900: 269

*Liburnia albovittata*, Matsumura 1931: 269

*Sogota albovittata* Esaki, 1932:2241

Umber and black; vertex umber with black intercarinal area. Frons and gena black with light carinae, clypeus umber with light carina. Vertex, Pronotum and mesonotum amber coloured with a median stramineous vitta extending from vertex to tip of scutellum; pronotum with prominent lateral carinae. Tegulae pale to stramineous. Fore wings hyaline with dark granules in veins and dark curving extending from sector of radius to anal vein. (Fig. 5B, 9D, 12D, 15D).

Head including eyes 0.3x width of pronotum, quadrate in dorsal view, vertex length 0.7x width across eyes (Fig. 5B, 12D). Frontoclypeus broad, frontal suture extending onto vertex. Median carina of vertex forked before frons (Fig. 15D). Fastigium rounded in lateral view (Fig. 9D). Pronotum 3.8x wider than long; scutellum 1.2x wider than long (Fig. 15D).

**Male genitalia (Fig. 43A-E):** Pygofer 1.3x longer than wide with well defined ventral margin having median triangular sclerotised area (Fig. 43E). Segment ten and eleven combinedly long with 0.7x lateroapical processes; segment eleven short (Fig. 43C). Parameres 3x longer than wide; slightly curved medially with a serration, outer apical

end with spines (Fig. 43D). Aedeagus 2.2x longer than wide; deeply curved with longer and shorter lobe; longer lobe with dorso-apical gonopore and ventral spines (Fig. 43A, B).

**Measurements (mm):** Male 2.6 long, 0.2 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material Studied:** INDIA: Andra Pradesh; 3♂ Tirupati, (13°62'88"N, 79°41'92" E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC). Uttarkhand: 1♂, Hawalbagh (29°64'28"N 79°63'27"E) 25.xii.2018 Sunil (NPC).

**Remarks:** The species can be differentiated by the pronotum and mesonotum amber coloured with a median stramineous vitta extending from vertex to tip of scutellum and aedeagus with ventrally deep curved

### **Genus *Toya* Distant, 1906**

Type species: *Toya attenuata* Distant, 1906: 472

**Amended diagnosis:** Stramineous. Head including eyes subequal to pronotum. Vertex stramineous to black with Y shaped carina. Frons, gena and clypeus black with stramineous, frons narrowest at base. Basally clypeus as broad as frons apex. Thorax stramineous to black. Fore wings hyaline with or without claval pterostigma. Dorsocaudal margin of the pygofer expanded, with apices medially inflected. The armature of the diaphragm wider than long. Aedeagus of most species slightly curved dorsad, bearing a lateral row of teeth near midlength on both sides along with several subapical dorsal teeth.

**Remarks:** Smaller planthoppers with black intercarinal area of frons and can be differentiated from other genera by the armature of diaphragm wider than long.

### ***Toya nigra* (Crawford) [Fig. 5C, 9E, 12E, 15E, 44A-E] (New record)**

*Megamelus erectus* Crawford, 1914: 624.

*Delphacodes axonopi* Fennah, 1945: 434-435

*Delphacodes nigra* (Crawford, 1914), new combination and emendation by Muir and Giffard, 1924: 32.

*Delphacodes axonopi* Fennah, 1945: 434-435, fig. 107-110, synonymy by Gonzon and Bartlett 2007: 224.

Black to fuscous. Vertex fuscous with yellow mosaic. Frons, gena and clypeus black with stramineous carina. Antennal scape black and pedicel stramineous. Thorax black. Pronotum fuscous with black mosaic spot, light yellow carina. Mesonotum black with yellowish hindmargin, black carina. Tegulae concolourous with thorax. Forewings

hyaline with concolours veins and claval pterostigma. Abdomen black with yellowish circular patch at notum base. (Fig. 5C, 9E, 12E, 15E)

Head including eyes as wide as pronotum. Vertex length 0.3x width across eyes; sinuate in front (Fig. 5C, 12E). Frons longer than wide with median carina forked just before frons. Clypeus as wide as apex of frons, rostrum supassing mesocoxae. Antenna terete, second segment longer than first (Fig. 15E). Fastigium rounded in lateral view (Fig. 9E). Pronotum 4.5x wider than long; light carina, lateral carina not reaching hind margin. Scutellum 1.1x wider than long; carina inconspicuous (Fig. 12E).

**Male genitalia (Fig. 44A-E):** Pygofer 1.2x longer than wide; dorsocaudal margin expanded, with apices medially inflected, diaphragm well developed, wider than long with broad U shaped armature (Fig. 44D). Segment ten and eleven combinedly 2.1x longer than wide with 0.3x lateroapical processes; segment eleven moderately long (Fig. 44C). Parameres 4.4x longer than wide; broad, basally broad bulged, inner margin sinuate, apically two lobed, laterally projected inner lobe give elbow shape to apex (Fig. 44E). Aedeagus 5.3x longer than wide; basally curved to dorsad, tubular, apical 2/3 armed with parallel rows of sublateral teeth; right latero- apical gonopore (Fig. 44A, B).

**Measurements (mm).** Male 2.1 long, 0.4 wide across eyes, 0.3 wide across hind margin of pronotum.

**Material examined:** India: Uttarkhand: 3♂, Hawalbagh (29°64'28"N 79°63'27"E) 25.xii.2018. Mercury vapour light trap coll. Sunil (NPC). Maharastra: 2♂, Malkhed forest (20°50'40"N 77°51'40"E) 18.xii.2018. Mercury vapour light trap coll. Akash (NPC)

**Remarks:** *Toya nigra* closely allied to the type species *Toya attenuata* due to similarity of color and by features of the male genitalia. This species differs from by *T. attenuata* in having a more pronounced inner angle of the parameres, greatly expanded dorsocaudal angle of pygofer and without medioventral processes of diaphragm.

***Toya tuberculosa* (Distant) [Fig. 5D, 9F, 12F, 15F, 45A-E] (New record)**

*Liburnia varia* Hesse, 1925, original combination

*Delphacodes varia* (Hesse, 1925); comb. by Muir (1929: 220).

*Toya (Delphacodes) varia* (Hesse, 1925); by Linnavuori (1973: 107).

*Toya varia* (Hesse, 1925); comb. by Fennah (1964: 142); synonym of *Toya tuberculosa* (Distant) by Fennah (1976: 269)

*Toya terryi* (Muir, 1917); synonym of *Toya tuberculosa* (Distant) by Fennah (1975: 117)  
*Liburnia tuberculosa* Distant, 1916, original combination  
*Toya tuberculosa* (Distant, 1916); comb. by Fennah (1976: 269)  
*Toya hispijimensis* Asche, 1980; synonym of *Toya tuberculosa* (Distant) by Asche (1988: 224)  
*Toya terryi* (Muir, 1917) status revivisco by Ding (2006: 506)  
*Delphacodes terryi* Muir, 1917, original combination

Stramineous to light yellow. Vertex stramineous. Frons, gena and clypeus black with stramineous carina. Antennal scape black basally and pedicel stramineous. Thorax stramineous. Pronotum and mesonotum light yellow with light carina. Tegulae concolourous with thorax. Forewings hyaline with dark veins and claval pterostigma absent. Abdomen black with yellowish circular patch at notum base. (Fig. 5D, 9F, 12F, 15F)

Head including eyes as wide as pronotum. Vertex length 0.3x width across eyes; sinuate in front (Fig. 5D, 12F). Frons longer than wide with median carina forked just before frons. Clypeus as wide as apex of frons, rostrum surpassing mesocoxae. Antenna terete, second segment longer than first (Fig. 15F). Fastigium rounded in lateral view (Fig. 9F). Pronotum 4.5x wider than long; light carina, lateral carina not reaching hind margin. Scutellum 1.1x wider than long; carina inconspicuous (Fig. 12F).

**Male genitalia (Fig. 45A-E):** Pygofer 1.1x longer than wide; dorsocaudal margin not expanded, diaphragm well developed, wider than long with broad U shaped armature (Fig. 45D). Segment ten and eleven combinedly 2.1x longer than wide with ventrally curved lateroapical processes; segment eleven moderately long (Fig. 45C). Parameres 4.1x longer than wide; basally broad, inner wavy margin sinuate with inner curving (Fig. 45E). Aedeagus 4.2x longer than wide; basally concave and apically recurved tubular, ventally armed with parallel rows of sublateral teeth; right latero- apical gonopore (Fig. 45A, B).

**Measurements (mm).** Male 3.1 long, 0.5 wide across eyes, 0.4 wide across hind margin of pronotum.

**Material examined:** India: Uttarkhand: 5♂, Hawalbagh (29°64'28"N 79°63'27"E) 25.xii.2018 Mercury vapour light trap coll. Sunil (NPC). Maharastra: 4♂, Malkhed forest (20°50'40"N 77°51'40"E) 18.xii.2018. Mercury vapour light trap coll. Akash (NPC)

**Remarks:** *Toya tuberculosa* closely allied to the *Toya attenuata* Distant due to similarity of color and by features of the male genitalia. This species differs from by *T. attenuata* in having aedeagus basally concave and apically recurved tubular, ventally armed with parallel rows of sublateral teeth.

**Genus *Unkanodes* Fennah**

Type species: *Unkana sapporona* Matsumura 1935: 131

**Amended diagnosis:** Black. Head including eyes as broad as pronotum. Vertex stramineous with three triangular spots, as long as wide, slightly projected in front of eyes. Frons rectangular, same width throughout, carina prominent, median carina forked before frons. Antenna cylindrical, basal segment black second segment stramineous. Thorax tricarinate. Pronotum black with stramineous median vitta at base, lateral carinae not reaching. Mesonotum black with offwhite median carinae. Forewings hyaline. Laterodorsal angle of pygofer produced; diaphragm well developed with median lobe. Aedeagus tubular with regularly placed spines. Parameres flattened with curved apex.

**Remarks:** This genus can be distinguished from other genera of Delphacini by a median stramineous vitta on thoracic notum, laterodorsal angle of pygofer produced and aedeagus tubular with regularly placed spines.

***Unkanodes latespinosa* (Dlabola, 1954) [Fig. 5E, 5F, 9G, 12G, 15G, 46A-E] (New report)**

*Calligypona latespinosa* Dlabola, 1954: 33

Black; Vertex stramineous with yellow spots. Frons, clypeus and gena black with yellow carinae. Pronotum black with V shaped stramineous median vitta, lateral angle stramineous. Mesonotum black with concolourous lateral carinae; prominent off white median carina. Tegulae stramineous. Abdomen black with yellow circular vitta at abdominal base. Fore wings hyaline with claval pterostigma (Fig. 5E, 5F, 9G, 12G, 15G).

Head including eyes same width of pronotum. Vertex length 0.3x width across eyes (Fig. 5E, 12G). Frons rectangular; median carina forked before frons. Antenna cylindrical, basal segment black distal segment stramineous (Fig. 15G). Fastigium rounded in lateral view (Fig. 9G). Pronotum 4.4x wider than long; tricarinate, lateral carinae not reaching to hind margin. Scutellum 1.2x wider than long; carina simple (Fig. 12G).

**Male genitalia (Fig. 46A-E):** Pygofer 1.1x longer than wide with well developed diaphragm having triangular median process; laterodorsal angle strongly produced (Fig. 46E). Segment ten and eleven combinedly 0.9x longer than wide along with 1.2x lateroapical processes; segment eleven short (Fig. 46D). Parameres 3.1x longer than wide; deeply curved inner margin with hooked apex (Fig. 46C). Aedeagus 8x longer than wide; tubular, elbow-shaped with subapical rows of spines present laterally; gonopore apical (Fig. 46A, B).

**Measurements (mm).** Male 3.7 long, 0.7 wide across eyes, 0.5 wide across hind margin of pronotum.

**Material studied.** INDIA: Ladakh; 10♂ Leh, (34°09'9.32"N 77°34'37.38" E) 15.viii.2018, Sweep net Coll. Naresh Meshram (NPC). Himachal Pradesh; 5♂ Kalpa, Kinnaur (31°32'11.33"N 78°15'33.98"E) 15.viii.2017, Mercury vapour light trap coll. Ramya (NPC).

**Remarks:** *Unkanodes latespinosa* can be identified by the triangular spots on vertex, white median carinae of mesonotum and male genitalia especially upcurved elbow-shaped aedeagus. Flattened parameres with hooked apex.

### **Tribe Tropidocephalini Muir**

#### **Genus *Arcofacies* Muir 1915 (New record)**

Type species: *Arcofacies fullawayi* Muir, 1915: 320

**Amended diagnosis:** General color yellowish green to yellowish brown. A white median longitudinal line bordered with dark brown or black extends from the apex of the frons to the end of mesonotum. Lateral parts of pronotum each with oblique white band bordered with brown or dark brown. Forewings speckled with dark brown markings, in dark portion veins bear white spots, tectiform at rest. Head including eyes narrower than pronotum. Vertex trapeziform, with apical margin distinctly emarginate at both sides of median point, lateral carinae concave, submedian carinae transverse. Vertex and frons at right angle. Antennae cylindrical, scape shorter than pedice. Pronotum with lateral carinae extending to hind margin, converging apically, median carina weak. Segment 10 of male collar-shaped, lateroapical angles produced into spinous processes or not, armature of diaphragm V-shape. Aedeagus tubular or flat, with spinous process or not, orifice subapical. Paramere long, simple, broad at base, narrowing apically, basal angle intumescent.

**Remarks:** The genus can be distinguished from other genera of Tropidocephalini by vertex and frons at right angle, white median longitudinal line bordered with dark brown or black extends from the apex of the frons to the end of mesonotum and aedeagus tubular or flat, with spinous process or not.

***Arcofacies securisus* sp. nov. 6 [Fig. 5G, 5H, 9H, 12H, 15H, 47A-G, 59I-L]**

Olive drab to pea green; vertex and face grey green with green carinae. Median longitudinal line, green bordered with black strip, extending from the apex of the frons to end of the mesonotum. Intercarinal area of thorax amber coloured, white lateral area of pronotum housing the base of tegulae. Tegulae creamy white with black terminal stripe. Fore wings are hyaline with dark veins bordered with fuscous grey, having prominent white granules. Pale green abdomen with grey green abdominal tip in male. (Fig. 5G, 5H, 9H, 12H, 15H)

Head nearly quadrate with emerginate carinae and length 0.8x of width of pronotum. Vertex trapeziform with well defined margins and length 0.4x width across eyes (Fig. 5G, 12H). Face 1.5x as long as wide; median carina of frons extended upto anterior margin of vertex, bifurcated anteriorly, connecting to submedian carinae forms small cell (Fig. 15H). Fastigium flattened lateral view with emerginate median carina, postclypeus at right angle to frons (Fig. 9H). Pronotum with lateral carinae extending to hind margin; length 0.3x of width. Scutellum with lateral carina diverging near hind margin; length 0.5x of width (Fig. 12H).

**Male genitalia (Fig. 47A-G):** Pygofer 1.8x longer than wide (Fig. 47E); posterior margin strongly produced caudad near ventral aspect in lateral view (Fig. 47F). Segment ten and eleven combinedly 1.5x longer than wide; concave innermargin with truncate lateroapical processes (Fig. 47C). Paramere slender 4.5x longer than wide, basal angle intumescent, narrowing apically (Fig. 47G). Aedeagus 5x longer than wide; wavy tube with modified hook apically, orifice subapical; with spinous process from base (Fig. 47A, B).

**Female genitalia (Fig. 59I-L):** Valvulae I in lateral view (Fig. 59I, J), dorsal margin smoothly sculptured; ventral margin even with membranous medio-basal area. Valvulae II (Fig. 59K, L), in lateral view concave, dorsal margin with serrations deep with flat tip, decreasing in size, extending from median to apex of blade; ventral margin even with medio-basal translucent membrane and deep trough at apex.



**Measurements (mm).** Male 5.6 mm long, 1.11 mm wide across eyes, 0.94 mm wide across hind margin of pronotum. Female 6.2 long, 1.03 wide across eyes, 0.95 wide across hind margin of pronotum.

**Type material.** Holotype ♂, INDIA: Himachal Pradesh; Bilaspur: Berthin (31°21'35.18"N 76°39'52.38"E), 08.x.2018, Sweep net Coll. Akash, (NPC). Paratype 5 ♂ and 6 ♀, with same data as on holotype.

**Remarks.** This species closely resembles *A. ampelocalamus* Chen, Yang and Tsai but differs in habitus colour; Aedeagus wavy tube with modified hook apically, orifice subapical; with spinous process from base. Segment 10 with truncate lateroapical processes.

### **Genus *Arcofaciella* Fennah, 1956**

Type species: *Arcofaciella verrucosa* Fennah, 1956: 467

**Amended diagnosis:** Stramineous to green. Head including eyes narrower than pronotum. Vertex trapezoid, apical margin truncate, submedian carinae absent. Frons longer than broad with ridged median carina, in lateral view bowshaped. Rostrum reaching mesocoxae. Thoracic notum with distinct carinae. Pronotum with lateral carinae attaining hind margin. Forewings with dark veins having bead like structure. Post- tibial spur cultrate, concave on inner surface. Segment 10 sunk in dorsal emargination of pygofer. Pygofer longer than wide with well developed diaphragm. Aedeagus with a spinose process arising basally. Parameres narrow oblong.

**Remarks:** The genus can be distinguished by the shape of carinae of vertex, Postclypeus at right angle to frons (in lateral view). Antennae cylindrical in cross-section. Segment 10 of male ring-like, without latero-apical process. This genus is similar to *Arcofacies* Muir (1915) but differs from the latter in the shape of frons, in the relative size of the antennae and mesonotum is gibbous (Liang and Jiang 2004).

### ***Arcofaciella sinuata* sp. nov. 7 [Fig. 5I, 5J, 9I, 12I, 15I, 48A-G, 59M-P]**

Tawny to olive drab; vertex and face tawny with light carinae follows darks spots on either side. Pronotum and mesonotum tawny with grey marking on either side. Intercarinal area of thorax harmonious with off white and light yellow, tegulae dull grey. Fore wings dull grey with larger hyaline area extended from base of anal margin to subcosta and subapical smaller hyaline area; veins dark having prominent white granules along, ended in black granules at margin of wing. Male having Light green

abdomen with grey abdominal tip. Pale green abdomen in female having light orange stripe on sternum (Fig. 5I, 5J, 9I, 12I, 15I).

Head nearly quadrate with emerginate carinae and length 0.8x of width of pronotum. Vertex trapezoid with well defined margins broad at base and length 0.5x of width across eyes (Fig. 5I, 12I). Frons hexagonal shaped with extended lower margins; Postclypeus curved caudad, median carina of frons bifurcated near anterior margin of vertex, connecting to submedian carinae forms small cell (Fig. 15I). Fastigium flattened in lateral view with emerginate median carina (Fig. 9I). Pronotum with nearly convex lateral carinae extending to hind margin; length 0.1x of width. Scutellum with lateral carina extended to hind margin and length 0.9x of width (Fig. 12I).

**Male genitalia (Fig. 48A-G).** Pygofer as long as wide; with inverted pot shaped opening (Fig. 48G); posterior margin slightly produced at middle in lateral view (Fig. 48E). Segment ten and eleven combinedly 2.2x longer than wide without lateroapical processes; segment eleven moderately long (Fig. 48C). Paramere slender, long convergent apically with bulged latero-subapical region (Fig. 48F). Aedeagus nearly dumbbell with broad orifice ends in hook like extension ventrally; dorsal base with long curved process (Fig. 48A, B).

**Female genitalia (Fig. 59M-P).** Valvulae I in lateral view (Fig. 59M, N), dorsal margin light sculptured even throughout; ventral margin even with membranous medio-basal area. Valvulae II (Fig. 59O, P), in lateral, dorsal margin with sparsely spaced denticles, extending basal half to apex of blade; ventral margin even.

**Measurements (mm).** Male 6.0 mm long, 1.43 mm wide across eyes, 0.94 mm wide across hind margin of pronotum. Female 6.2 long, 1.38 wide across eyes, 0.88 wide across hind margin of pronotum.

**Material studied:** Holotype ♂, INDIA: Himachal Pradesh: Bilaspur: Berthin (31°21'35.18"N 76°39'52.38"E), 08.x.2018, Sweep net Coll. Niranjana, (NPC). Paratype 15 ♂ and 16 ♀, with same data as on holotype.

**Remarks.** This species closely resembles *A. verrucosa* Fennah, but differs in habitus colour and aedeagus dumbbell with broad orifice ends in hook like extension ventrally.

**Genus *Bambusiphaga* Huang and Ding, 1979 (New record)**

Type species: *Bambusiphaga nigropunctata* Huang and Ding, 1979:170

**Amended diagnosis:** Yellowish orange; Head obliquely rounded in front, vertex and face pale yellow. Fastigium rounded in lateral view; frons somewhat rectangular shaped. Eyes, tegulae, mesonotum, and abdominal tergites darker than remainder. Scutellum with black transverse vitta at hind margin. Tegulae black. Fore wings hyaline with dark coastal margin. Pronotum with lateral carinae progressively diverged and reaching hind margin. Mesonotum with median carinae reaching to tip of scutellum and two lateral carinae. Pygofer longer than wide; dorsolateral margin slightly produced; ventral margin with round opening; without diaphragm. Segment ten rounded with differently modified lateroapical processes; housing inconspicuous segment eleven.

**Remarks:** The genus can be differentiated by vertex with submedian carinae, anterior margin of vertex evenly rounded or truncated. Male genitalia structures differently modified with respective species.

***Bambusiphaga unispina* Ramya and Meshram (sp. nov. 8) [Fig. 5K, 9J, 12J, 15J, 49A-E]**

Yellowish orange; vertex and face pale yellow. Eyes, tegulae, mesonotum, and abdominal tergites darker than remainder. Scutellum with black transverse vitta at hind margin. Tegulae black. Fore wings hyaline with dark coastal margin (Fig. 5K, 9J, 12J, 15J).

Head obliquely rounded in front and 1.4x wider than pronotum. Vertex length 0.2x width across eyes (Fig. 5K, 12J). Face 1.5x as long as wide; frons somewhat rectangular shaped; frontoclypeus broad, frontal suture reaching up to vertex; median carina extended up to anterior margin of vertex; Ocelli present (Fig. 15J). Fastigium rounded in lateral view (Fig. 9J). Pronotum 0.3x as long as wide and 0.5x length of scutellum; lateral carinae progressively diverged and reaching hind margin. Mesonotum with median carinae reaching to tip of scutellum and two lateral carinae (Fig. 12J).

**Male genitalia (Fig. 49A-E).** Pygofer 1.5x longer than wide; dorsolateral margin slightly produced; ventral margin with round opening; without diaphragm. Segment ten rounded short structure without lateroapical processes; housing inconspicuous segment eleven (Fig. 49D, E). Paramere slender 5.2x longer than wide, bulged basally and truncate apically (Fig. 49C). Phallobase uniform throughout except narrowed and

curved at apex. Aedeagus attached to connective with emarginate base. Aedeagus with apical half with 2 branches, main branch at right, apically modified as a node around orifice; left branch long, curved, acute apically; mid-lateral process, arising on dorsal side, short comparatively, acute apically, directed ventrad (Fig. 49A, B).

**Measurements (mm).** Male 3.4 long, 0.5 wide across eyes, 0.6 wide across hind margin of pronotum.

**Type material** Holotype ♂, INDIA: Himachal Pradesh, Palampur, CSK-HPKV, (32°10'03"N 76°54'65"E), 10.viii.2018, on mercury vapour lamp Coll. Sunil (NPC).

**Remarks.** Externally this species closely resembles *B. taiwanensis* but differs in scutellum with transverse vitta at hind margin; aedeagus (phallosome) with apical half with 2 branches, main branch at right, apically modified as node around orifice; left branch long, curved, acute apically; mid-lateral process, arising on dorsal side, short comparatively, apex acute, directed ventrad.

***Bambusiphaga* sp. nov. 9 [Fig. 5L, 6A, 9K, 12K, 15K, 50A-E, 60A-D]**

Yellowish; vertex and face pale yellow. Compound eyes oil red, in contrast to body colour. Tegulae, mesonotum, and abdominal tergites yellowish. Thoracic notum with concolourous carina. Fore wings hyaline with yellowish veins (Fig. 5L, 6A, 9K, 12K, 15K).

Head obliquely rounded in front and 0.3x width of pronotum. Vertex length 0.4x width across eyes (Fig. 5L, 12K). Face 2.5x longer than wide; frons rectangular shaped; frontoclypeus broad, frontal suture reaching vertex; median carina extended up to anterior margin of vertex; Ocelli present (Fig. 15K). Fastigium angled in lateral view (Fig. 9K). Pronotum 0.3x as long as wide and 0.3x length of scutellum; lateral carinae progressively diverged and reaching hind margin. Mesonotum with median carinae reaching to tip of scutellum and two lateral carinae inconspicuous (Fig. 12K).

**Male genitalia (Fig. 50A-E).** Pygofer 1.8x longer than wide; medio ventral margin with V shaped opening; without diaphragm (Fig. 50D). Segment ten and eleven combinedly 1.7x longer than wide, segment ten with single long lateroapical processes, extending beyond medioventral margin of pygofer (Fig. 50C). Paramere 7.5x longer than wide, curved with apically divergent lateral extension (Fig. 50E). Aedeagus 4.6x longer than wide; broad tubular basally and twisted medially; gonopore apical, surrounded by 3 branches (Fig. 50A, B).

**Female genitalia (Fig. 60A-D).** Valvulae I in lateral view (Fig. 60A, B), dorsal margin concave with sculptured area extended from median to apex of blade; ventral margin even with dark band bordering it. Valvulae II (Fig. 60C, D), in lateral view concave basally and convex apically; dorsally ornamented with 13 stout teeth extending from median to apex of blade; ventral margin even with dark border giving curing appearance.

**Measurements (mm).** Male 3.6 long, 0.5 wide across eyes, 0.5 wide across hind margin of pronotum. Female 3.9 long, 0.6 wide across eyes, 0.6 wide across hind margin of pronotum.

**Type material:** Holotype ♂, INDIA: Himachal Pradesh, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Paratype 2♂ with same data as on holotype, 2♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC)

**Remarks.** This species resembles *B. unispina* but differs in habitus colour; aedeagus twisted with 3 apical branches and segment 10 with a single, long lateroapical process.

### **Genus *Purohita* Distant**

Type species: *Purohita cervina* Distant, 1906: 470

**Amended diagnosis:** Light green to stramineous. Large planthoppers. Head including eyes distinctly narrower than pronotum. Vertex as long as wide with lateral carinae raised or excavated. Frons in middle line longer than wide at widest part, median carina forked at base. Ocelli distinct at posterior margin of eye. Antennal segments foliaceous, scape longer and wider than short and flattened pedicel. Forewing hyaline, veins concolorous, granulate with minute hairs. Male pygofer dorsal margin is longer than ventral, in lateral view triangular, ventral margin sinuate. Segment 10 elongate without lateroapical processes.

**Remarks:** This genus can be differentiated from other genera of Tropidocephalini by longer flattened antenna, pygofer dorsal margin is longer than ventral, in lateral view triangular, ventral margin sinuate. Segment 10 elongate without lateroapical processes.

### ***Purohita taiwanensis* Muir [Fig. 6B, 6C, 9L, 12L, 15L, 51A-F, 60E-H]**

*Purohita taiwanensis* Muir, 1914:56

Stramineous green. Vertex concolorous with thorax. Frons and gena basal half fuscous and distal half same as body. Clypeus and rostrum concolorous with body. Antennal dark with black spots. Thorax stramineous green. Pronotum and mesonotum with light stripes and light carina. Tegulae concolorous with thoracic notum. Forewings hyaline, veins with dark suffusion. Abdomen light green with black stripe on abdominal notum. (Fig. 6B, 6C, 9L, 12L, 15L)

Head including eyes 0.7x width of pronotum, slightly narrower than pronotum. Vertex length 0.3x width across eyes, lateral carina raised (Fig. 6B, 6C, 12L). Frons longer than wide, carina keeled, median carina not forked; clypeus base slightly wider than as apex of frons, rostrum reaching mesocoxae; antennal segments foliaceous, scape longer and wider than short and flattened pedicel (Fig. 15L). Fastigium rounded in lateral view (Fig. 9L). Pronotum 4.9x wider than long; light carina. Scutellum 1x wider than long; light carina (Fig. 12L).

**Male genitalia (Fig. 51A-F):** Pygofer 1.6x longer than wide; Ventral margin of pygofer with an elongate pointed tooth-like process, triangular laterally (Fig. 51B, C). Segment ten and eleven combinedly 1.4x longer than wide, without lateroapical processes; segment eleven long (Fig. 51E). Parameres 5.4x longer than wide; sinuate, with deeply curved apical inner margin and basally broad (Fig. 51F). Aedeagus 5.8x longer than wide; Aedeagus decurved medioventrally, apex acute almost reaching ventral margin of pygofer, gonopore subapical. Phallobasal process arising from ventral aspect (Fig. 51A, D).

**Female genitalia (Fig. 60E-H).** Valvulae I in lateral view (Fig. 60E, F), dorsal margin concave with smoothly sculptured area extended from median to apex of blade; ventral margin even with dorsal margin. Valvulae II (Fig. 60G, H), in lateral view concave basally and straight apically; with flat serrations extending from median to apex of blade; ventral margin even with medio-basal translucent membrane and light trough at apex.

**Measurements (mm).** Male 4.6 long, 0.7 wide across eyes, 0.7 wide across hind margin of pronotum. Female 5.6 long, 0.8 wide across eyes, 0.7 wide across hind margin of pronotum.

**Material examined:** INDIA: Himachal Pradesh; 6♂, 5♀, Nauni, (30°85'70"N, 77°16'74"E) 14.vii.2017, Sweep net, Mercury vapour light trap Coll. Ramya (NPC):

8♂, 3♀ Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Delhi; 3♂, Pusa Campus (28.6374° N, 77.1629° E), 14.xiii.2018, Sweep net, Mercury vapour light trap Coll. Ramai (NPC).

**Remarks:** *Purohita taiwanensis* mostly feed on bamboo. In the study all specimens were collected from bamboo. This species can be easily identified by the structure of antenna and aedeagus decurved medioventrally, apex acute almost reaching ventral margin of pygofer; with a basal process.

### **Genus *Tropidocephala* Stal**

Type species: *Tropidocephala flaviceps* Stal, 1855: 93

**Amended diagnosis:** Black to yellow. Head including eyes narrower than pronotum. Vertex producing in front of eyes apparently or very much, tricarinate. Frons longer in middle line, than wide at widest part, median carina forked at base of frons. Clypeus wider at base than apex of frons or subequal, Rostrum attaining mesocoxae. Antennae short, cylindrical. Ocelli present. Post tibial spur without teeth on hind margin. Pronotum tricarinate, lateral carinae well developed, posteriorly converging and attaining hind margin. Forewing veins with small hair-bearing granules. Male genitalia characters with wide variation in shapes of pygofer, paramere and aedeagus. Pygofer diaphragm well developed, lateral margin with or without production, ventral margin with distinct medioventral process. Aedeagus asymmetrical with distinct phallobase, slender, curved ventrad, phallobase broad at base, concave submedially to receive aedeagus with very long process apically or basoventrally. Aedeagus fastened in anal segment, supporting plate irrecoznizable. Parameres long, basal angle with or without long process.

**Remarks:** *Tropidocephala* is the largest genus of Tropidocephalini. It can be distinguished from other genera by the distinct vertex producing in front of eyes apparently or very much, tricarinate.

### **Key to species of *Tropidocephala***

1. Habitus stramineous to vermillion, vertex distinctly longer than width at base (Fig. 12N), abdomen completely orange, fore wings hyaline with darker suffusion around veins (Fig. 6F, 9N)  
..... *Tropidocephala sinuosa* Yang and Yang
- Habitus black with bright green vertex and thorax, vertex longer than width at base, not as long as above (Fig. 12M, 12O), forewings black (Fig. 6D, 6G)  
..... 2

2. Fore wings black with light green wavy vitta at base of anal margin unite to form median vitta of wings (Fig. 6G), paramere broad with median and basal small process (Fig. 54E) .....*Tropidocephala tuberipennis* (Mulsant and Rey)
- Fore wings completely black without light green vitta (Fig. 6D), paramere broad with basally branched strong process and a small curved on apex of main branch (Fig. 52E).....*Tropidocephala festiva* (Distant)

***Tropidocephala festiva* (Distant) [Fig. 6D, 6E, 9M, 12M, 15M, 52A-G, 60E-H]**

*Smara festiva* Distant 1906: 478

Black to greenish. Vertex yellowish green with black carinal border. Frons black with median greenish band across, gena and clypeus black with black carina. Antennal striped with black and green. Thorax black, notum yellowish green with black carina boarder. Prothorax yellowish green with notum concolourous with thoracic notum. Mesonotum black with notum concolorous with thoracic notum. Tegulae concolourous with thoracic notum. Forewings black with basal yellowish green stripes. Abdomen black. (Fig. 6D, 6E, 9M, 12M, 15M)

Head including eyes 0.8x width of pronotum, narrower than pronotum. Vertex length 0.8x width across eyes, distinctly projected in front, median carina bordered with black stripes (Fig. 6D, 12M). Frons longer than wide, ventrally curved from lateral view giving roof like appearance, median carina forked at base of frons frons. Clypeus base slitely wider than as apex of frons, rostrum supassing mesocoxae; antenna terete, second segment longer than first (Fig. 14L). Fastigium triangular lateral view (Fig. 9M). Pronotum 2.5x wider than long; light carina bordered with black stripes, lateral carina reaching hind margin. Scutellum 1x wider than long; carina conspicuous bordered with black stripes (Fig. 12M).

**Male genitalia (Fig. 52A-G):** Pygofer 1.2x longer than wide; lateral margin strongly produced, ventral margin with sinuate median process, diaphragm weakly developed (Fig. 52A, G). Segment ten and eleven combinedly 0.8x longer than wide; segment eleven long (Fig. 52C). Parameres 3.7x longer than wide; main body subequally in wide, elongate, apical sixth narrowed and curved, basal angle produced into a long process (Fig. 52D, F). Aedeagus 5.3x longer than wide; slender, basal portion of phallobase in dorsal view with triangular production at apex, and widely lobed at base at right side, process of phallobase arising from apex, in profile with subapical portion granulate, apex truncated and pointed at basal angle (Fig. 52B, E).



**Female genitalia (Fig. 60I-L).** Valvulae I in lateral view (Fig. 60I, J), dorsal margin convex, sculptured area extending from base to apex; ventral margin even. Valvulae II (Fig. 60K, L), in lateral view, dorsal margin with serrations decreasing in size, extending from median to apex of blade; ventral margin even with medio-basal translucent membrane.

**Material Examined:** INDIA: Uttarkhand; 5♂ 7♀, Ranichauri-KVK. (27°17'50"N 85° 98'15"E) 07.x.2017, Sweep net Coll. Akash (NPC). Himachal Pradesh: 2♂, 3♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Andhra Pradesh: 4♂ 3♀ Tirupati, (13°62'88"N, 79°41'92" E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC). Arunachal Pradesh: 4♂ 3♀, (27°59'34"N, 94°42'15" E) 30.vi.2018, Mercury vapour light trap coll. Stuti (NPC).

**Measurements (mm).** Male 3.6 long, 0.5 wide across eyes, 0.7 wide across hind margin of pronotum. Female 3.8 long, 0.6 wide across eyes, 0.6 wide across hind margin of pronotum.

**Remarks:** *Tropidocephala festiva* closely resembles *Tropidocephala brunnipennis* in external morphology except the wing colouration. However the species can be differentiated by the presence of medioventral process of pygofer and basal angle of pygofer with a long process.

***Tropidocephala sinuosa* Yang and Yang [Fig. 6F, 9N, 12N, 15N, 53A-E] (New record)**

*Tropidocephala sinuosa* Yang and Yang, 1986a:28

Vermilion. Vertex light yellow. Frons, gena and clypeus concolorous with body. Antennal light yellow to creamy white. Thorax light yellow with orange intercarinal stripes. Tegulae concolorous with thoracic notum. Forewings hyaline, concolorous veins, basal and apical half with brown area. Abdomen blackvermilion (Fig. 6F, 9N, 12N, 15N).

Head including eyes 0.7x width of pronotum, narrower than pronotum. Vertex length 1.2x width across eyes, distinctly projected in front with lateral margins excavated, roof like in lateral view (Fig. 6F, 12N). Frons longer than wide, carina keeled, median carina forked at base of frons. Clypeus base slightly narrower than apex of frons, rostrum reaching mesocoxae. Antenna terete, small, second segment longer than first (Fig. 15N). Fastigium triangular lateral view (Fig. 9N). Pronotum 2.5x wider than long; light carina. Scutellum 1.2x wider than long; light carina (Fig. 12N).

**Male genitalia (Fig. 53A-E):** Pygofer 1.3x longer than wide; lateral margin strongly produced with baso-lateral processes, ventral margin with sharp single process (Fig. 53C, E). Segment ten and eleven combinedly 1.3x longer than wide, latero apical margin slightly produced; segment eleven long (Fig. 53B). Parameres 3.8x longer than wide, diverging apically; bent medio-laterally (Fig. 53D). Aedeagus 5.7x longer than wide; slender, phallosome broad leaf like, a long slender process produced from phallosome directed ventrally, the aedeagus structure is housed inside the Segment 10 inseparably (Fig. 53A, B).

**Measurements (mm).** Male 3.5 long, 0.5 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material Examined:** INDIA: Andhra Pradesh; 4♂ Tirupati, (13°62'88"N, 79°41'92"E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC).

**Remarks:** *Tropidocephala sinuosa* can be easily distinguished from other species of *Tropidocephala* by expanded vertex and lateral margin of pygofer strongly produced with baso-lateral processes, ventral margin with sharp single process.

***Tropidocephala tuberipennis* (Mulsant and Rey, 1855) [Fig. 6G, 6H, 9O, 12O, 15O, 54A-E, 60M-P] (New record)**

*Delphax tuberipennis* Mulsant and Rey, 1855: 197

*Tropidocephala elegans* Fieber, 1872

Black to greenish. Vertex yellowish green. Frons basal half greenish and distal half black. Gena and clypeus black with black carina. Antennal striped with black and green. Thorax black, notum yellowish green. Prothorax yellowish green light carina. Mesonotum black with notum concolorous with thoracic notum. Tegulae concolorous with thoracic notum. Forewings hyaline with basal and distal black band, anal margin with zig-zag greenish band, united to form a median line over abdomen. Abdomen black. (Fig. 6G, 6H, 9O, 12O, 15O)

Head including eyes 0.8x width of pronotum, narrower than pronotum. Vertex length 0.7x width across eyes, distinctly projected in front (Fig. 6G, 12O). Frons longer than wide, carina slightly keeled, median carina forked at base of frons frons. Clypeus base slightly wider than as apex of frons, rostrum reaching mesocoxae. Antenna terete, second segment longer than first (Fig. 15O). Fastigium triangular lateral view (Fig. 9O). Pronotum 2.6x wider than long; light carina. Scutellum 1.1x wider than long; light carina (Fig. 12O).

**Male genitalia (Fig. 54A-E):** Pygofer 1.1x longer than wide; lateral margin strongly produced with baso-lateral processes, ventral margin with sharp single process, diaphragm weakly developed (Fig. 54C, D). Segment ten and eleven combinedly 0.9x longer than wide; segment eleven long (Fig. 54A). Parameres 3.5x longer than wide; each with two short processes, one at base, another at basal third of inner margin, directed mesodorsad (Fig. 54E). Aedeagus 5.8x longer than wide; with Aedeagus slender, phallobasal process arising from apical portion. (Fig. 54A, B).

**Female genitalia (Fig. 60M-P):** Valvulae I in lateral view (Fig. 60I-J) dorsal margin, sculptured area extending from median to apex; ventral margin even. Valvulae II (Fig. 60K-L), in lateral view, dorsal margin with deep serrations decreasing in size at apex, extending from median to apex of blade; ventral margin even with medio-basal translucent membrane.

**Measurements (mm).** Male 3.7 long, 0.6 wide across eyes, 0.7 wide across hind margin of pronotum. Female 3.8 long, 0.6 wide across eyes, 0.6 wide across hind margin of pronotum.

**Material Examined:** INDIA: Uttarkhand; 7♂ 5♀ Ranichauri-KVK. (27°17'50"N 85° 98'15"E) 07.x.2017, Sweep net Coll. Akash (NPC). Himachal Pradesh: 4♂, 3♀, Berthin, Bilaspur, (31°21'35.18"N 76°39'52.38"E) 08.x.2018 Akash, Niranjana (NPC). Andhra Pradesh; 2♂ 2♀ Tirupati, (13°62'88"N, 79°41'92"E) 28.ii.2018, Mercury vapour light trap coll. Rajagopal (NPC). Arunachal Pradesh: West siang, Basar 4♂ 3♀, (27°59'34"N, 94°42'15"E) 30.vi.2018, Mercury vapour light trap coll. Stuti (NPC).

**Remarks:** *Tropidocephala tuberipennis* closely resembles *Tropidocephala festiva* in external morphology except the wing markings. However the species can be easily differentiated by the parameres with two short processes.

#### 4.4. GeneBank submissions of the Delphacinae species.

The DNA amplification was carried out by using 4 genes viz., mtCOI (650bp region), 28srDNA D2 and D9-D10 region and Histone gene. The sequences of these were submitted to NCBI gene bank and the Accession number of these is given in the following table. The species name given in the parenthesis are the new name proposed to the putative new species while submitting the sequences to the NCBI GenBank. The species with '\*' are the species for which the sequences were retrieved from

NCBI GenBank and used for the phylogenetic analysis along with the sequences obtained from the present study.

**Table 6: Barcodes of sequences used in phylogenetic studies**

| SI no.                   | Organism name                                                             | Genebank Accession no. |                        |                    |
|--------------------------|---------------------------------------------------------------------------|------------------------|------------------------|--------------------|
|                          |                                                                           | mt COI (650bp region)  | 28s rDNA D9-D10 region | 28s rDNA D2 region |
| Tribe Delphacini species |                                                                           |                        |                        |                    |
| 1                        | <i>Nilaparvata lugens</i>                                                 | MK681427<br>MK922239   | MN116008<br>MN116009   | MN957007           |
| 2                        | <i>Falcotoya daluoensis</i>                                               | MK681428               | MN116006<br>MN116007   |                    |
| 3                        | <i>Perkinsiella insignis</i>                                              | MK681429<br>MK681430   | MN116023<br>MN116024   | MN957010           |
| 4                        | <i>Cemus sauteri</i>                                                      | MK686037<br>MK686038   | MN116017<br>MN116018   | MN957787           |
| 5                        | <i>Cemus zhitus</i>                                                       | MK686039<br>MK686040   | MN116013<br>MN116014   |                    |
| 6                        | <i>Terthron albovittatum</i>                                              | MK686035<br>MK686036   | MN116015<br>MN116016   | MN957009           |
| 7                        | <i>Toya nigra</i>                                                         | MK686041<br>MK686042   | MN116027<br>MN116028   |                    |
| 8                        | <i>Sogatella vibix</i>                                                    | MK694717<br>MK694718   | MN116032               | MN944555           |
| 9                        | <i>Sogatella kolophon</i>                                                 | MK694723               | MN116029               |                    |
| 10                       | <i>Sardia rostrata</i>                                                    | MK694719<br>MK694720   | MN116025<br>MN116026   | MN957788           |
| 11                       | <i>Coronacella sinhalana</i>                                              | MK694724<br>MK694725   | MN116019<br>MN116020   |                    |
| 12                       | <i>Nycheuma nilotica</i>                                                  | MK694721<br>MK694722   | MN116011<br>MN116012   | MN957786           |
| 13                       | <i>Laodelphax striatellus</i>                                             | MK248734               | MN096666<br>MN096667   |                    |
| 14                       | <i>Peregrinus maidis</i>                                                  | MK922240<br>MK922241   |                        |                    |
| 15                       | <i>Parasogata</i> sp. nov.<br>( <i>Parasogata sexpartita</i><br>sp. nov.) | MN787519               |                        |                    |
| 16                       | <i>Eoeurysa</i> sp.<br>( <i>Eoeurysa sagitta</i> )                        | MN787520<br>MN787521   |                        |                    |
| 17                       | <i>Neunkanodes unispinatus</i>                                            |                        |                        | MN957006           |
| 17                       | * <i>Chloriona unicolor</i>                                               | AF304417               |                        |                    |

|                                |                                                                  |                      |                      |          |
|--------------------------------|------------------------------------------------------------------|----------------------|----------------------|----------|
| 18                             | <i>*Eoeurysa flavocapitata</i>                                   | HM233903             | HM233851             |          |
| 19                             | <i>*Metadelphax propinqua</i>                                    | HM017486             | HM017350             |          |
| 20                             | <i>*Nilaparvata bakeri</i>                                       | JX266790             | KX246078             |          |
| 21                             | <i>*Opiconsiva nigra</i>                                         | KX246227             | KX246064             |          |
| 22                             | <i>*Shadelphax eforiae</i>                                       | KX246253             |                      |          |
| 23                             | <i>*Sogatella furcifera</i>                                      | JQ305716             | KX246029             |          |
| 24                             | <i>*Tagosodes pusanus</i>                                        | HM233913             | HM233865             |          |
| 25                             | <i>*Unkanodes sapporona</i>                                      | KX246199             | KX246034             |          |
| Tribe Tropidocephalini species |                                                                  |                      |                      |          |
| 26                             | <i>Arcofacies</i> sp.<br>( <i>Arcofacies securisus</i> sp. nov.) | MK922242<br>MK922243 | MN116030<br>MN116031 |          |
| 27                             | <i>Arcofaciella</i><br>( <i>Gufacies sinuate</i> sp. nov.)       | MK922244<br>MK922245 | MN116034<br>MN116035 |          |
| 28                             | <i>Purohita taiwanensis</i>                                      |                      | MN116033             |          |
| 29                             | <i>Tropidocephala sinuosa</i>                                    |                      | MN116021<br>MN116022 | MN957008 |
| 30                             | <i>*Arcofacies strigatipennis</i>                                | KX246184             | KX246014             |          |
| 31                             | <i>*Bambusiphaga taibaishana</i>                                 | KX246183             | KX246013             |          |
| 32                             | <i>*Tropidocephala festiva</i>                                   | KX246168             | KX245997             |          |

**Phylogenetic analyses:** The selected taxa for the phylogenetic analysis were the species of the genus occurring in India. Most of the sequences were from our own study and 12 sequences were retrieved from NCBI GenBank. A total of 32 taxa comprising of 4 gene sets (28S region D2 and D9-D10, mtCOI and Histone) were used for the exploration and placement species. In a total matrix length of 2588 bp for the combined DNA sequences used for phlogenetic analysis. The taxon sample

included the 28 species from tribe Delphacini and 8 species from tribe Tropidocephalini. *Cixius scrupeus* was used as outgroup.

The Phylogram from maximum likelihood (ML) analysis of combined data is shown in Fig. 61. The tree is well resolved with both SH-like approximate likelihood ratio test (SH-aLRT) and ultrafast bootstrap (UFB) scores, which specify that most branches have moderate to high support. The phylogram from the analysis shows that, both the tribe Delphacini and Tropidocephalini are bifurcated into two clear clades and supporting both the tribe as paraphyletic in nature.

The tribe Tropidocephalini forms three clades of which the first clade formed by species of genus *Tropidocephala*, i.e., *T. festiva* and *T. tuberipennis*; the second clade species *Arcofacies strigatipennis*, *Bambusiphaga taibaishana* and third clade species formed by species *Purohita taiwanensis*, *Arcofacies securisus* sp. nov. *Arcofaciella sinuata* sp. nov. and *Tropidocephala sinuosa* with average SH-aLRT value 86.7 and 94.1 UFB value. Based on this the genera of tribe going paraphyletic with more than one ancestors.

The tribe delphacini forms seven clades. The first clade formed by *Nilaparvata bakeri* and *Unkanodes sapporona*, second clade with *Tagosodes pusanus* *Metadelphax propinqua* *Eoeurysa flavocapitata*, third clade with *Sogatella Vibix*, *Eoeurysa sagitta* sp. *Neukanodes unispinatus*, *Parasogata sexpartita* sp. nov. and *Peregrinus maidis*, fourth clade formed by *Coronacella sinhalana*, *Falcotoya daluoensis*, *Cemus zhitus*, fifth clade formed by *Nycheuma nilotica* and *Toya nigra*, the sixth clade is formed by *Sogatella furcifera*, *Sardia rostrata*, *Toya propinqua* and the seventh clade with species *Terthron albobittatum* and *Laodelphax striatellus*. The species *Shadelphax eforiae*, *Chloriona unicolor*, *Sogatella kolophon*, *Phyllodinus* sp. nov. *Cemus sauteri*, *Perkinsiella insignis* and *Nilaparvata lugens* do not form clade with any other species. The branching in Delphacini well supported by average SH-aLRT value 82.2 and 87.6 UFB values. Based on this the genera and tribe of Delphacinae are paraphyletic in nature. The results of our study highlight that both the tribe Delphacini and Tropidocephalini are paraphyletic in nature and it is clearly resolved and supported by the data used in the study.

## 5. DISCUSSION

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The results of the Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea) from India comprising 10,213 specimens collected from various biogeographic locations of nine Indian states revealed that Indian delphacids account rise from 51 previously described species to 73 described species. The survey and collection has been done from 26 different localities from 9 states such as Arunachal Pradesh, Andhra Pradesh, Himachal Pradesh, Maharastra, Nagaland, Karnataka, Kerala, union territory of Delhi and Ladhak. Collections were carried out by sweep net, mercury vapor lamp light trap and aspirator. Standard protocols were followed for procuring and processing the samples for morphological and molecular studies. 1. Morphological studies: sorting, pinning, labeling and genitalia dissection. 2. Molecular studies: specimens stored in 100% alcohol under -20°C, DNA extraction according to manufactures protocol and amplified product of 4 gene regions (mtCOI, 28SD2, 28SD9-D10 and Histone gene) were sequenced, sequences were submitted to NCBI Genbank.

The complete annotated checklist is provided for 4 subfamilies, 5 tribes, 36 genera and 73 species of Indian fauna. It comprises of species valid name, synonyms, details of type species, Indian distribution, type locality and type deposition. The checklist provide the complete information on Indian fauna. Along with this illustrative keys were provided for subfamily, tribe, genera and species of Delphacidae. We have also provided the illustrative diagnostic keys for identification of delphacids in rice agro ecosystems. These keys helps in authentic and rapid identification of species.

The study describes 39 species, which includes 9 new species described under *Eoeurysa*(1), *Harmalia*(1), *Parasogata*(1), *Phyllodinus*(1), *Soagata*(1) genera of Delphacini and *Arcofacies*(1), *Arcofaciella*(1), *Bambusiphaga*(2) genera of Tropidocephalini, along with 13 species new records from India (*Cemus sauteri*, *Cemus zhitus*, *Chloriona unicolor*, *Mahmutkashgaria liboensis*, *Miranus varians*, *Neunkanodes unispinatus*, *Shadelphax eforiae*, *Toya nigra*, *Toya tuberculosa*, *Unkanodes latespinosa* of Delphacini and *Tropidocephala sinuosa*, *Tropidocephala tuberipennis* and *Purohita taiwanensis* of Tropidocephalini) and 9 genus new records from India (*Chloriona*, *Mahmutkashgaria*, *Miranus*, *Neunkanodes*, *Parasogata*,

*Phyllodinus*, *Shadelphax*, of Delphacini and *Arcofacies*, *Bambusiphaga* of tropidocephalini). Till date 51 species were recorded from India, in present study we have added 9 new species and 13 newly reported species from India. In total 23 species were added to Indian fauna of Delphacidae, which account for 45% of the previously described species. Barcoding and phylogeny analysis was carried out by using 4 genes viz., mtCOI (650bp region), 28SD2, 28SD9-D10 and Histone gene. The relationship among the various taxa described in the study is discussed in the following pages.

### 5.1. Family Delphacidae

Delphacidae is the second largest family of Fulgoroidea, constituting important agricultural pest. Members of the family are identified based on the presence of hind tibial spur (calcar). It comprises of six subfamilies (Asiracinae Motschulsky, 1863; Delphacinae Leach, 1815; Kelisiinae Wagner, 1963; Plesiodelphacinae Asche, 1985; Stenocraninae Wagner, 1963; Vizcayinae Asche, 1990) and 14 tribes (Tribe Asiracini Fieber, 1872; Eodelphacini Emeljanov 1995; Idiosystatini Emeljanov, 1995; Neopunanini Emeljanov, 1995; Platysystatini Emeljanov, 1995; Tetrasteirini Emeljanov, 1995; Ugyopini Fennah, 1979; Plesiodelphacini Asche, 1985; Kelisiini Wagner, 1963; Vizcayini Asche, 1990; Stenocranini Wagner, 1963; Tropidocephalini Muir, 1915; Saccharosydniini Vilbaste, 1968; Delphacini Leach, 1815) and 2,214 extant described species worldwide. First extensive study on Indian Delphacidae was done by Distant (1906, 1916). From India, 4 subfamilies (Asiracinae Motschulsky, 1863; Delphacinae Leach, 1815; Stenocraninae Wagner, 1963; Vizcayinae Asche, 1990), 5 tribes (Ugyopini Fennah, 1979; Vizcayini Asche, 1990; Stenocranini Wagner, 1963; Tropidocephalini Muir, 1915; Delphacini Leach, 1815), 27 genera and 51 species (including species from present study) has been described, which is very less in comparison to world described species.

### 5.2 Subfamily Delphacinae

Delphacinae is the largest subfamily of Delphacidae, includes three tribes Delphacini, Tropidocephalini and Saccharosydniini. The important subfamily characters, Post-tibial spur with or without teeth on hind margin; aedeagus fused with phallobase to form phallosome, differentiate the subfamily from others. In the present



study aedeagus is the generally used term for phallotheca to make it more convenient to use and understand. Most of the described species from India (51 species) are from Delphacinae because of its wide distribution and highest species diversity in tropics.

### 5.2.1 Tribe Delphacini

Delphacini (Delphacinae) is the largest tribe of Delphacidae with 328 genera and 1,631 species (Bourgoin 2019). Individuals of the tribe recognized by the hind-tibial spur with teeth on hind margin; aedeagus fused with phallobase to form phallotheca. Most of the species are grass feeders and includes vectors of plant diseases too.

#### 5.2.1.2 The Generic and species affinities of Delphacini

##### Relationship between the species of *Cemus* Fennah

Dark grey to black habitus, Forewing veins ornamented with prominent black granules and asymmetrical aedeagus, makes the genus *Cemus* Fennah. Externally very similar to the genus *Mahmuktashgaria*, however the earlier can be differentiated by the smaller habitus and absence of median process of the pygofer.

Two species, *Cemus sauteri* (Muir) and *Cemus zhitus* Kuoh are studied here, both the species are new record to India. *Cemus sauteri* earlier recorded from China, Japan, Fiji, Srilanka and Australia and *Cemus zhitus* earlier recorded from China only. Externally both species very similar and theses can only be differentiated by the male genitalia characters, especially the aedeagus and parameres. Brachypterous form is similar in appearance except the sclerotization and length of wing.

The genus *Chloriona* Fieber newly recorded from India with a species *Chloriona unicolor* Herrich-Schaffer, earlier it was recorded from Southern palearctic countries except India. The species externally similar to *Sogata* sp. nov. and can be differentiated from the later by converging vertex, parameres reaching the laterodorsal angles of pygofer and aedeagus flattened, ornamented with subapical spines at base of gonopore.

Genus *Coronacella* Metcalf characterized by small, with black and white patterned, cryptic with other delphacids, pronotum with white transverse band on posterior three fourth of pronotum. *Coronacella sinhalana* (Kirkaldy) externally look very similar to *Laodelphax striatellus* (Fallen, 1826) except black median carina of frons, however the genitalia structure vary widely.

*Eoeurysa* Muir, 1913 is an economically important genus feeds on sugarcane. It comprised of two described species, *Eoeurysa flavocapitata* Muir and *E. arudina* Kouh and Ding. *Eoeurysa flavocapitata* Muir was reported on sugarcane from India (Chatterjee, 1971). We described new species *Eoeurysa* sp. nov., which is distinctly dorsoventrally flattened body, converging vertex and forewings held roof like, but differs from both described species by the white habitus and genitalia structure.

The genus *Falcotoya* Fennah is new report to India with a species *Falcotoya daluoensis* Ding, it was earlier recorded from China. Members of the genus differentiated by the approximately sickle shaped aedeagus ornamented with small teeth. This species externally similar to *Laodelphax striatellus*, but can be distinguished by the bifurcated median carina at base of frons and tubular aedeagus sickle shaped with rows of spines.

Genus *Harmalia* Fennah characterized by the pygofer with expanded dorsal portion in caudal view, armature of the diaphragm longer than wide. The *Harmalia* sp. nov. can be distinguished by congeners by the yellowish orange habitus, tubular aedeagus with basal extension, armature of diaphragm with a stout process and hook like parameres.

Genus *Laodelphax* Fennah comprises small individuals with black and white patterned and cryptic with other delphacids. This genus very similar to *Coronacella* Metcalf, however it can be differentiated by the white median carinae of frons. *Laodelphax striatellus* (Fallen, 1826) is only one species studied here and reported from Delhi NCR for the first time. It is economically very important pest in East Asian countries such as China, Korea and Japan, transmitting Rice Stripe Virus (RSV) (Otuka, 2013). The pest density in India increasing upon time and it may attain the major pest status if the competition is low. This species can get confused with *Coronacella sinhalana* (Kirkaldy) and *Falcotoya daluoensis* Ding until the keen observation is made.

Genus *Mahmutkashgaria* (Chen and Ding, 2002) externally similar to *Cemus* Fennah except in habitus size. This genus contains larger species with midventral processes of pygofer and subapical lateral process of paramere are unusual characters of this genus. The genus represented by two species, *Mahmutkashgaria sulculatus* (Ding) and *Mahmutkashgaria liboensis* (Chen) from China. The genus is newly reported from India along with a species *Mahmutkashgaria liboensis* (Chen).

The genus *Metadelphax* Wagner greatly related to *Toya* Distant and can be differentiated by pygofer dorsal portion expanded in caudal view with apices inflected (usually medially or ventromedially directed) and armature of the diaphragm longer than wide. *Metadelphax propinqua* (Fieber, 1866) which is the most commonly occurring species in rice ecosystems. Brachypterous form were found in the *M. propinqua*.

The genus *Nilaparvata* Distant cosmopolitan in distribution with species *N. lugens* found almost in all the states of India. The key character of the genus is the presence of 1-5 small spines on the inner side of the hind basitarsi. Out of 19 species of this genus two were described from India i.e *N. lugens* and *N. bakeri* (Nimisha, 2008). Present study includes only *Nilaparvata lugens* which is very similar to *N. bakeri* externally but varies in the male genitalia characters like upturned aedeagus and triangular apical end of paramere.

Genus *Nycheuma* Fennah studied with species *Nycheuma nilotica* Linnavuori. The species externally resembles *Peregrinus maidis* (Ashmead) but can be distinguished by the forewing markings and male genitalia structure. Species of this genus show distinct alary dimorphism. Present study records the stramineous macropterous forms and black forewing covering the full abdomen length in brachypterous forms.

Genus *Opiconsiva* Distant differs from other genera of Delphacini in the the shiny black mesonotum and tubular aedeagus with basal foldings. The species, *Opiconsiva tangaria* (Matsumura, 1910) recorded during study externally cryptic with other delphacini species but can be differentiated by the tubular aedeagus and Parameres relatively flattened, apically bifurcated. Black colour brachypterous form recorded here.

This genus *Parasogata* Zhou, Yang and Chen, 2018 is readily recognized by its large size, vertex, pronotum and mesonotum bearing an uninterrupted white fascia. The genus externally similar to *Sogata* Distant, 1906 but separated by the phallus being up-curved with a row processes at subapically. The genus earlier recorded from china and present study report the genus as new record to India along with *Parasogata sexpartita* sp. nov. which differs from other described species by aedeagus with 6 subapical dorsal processes; segment 10 with 2-pair of processes, ventral about 4x length of dorsal.

*Peregrinus* Kirkaldy includes the larger species and can be identified by the extremely long aedeagus and absence of the lateroapical process of the tenth segment. *Peregrinus maidis* (Ashmead) is very similar to *Nycheuma nilotica* Linnavuori in external appearance except habitus length. The genus *Perkinsiella* Kirkaldy includes the larger species. The triangular scape of antenna and large white vitta along the intracarinal area of thorax, differentiate it from other genera of delphacidae.

#### **Relationship between the species of *Perkinsiella* Kirkaldy**

Two species of the genus, *Perkinsiella insignis* (Distant) and *Perkinsiella sinensis* Kirkaldy were studied. The *Perkinsiella insignis* (Distant) black species whereas *Perkinsiella sinensis* Kirkaldy stramineous. *Perkinsiella insignis* can be differentiated by flattened aedeagus, ventrally curved with pair of symmetrical subapical processes. Both the species were reported as pests of maize and sugarcane and vectors of Fiji disease and Sugarcane yellow leaf phytoplasma.

The genus *Phyllodinus* Van Duzee characterized by the enlarged femur and tibia of front and middle legs. Members of this genus externally resembles genus *Cemus* Fennah but varies based on the enlarged portion of leg. Brachypterous forms are more prevalent in this genus. The genus is controversial with only one valid i.e., *Phyllodinus nervatus* Van Duzee other described species are shifted to *Cemus* Fennah. The *Phyllodinus* sp. nov. described here assigned to the genus by the enlarged femur and tibia of front and middle legs. One can easily misidentify this species with brachypterous form of *Cemus sauteri* (Muir) unless get acquainted with genus level characters. This species differs from *P. nervatus* Van Duzee by pygofer with medioventral sharp spine like processes and aedeagus decurved with apical gonopore, decurved process of same length with acute apex.

The genus *Sardia* Melichar unique among the genera of Delphacini in having dark colored forewing and thorax in addition to the elongate head projecting beyond the compound eyes (Asche, 1990) and pointed vertex. This genus is represented by a single species *S. rostrata* Melichar and it is very distinct from all other species in the present study by the tubular aedeagus with slightly curved apex and Parameres sickle shaped.

The genus *Shadelphax* Ding is newly reported from India along with species *Shadelphax eforiae* (Dlabola), earlier it was recorded from China, Iran, Mangolia.

This is similar to *Opiconsiva tangaria* (Matsumura, 1910) in external appearance except pronotum colour and diverging parameres, pygofer without median process; aedeagus with dorsolateral spines from meddile to apex and left side with many small teeth at central to basal areas.

*Sogata* Distant comprises moderately larger species, frons with black intercarinal areas, aedeagus ventrally curved without any teeth. The *Sogata* sp. recorded in the study is closely related to *C. unicolor* based on external appearance. However this species can be easily identified by black intercarinal areas of frons and aedeagus without any processes, basally broad with apically sharp decurved apex.

### **Relationship between the species of *Sogatella* Fennah**

The genus *Sogatella* Fennah includes slender planthoppers with a pale white vitta extending from vertex to mesonotum, aedeagus twisted with two rows of small teeth (Wilson and Claridge, 1991). Coloration of vertex, frons, clypeus, thorax and claval pterostigma variable.

During the study 3 species, *Sogatella furcifera* (Horvath); *Sogatella kolophon* (Kirkaldy); *Sogatella vibix* (Haupt) were recorded from this genus. All three species were commonly occurring in rice fields as pest and vectors of important rice diseases Southern rice black-streaked dwarf virus (SRBSDV) which caused outbreak of disease in Southern china. Most economically important the *Sogatella furcifera* (Horvath), which occur in more population than other two species. *S. furcifera* can be differentiated from *S. kolophon* and *S. vibix* (Haupt) species by black face, claval pterostigma of wings, twisted aedeagus with two rows of spines and ventral margin of the pygofer with a stout median process. *S. kolophon* can be differentiated from other two species by stramineous face, dark suffusion of wings, absence of claval pterostigma and twisted aedeagus with two parallel rows and lateral gonopore at apex. *S. vibix* can be differentiated from other two species by dark gena contrasting with stramineous frons and parallel rows aedeagus spines uniting ventrally.

The genus *Tagosodes* Asche & Wilson is often confused with the genus *Sogatella* as they closely resemble each other but differ in the Forewings hyaline with black markings and straight tubular aedeagus. In the genus *Tagosodes* the diaphragm never forms a broad U-shape as in *Sogatella*, the aedeagus more or less straight tube and never twisted (Asche, 1990) *Tagosodes pusanus* Acshe and Wilson is the only

representative species under this genus (Asche and Wilson, 1990), which is similar to *Sogatella furcifera* (Horvath) and can be differentiated by Forewings hyaline with black apical margin and straight tubular aedeagus with irregularly placed apical spines.

*Terthron* Fennah can be differentiated by pronotum and mesonotum amber coloured with a median stramineous vitta extending from vertex to tip of scutellum. *Terthron albovittatum* (Matsumura) can be differentiated by the genus characters plus aedeagus tubular and deeply curved ventrally.

### **Relationship among the species of the genus *Toya* Distant**

*Toya* Distant genus comprises small planthoppers with very short vertex that distinguishes them from other genera of Delphacinae (Wilson and Claridge, 1991). *Toya bridwelli* (Muir) is species earlier reported from India. *Toya nigra* (Crawford) and *Toya tuberculosa* (Distant) were recorded during the present study.

Intercarinal areas of frons are light fuscous in *Toya tuberculosa* whereas it is dark fuscous in *Toya nigra*, other characters of male genitalia like process on the medio-dorsal margin of the diaphragm, shape of paramere and aedeagus vary across the species. Both species are new record to India, *Toya nigra* was earlier reported from New world and *Toya tuberculosa* was earlier reported from Spain, Turkey, Italy.

The genus *Unkanodes* Fennah recognized by mesonotum black with offwhite median carinae; laterodorsal angle of pygofer produced; aedeagus tubular with regularly placed spines. *Unkanodes latespinosa* (Dlabola) studied with both macropterous and brachypterous forms. Present study report this genus and species as new record to India, it was earlier reported from Afganistan, Mangolia, Iran, Turkey.

### **5.2.2 Tribe Tropidocephalini**

Tropidocephalini is the second largest tribe of Delphacinae (Hemiptera: Delphacidae) established by Muir, 1915. This tribe includes 37 genera (192 species), with its distribution in Oriental, Palearctic, Afrotropical, Neotropical, Australian and Pacific regions of the world (Huang *et al.*, 2018, Bourgoïn 2019). Bamboo (Poaceae, subfamily Bambusoideae) is the major host of most species of the tribe and some species feed on other grasses (Poaceae) (Chen 2003, Chen and Tsai 2009).

### 5.2.2.1 The Generic and species affinities of Tropidocephalini

The genus *Arcofacies* Muir is newly reported from India with species *Arcofacies* sp. nov distinguished by the median longitudinal vitta, bordered with dark brown, from frons apex to the end of mesonotum; the vertex and frons at right angle (in lateral view), the postclypeus strongly receding (in lateral view) relative to frons, and the aedeagus tubular or flat, with or without basal spinous process. The *Arcofacies* sp. is differs from all seven described species by aedeagus wavy tube with modified hook apically, orifice subapical; with spinous process from base. This species is collected on Bamboo plants.

*Arcofaciella* Fennah distinguishable from other genera, by strongly bent postclypeus, right angle to frons and frons in midline about 1.4x wider than maximum width. The genus has two currently available species *Arcofaciella verrucosa* Fennah, 1956 and *Arcofaciella obflexa* Guo and Liang, 2005. The present study describes *Arcofaciella* sp. nov. and new report of the genus with this species. The *Arcofacies* sp. and *Arcofaciella* sp. nov resemble each other externally.

Genus *Bambusiphaga* can be differentiated by anterior margin of vertex evenly rounded or truncated. Male genitalia differently modified with respective species. Most of the species of *Bambusiphaga* feed on Bamboo. Present study report the genus *Bambusiphaga* as new record to India along with two new species *Bambusiphaga unispina* Ramya and Meshram, and *Bambusiphaga* sp. nov.

Genus *Purohita* Distant peculiar in having antennal segments foliaceous, scape longer and wider than short and flattened pedicel. From India three species has been described and *Purohita taiwanensis* Muir is new record from India earlier it was recorded from Taiwan and Japan. Most of the species feed on the Bamboo and *Purohita taiwanensis* is also collected from Bamboo.

### 5.2.1.2.3. Relationship between the species of Tropidocephala Stal

The genus *Tropidocephala* Stal can be distinguished from other genera of Tropidocephalini by vertex producing in front of eyes apparently or very much, tricarinate. It is well distributed in tropics with around 50 described species out of which 8 species from India and present study reported *T. sinuosa* and *Tropidocephala tuberipennis* as new record to India. *T. sinuosa* was earlier reported from Taiwan whereas *Tropidocephala tuberipennis* was reported from Egypt, Israel, Italy.

In the present study we recorded three species, *Tropidocephala festiva* (Distant) *Tropidocephala sinuosa* Yang and Yang and *Tropidocephala tuberipennis* (Mulsant and Rey). Externally *T. festiva* (Distant) and *T. tuberipennis* (Mulsant and Rey) show greatest similarity except the colouration of wing. *Tropidocephala sinuosa* Yang and Yang differs from the both species by having distinctly protruding vertex than other two species and having orange habitus colour.

## 5.2 Phylogenetic analysis:

The very first phylogenetic analysis for Indian Delphacid fauna was carried out by using total of 32 species comprising of 4 gene sets (28S region D2 & D9-D10, mtCOI and Histone). Most of the sequence data used were from our own study and few of them were retrieved from NCBI GenBank. The maximum likelihood analysis carried out by using IQtree yielded a phylogram with well resolved clades. The two tribes of Delphacinae are shown as paraphyletic with well supported SH-like approximate likelihood ratio test (SH-aLRT) and ultrafast bootstrap (UFB) values. The results with the combined data set here shows the species, genera and tribes are paraphyletic in nature, which in contrast to the earlier phylogenetic studies statement as Delphacini and Tropidocephalini are monophyletic. The contrasting results are justified by the 4 different gene regions in the present study where as earlier studies used only mtCOI and 28srDNA region. The more taxon sequence data with many number of genes may further yield much well resolved phylogenetic tree. The present study used available sequences for the taxa described from India.



## 6. SUMMARY AND CONCLUSIONS

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The Biosystematic studies of Delphacidae (Hemiptera: Fulgoroidea) from India was undertaken based on the specimens collected from 26 different localities from different states such as Arunachal Pradesh, Andhra Pradesh, Himachal Pradesh, Maharashtra, Nagaland, Karnataka, Kerala, union territory of Delhi and Ladakh. A total of 10,213 specimens were collected and examined. The study was mainly based on the male genitalia characters along with female genitalia apart from external morphology of both male and female specimens. The detailed literature survey and examination of the specimens revealed presence of one subfamily, Delphacinae. Thirty nine species across 31 genera (Delphacini: 26 genera; Tropidocephalini: 5 genera) were studied.

Provided the complete annotated checklist for the family Delphacidae from India. Checklist comprises of species valid name, synonyms, details of type species, Indian distribution, Type locality, Type deposition. Checklist account for 4 subfamilies, 5 tribes, 36 genus, and 73 species. This will help us to know valid name of the species and its distribution. Along with this Illustrative keys were provided for subfamily, tribe, genera and species of Delphacidae. Also we have provided the illustrative diagnostic keys for identification of delphacids in rice agro ecosystems of India, which can be widely used for the easy and rapid identification by IPM workers. We have redescribed 30 species of 25 genera from India with addition photographic illustrations of male and female habitus, genitalia, along with the brachypterous form in respective species. The barcodes were generated for 23 species using 4 genes viz., mtCOI (650bp region), 28srDNA D2 and D9-D10, and Histone gene. The phylogenetic analysis was carried out for all the barcoded species to give an evolutionary relationship among the presented taxa in the study.

Delphacinae is the largest subfamily among the subfamilies studied. It represented by two tribes, Delphacini and Tropidocephalini. Delphacini is the largest tribe studied, represented by 31 species from 21 genera. The species of delphacini are patterned with white, stramineous and black. Most of the species were cryptic in nature. The genera represented in Delphacini are *Cemus* Fennah, *Chloriona* Fieber, *Coronacella* Metcalf, *Eoeurysa* Muir, *Falcotoya* Fennah, *Laodelphax* Fennah, *Nilaparvata* Distant, *Nycheuma* Fennah, *Mahmuktashgaria* Kocak and Kemal,

*Metadelphax* Wagner, *Miranus* Chen & Ding, *Opiconsiva* Distant, *Parasogata* Zhou, Yang and Chen, *Peregrinus* Kirkaldy, *Perkinsiella* Kirkaldy, *Phyllodinus* Van Duzee, *Sardia* Melichar, *Shadelphax* Ding, *Sogata* Distant, *Sogatella* Fennah, *Tagosodes* Acshe and Wilson, *Terthron* Fennah, *Toya* Distant, *Unkanodes* Fennah. Seven genera (*Chloriona* Fieber, *Mahmuktashgaria* Kocak and Kemal, *Miranus* Chen & Ding, *Neukanodes* Yang, *Phyllodinus* Van Duzee, *Shadelphax* Ding and *Unkanodes* Fennah) and 10 species (*Cemus sauteri*, *Cemus zhitus*, *Chloriona unicolor*, *Mahmuktashgaria liboensis*, *Miranus varians*, *Neukanodes unispinatus*, *Shadelphax eforiae*, *Toya nigra*, *Toya tuberculosa*, *Unkanodes latespinosa*) were newly recorded from India.

Tropidocephalini is the second largest tribe of Delphacinae. It represented by five genera, *Arcofacies* Fennah, *Arcofasciella* Fennah, *Bambusiphaga* Huang and Ding, *Purohita* Distant and *Tropidocephala* Stal. The two genera (*Arcofacies* Fennah, *Bambusiphaga* Huang and Ding) and three species (*Tropidocephala sinuosa*, *Tropidocephala tuberipennis* and *Purohita taiwanensis*) were newly recorded from India. Most of these species were collected on Bamboo.

## Conclusions:

- The present study described the 9 new species viz, *Arcofacies securisus* sp. nov., *Arcofaciella sinuata* sp. nov., *Bambusiphaga unispina* Ramya and Meshram, 2019, *Bambusiphaga* sp. nov., from Tropidocephalini and *Eoeurysa sagitta* sp. nov., *Harmalia* sp. nov., *Parasogata sexpartita* sp. nov., *Phyllodinus* sp. nov., *Sogata* sp. nov., from Delphacini.
- 13 species new record with 9 generic new records from India which led to addition of total 23 species to Indian fauna, which account for approximately 45% previously described species.
- Our Phylogenetic analysis by using by using 4 genes viz., mtCOI (650bp region), 28SD2, 28SD9-D10 and Histone gene, reveals the phylogenetic relationship among the genera and species within Delphacinae.
- Barcodes generated for the species in the present study helps in rapid identification and also act as reference sequence for the taxa which allow further molecular analysis and evolutionary studies among Delphacidae.

- We could resolve the complexity in *Laodelphax striatellus* Fallen by using mtCOI sequence as morphological features were not provided clear evidence of the species.
- Through present study we could conclude that the delphacid fauna is under studied taxa from India, further detailed survey and studies will definitely yield more number of new species and molecular studies will help to understand the evolutionary pattern and host plant relationships, which helps in better understanding the host plant-pest interactions.

## **Biosystematic studies of family Delphacidae (Hemiptera: Fulgoroidea) from India**

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### **ABSTRACT**

The planthopper family Delphacidae second largest and most economically important in Fulgoromorpha. It consists of 6 sub-families comprising 2,214 existing described species in 923 genera of 38 tribes worldwide. Many species cause considerable damage to graminaceous crops by feeding directly on the plants and by being vectors of plant pathogens. Being much economically important, Indian delphacids fauna was least investigated, accounting only 51 described species in comparison to 2214 species worldwide. Except, stray and isolated publications, the taxonomy of which stranded in uncertainty because of its less study and complexity in the group such as cryptic species, wing polymorphism and sexual dimorphism. Most of the previous studies were exclusively based on the morpho taxonomy with illustrations via line diagrams and there is no comprehensive work. The present work was aimed at describing the Indian delphacids along with key, checklist, photographic illustrations and molecular characterization. Survey and collections were conducted in 26 localities of 9 Indian states by using standard methods of collection (3.2) yielded 39 species of delphacids from Delphacini and Tropidocephalini of Delphacinae, which are described with photographic illustrations. For the description, characters studied were (3.10) with emphasis was given to male genitalia variation. Measurements were taken for above mentioned characters (3.11). Both macropterous and brachypterous of habitus, male genitalia and female genitalia illustrations were included for description. The complete annotated checklist is provided for 4 subfamilies, 5 tribes, 36 genera, and 73 species of Indian fauna. It comprises of species valid name, synonyms, details of type species, Indian distribution, type locality and type deposition. Along with this illustrative keys were provided for subfamily, tribe, genera and species of Delphacidae. We also provided the illustrative diagnostic key for identification of 12 most commonly occurring delphacids in rice agro ecosystems of India, which helps in authentic and rapid identification. DNA barcodes were generated and phylogenetic analysis was carried out based on four gene regions mtCOI, 28srDNA (D2 region and D9-10 region) and histone to understand the relationship among the various taxa, which yielded a well resolved phylogram indicating the paraphyletic nature of Delphacinae. The study contributed description 9 new species, 13 species new report and 9 generic new report to Indian delphacid fauna. The morphological and molecular characterization data was integrated to avoid ambiguity in identification.

## भारत से कुल (फैमिली) डेल्फसीडै (हेमिपेटेरा: फुल्गोरोइडीआ) का जैववर्गिकी अध्ययन

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### सार

पौध फुदका कुल डेल्फसीडै का दूसरा बड़ा और फुल्गोमोर्फा में आर्थिक रूप से सबसे महत्वपूर्ण है। इसमें 6 उपपरिवार हैं जिसमें विश्व की 2214 मौजूदा जातियां (स्पीशीज) हैं जो 925 पीढ़ी (जेनेरा) और 38 जनजातियां (ट्राइब) के हैं। इनमें से बहुत सी जातियां घास के परिवार की फसलों के पौधों को खाती हैं और कुछ पादप रोग जनक के वेक्टर का काम करते हैं। आर्थिक रूप से महत्वपूर्ण होने के बावजूद इन भारतीय डेल्फसीडै का कम अध्ययन किया गया अर्थात् 2214 जातियों (स्पीशीज) में से सिर्फ 51 प्रजातियों का ही अध्ययन किया गया। कुछ बिखरे हुए और पृथक प्रकाशनों को छोड़कर वर्गीकरण विज्ञान में इनका अध्ययन बहुत कम हुआ है क्योंकि इन समूहों में कुछ जटिलता भी है; जैसे गुप्त प्रजाति पंख बहुरूपता और, यौन बहुरूपता। पहले अधिकतर अध्ययनों में से इसे आकृति वर्गीकरण के साथ (लाइन डायग्राम) चित्र द्वारा दर्शाया जाता था; जो एक व्यापक कार्य नहीं होता था। वर्तमान अध्ययन में डेल्फसीडै की चेकलिस्ट, फोटो द्वारा दर्शना और अर्णवक लक्षण वर्णन (मॉलिक्यूलर कैरेक्टराइजेशन) को लक्षित किया गया है। सर्वेक्षण और संग्रह 9 भारतीय राज्यों के 26 स्थानों पर संग्रह के मानक तरीके जिनमें डेल्फसीडै में डेल्फासिने और ट्रेडेलसेफालिनी की 39 जातियां हैं जिसको फोटो के साथ विवरण दिया गया है। विवरण के लिए गुणों का अध्ययन में नर जनन अंग की विविधताओं पर लक्षण विशेष बल दिया गया है। पहले बतलाए गए सभी गुणों का माप भी किया गया है। हैबिट्स के दोनों मैक्रोप्टेरस और ब्रेकीप्टेरस के नर और मादा जननांग को शामिल किया गया है। पूरी सटीक चेक लिस्ट जिसमें भारतीय जिव 4 उपपरिवार (सब फैमिली) 5 जनजातियां (ट्राइब्स) 36 पीढ़ी (जेनेरा) और 73 जातियां (स्पीशीज) प्रदान की गईं। इसमें जातियों का वैद्य नाम समांतर शब्द टाइप जातियों का विस्तार भारतीय वितरण टाइप स्थान और टाइप निक्षेप दिया गया। इन दर्शायी हुयी कुंजी के अतिरिक्त डेल्फसीडै के उपपरिवार (सब फैमिली) जनजातिया (ट्राइब्स) पीढ़ी (जेनेरा) और जातियां (स्पीशीज) भी बताई गईं। हमने धान के भारतीय परिस्थितिकी में 12 सबसे आम डेल्फसीडै की पहचान की ओर नैदानिक की कुंजी भी बनाई जिसमें तीव्र और ठीक तरीके से पहचान की जा सकती है। DNA बारकोड भी बनाये और वंशावली विश्लेषण भी किया जो 4 जीन क्षेत्र mtCOI, 28srDNA (D2 क्षेत्र और D9 -10 क्षेत्र) और हिस्टोन जिसमें विभिन्न टैक्सा के संबंधों को समझने में मदद मिली; साथ ही एक अच्छी प्रकार से हल किया हुआ वंशावली ग्राम (फाइलों ग्राम) बना। जिससे डेल्फासिने की सम्यक प्रकृति का संकेत मिलता है। इस अध्ययन में भारतीय डेल्फासिड जीव की 9 नई जातियां, 13 जातियां के नए विवरण और 9 पीढ़ियों के नए विवरण मिले रूपात्मक और आणविकलक्षण वर्णन डाटा को एकीकृत करने से कीटों की पहचान करने में अस्पष्टता कम की जा सकती है।

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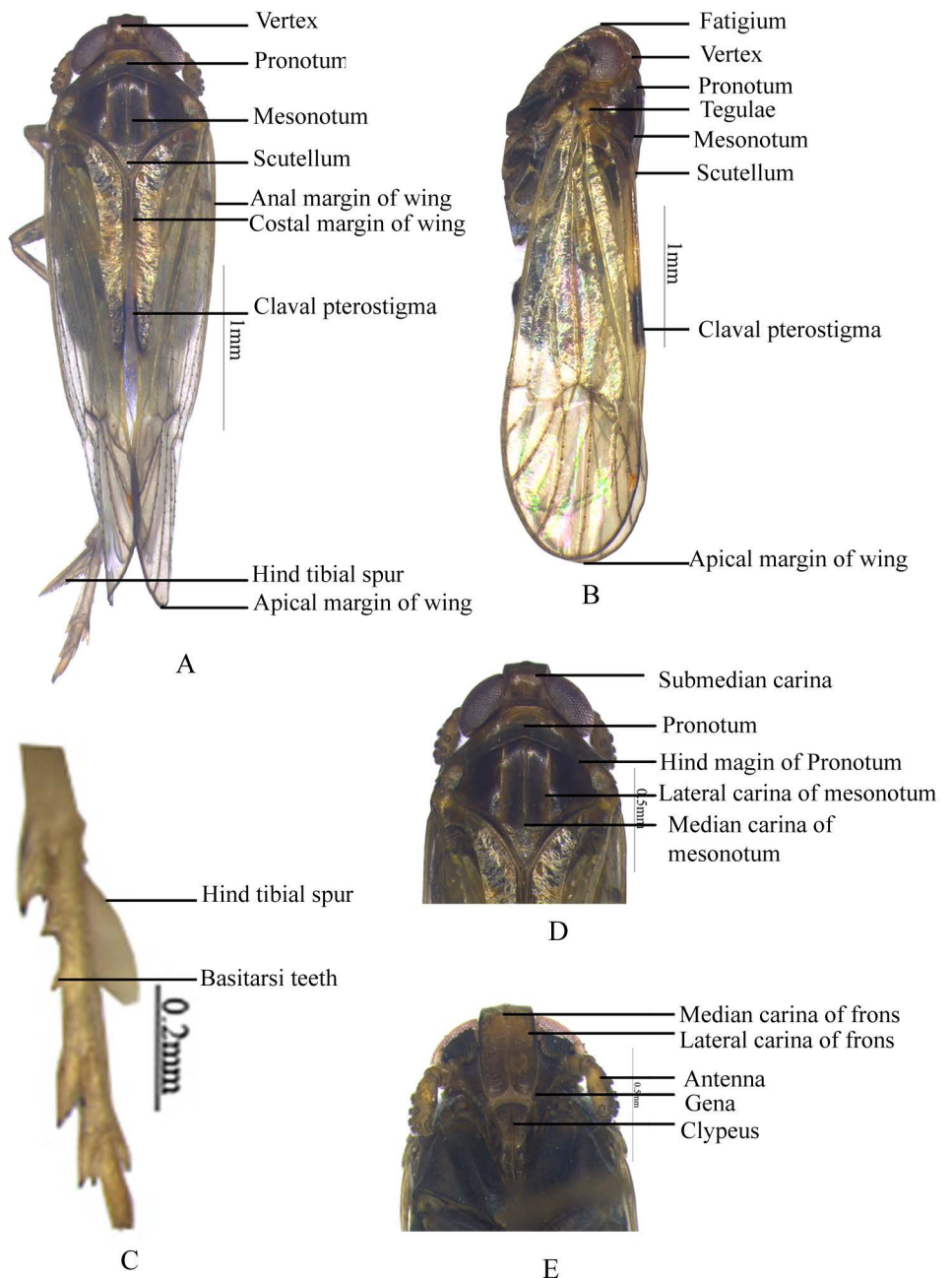


Plate: 1. Terminology of the characters used in the study. A. Habitus dorsal; B. Habitus lateral; C. Hindtibial spur and tarsi; D. Pronotum; E. Face

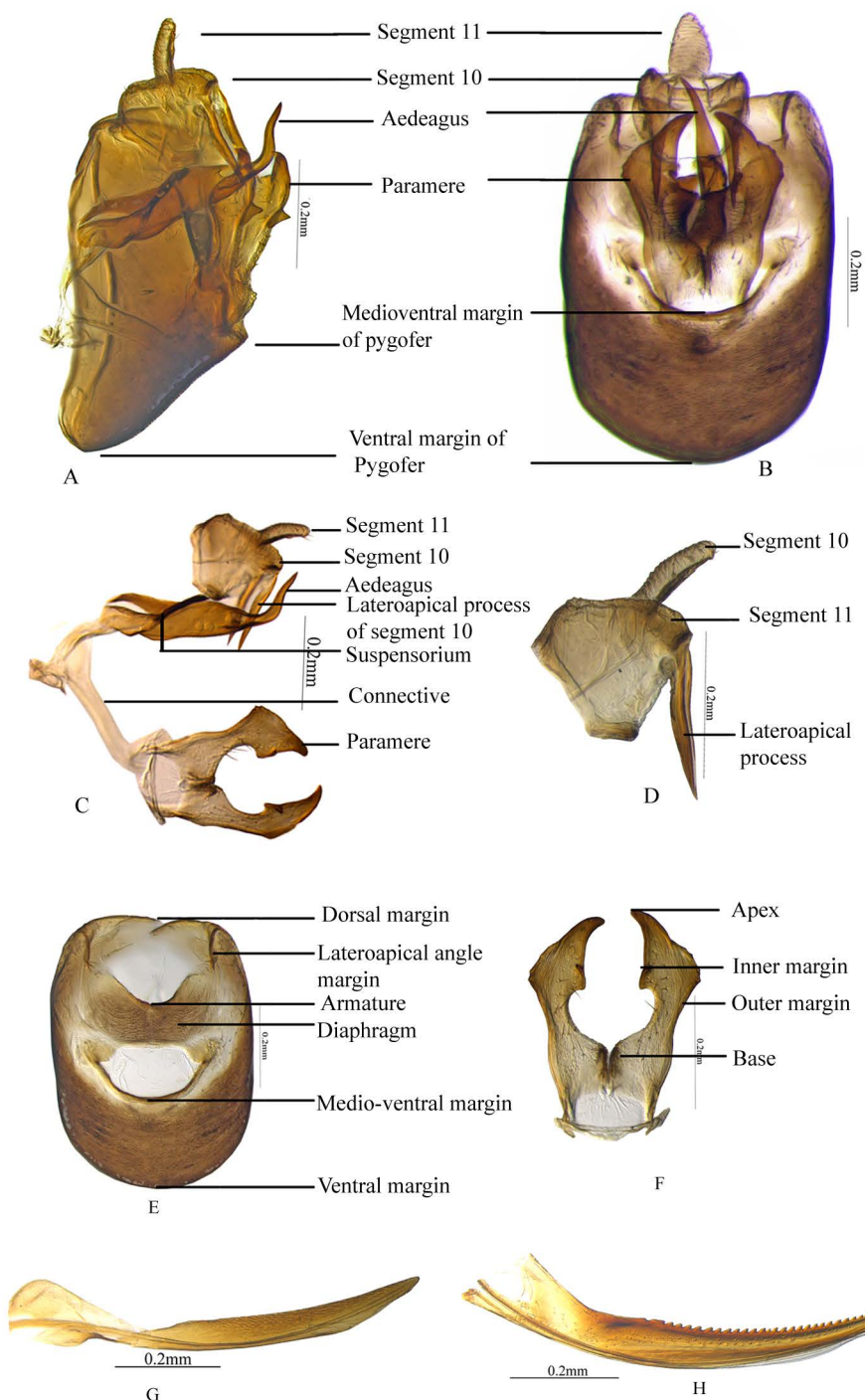


Plate: 2. Terminology of the characters used in the study. A, Genitalia lateral view; B, Genitalia caudal view; C, Aedeagal complex; D, Segment 10 and 11; E, Pygofer caudal view; F, Parameres caudal view; G, Valvulae I; H, Valvulae II

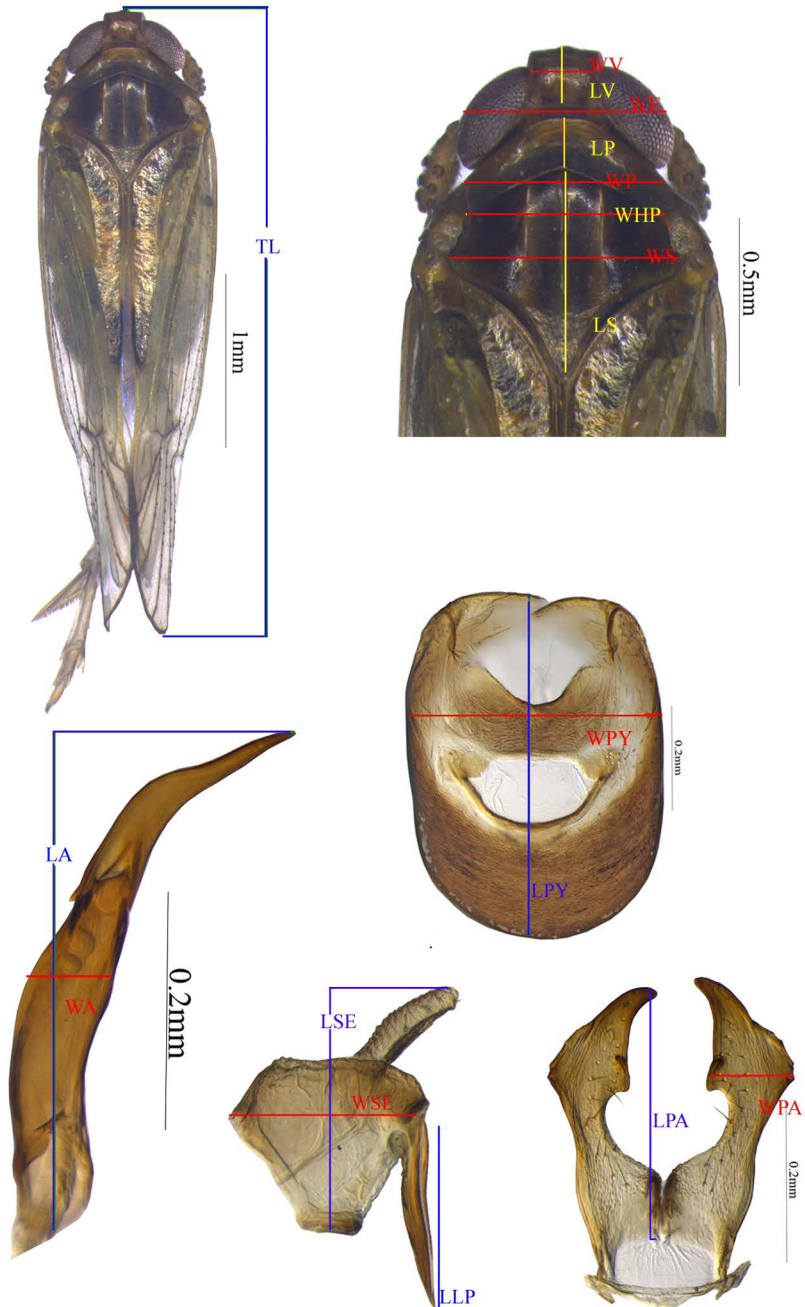


Plate 3. Measurements of morphological structures used in the study; Total length (TL) Length of pronotum (LP) Length of scutellum (LS); Length of vertex (LV); Length of pygofer (LPY); Length of Segment 10 and 11(LSE); Length of Latero-apical process(LLP); Length of paramere (LPA); Length of aedeagus (LA); Width across eyes (WE); Width of pronotum (WP); Width of vertex (WV); Width of scutellum (WS); Width of pygofer (WPY); Width of segment 10; Width of paramere (WPa); Width of aedeagus (WA); Width across hind margin of pronotum (WHP)





Plate. 4. Locations of Delphacidae specimen collection

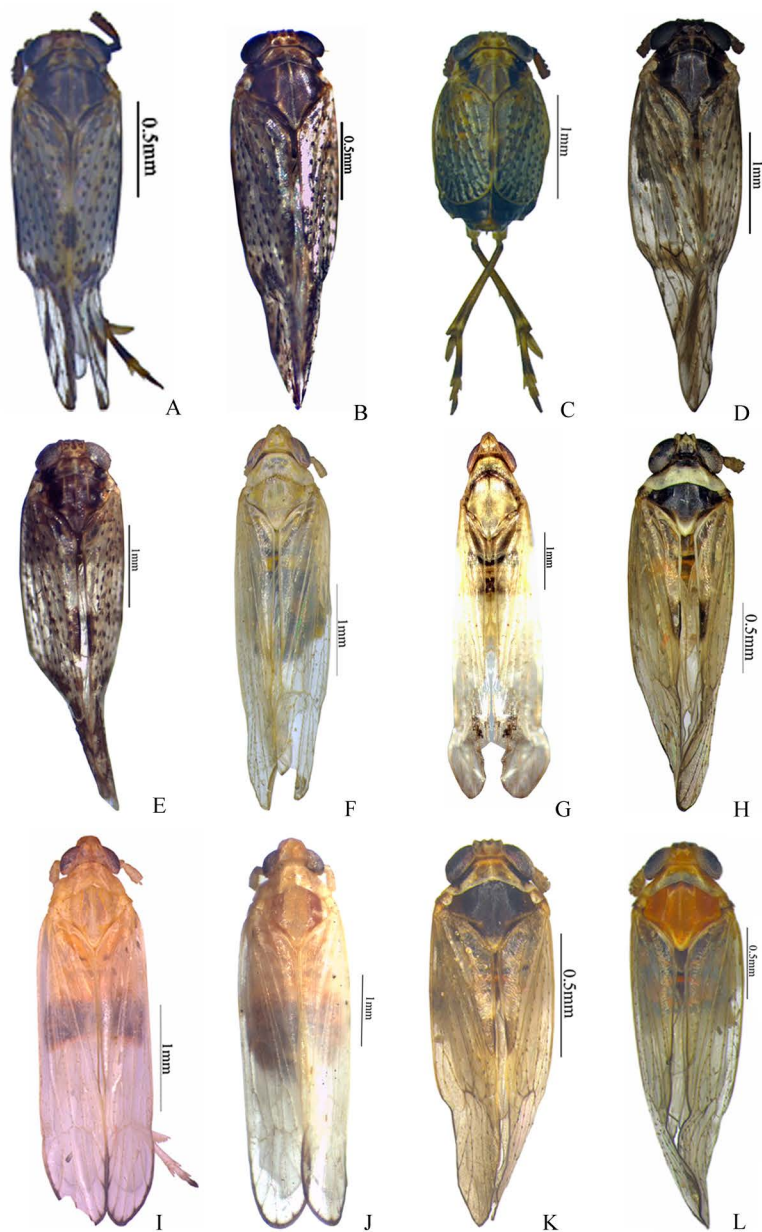


Fig. 1. Delphacini habitus dorsal. A. Male *Cemus sauteri* (Muir); B. Female *Cemus sauteri* (Muir); C. Brachpterous male *Cemus sauteri* (Muir); D. Male *Cemus zhitus* Kuoh; E. Female *Cemus zhitus* Kuoh; F. Male *Chloriona unicolor* (Herrich-schaffer); G. Female *Chloriona unicolor* (Herrich-schaffer); H. Male *Coronacella sinhalana* (Kirkaldy); I. Male *Eoeuryssa sagitta* sp. nov. 1; J. Female *Eoeuryssa sagitta* sp. nov. 1; K. Male *Falcotoya daluoensis* Ding; L. Male *Harmalia* sp. nov. 2.

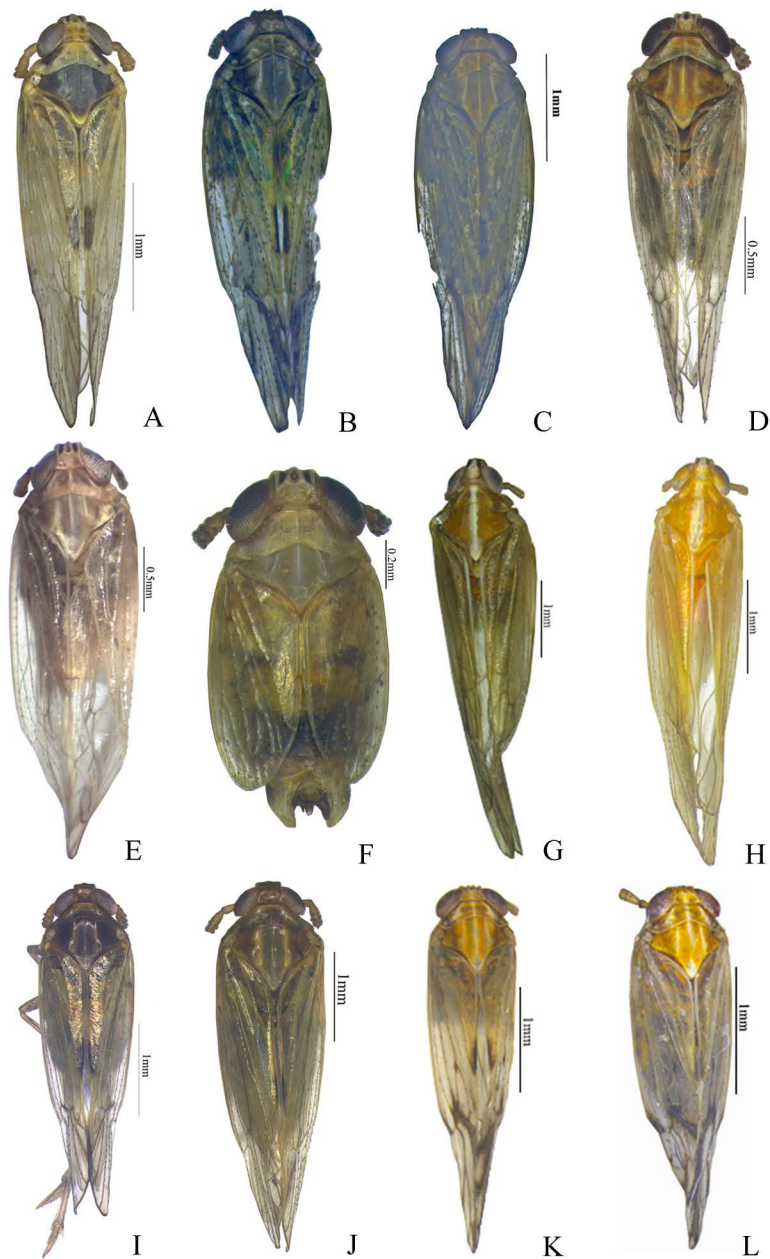


Fig. 2. Delphacini habitus dorsal, A. Male *Laodelphax striatellus* (Fallen); B. Male *Mahmutkashgaria liboensis* (Chen); C. Female *Mahmutkashgaria liboensis* (Chen); D. Male *Metadelphax propinqua* (Fieber); E. Female *Metadelphax propinqua* (Fieber); F. Brachypterous male *Metadelphax propinqua* (Fieber); G. Male *Miranus varians* (Kuoh); H. Male *Neunkanodes unispinatus* Hou, Yang and Chen; I. Male *Nilaparvata lugens* (Stål); J. Female *Nilaparvata lugens* (Stål); K. Male *Nycheuma nilotica* Linnavuori; L. Female *Nycheuma nilotica* Linnavuori.



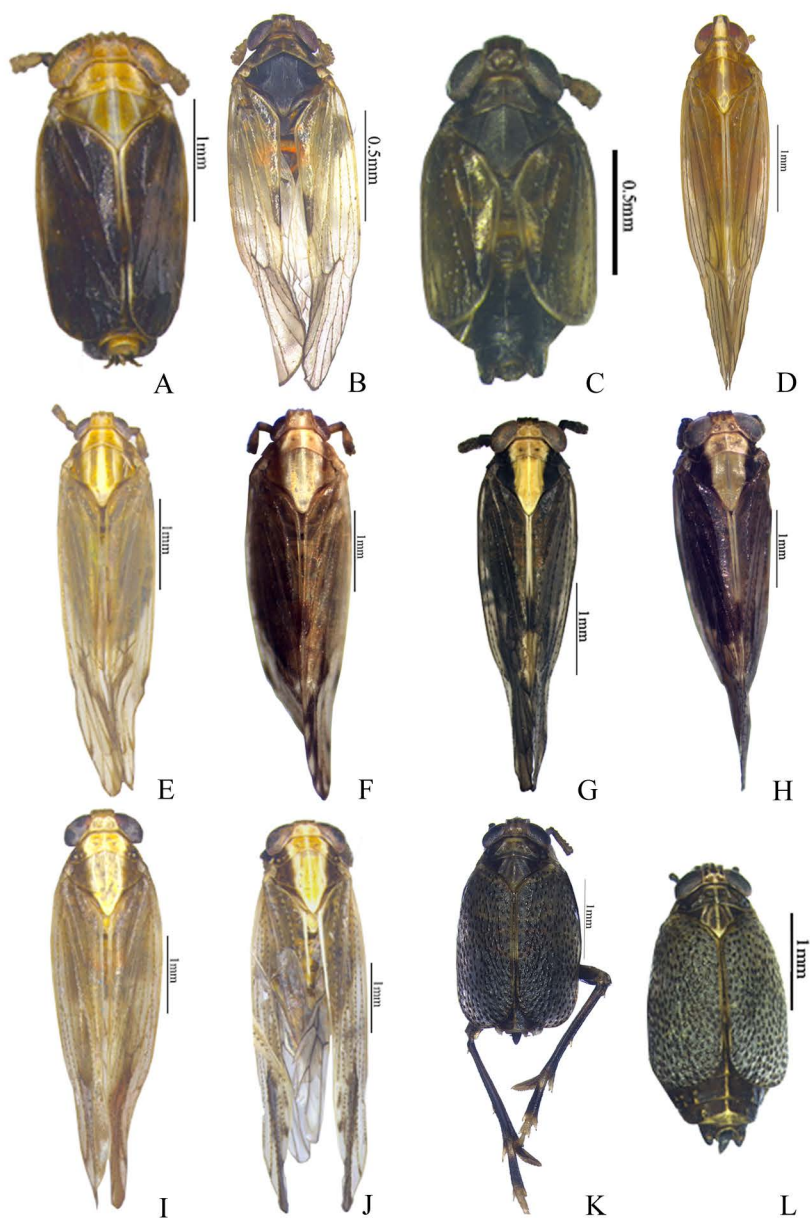


Fig. 3. Delphacini habitus dorsal, A. Brachypterous male *Nycheuma nilotica* Linnaevuori; B. Male *Opiconsiva tangaria* (Matsumura); C. Brachypterous male *Opiconsiva tangaria* (Matsumura); D. Male *Parasogata sexpartita* sp. nov. 3; E. Male *Peregrinus maidis* (Ashmaed); F. Female *Peregrinus maidis* (Ashmaed); G. Male *Perkinsiella insignis* (Distant); H. Female *Perkinsiella insignis* (Distant); I. Male *Perkinsiella sinensis* Kirkaldy; J. Female *Perkinsiella sinensis* Kirkaldy; K. Male *Phyllodinus* sp. nov. 4; L. Female *Phyllodinus* sp. nov. 4.



Fig. 4. Delphacini Habitus dorsal. A. Male *Sardia rostrata* Melichar ; B. Female *Sardia rostrata* Melichar; C. Male *Shadelphax eforiae* (Dlabola); D. Male *Sogata* sp. nov. 5; E. Female *Sogata* sp. nov. 5; F. Male *Sogatella furcifera* (Horvath); G. Female *Sogatella furcifera* (Horvath); H. Male *Sogatella kolophon* (Kirkaldy); I. Female *Sogatella kolophon* (Kirkaldy); J. Male *Sogatella vibix* (Haupt); K. Female *Sogatella vibix* (Haupt); L. Male *Tagosodes pusanus* (Distant).



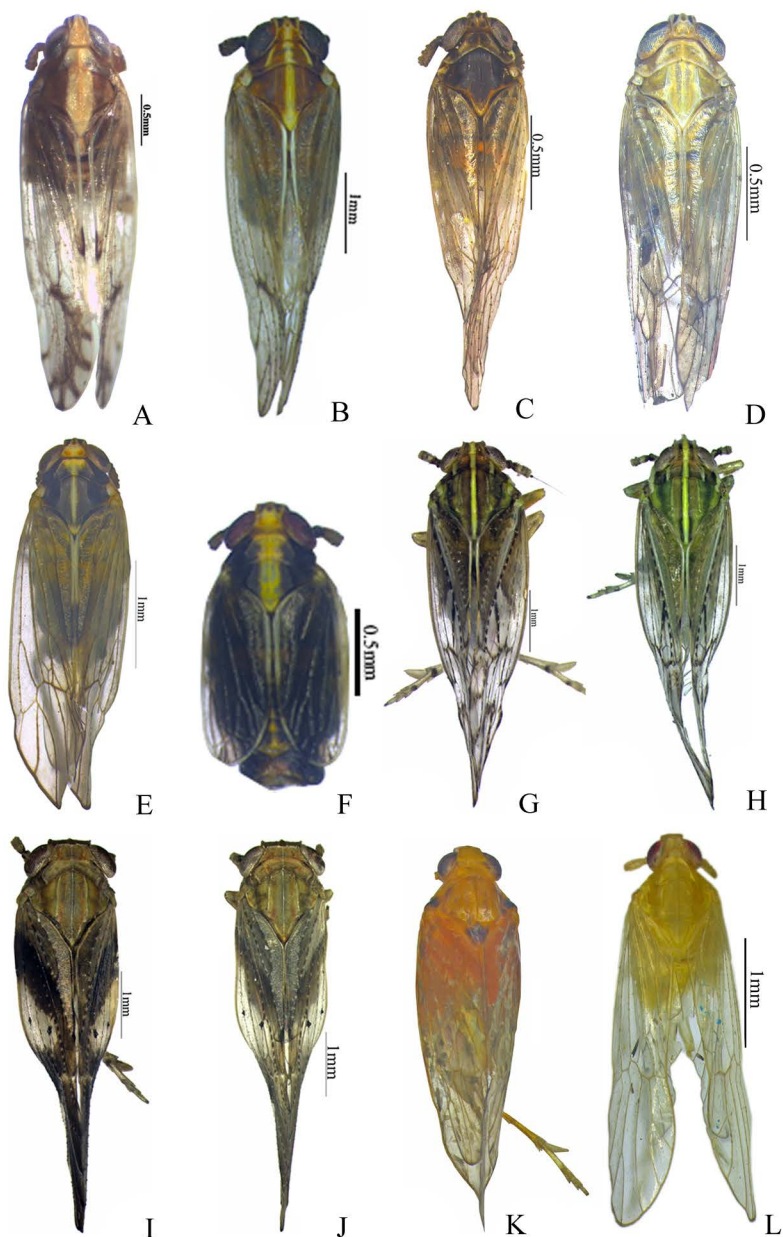


Fig. 5. Delphacini Habitus dorsal. A. Female *Tagosodes pusanus* (Distant); B. Male *Terthron albobittatum* (Matsumura); C. Male *Toya nigra* (Crawford) ; D. Male *Toya tuberculosa* (Distant); E. Male *Unkanodes latespinosa* (Dlabola); F. Brachpterous male *Unkanodes latespinosa* (Dlabola); G. Male *Arcofacies securisus* sp. nov. 6; H. Female *Arcofacies securisus* sp. nov. 6; I. Male *Arcofaciella sinuata* sp. nov. 7 ; J. I. Female *Arcofaciella sinuata* sp. nov. 7; K. Male *Bambusiphaga unispina* Ramya and Meshram 8; L. *Bambusiphaga* sp. nov. 9.

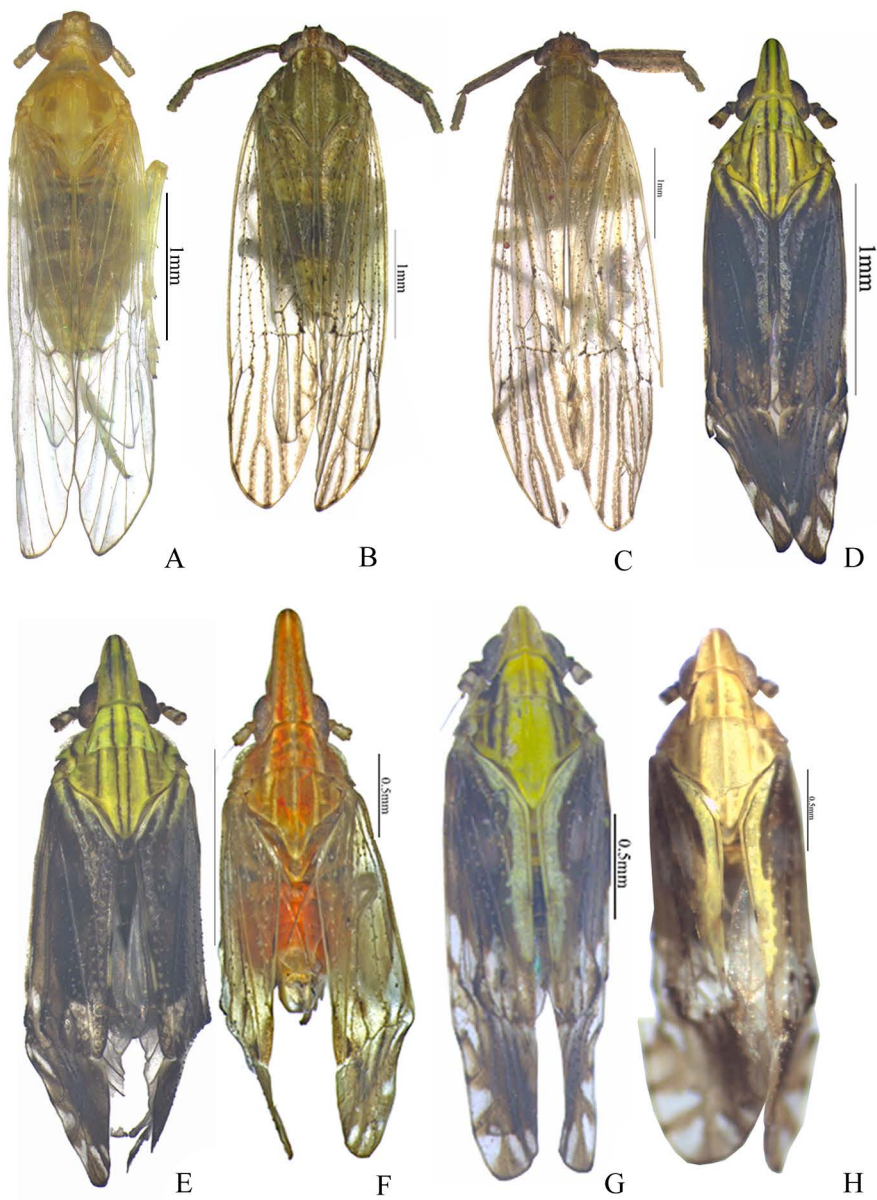


Fig. 6. Tropidocephalini habitus dorsal. A. Female *Bambusiphaga* sp. nov. 9; B. Male *Purohita taiwanensis* Muir; C. Female *Purohita taiwanensis* Muir; D. Male *Tropidocephala festiva* (Distant); E. Female *Tropidocephala festiva* (Distant) ; F. Male *Tropidocephala sinuosa* Yang and Yang; G. Male *Tropidocephala tuberipennis* (Mulsant and Rey); H. Female *Tropidocephala tuberipennis* (Mulsant and Rey).

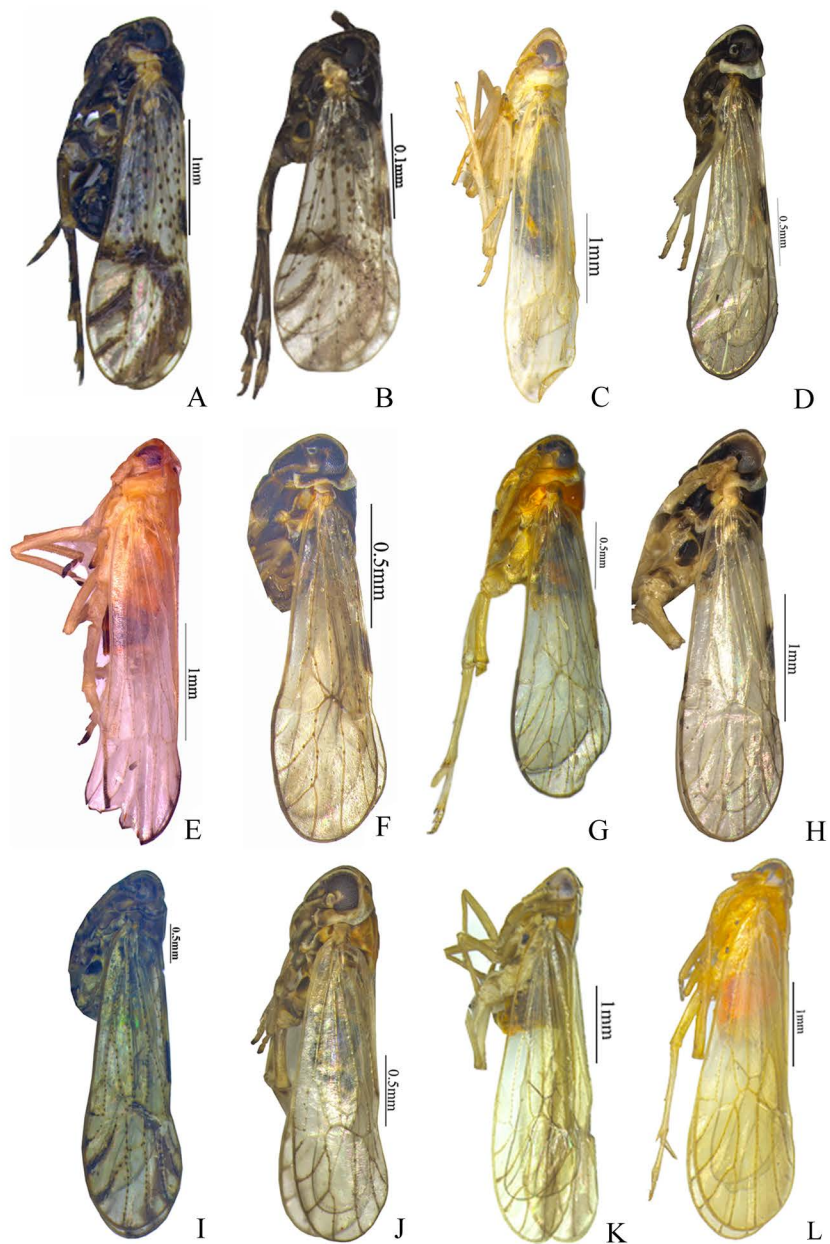


Fig. 7. Delphacini Habitus lateral. A. *Cemus sauteri* (Muir); B. *Cemus zhitus* Kuoh; C. *Chloriona unicolor* (Herrich-schaffer); D. *Coronacella sinhalana* (Kirkaldy); E. *Eoerysa sagitta* sp. nov. 1; F. *Falcotoya daluoensis* Ding; G. *Harmalia* sp. nov. 2; H. *Lao-delphax striatellus* (Fallen); I. *Mahmutkashgaria liboensis* (Chen); J. *Metadelphax propinqua* (Fieber); K. *Miranus varians* (Kuoh); L. Male *Neunkanodes unispinatus* Hou, Yang and Chen.



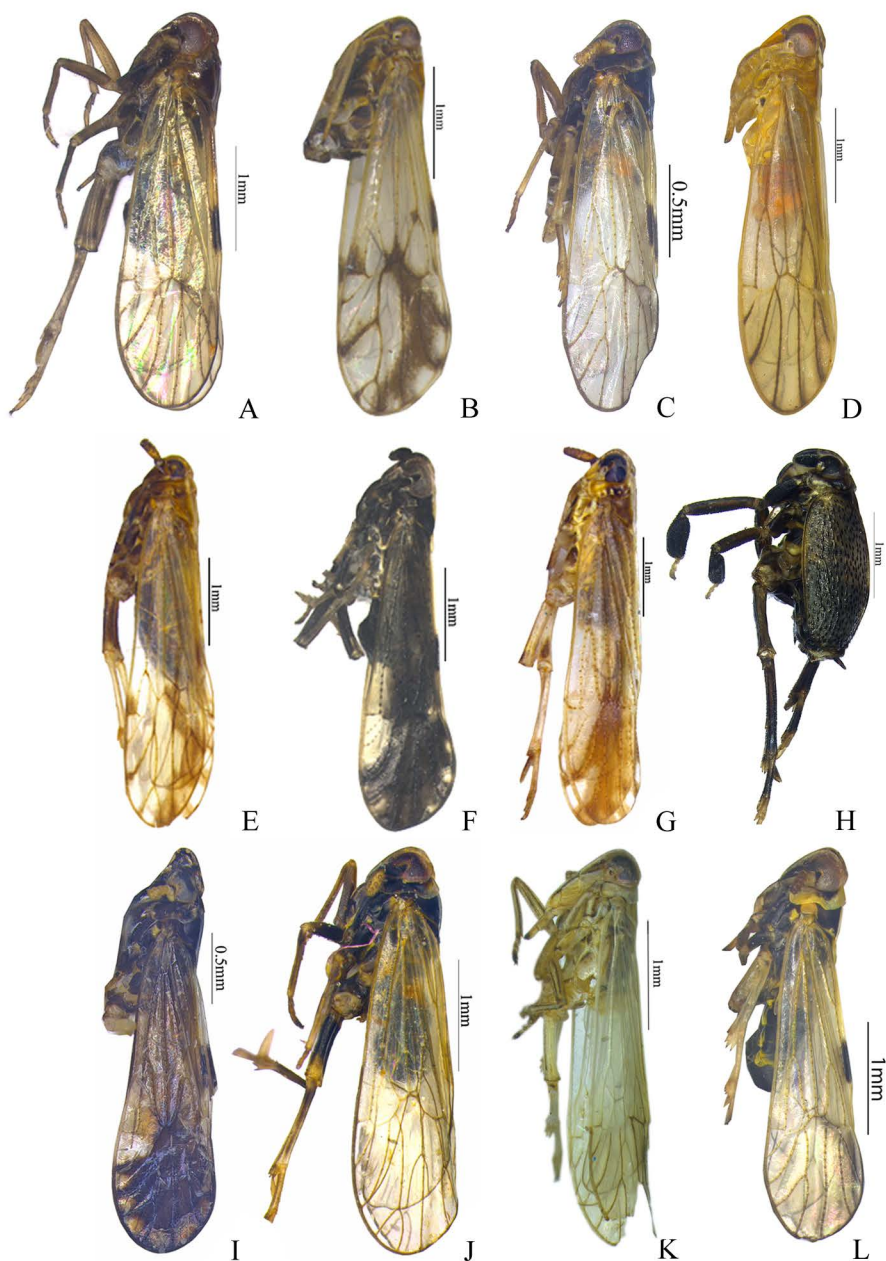


Fig. 8. Delphacini habitus lateral. A. *Nilaparvata lugens* (Stal); B. *Nycheuma nilotica* Linnavuori; C. *Opiconsiva tangaria* (Matsumura); D. *Parasogata* sp. nov. 3; E. *Peregrinus maidis* (Ashmaed); F. *Perkinsiella insignis* (Distant); G. *Perkinsiella sinensis* Kirkaldy; H. *Phyllodinus* sp. nov. 4; I. *Sardia rostrata* Melichar; J. *Shadelphax eforiae* (Dlabola); K. *Sogata* sp. nov. 5; L. *Sogatella furcifera* (Horvath).

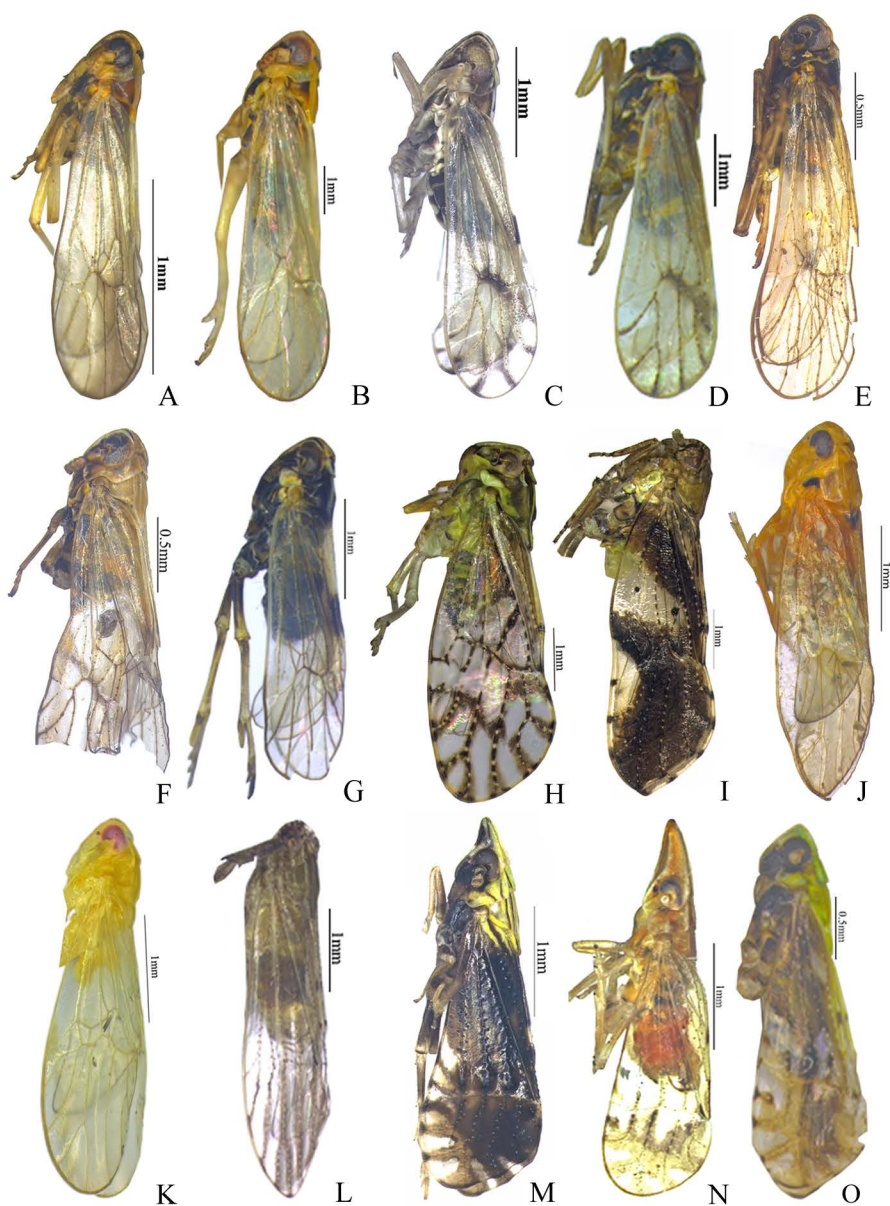


Fig. 9. Delphacini habitus lateral A. *Sogatella kolophon* (Kirkaldy); B. *Sogatella vibix* (Haupt); C. *Tagosodes pusanus* (Distant); D. *Terthron albowittatum* (Matsumura); E. Male *Toya nigra* (Crawford); F. *Toya tuberculosa* (Distant); G. *Unkanodes latespinosa* (Dlabola); H. *Arcofacies securisus* sp. nov. 6; I. *Arcofaciella sinuata* sp. nov. 7; J. *Bambusiphaga unispina* Ramya & Meshram 8; K. *Bambusiphaga* sp. nov. 9; L. *Purohita taiwanensis* Muir; M. *Tropidocephala festiva* (Distant); N. *Tropidocephala sinuosa* Yang and Yang; O. *Tropidocephala tuberipennis* (Mulsant and Rey) .

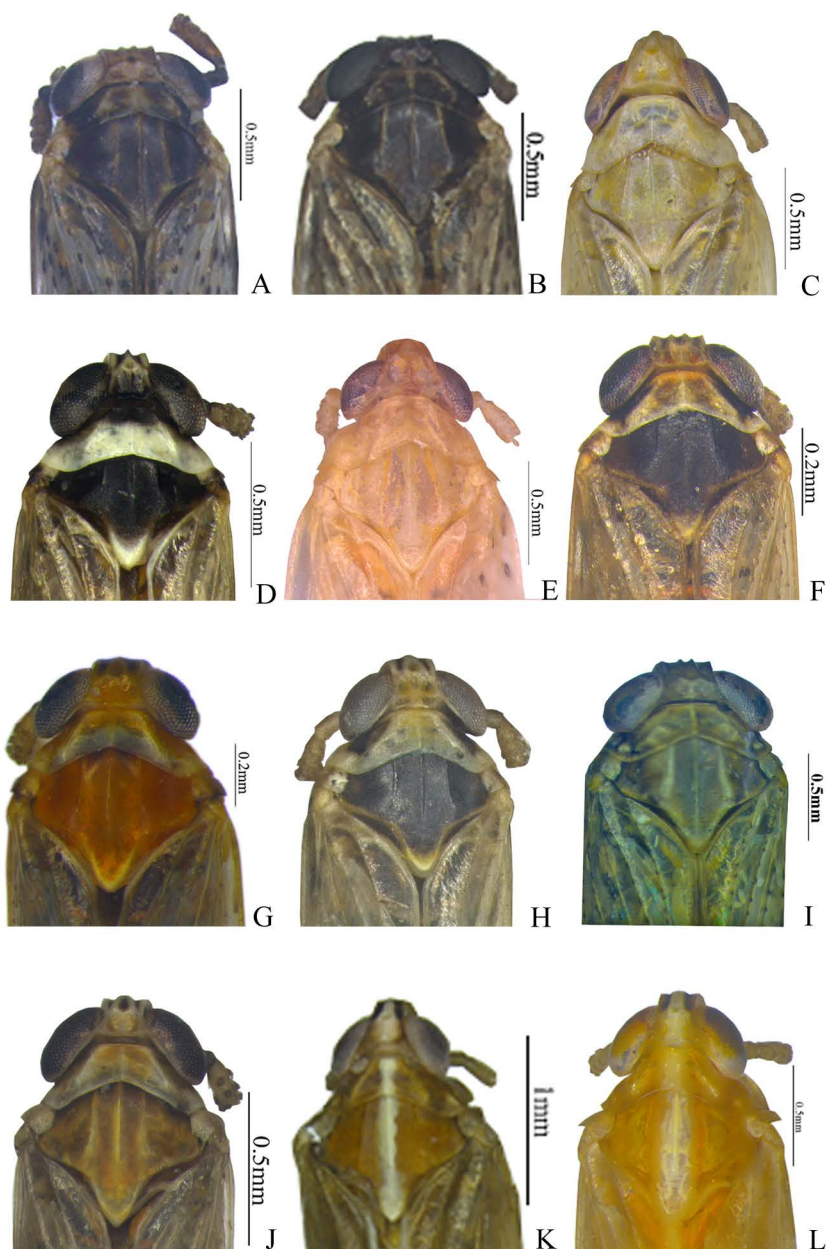


Fig. 10. Delphacini pronotum. A. *Cemus sauteri* (Muir); B. *Cemus zhitus* Kuoh; C. *Chloriona unicolor* (Herrich-schaffer); D. *Coronacella sinhalana* (Kirkaldy); E. *Eoeurysa sagittata* sp. nov. 1; F. *Falcotoya daluoensis* Ding; G. *Harmalia* sp. nov. 2; H. *Laodelphax striatellus* (Fallen); I. *Mahmutkashgaria liboensis* (Chen); J. *Metadelphax propinqua* (Fieber); K. *Miranus varians* (Kuoh); L. *Neunkanodes unispinatus* Hou, Yang and Chen.



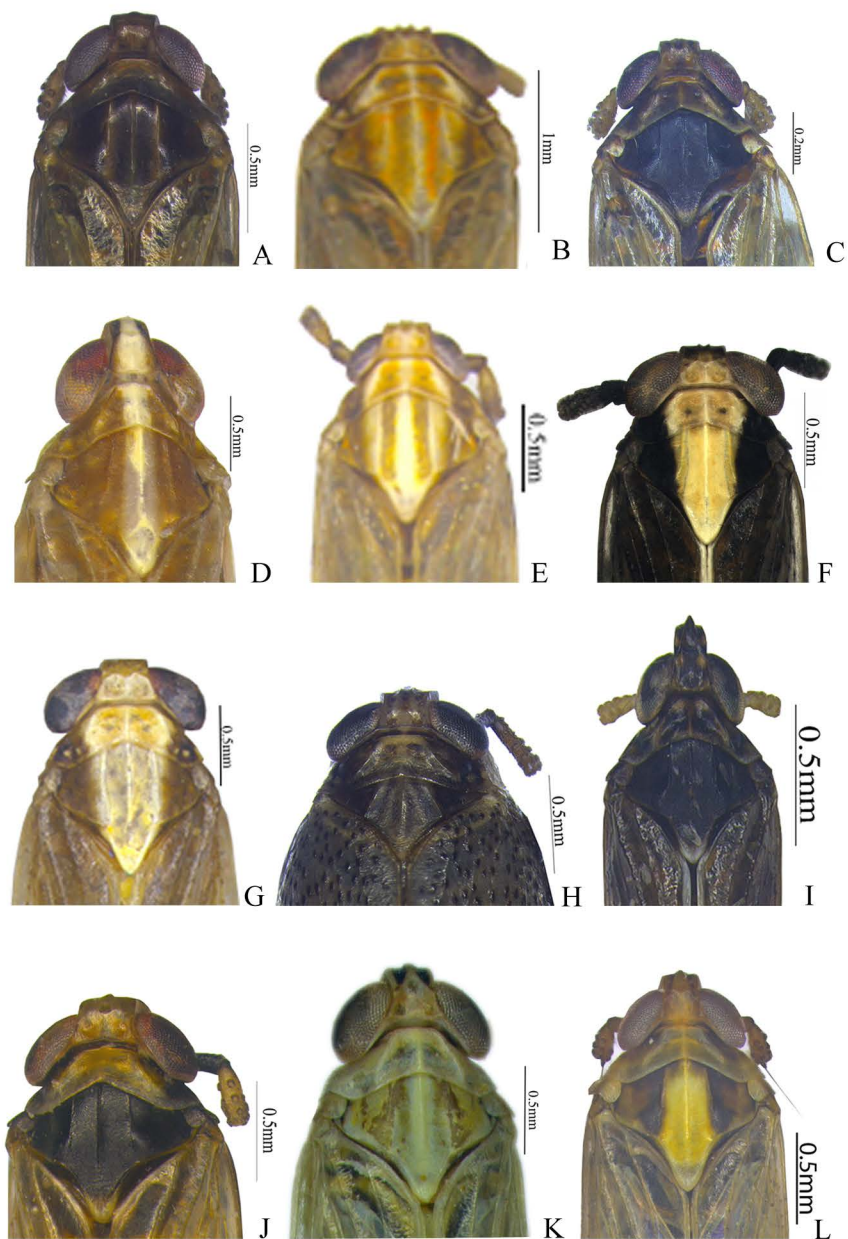


Fig. 11. Delphacini pronotum. A. *Nilaparvata lugens* (Stål); B. *Nycheuma nilotica* Linnavuori; C. *Opiconsiva tangaria* (Matsumura); D. *Parasogata sexpartita* sp. nov. 3; E. *Peregrinus maidis* (Ashmead); F. *Perkinsiella insignis* (Distant); G. *Perkinsiella sinensis* Kirkaldy; H. *Phyllodinus* sp. nov. 4; I. *Sardia rostrata* Melichar; J. *Shadelphax eforiae* (Dlabola); K. *Sogata* sp. nov. 5; L. *Sogatella furcifera* (Horváth).

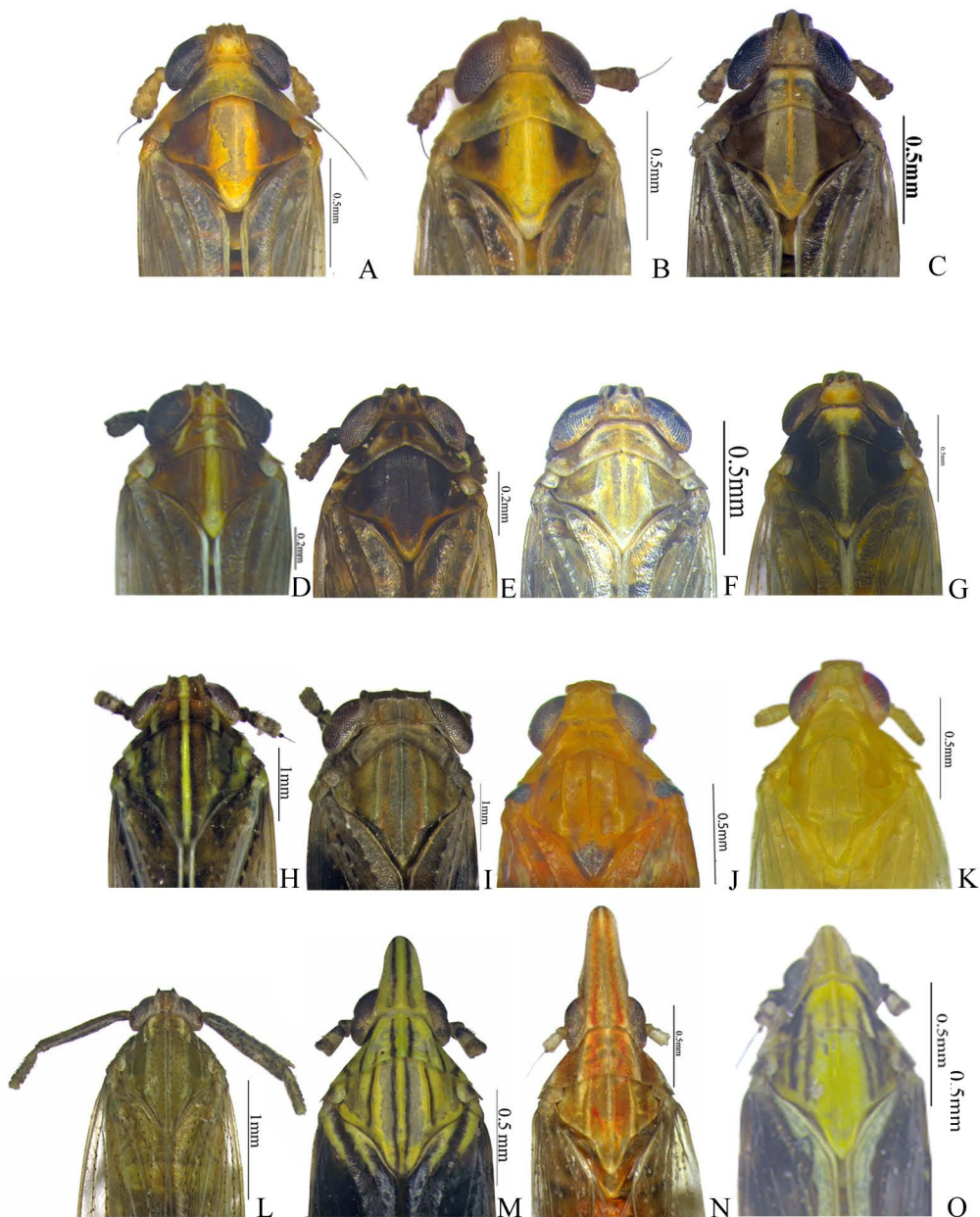


Fig. 12. Delphacini pronotum. A. *Sogatella kolophon* (Kirkaldy); B. *Sogatella vibix* (Haupt); C. *Tagosodes pusanus* (Distant); D. *Terthron albovittatum* (Matsumura); E. Male *Toya nigra* (Crawford); F. *Toya tuberculosa* (Distant); G. *Unkanodes latespinosa* (Dlabola); H. *Arcofacies securisus* sp. nov. 6; I. *Arcofaciella sinuata* sp. nov. 7; J. *Bambusiphaga unispina* Ramya and Meshram 8; K. *Bambusiphaga* sp. nov. 9; L. *Purohita taiwanensis* Muir; M. *Tropidocephala festiva* (Distant); N. *Tropidocephala sinuosa* Yang and Yang; O. *Tropidocephala tuberipennis* (Mulsant and Rey).



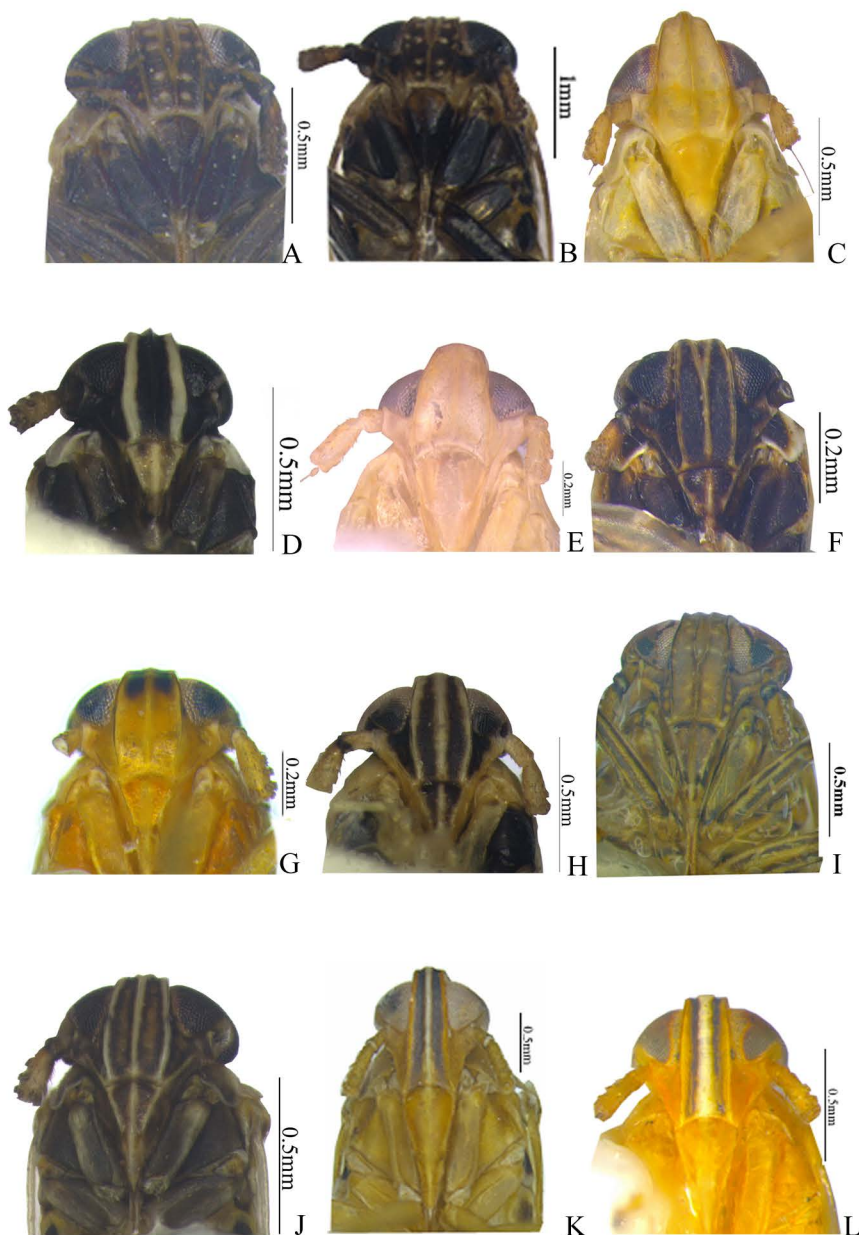


Fig. 13. Delphacini face. A. *Cemus sauteri* (Muir); B. *Cemus zhitus* Kuoh; C. *Chloriona unicolor* (Herrich-schaffër); D. *Coronacella sinhalana* (Kirkaldy); E. *Eoeuryssa sagitta* sp. nov. 1; F. *Falcotoya daluoensis* Ding; G. *Harmalia* sp. nov. 2; H. *Laodelphax striatellus* (Fallen); I. *Mahmutkashgaria liboensis* (Chen); J. *Metadelphax propinqua* (Fieber); K. *Miramus varians* (Kuoh); L. Male *Neunkanodes unispinatus* Hou, Yang and Chen.

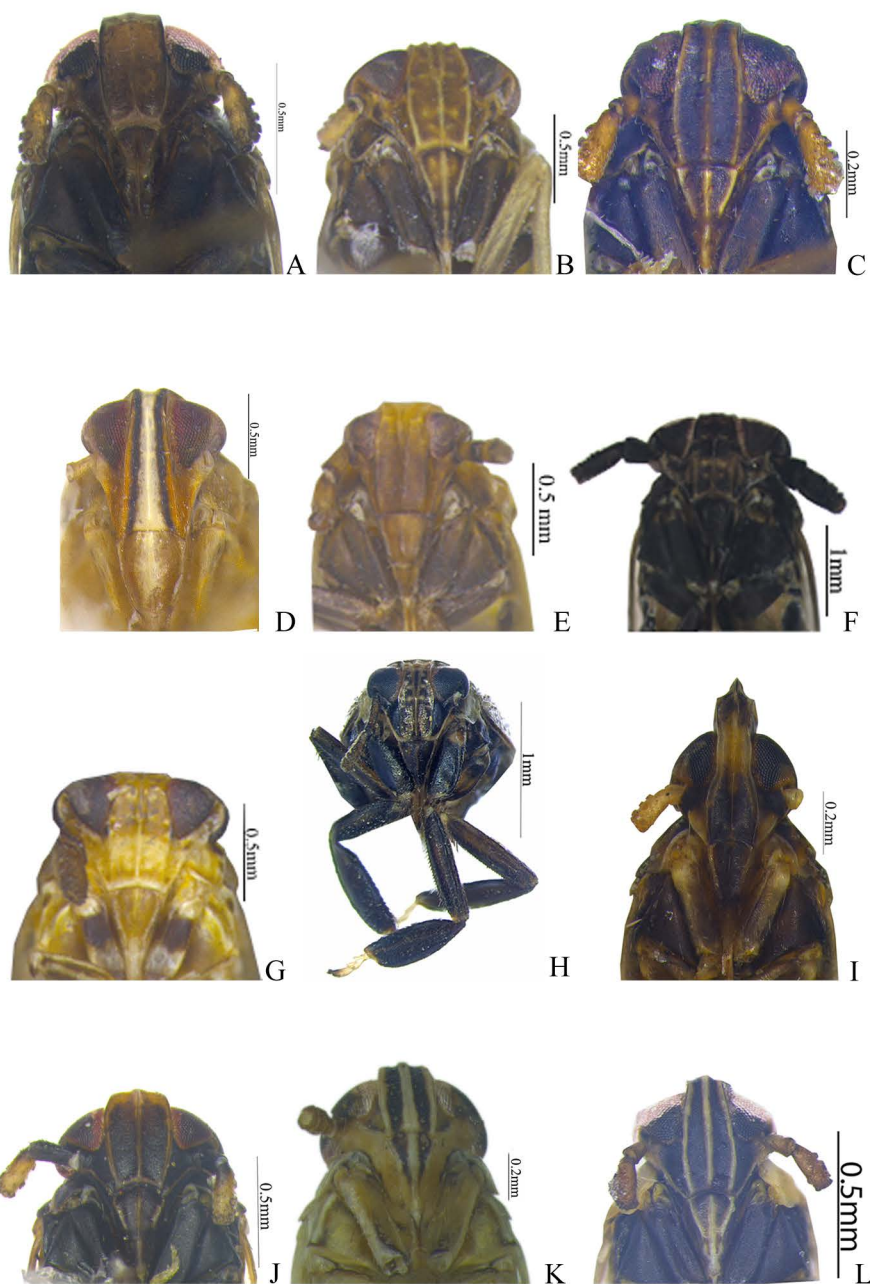


Fig. 14. Delphacini face. A. *Nilaparvata lugens* (Stal); B. *Nycheuma nilotica* Linnavuori; C. *Opiconsiva tangaria* (Matsumura); D. *Parasogata sexpartita* sp. nov. 3; E. *Peregrinus maidis* (Ashmaed); F. *Perkinsiella insignis* (Distant); G. *Perkinsiella sinensis* Kirkaldy; H. *Phyllodinus* sp. nov. 4; I. *Sardia rostrata* Melichar; J. *Shadelphax eforiae* (Dlabola); K. *Sogata* sp. nov. 5; L. *Sogatella furcifera* (Horvath).

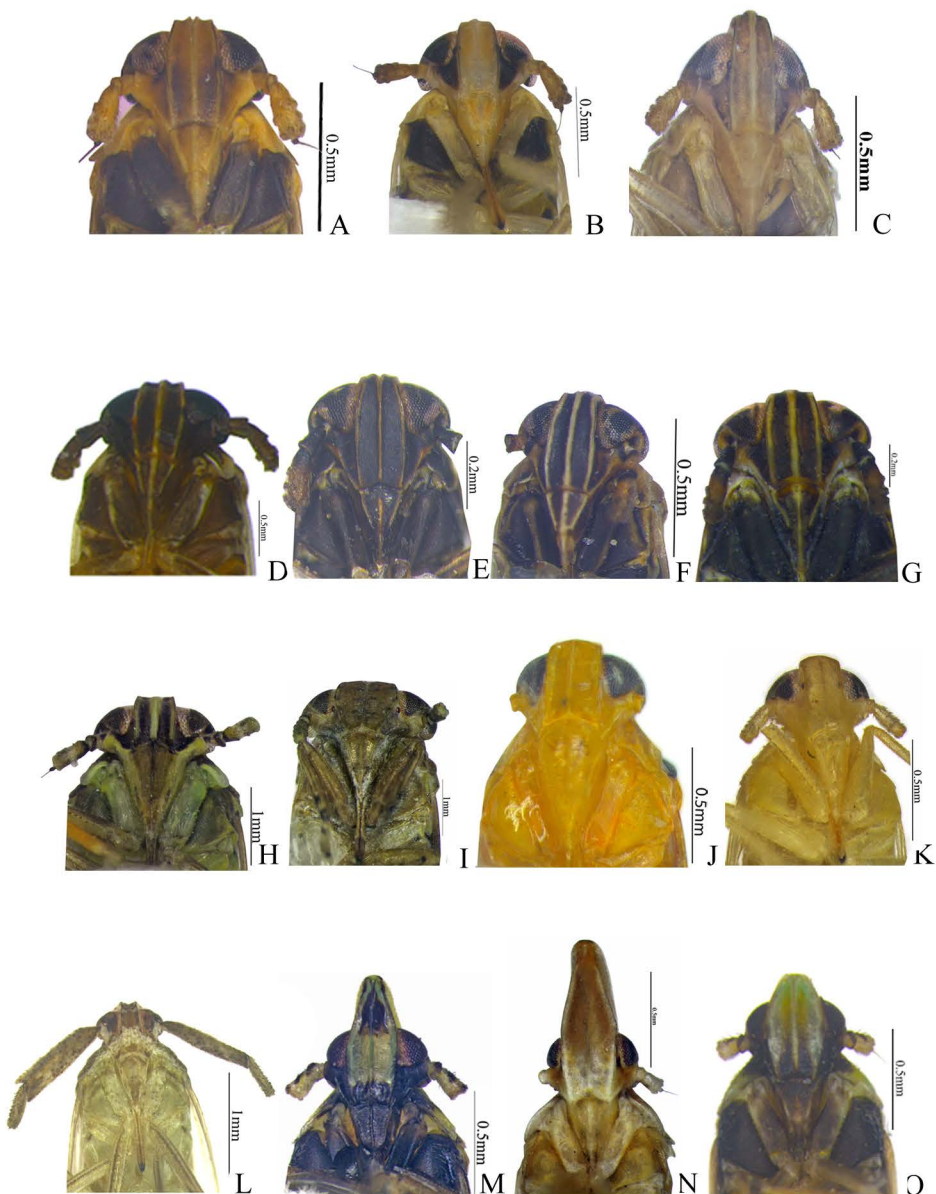


Fig. 15. Delphacini face. A. *Sogatella kolophon* (Kirkaldy); B. *Sogatella vibix* (Haupt); C. *Tagosodes pusanus* (Distant); D. *Terthron albovittatum* (Matsumura); E. *Toya nigra* (Crawford); F. *Toya tuberculosa* (Distant); G. *Unkanodes latespinosa* (Dlabola); H. *Arcofacies securisus* sp. nov. 6; I. *Arcofaciella sinuata* sp. nov. 7; J. *Bambusiphaga unispina* Ramya and Meshram 8; K. *Bambusiphaga* sp. nov. 9; L. *Purohita taiwanensis* Muir; M. *Tropidocephala festiva* (Distant); N. *Tropidocephala sinuosa* Yang and Yang; O. *Tropidocephala tuberipennis* (Mulsant and Rey).



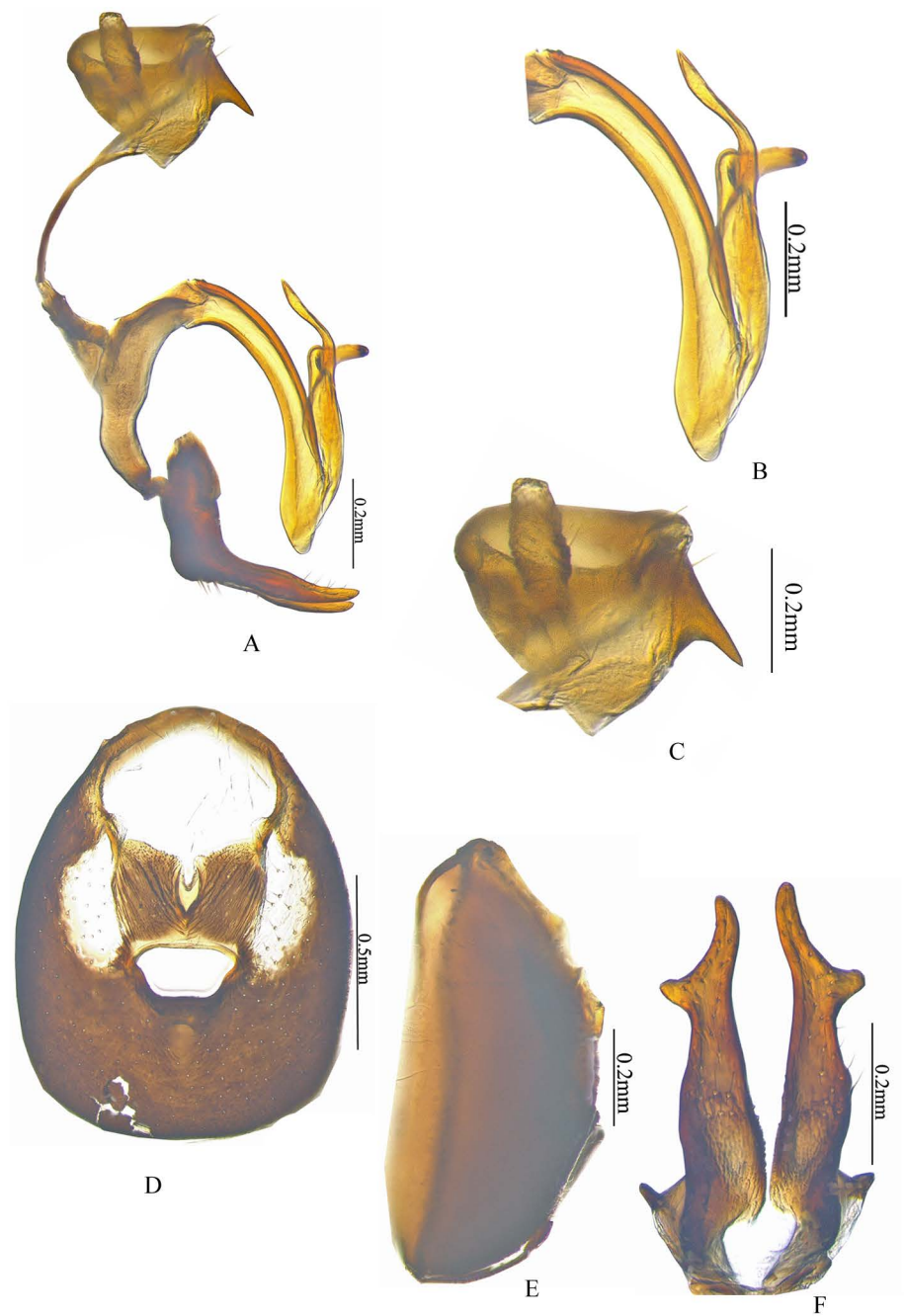


Fig. 16. *Cemus sauteri* (Muir) male genitalia. A. Aedeagal complex; B. Aedeagus right view ; C. Segment ten and eleven; D. Pygofer caudal view; E. Pygofer lateral view; F. Parameres caudal view.

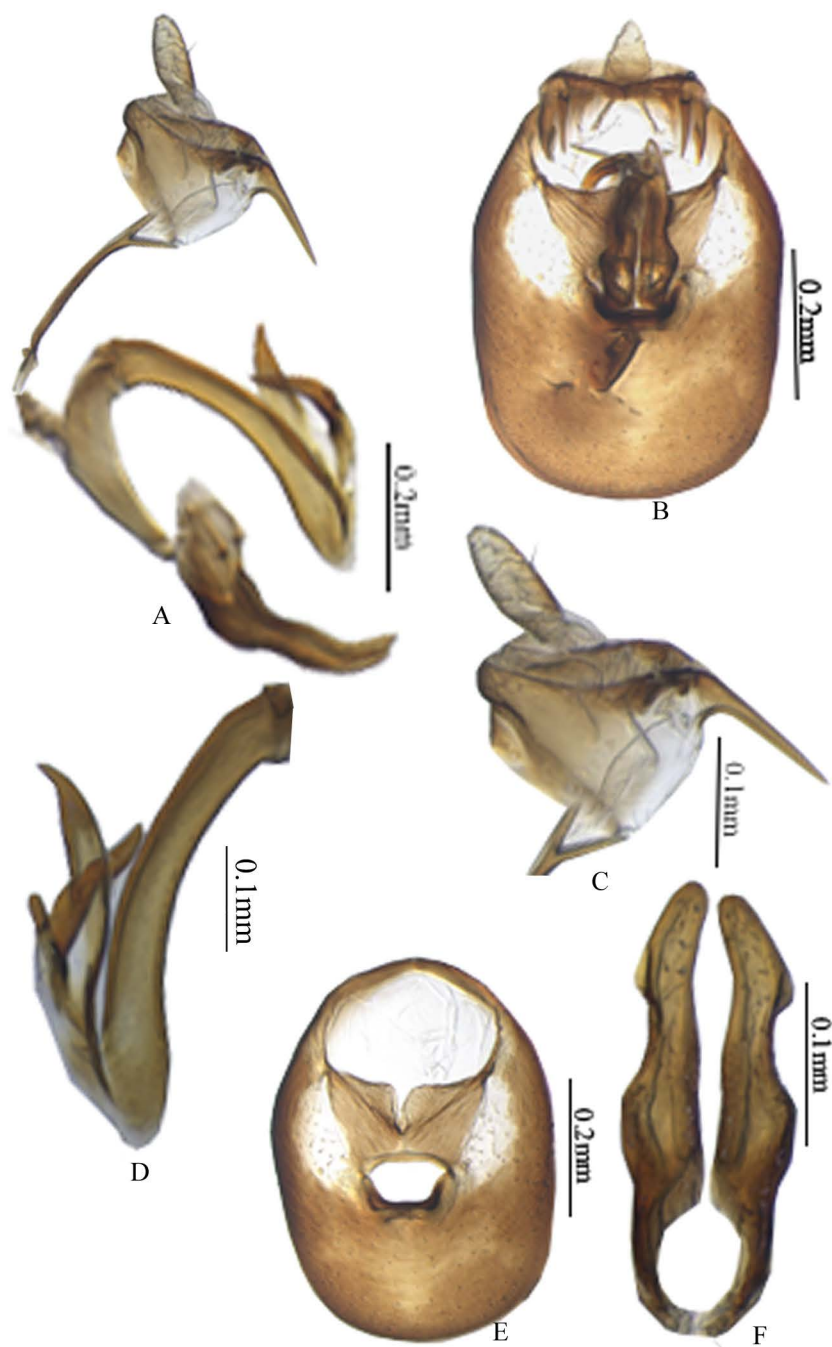


Fig. 17. *Cemus zhitus* Kuoh, male genitalia. A. Aedeagal complex; B. Male genitalia; C. Segment ten and eleven; D. Aedeagus left view; E. Pygofer caudal view; F. Parameres caudal view.

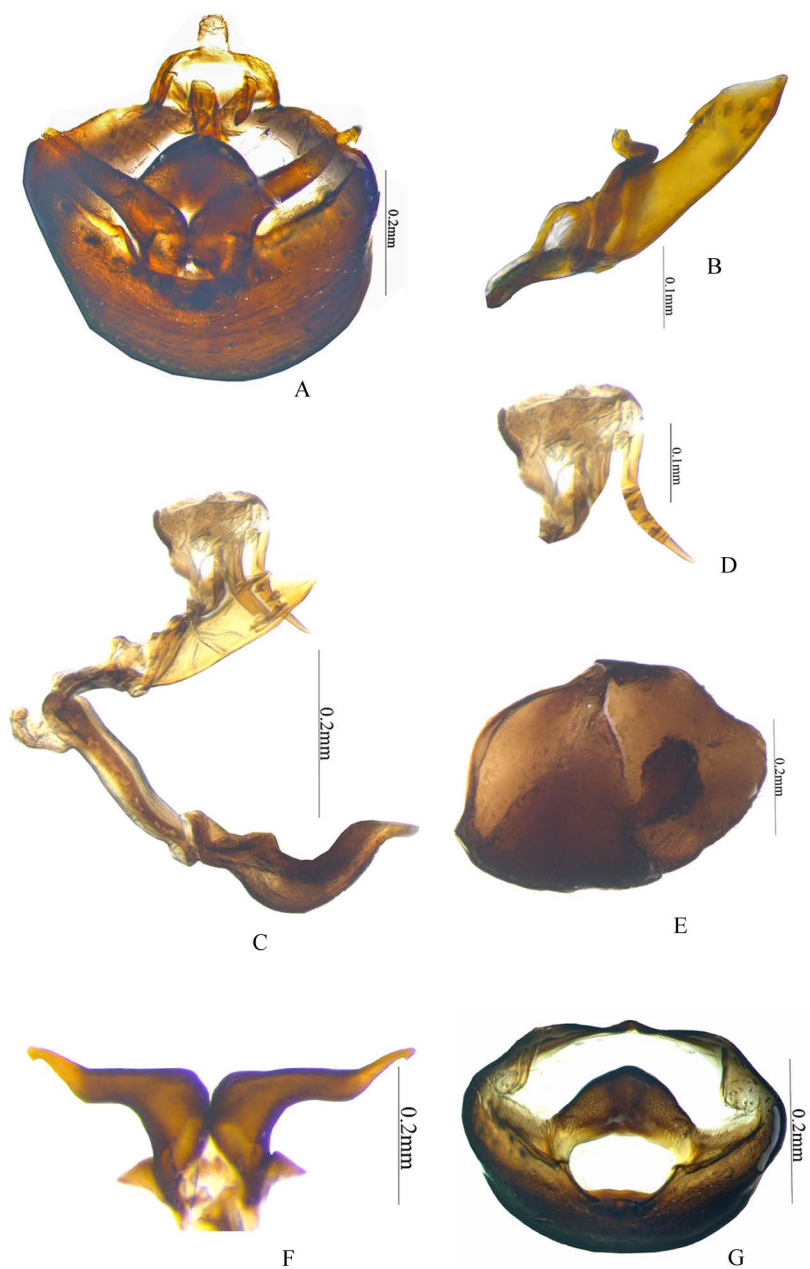


Fig. 18. *Chloriona unicolor* (Herrich-schaffer), male genitalia. A. Male genitalia; B. Aedeagus right view; C. Aedeagal complex; D. Segment ten and eleven; E. Pygofer lateral view; F. Parameres caudal view; G. Pygofer caudal view;

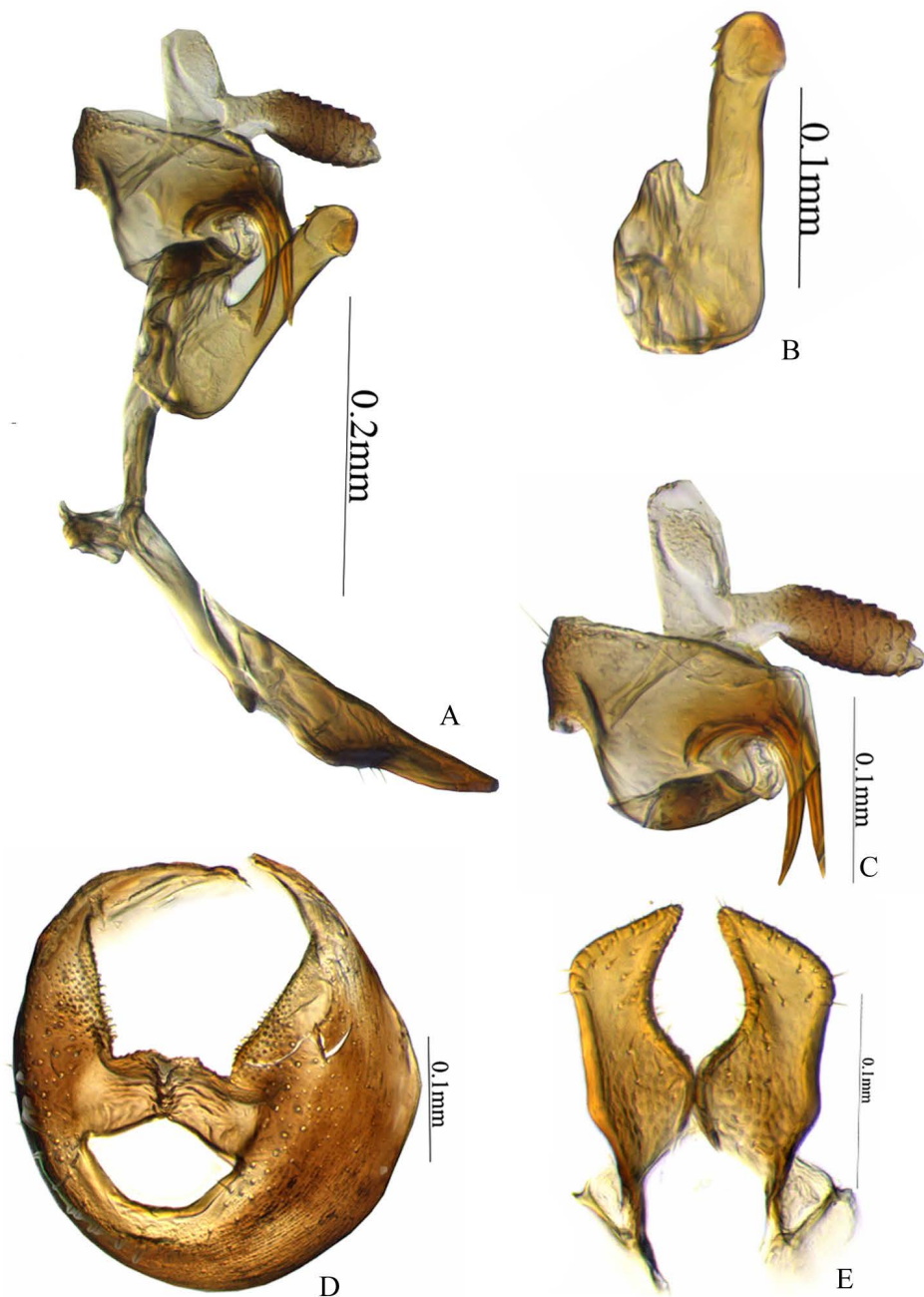


Fig. 19. *Coronacella sinhalana* (Kirkaldy), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Parameres caudal view.



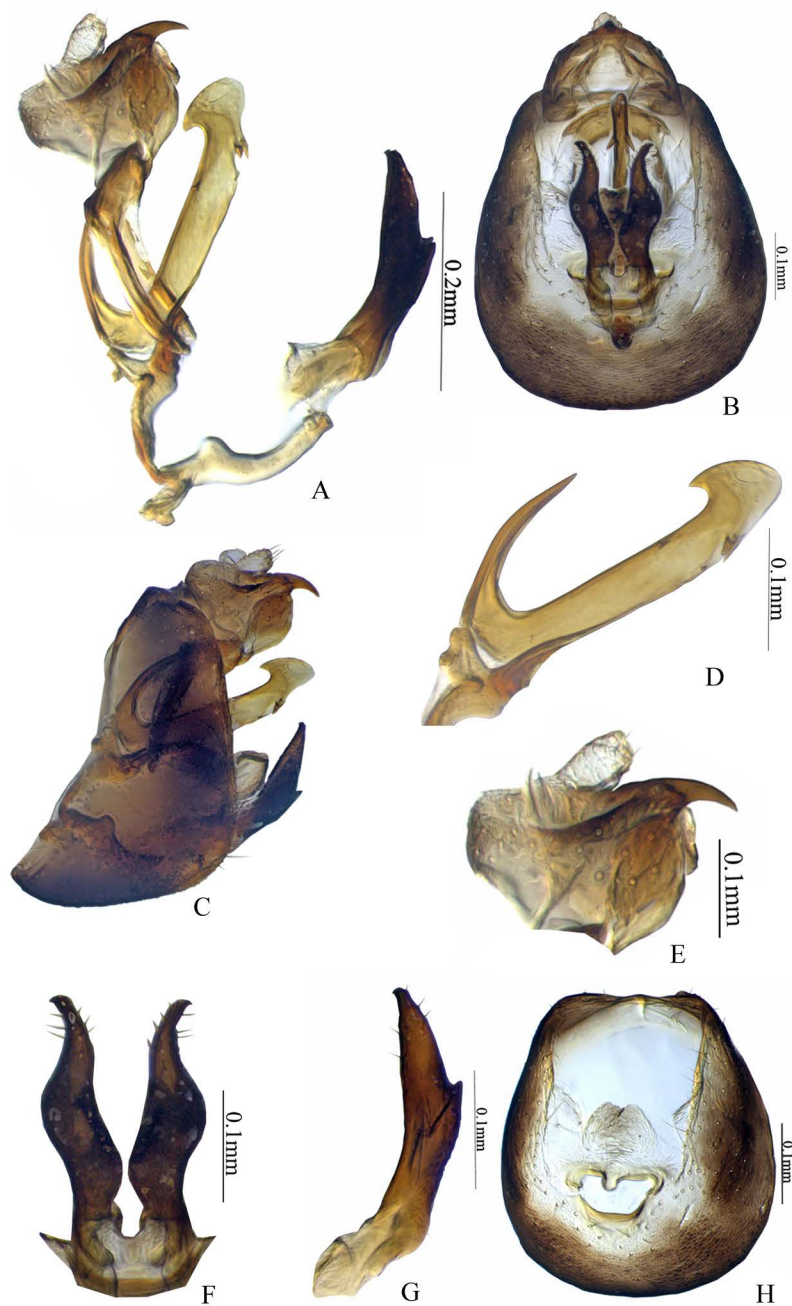


Fig. 20. *Eoeurysa sagitta* sp. nov. 1, male genitalia. A. Aedeagal complex; B. Male genitalia caudal view; C. Male genitalia lateral view; D. Aedeagus right view; E. Segment ten and eleven; F. Parameres caudal view; G. Paramere lateral view; H. Pygofer caudal view.



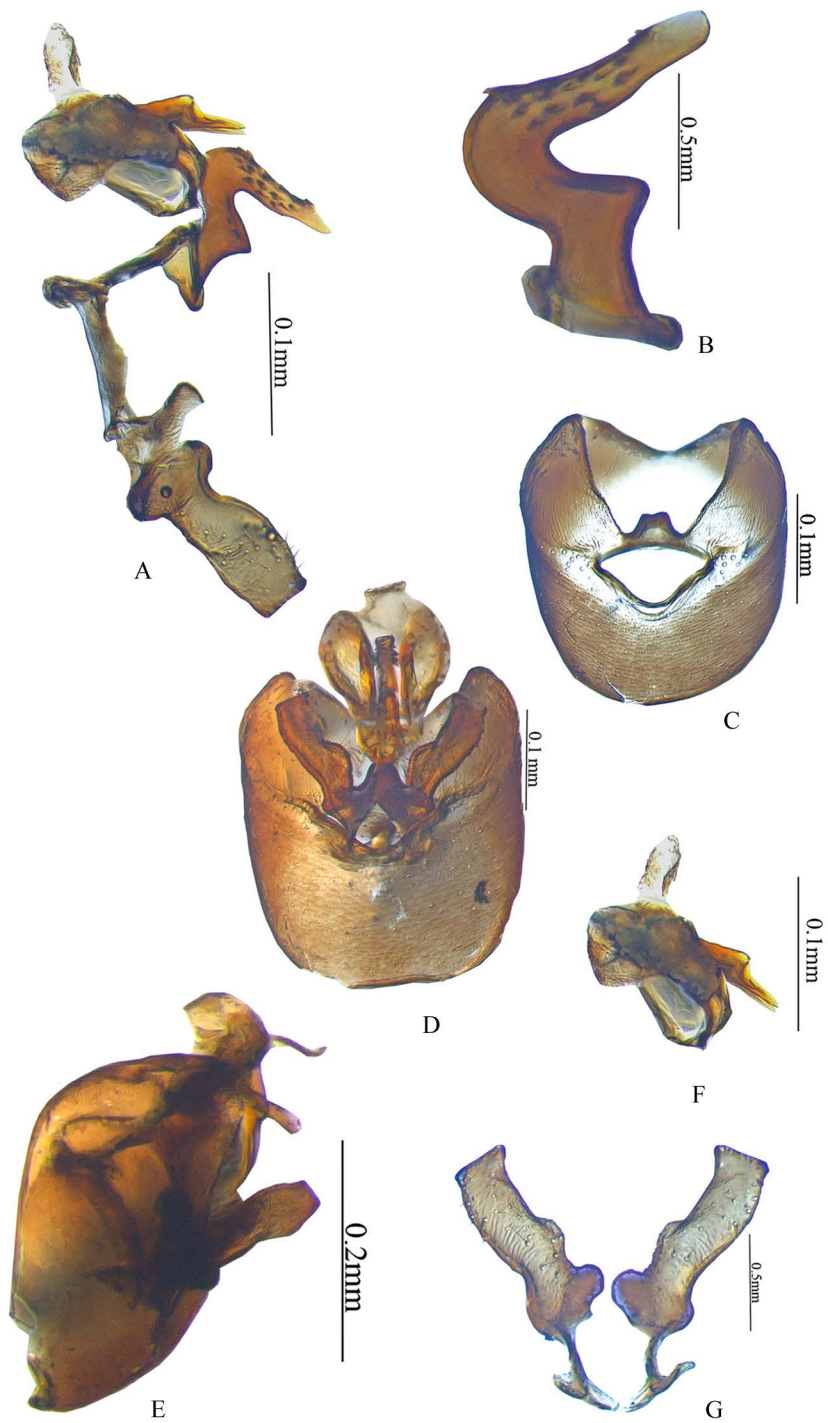


Fig. 21. *Falcotoya daluoensis* Ding, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Pygofer caudal view; D. Male genitalia caudal view; E. Male genitalia lateral view; F. Segment ten and eleven; G. Parameres caudal view.

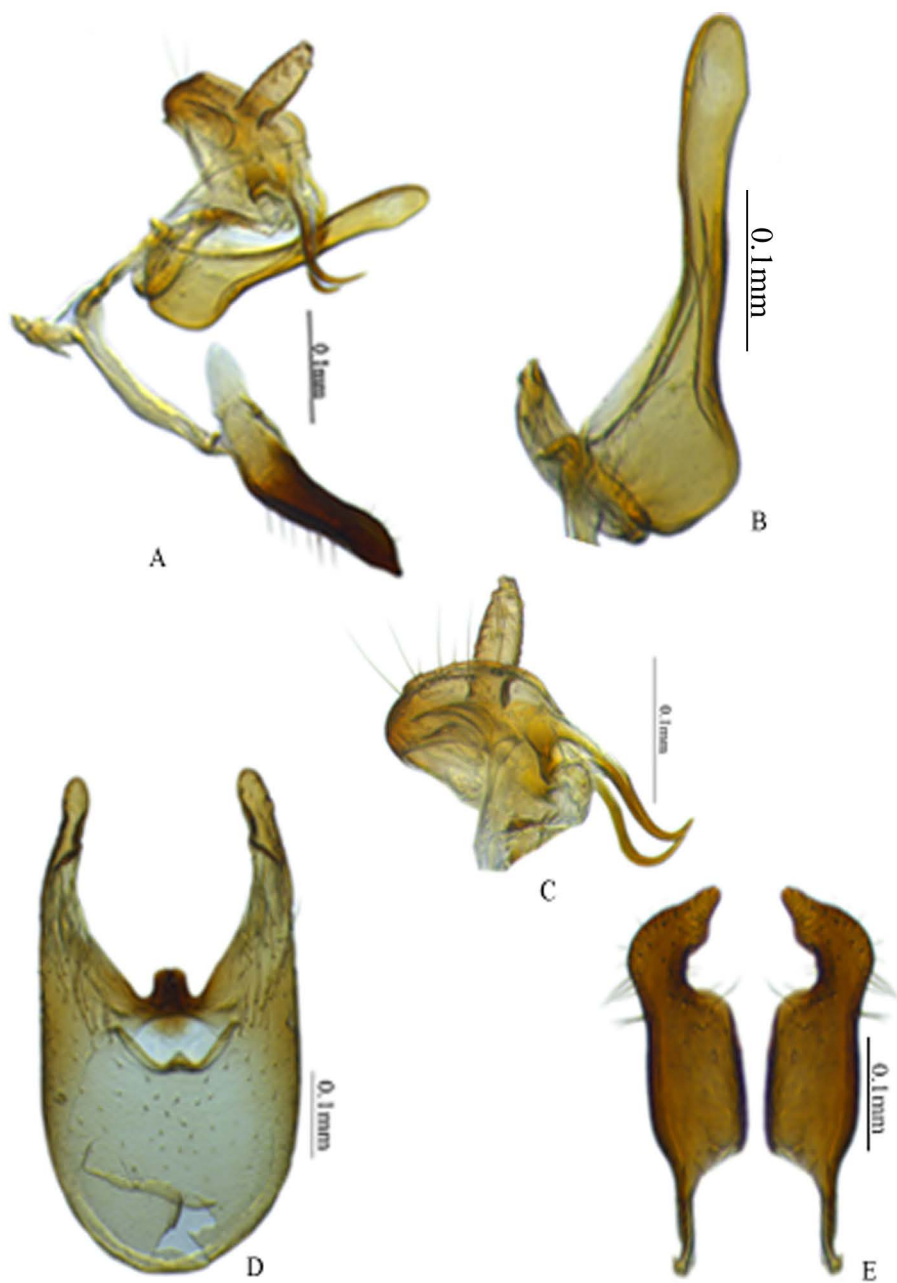


Fig. 22. *Harmalia* sp. nov. 2, male genitalia. A. Aedeagal complex; B. Aedeagus right view ; C. Segment ten and eleven; D. Pygofer caudal view; E. Parameres caudal view.

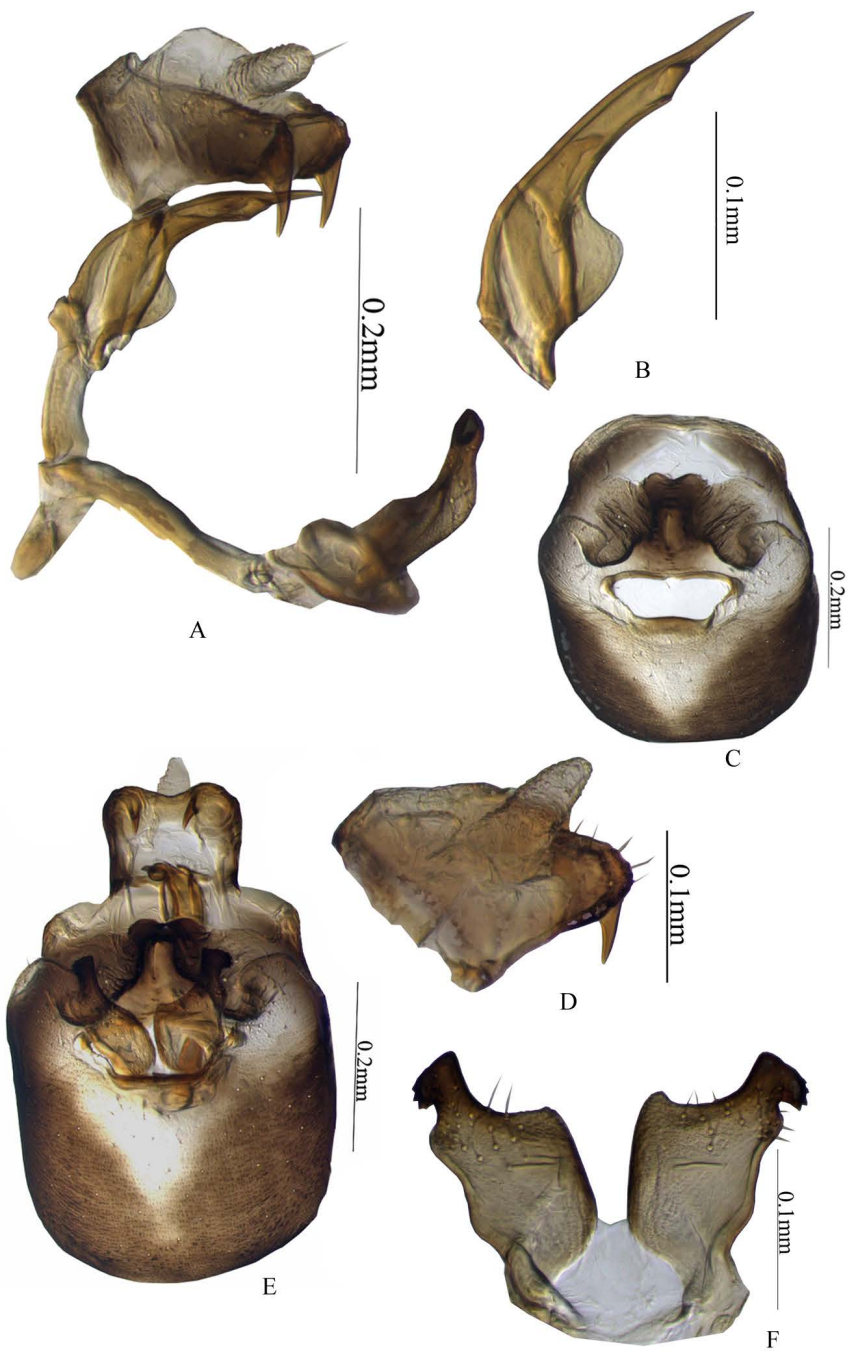


Fig. 23. *Laodelphax striatellus* (Fallen), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Pygofer caudal view; D. Segment ten and eleven; E. Male genitalia caudal view; F. Parameres caudal view.

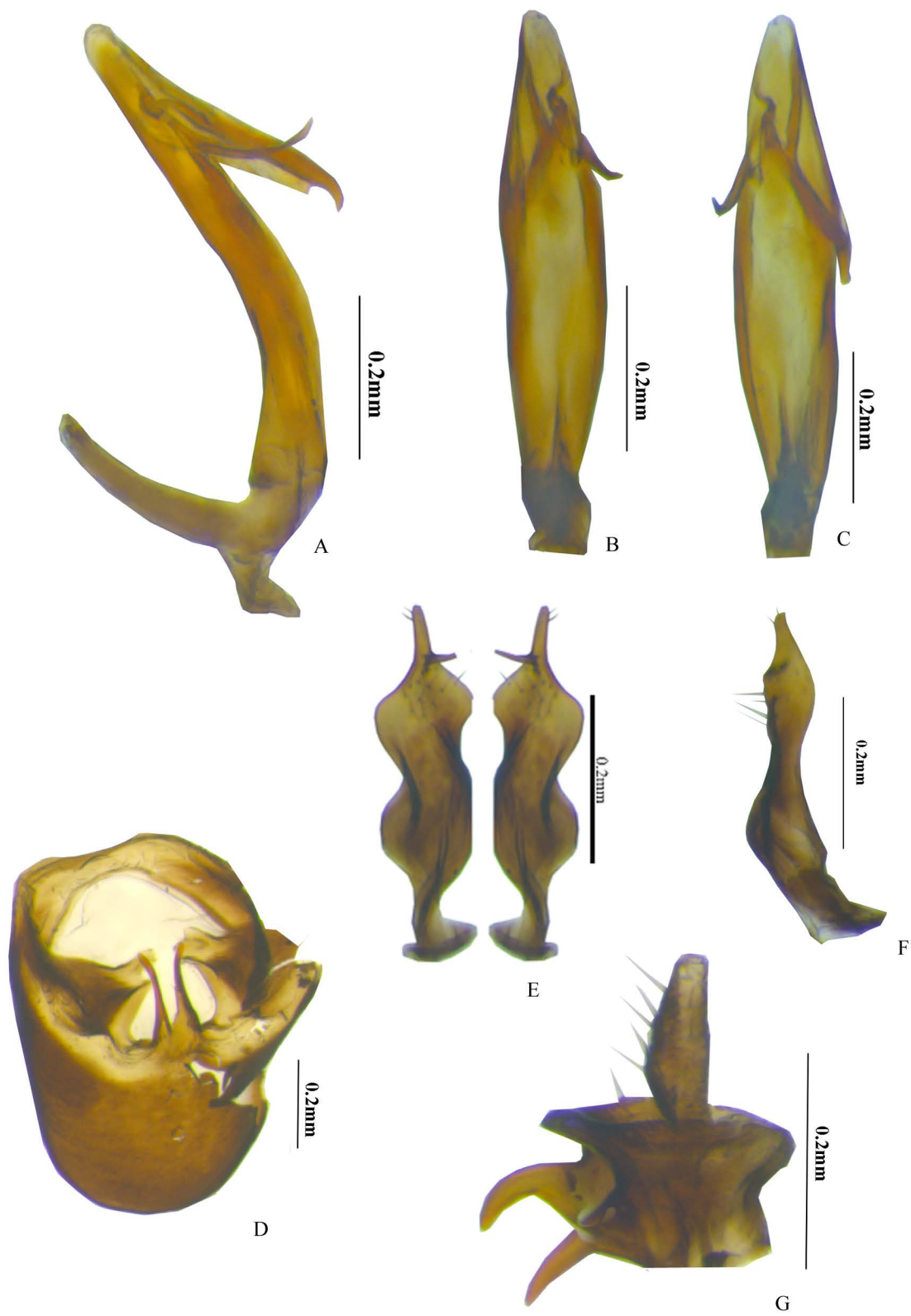


Fig. 24. *Mahmutkashgaria liboensis* (Chen), male genitalia. A. Aedeagus right view; B. Aedeagus dorsal view; C. Aedeagus ventral view; D. Pygofer caudal view; E. Parameres caudal view; F. Paramere lateral view; G. Segment ten and eleven.



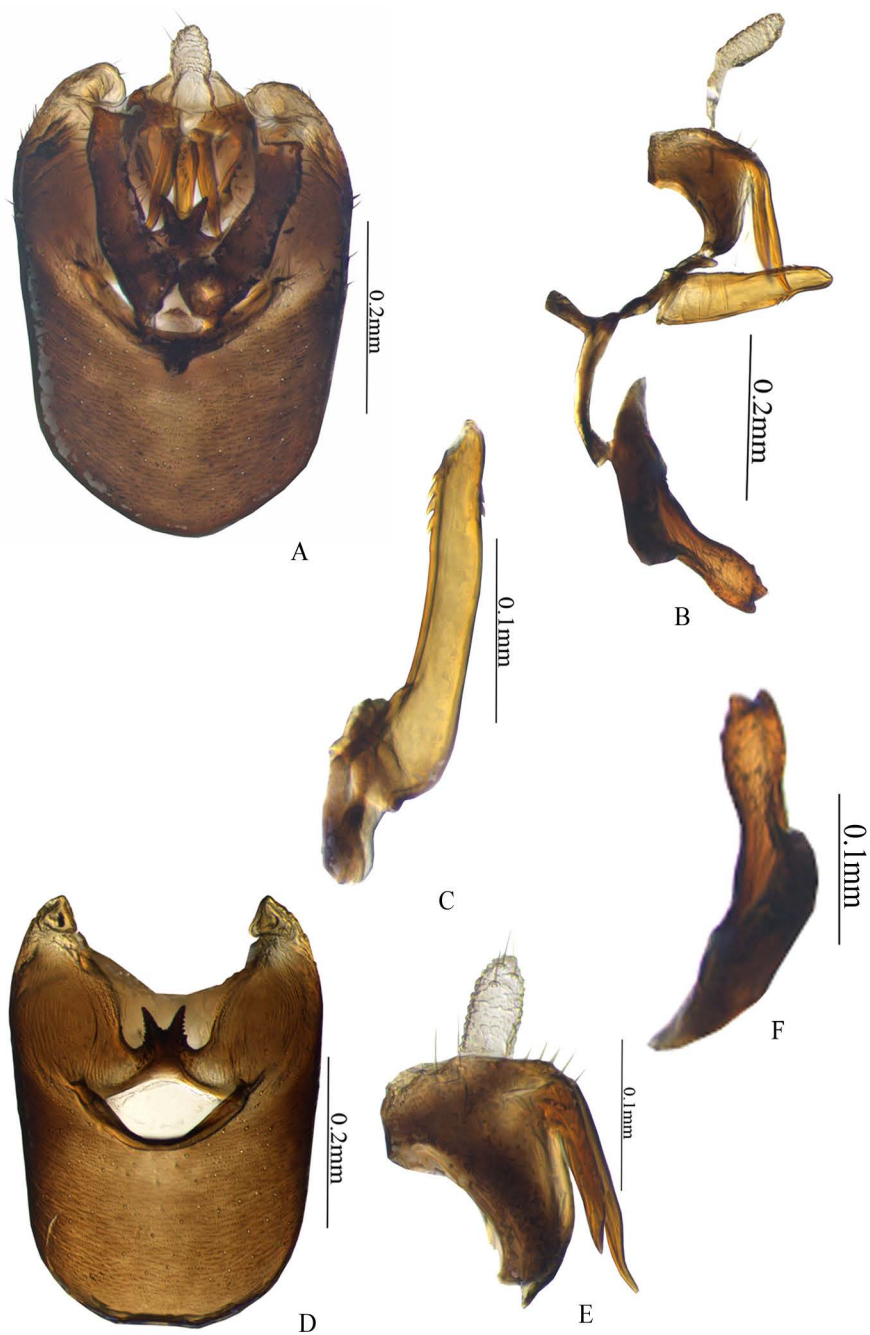


Fig. 25. *Metadelphax propinqua* (Fieber), male genitalia. A. Male genitalia caudal view; B. Aedeagal complex; C. Aedeagus right view; D. Pygofer caudal view; E. Segment ten and eleven; F. Paramere lateral view.

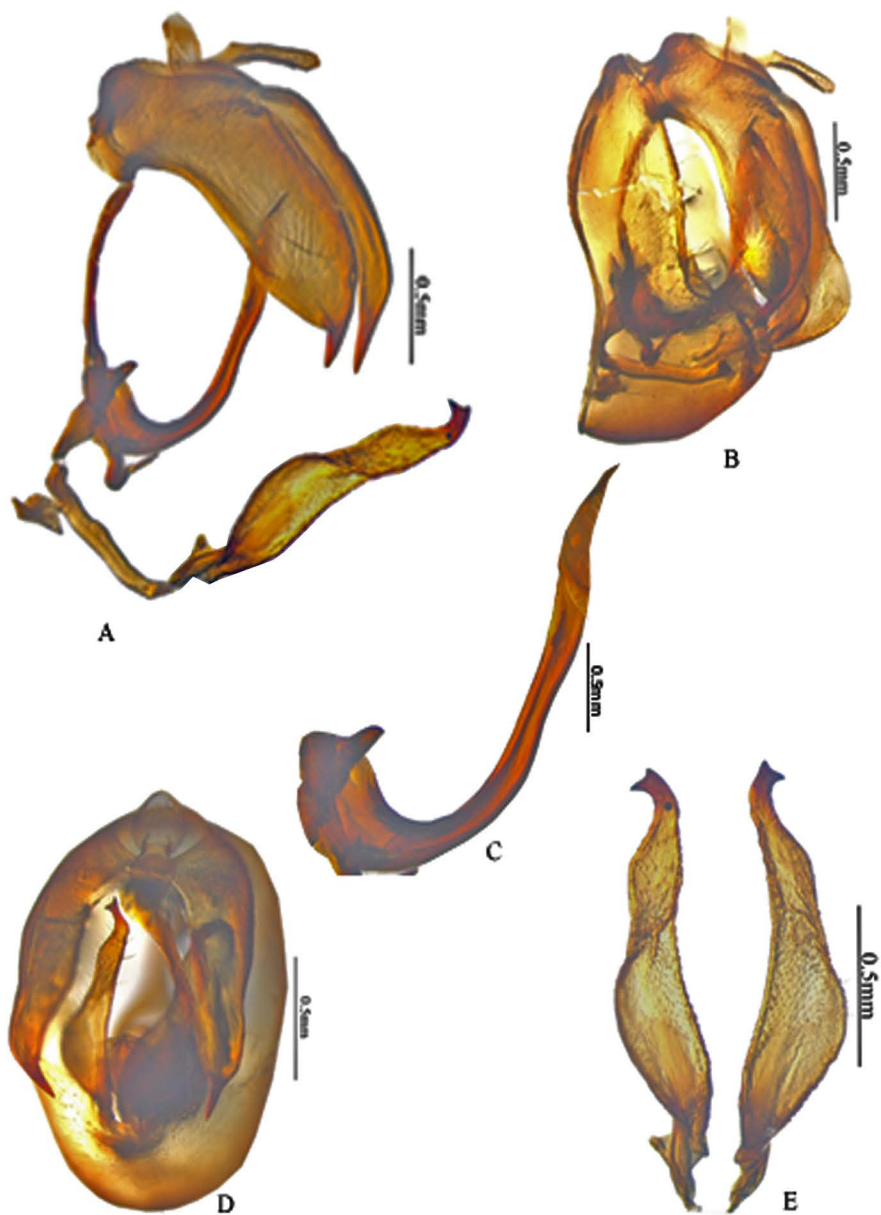


Fig. 26. *Miranus varians* (Kuoh), male genitalia. A. Aedeagal complex; B. Genitalia lateral view; C. Aedeagus right view; D. Genitalia caudal view; E. Parameres caudal view.

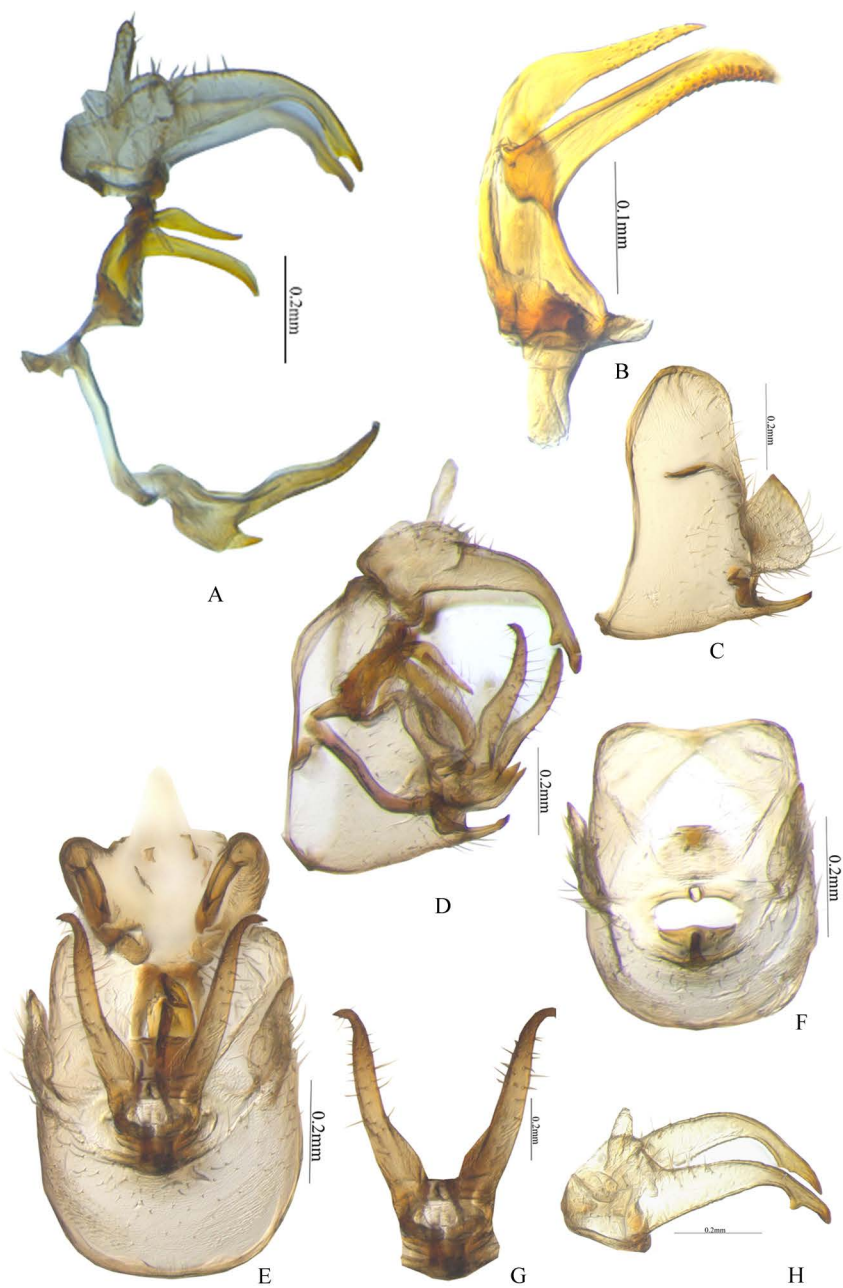


Fig. 27. *Neunkanodes unispinatus* Hou, Yang and Chen, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Pygofer lateral view; D. Genitalia lateral view; E. Genitalia caudal view; F. Pygofer caudal view; G. Parameres caudal view; H. Segment ten and eleven.

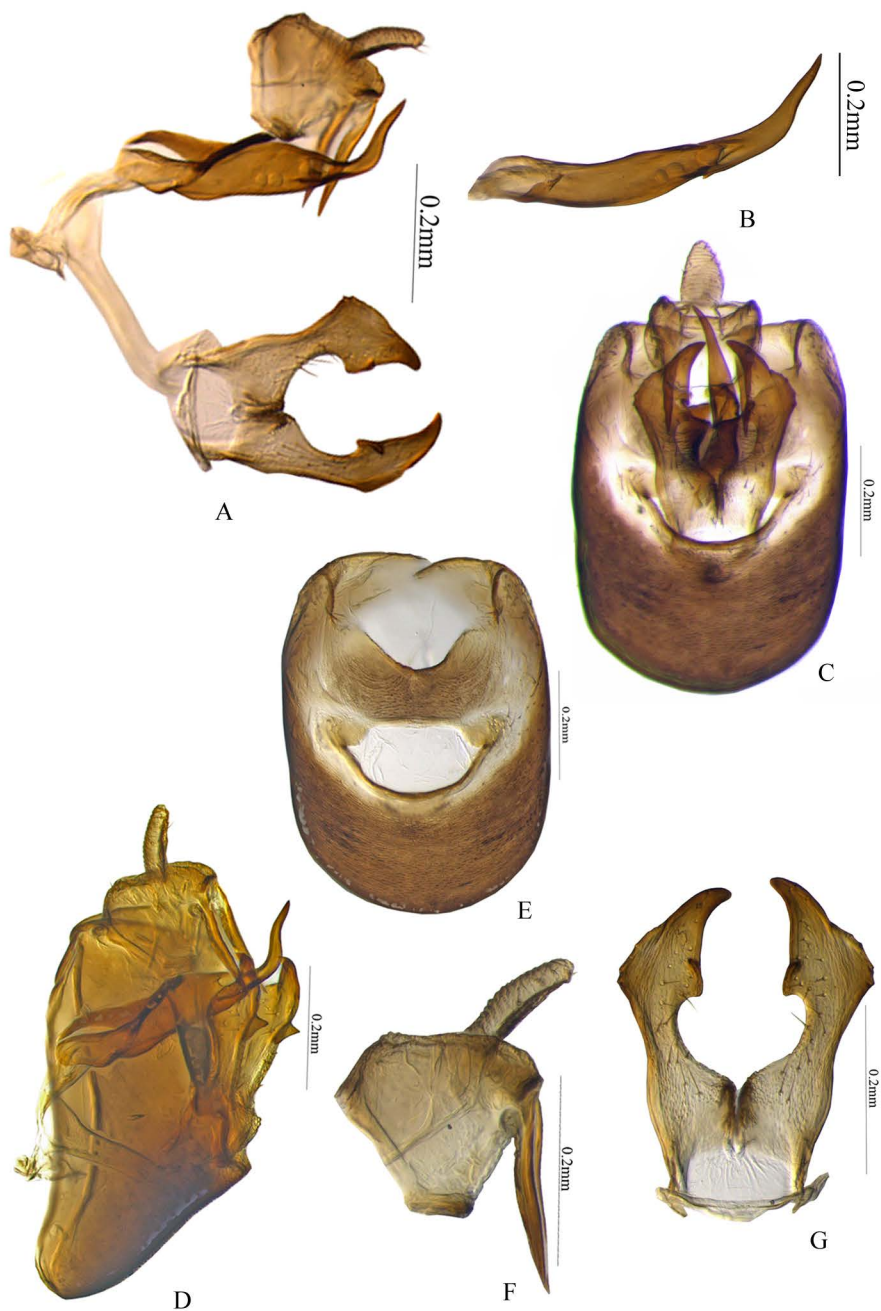


Fig. 28. *Nilaparvata lugens* (Stal), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Genitalia caudal view; D. Genitalia lateral view; E. Pygofer caudal view; F. Segment ten and eleven; G. Parameres caudal view.



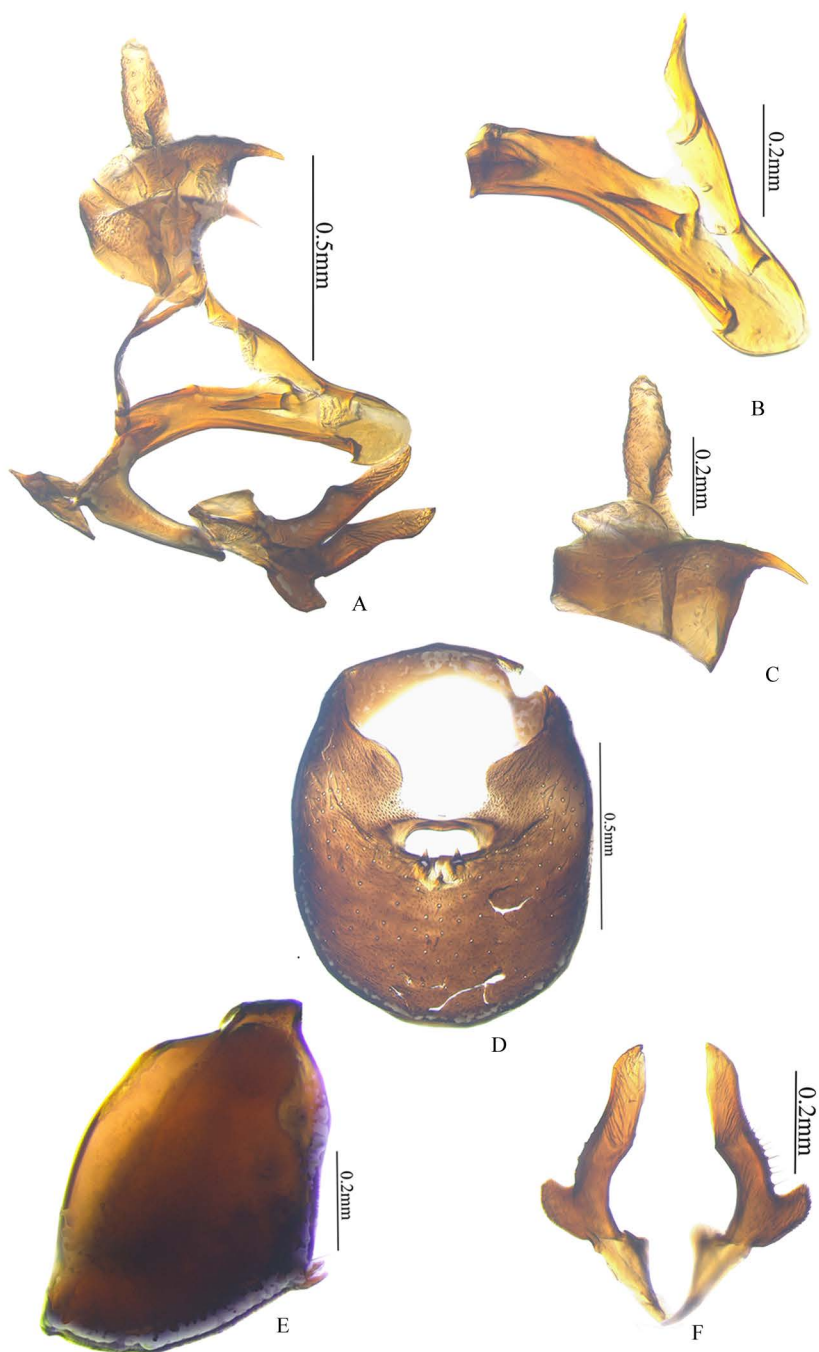


Fig. 29. *Nycheuma nilotica* Linnavuori, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Pygofer lateral view; F. Parameres caudal view.

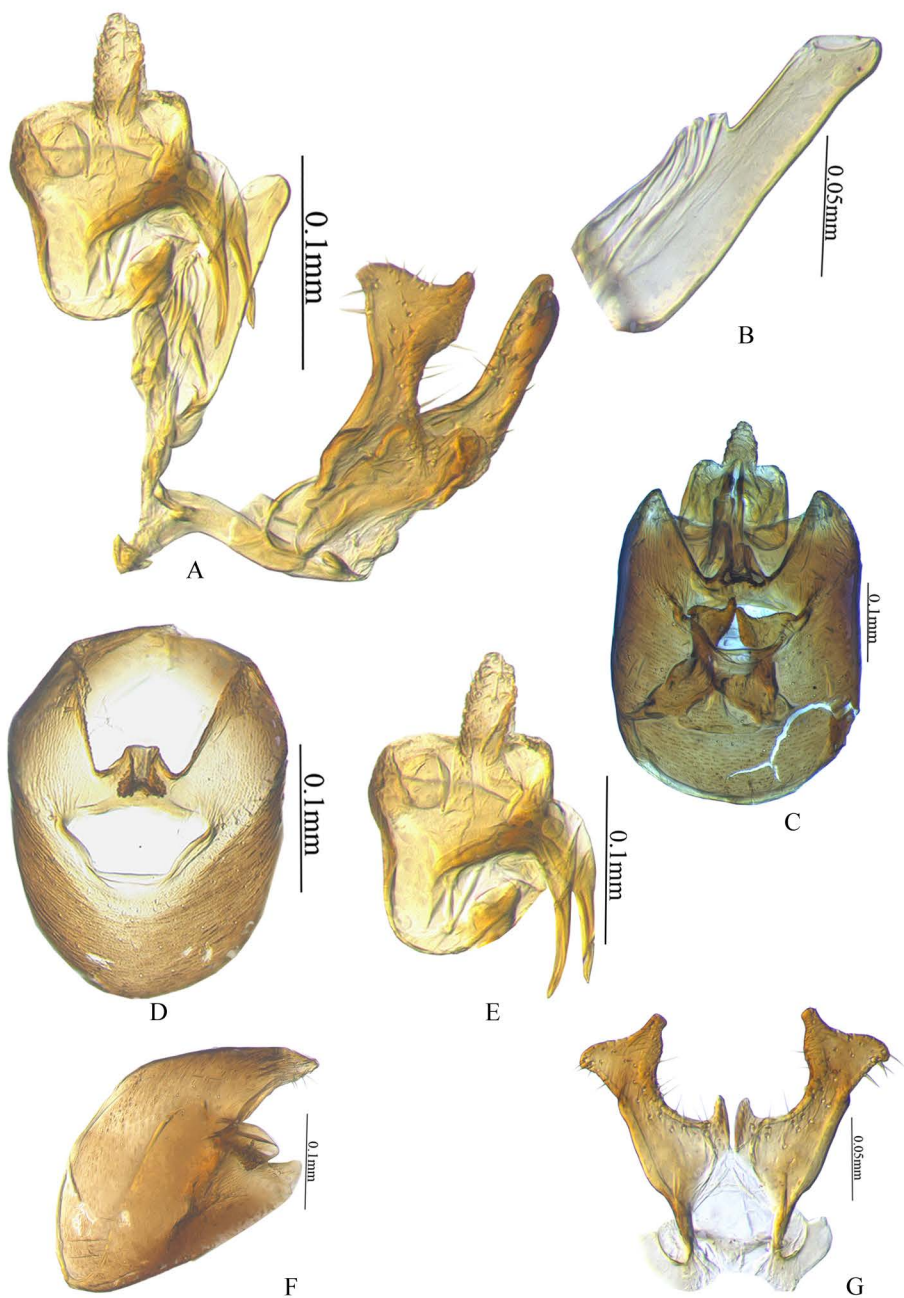


Fig. 30. *Opiconsiva tangaria* (Matsumura), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Genitalia caudal view; D. Pygofer caudal view; E. Segment ten and eleven; F. Pygofer lateral view; G. Parameres caudal view.

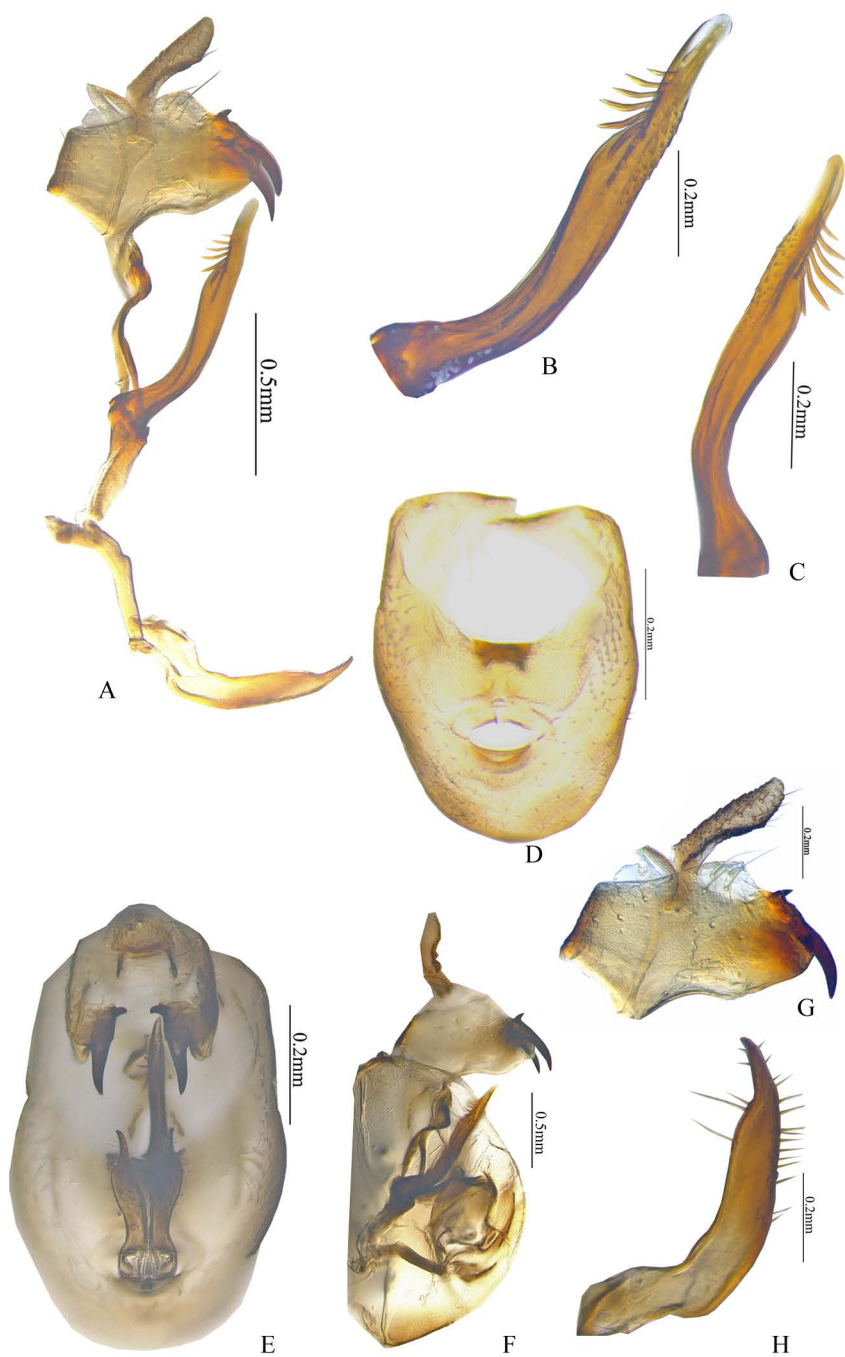


Fig. 31. *Parasogata sexpartita* sp. nov. 3, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Aedeagus left view; D. Pygofer caudal view; E. Genitalia caudal view; F. Genitalia lateral view; G. Segment ten and eleven; H. Paramere lateral view.

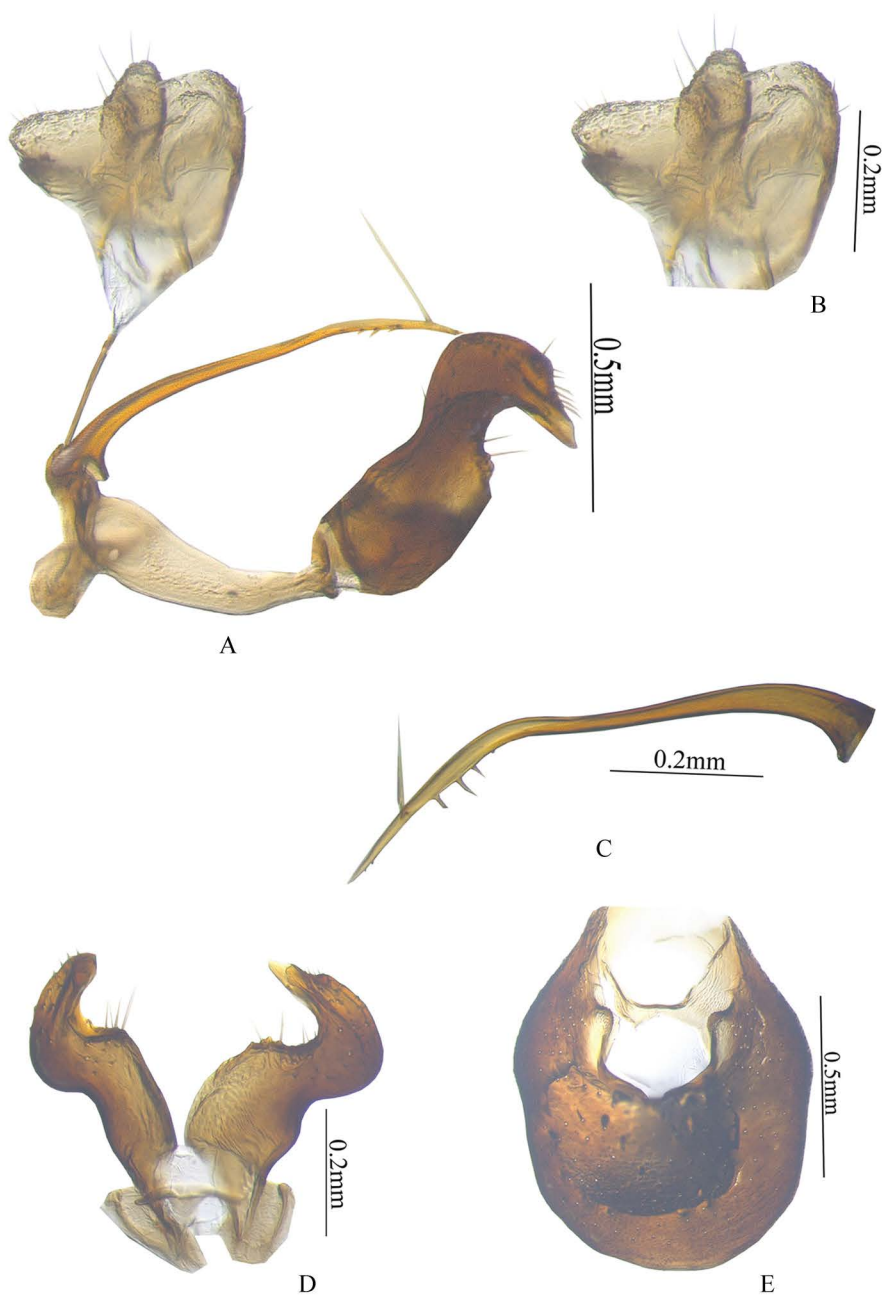


Fig. 32. *Peregrinus maidis* (Ashmaed), male genitalia. A. Aedeagal complex; B. Segment ten and eleven; C. Aedeagus left view; D. Paramere caudal view; E. Pygofer caudal view.

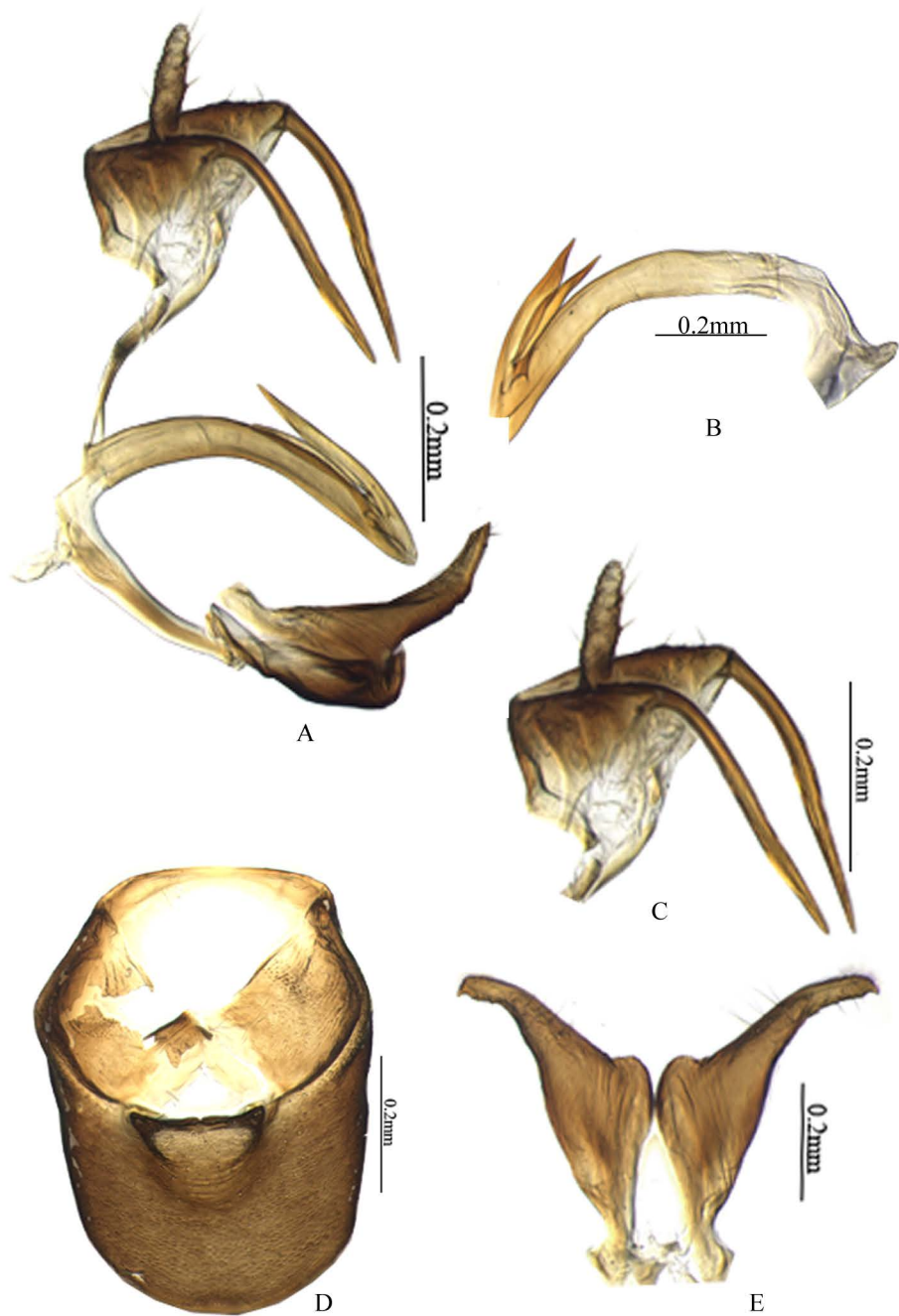


Fig. 33. *Perkinsiella insignis* (Distant), male genitalia. A. Aedeagal complex; B. Aedeagus left view; C. Segment ten and eleven; D. Pygofer caudal view; E. Paramere caudal view.



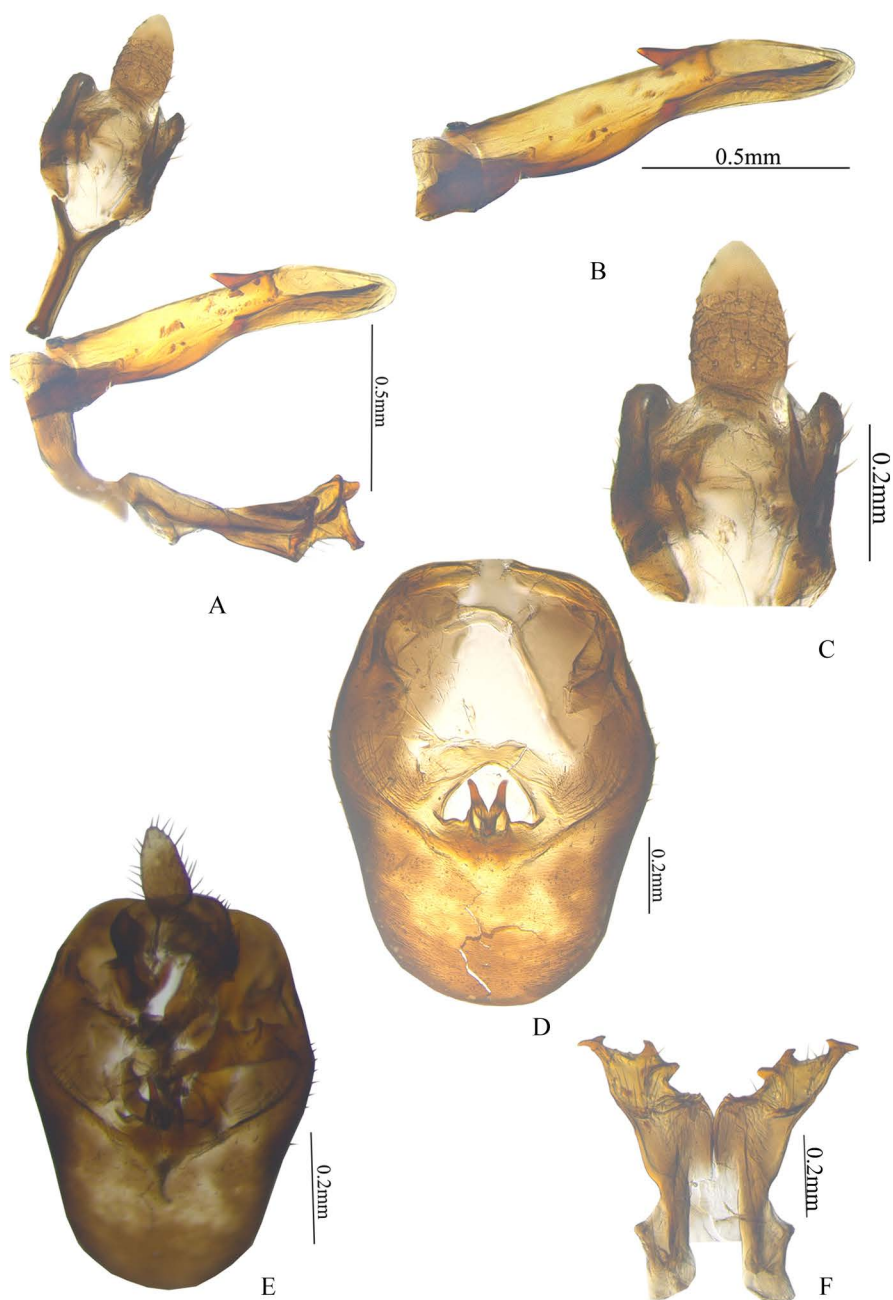


Fig. 34. *Perkinsiella sinensis* Kirkaldy, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Male genitalia caudal view; F. Parameres caudal view.

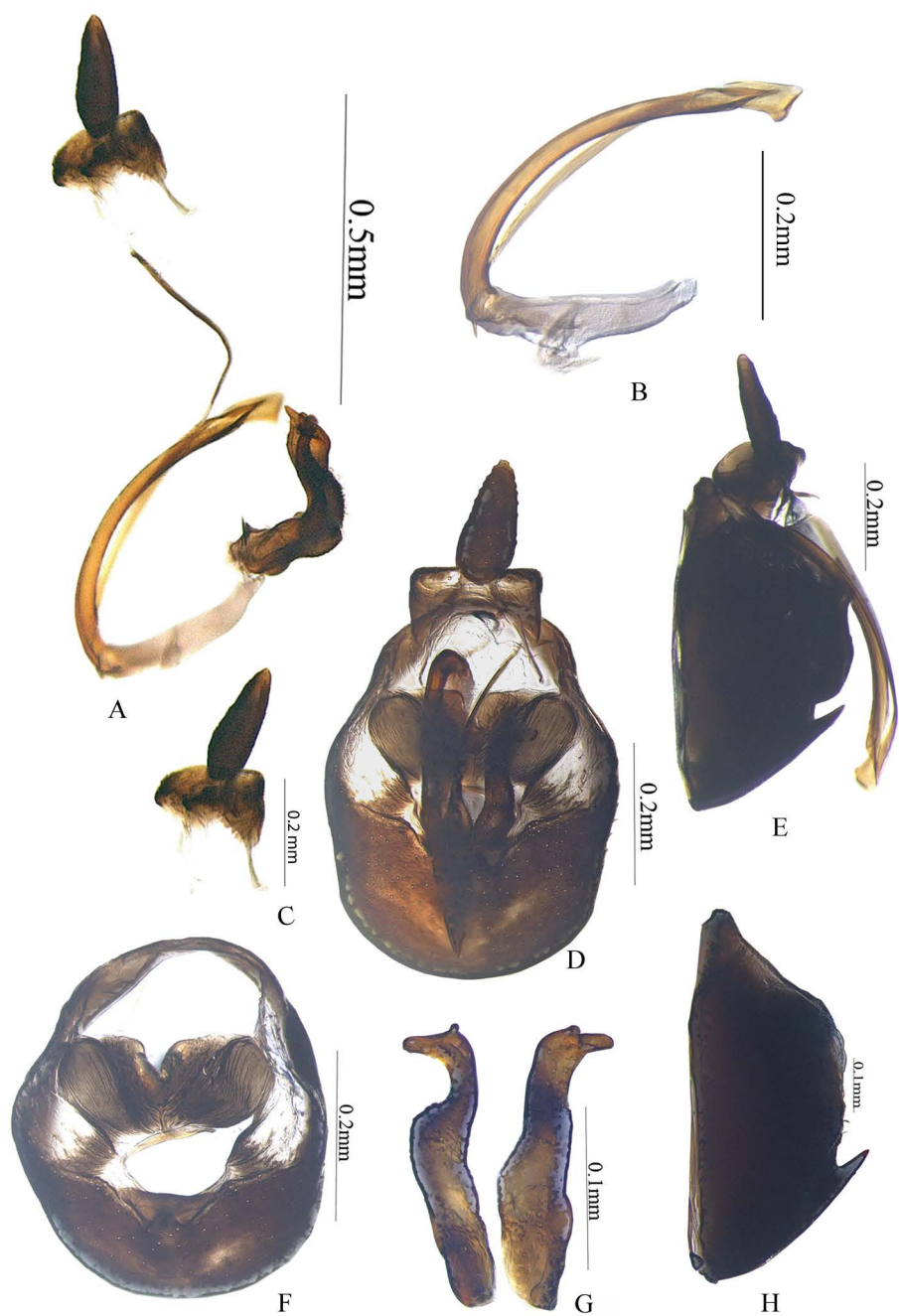


Fig. 35. *Phyllodinus* sp. nov. 4, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Genitalia caudal view; E. Genitalia lateral view; F. Pygofer caudal view; G. Parameres caudal view; H. Pygofer lateral view.

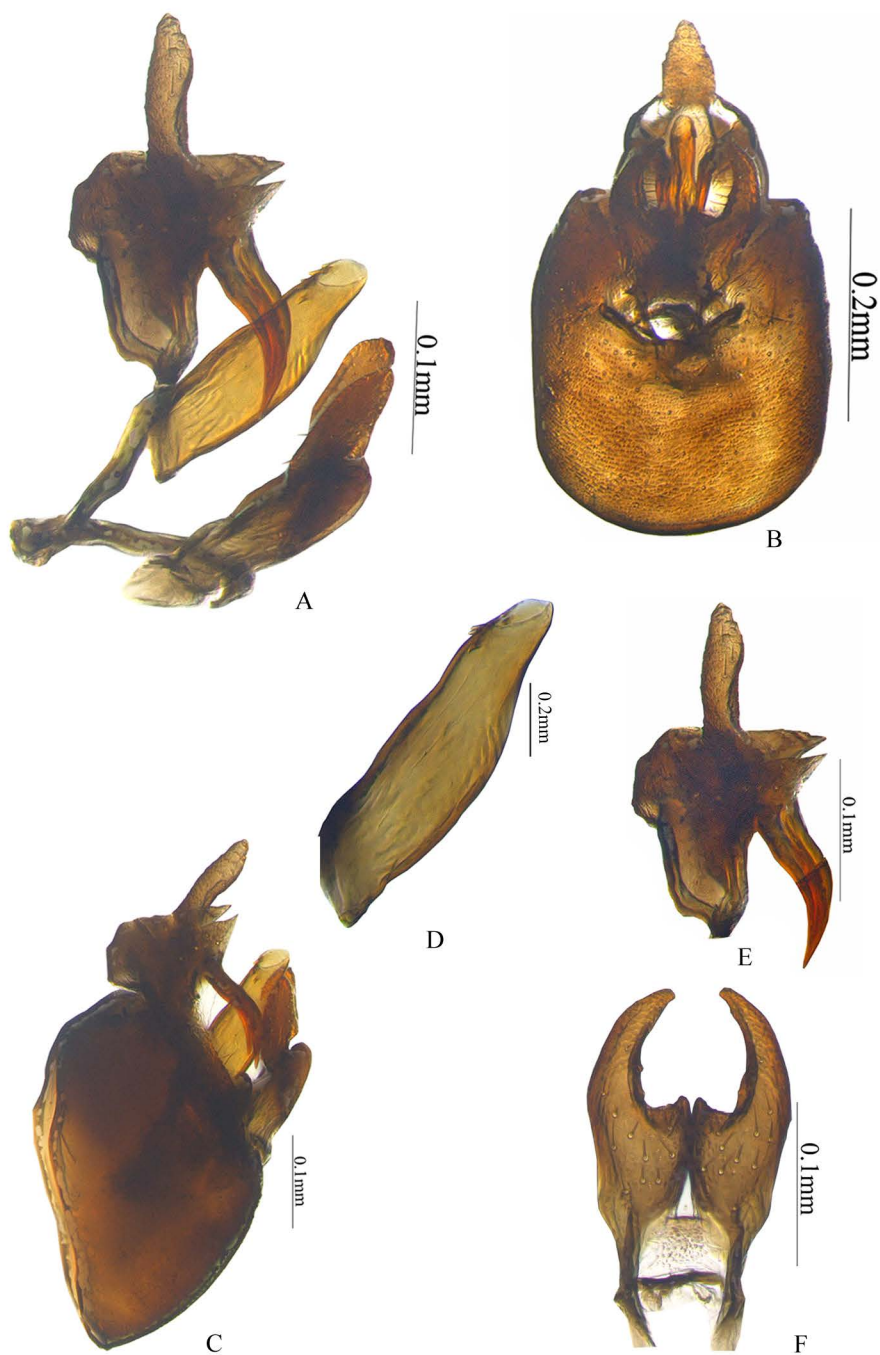


Fig. 36. *Sardia rostrata* Melichar, male genitalia. A. Aedeagal complex; B. Genitalia caudal view; C. Genitalia lateral view; D. Aedeagus right view; E. Segment ten and eleven; F. Parameres caudal view.



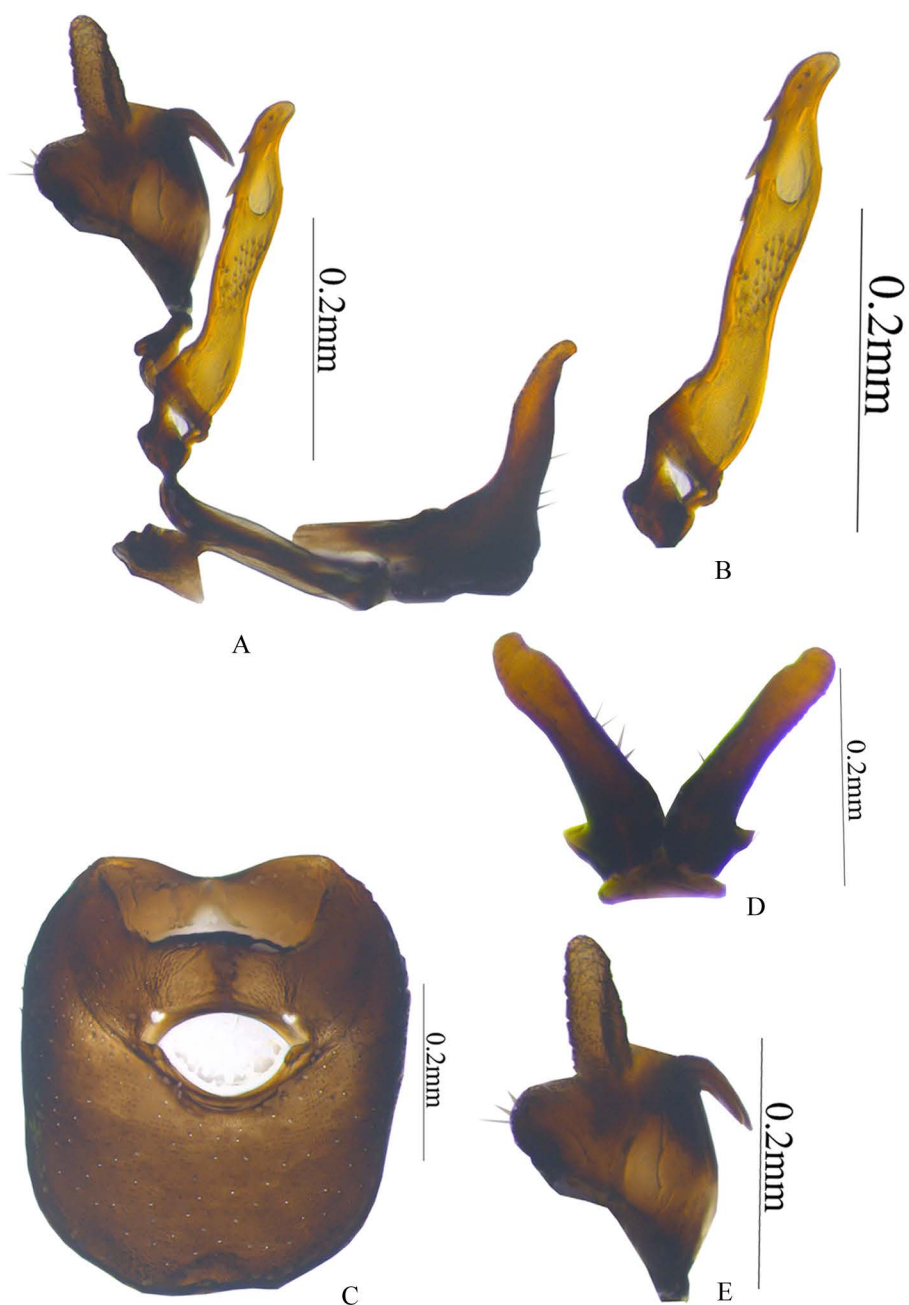


Fig. 37. *Shadelphax eforiae* (Dlabola), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Pygofer caudal view; D. Parameres caudal view; E. Segment ten and eleven.

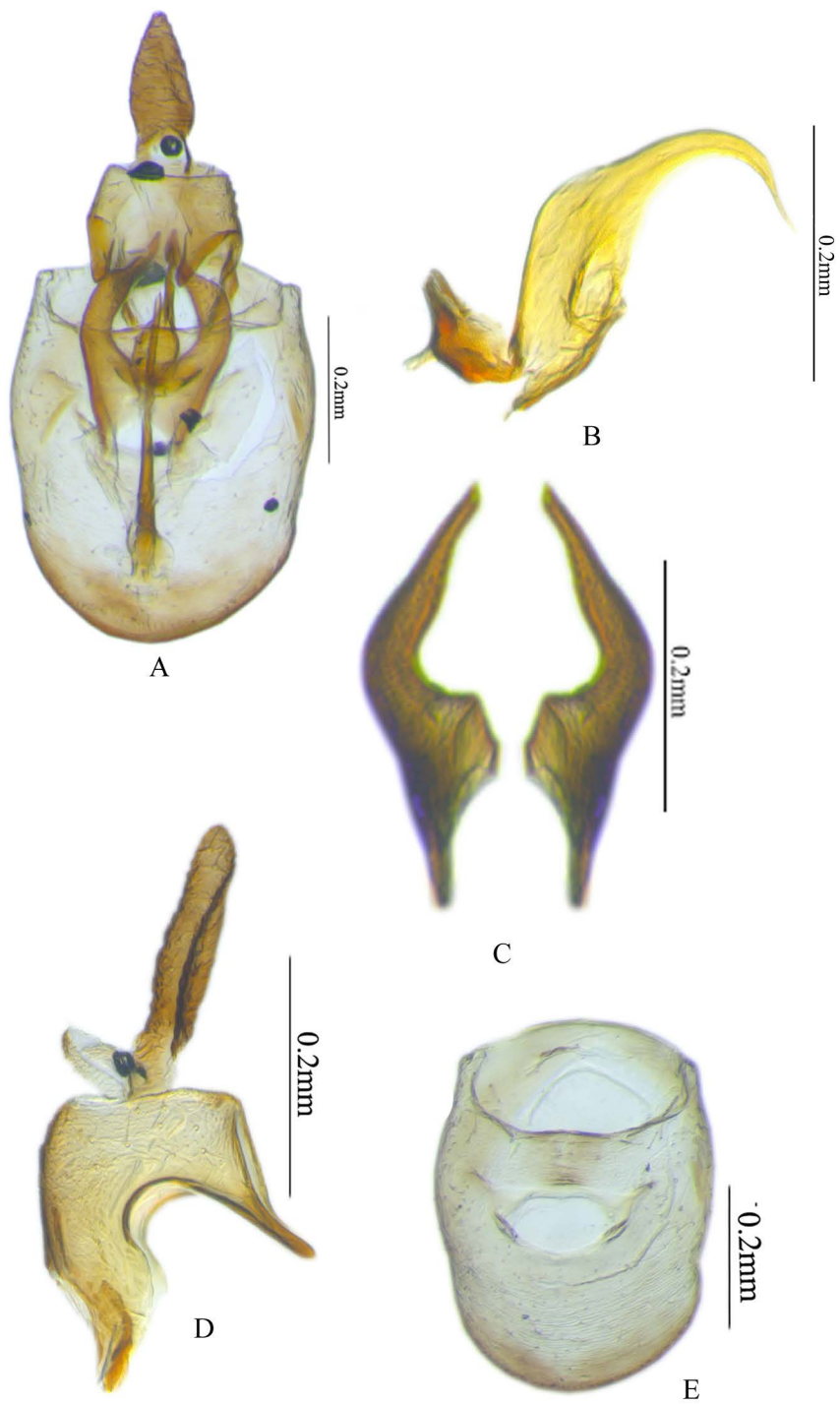


Fig. 38. *Sogata* sp. nov. 5, male genitalia. A. Genitalia caudal view; B. Aedeagus right view; C. Parameres caudal view; D. Segment ten and eleven; E. Pygofer caudal view.

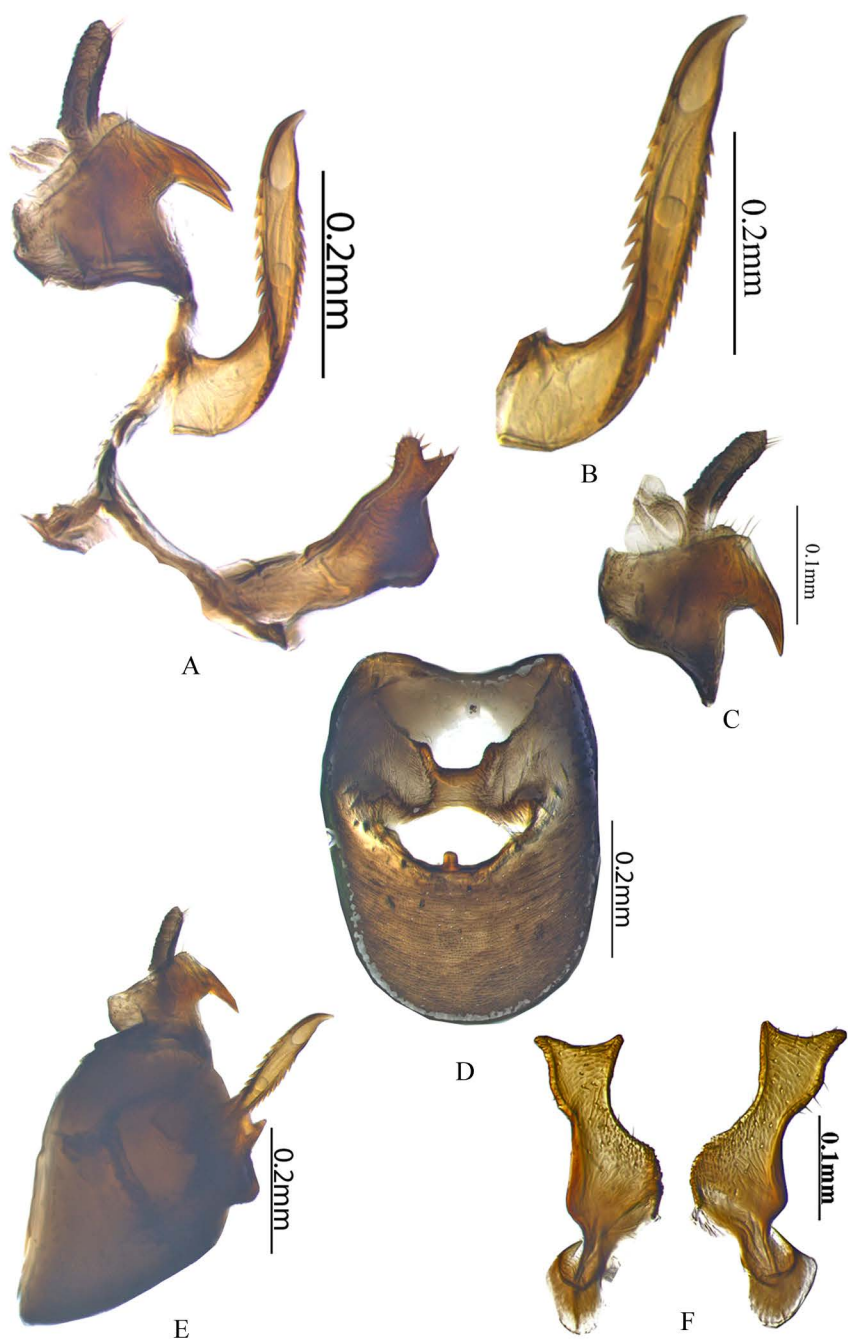


Fig. 39. *Sogatella furcifera* (Horvath), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Genitalia lateral view; F. Parameres caudal view.

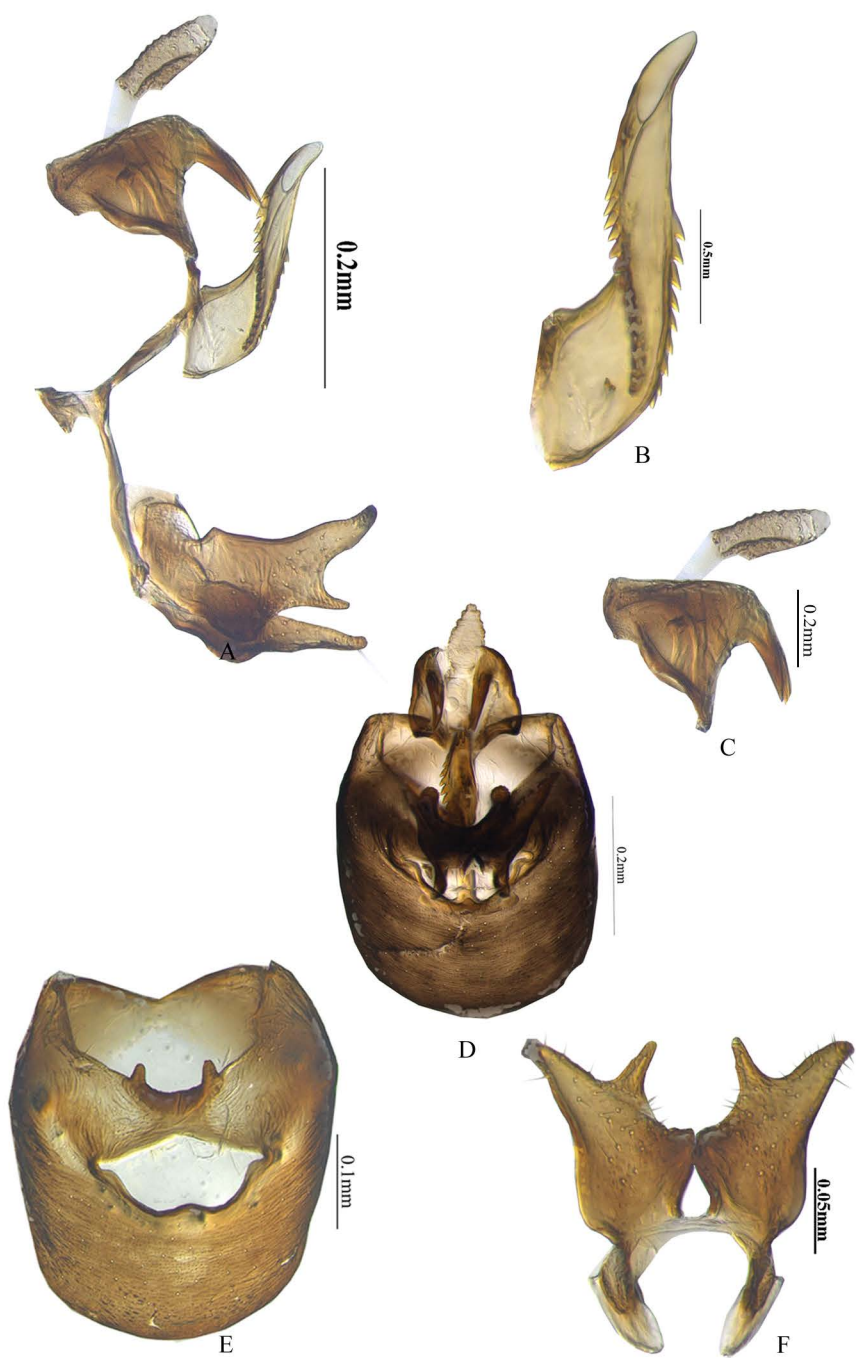


Fig. 40. *Sogatella kolophon* (Haupt), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Genitalia caudal view; E. Pygofer caudal view; F. Parameres caudal view.

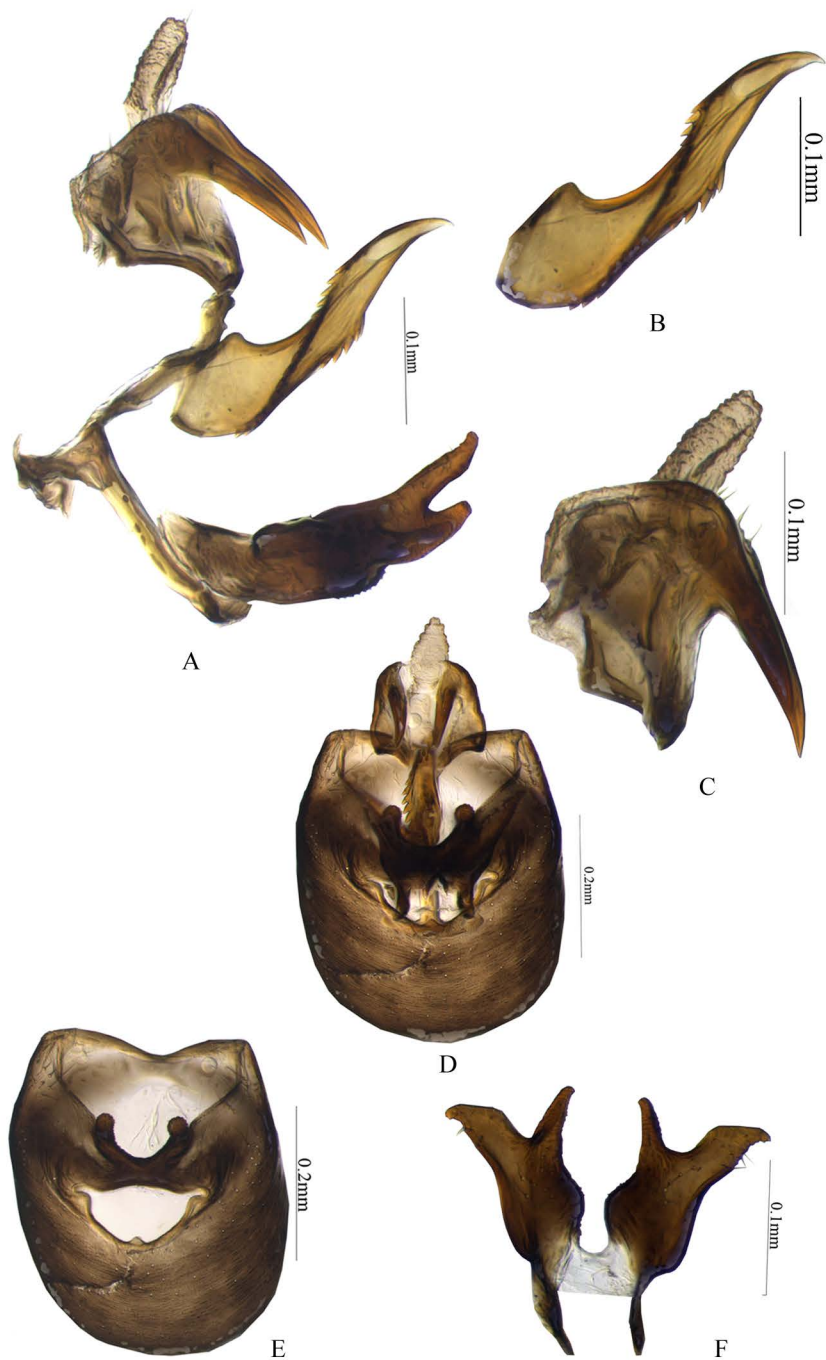


Fig. 41. *Sogatella vibix* (Kirkaldy), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Genitalia caudal view; E. Pygofer caudal view; F. Parameres caudal view.



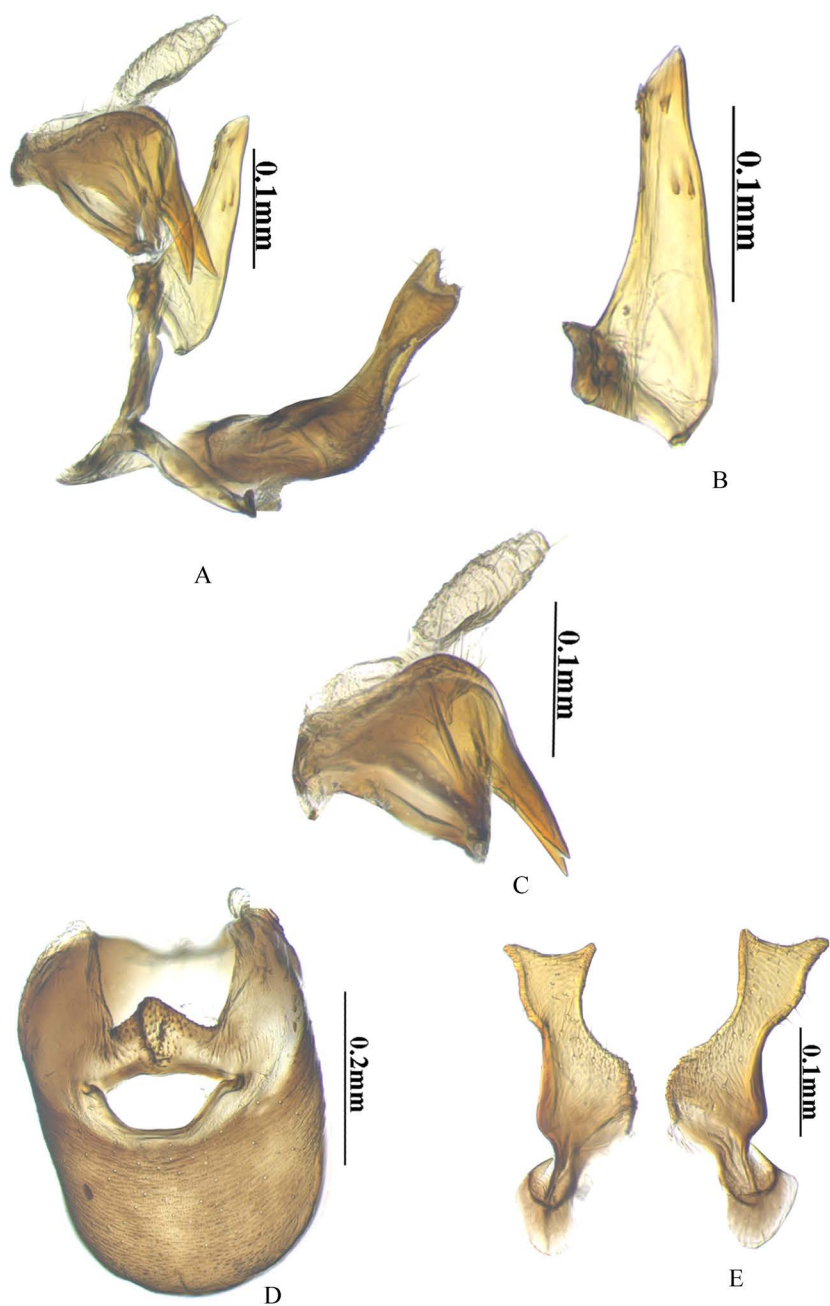


Fig. 42. *Tagosodes pusanus* (Distant), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Parameres caudal view.

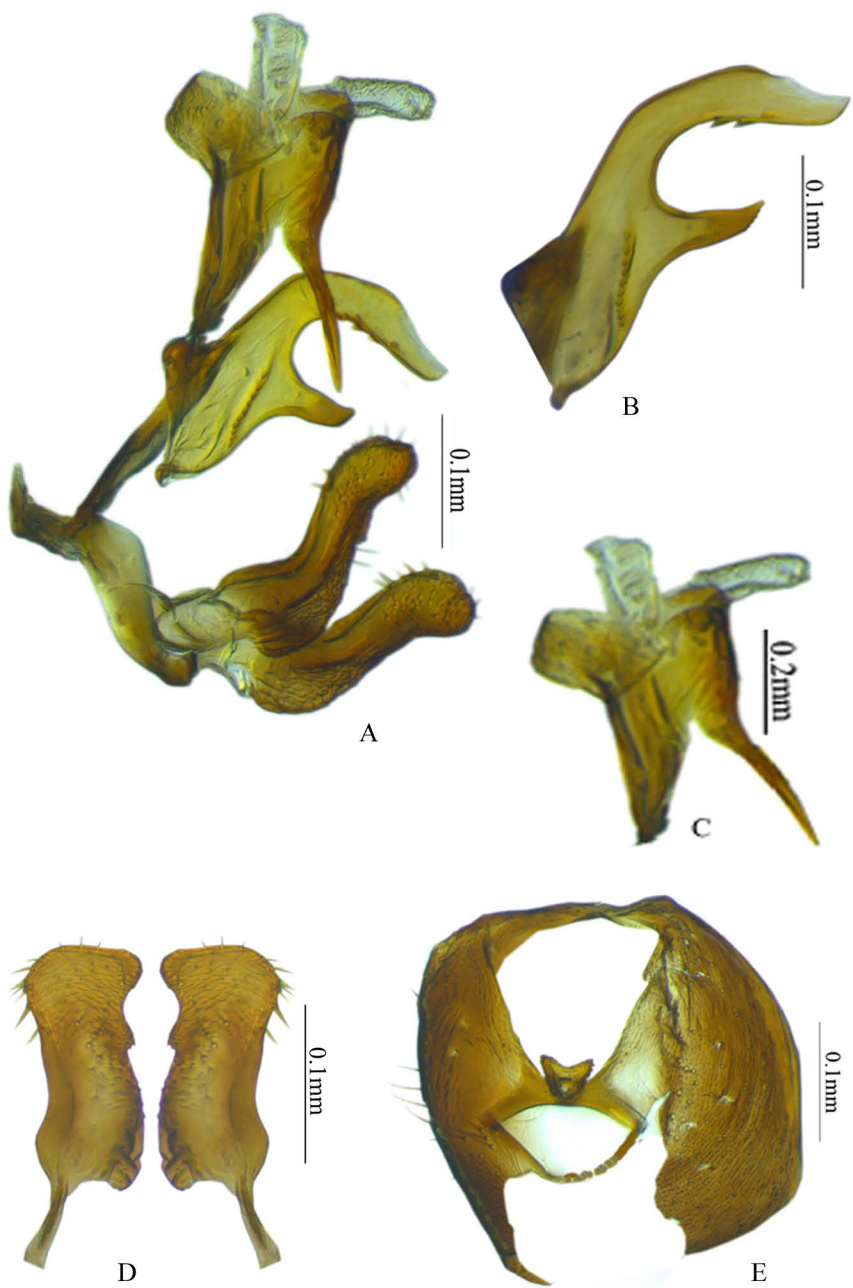


Fig. 43. *Terthron albovittatum* (Matsumura), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Parameres caudal view; E. Pygofer caudal view.

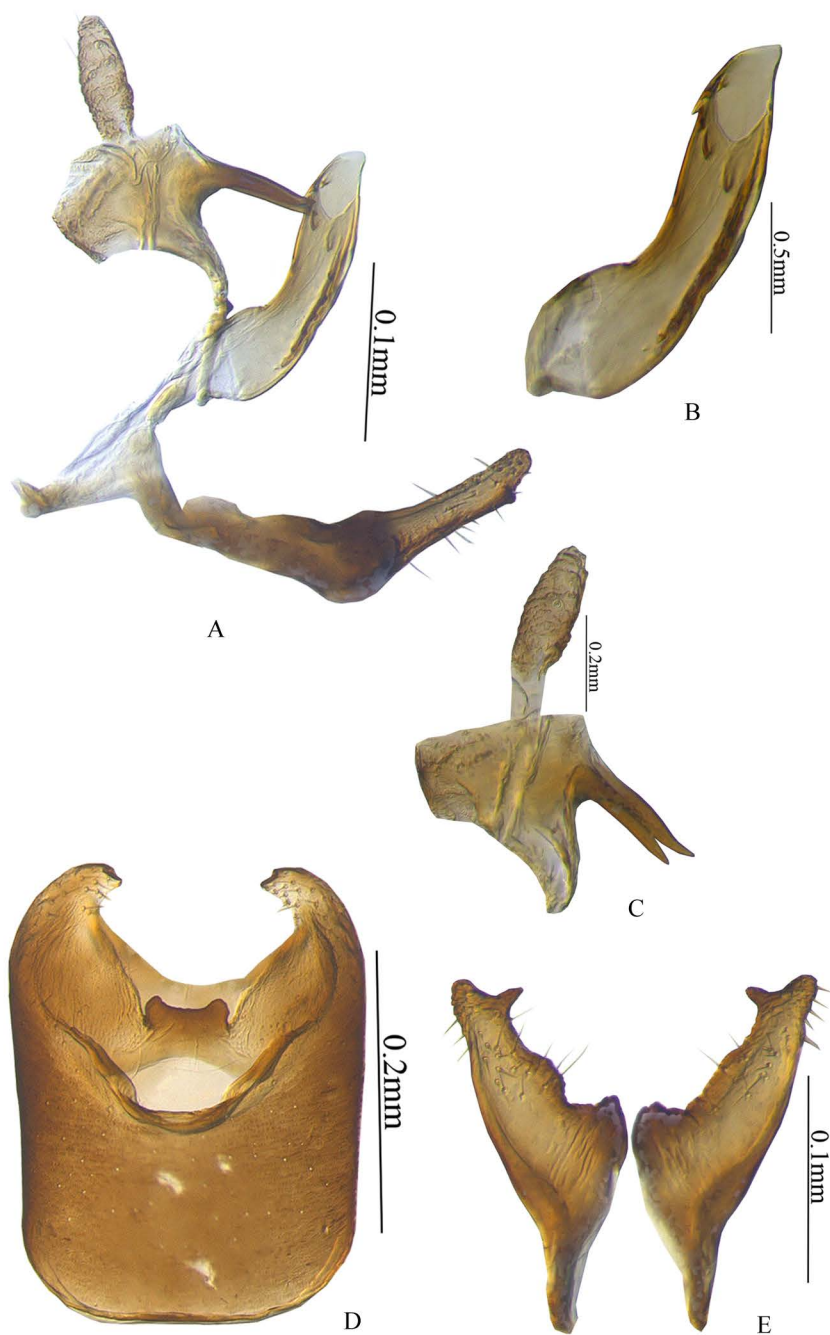


Fig. 44. *Toya nigra* (Crawford), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Parameres caudal view.



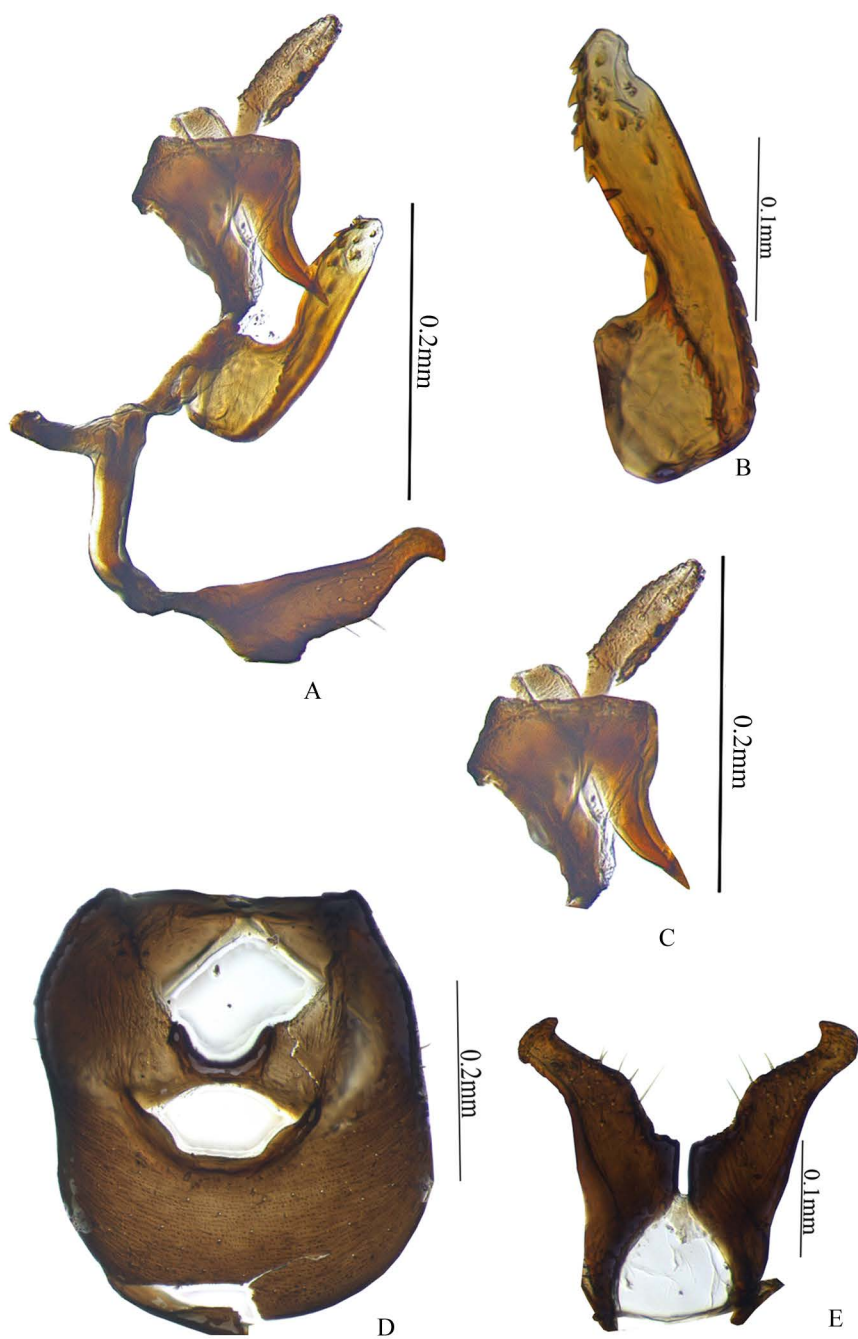


Fig. 45. *Toya tuberculosa* (Distant), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Pygofer caudal view; E. Parameres caudal view.



Fig. 46. *Unkanodes latespinosa* (Dlabola), male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Parameres caudal view; D. Segment ten and eleven; E. Pygofer caudal view.

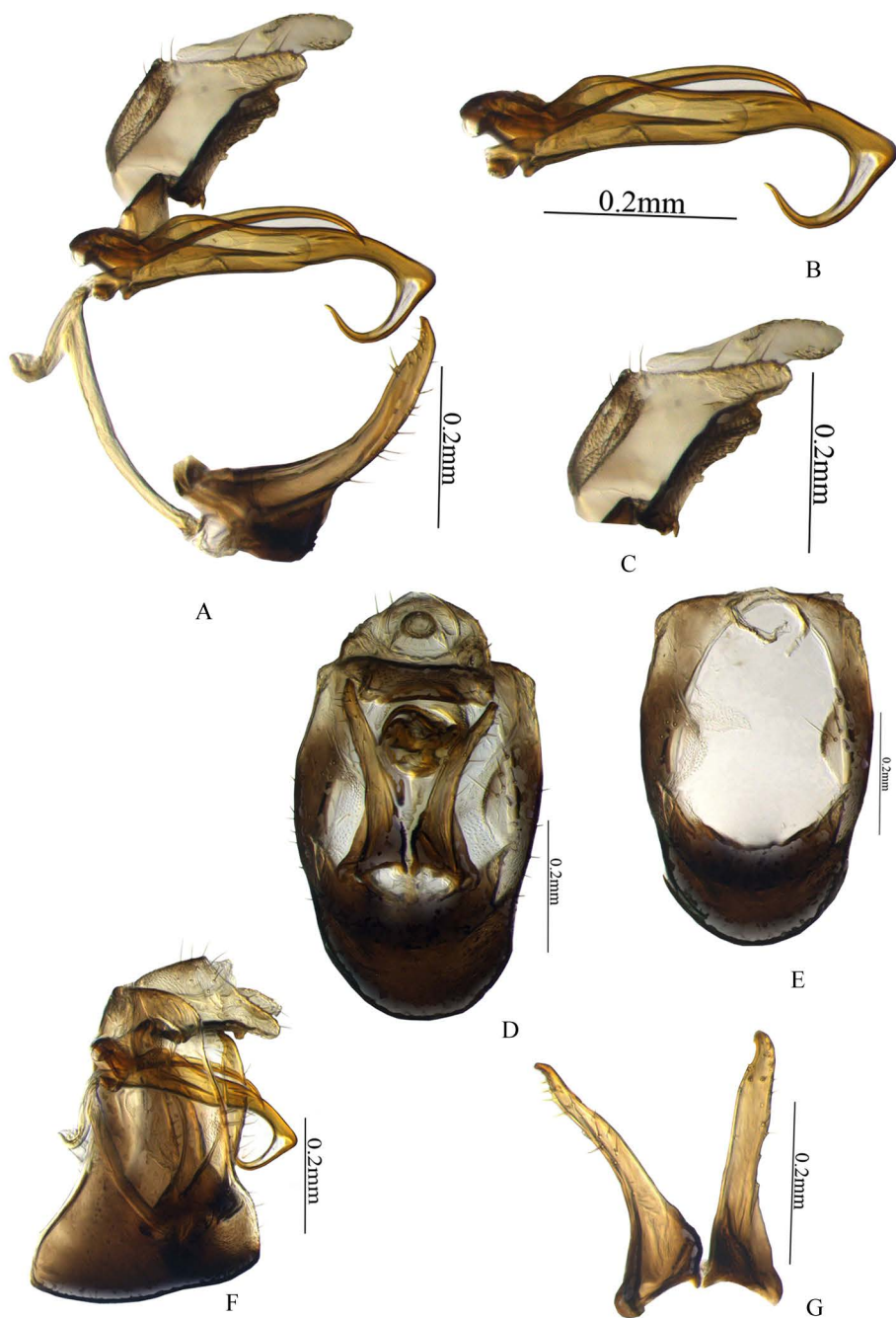


Fig. 47. *Arcofacies securisus* sp. nov. 6, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Genitalia caudal view; F. Genitalia lateral view; E. Pygofer caudal view; G. Parameres caudal view.



Fig. 48. *Arcofaciella sinuata* sp. nov. 7, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Segment ten and eleven; D. Genitalia caudal view; F. Genitalia lateral view; E. Parameres caudal view; G. Pygofer caudal view.

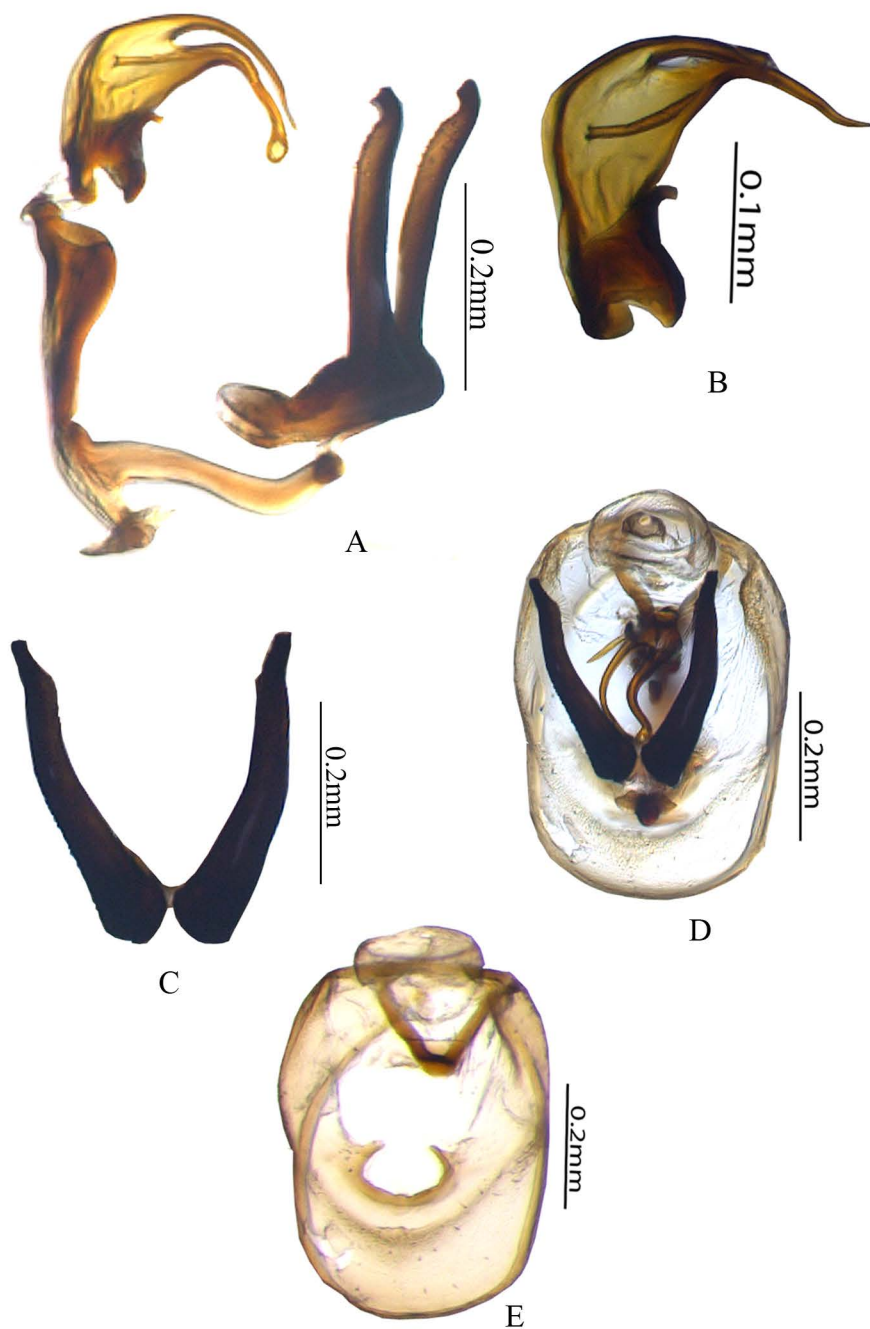


Fig. 49. *Bambusiphaga unispina* Ramya and Meshram 8, male genitalia. A. Aedeagal complex; B. Aedeagus right view; C. Parameres caudal view; D. Genitalia caudal view; E. Pygofer caudal view with segment ten and eleven.



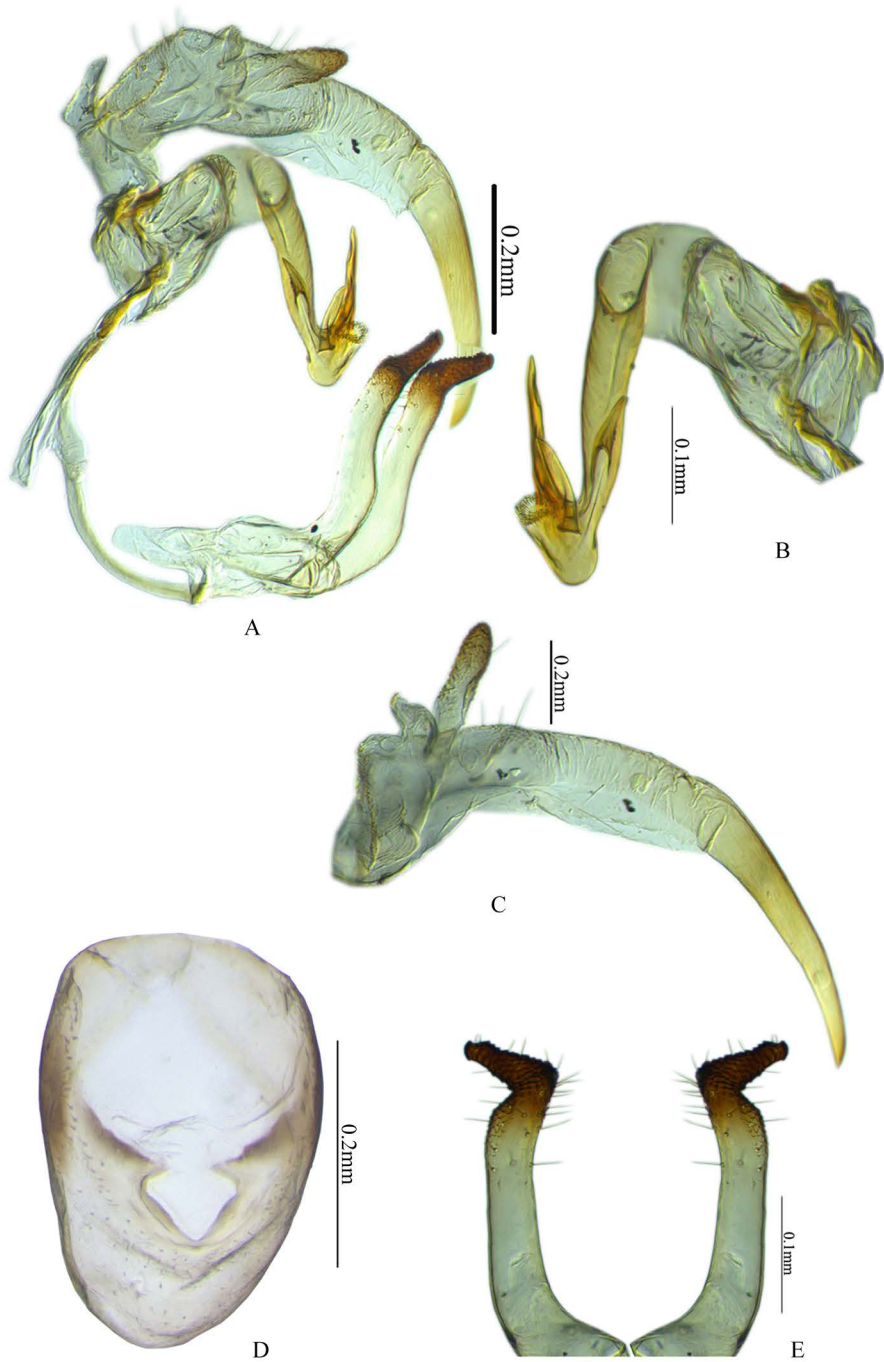


Fig. 50. *Bambusiphaga* sp. nov. 9, male genitalia. A. Aedeagal complex; B. Aedeagus left view; C. Segment ten and eleven; D. Pygofer caudal view; E. Parameres caudal view.

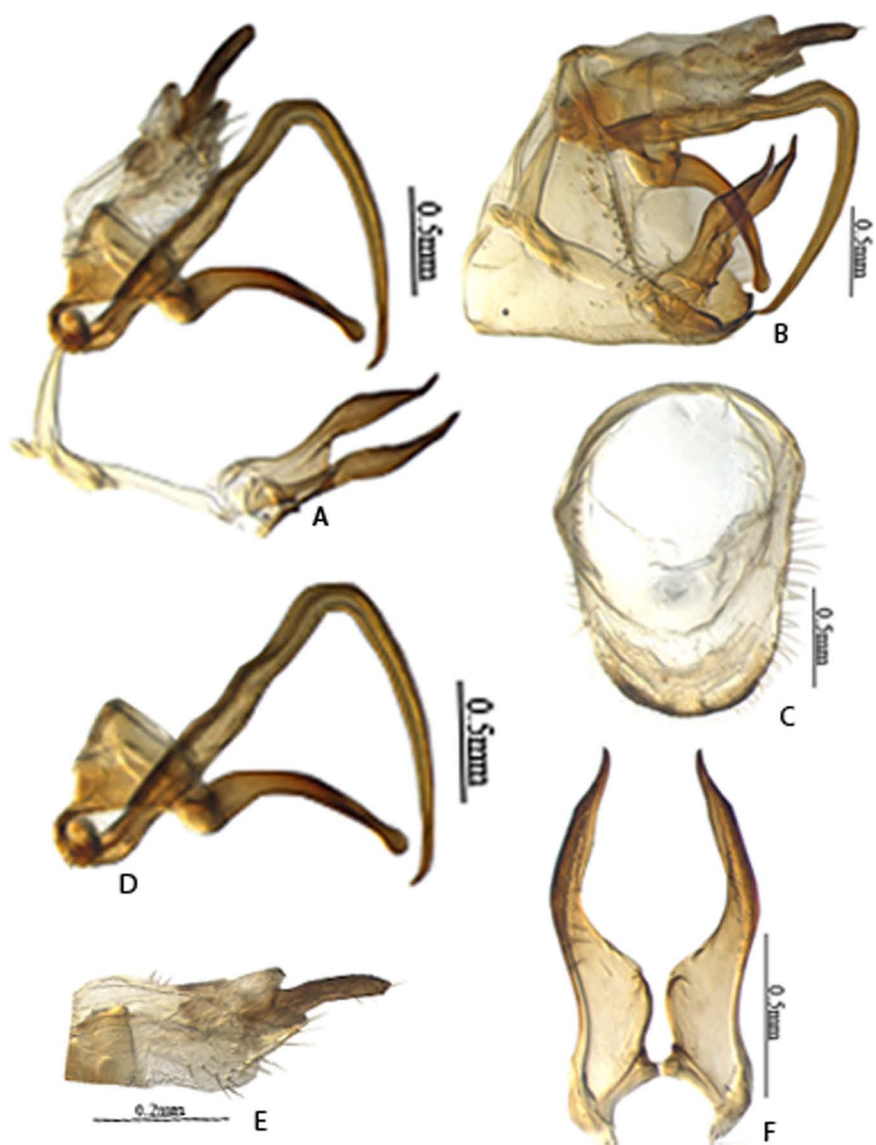


Fig. 51. *Purohita taiwanensis* Muir, male genitalia. A. Aedeagal complex; B. Genitalia lateral view; C. Pygofer caudal view; D. Aedeagus right view; E. Segment ten and eleven; F. Parameres caudal view.



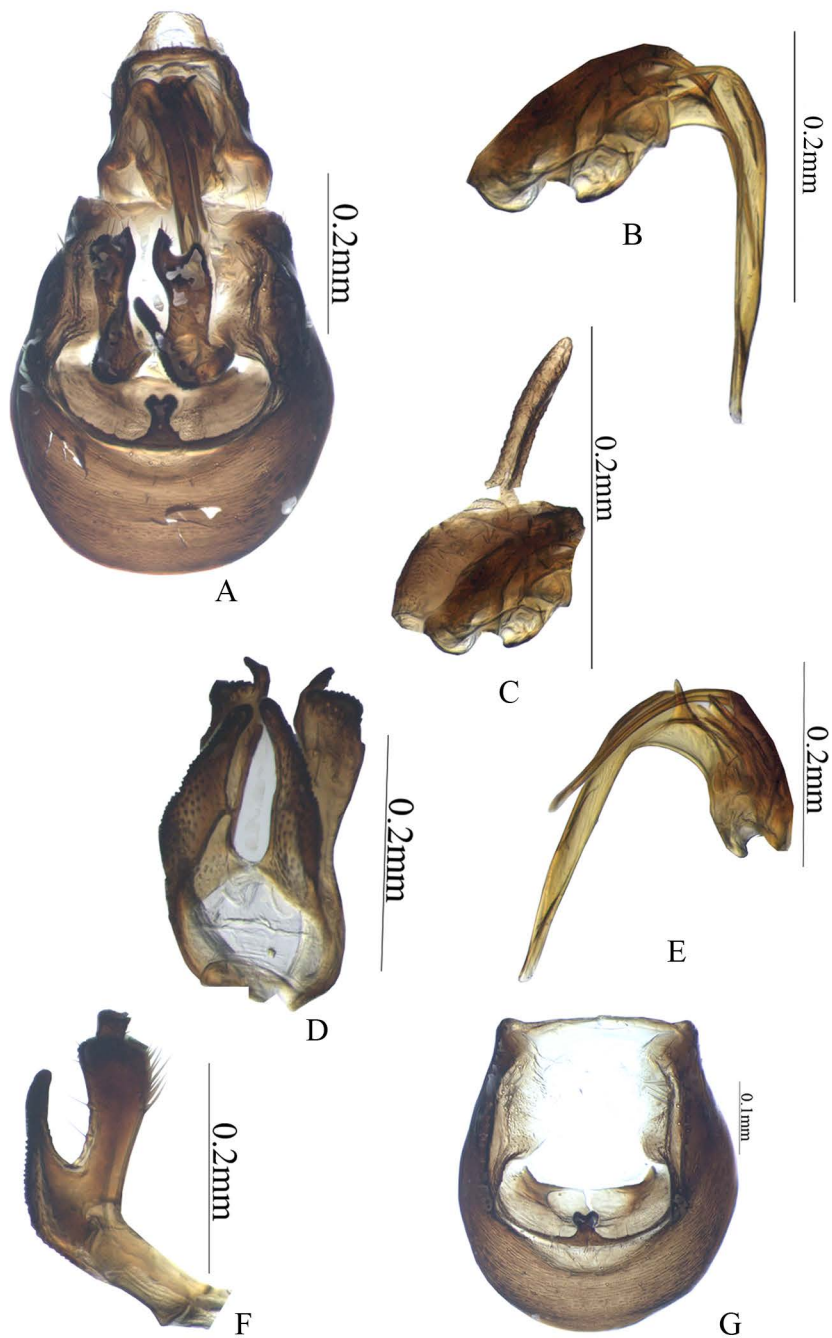


Fig. 52. *Tropidocephala festiva* (Distant), male genitalia. A. Genitalia caudal view; B. Aedeagus right view; C. Segment ten and eleven; D. Parameres caudal view; E. Aedeagus left view; F. Paramere lateral view; G. Pygofer caudal view.

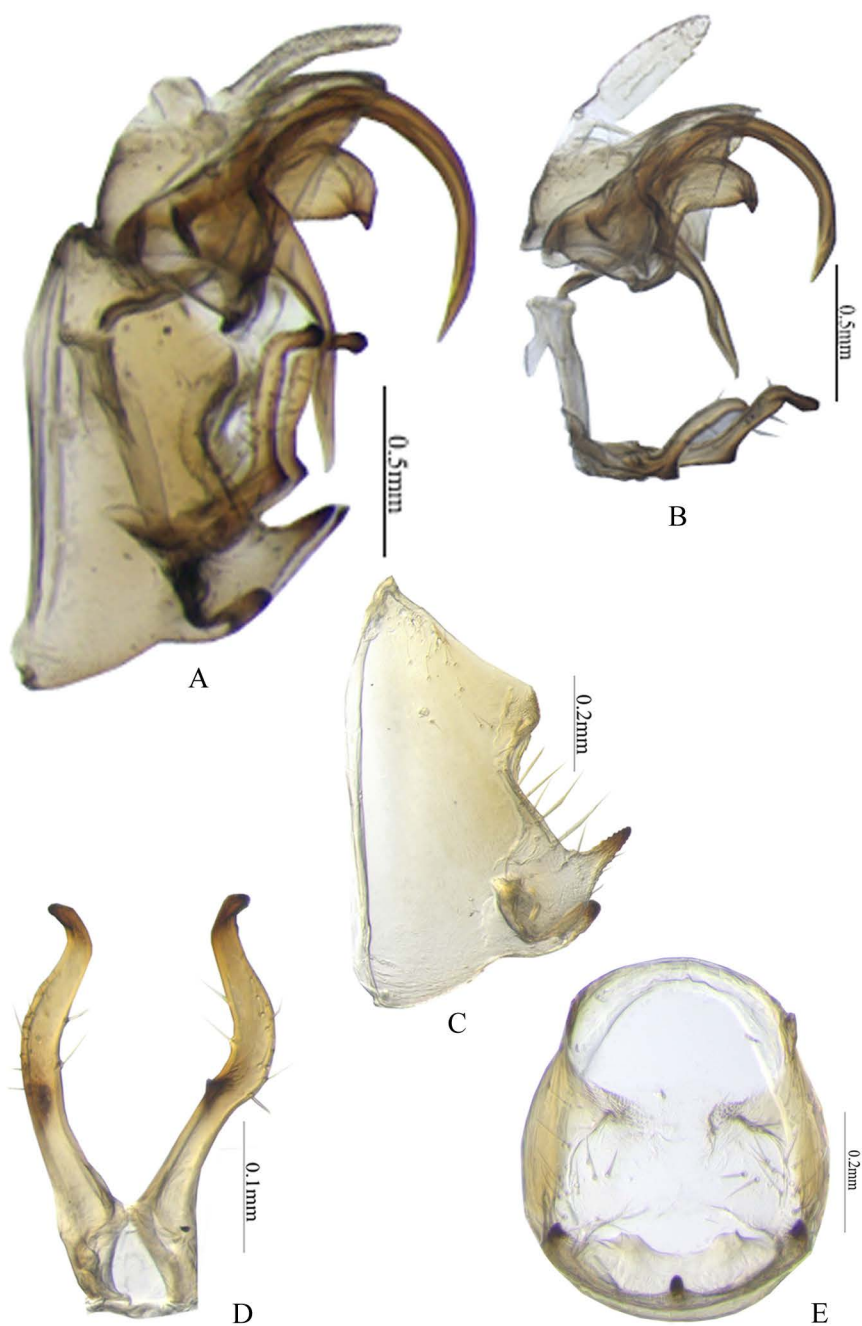


Fig. 53. *Tropidocephala sinuosa* Yang and Yang, A. Genitalia lateral view; B. Aedeagal complex, C. Pygofer lateral view; D. Parameres caudal view; E. Pygofer caudal view.

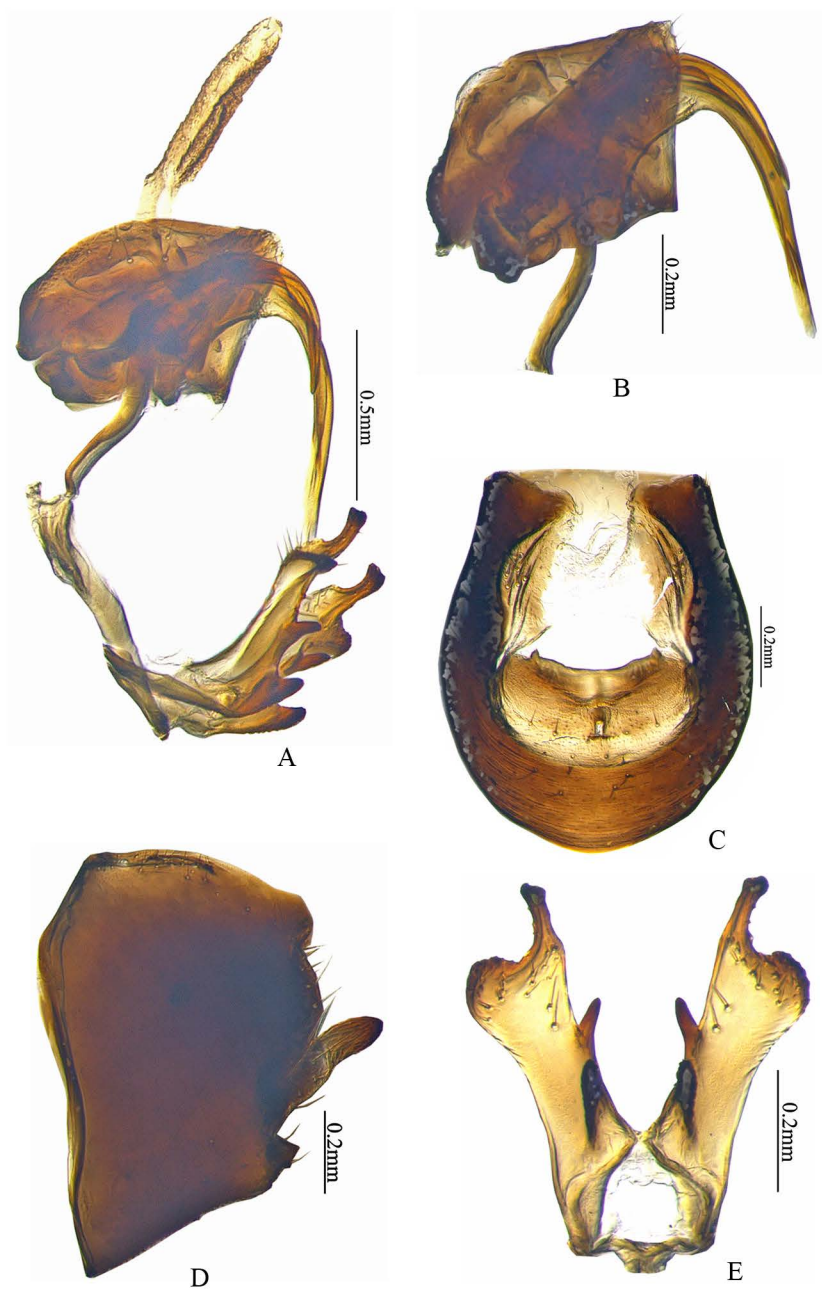


Fig. 54. *Tropidocephala tuberipennis* (Mulsant and Rey), male genitalia. A. Aedeagal complex; B. Aedeagus right view. C. Pygofer caudal view; D. Genitalia lateral view; E. Parameres caudal view.

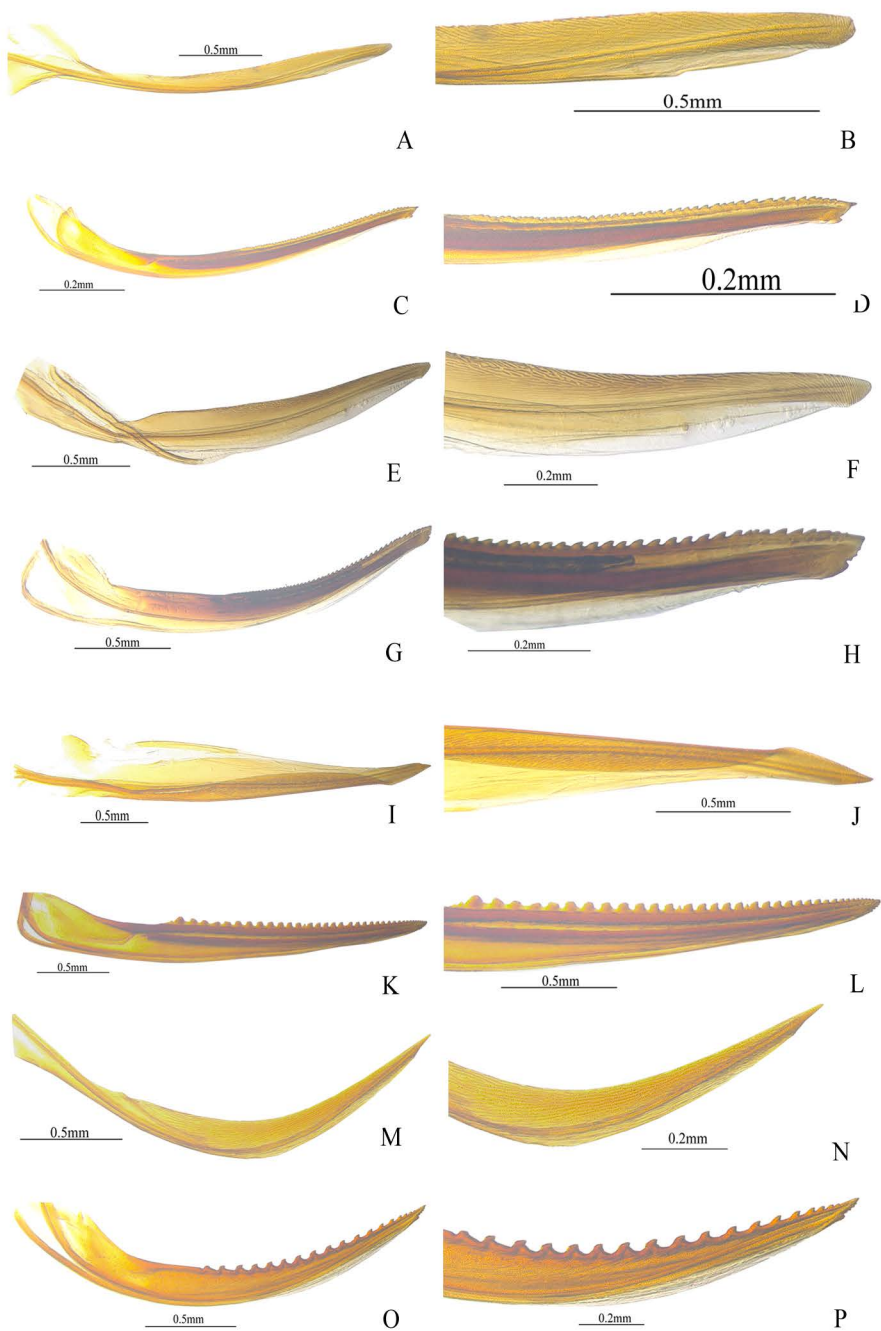


Fig. 55. Species of Delphacini: Female valvulae I and II. *Cemus sauteri* (Muir): A & B. Valvula I; C & D. Valvula II. *Cemus zhitus* Kuoh: E & F. Valvula I; G & H. Valvula II. *Chloriona unicolor* (Herrich-schaffer): I & J. Valvula I; K & L. Valvula II. *Eoeurysa sagitta* sp. nov. I: M & N. Valvula I; O & P. Valvula II.

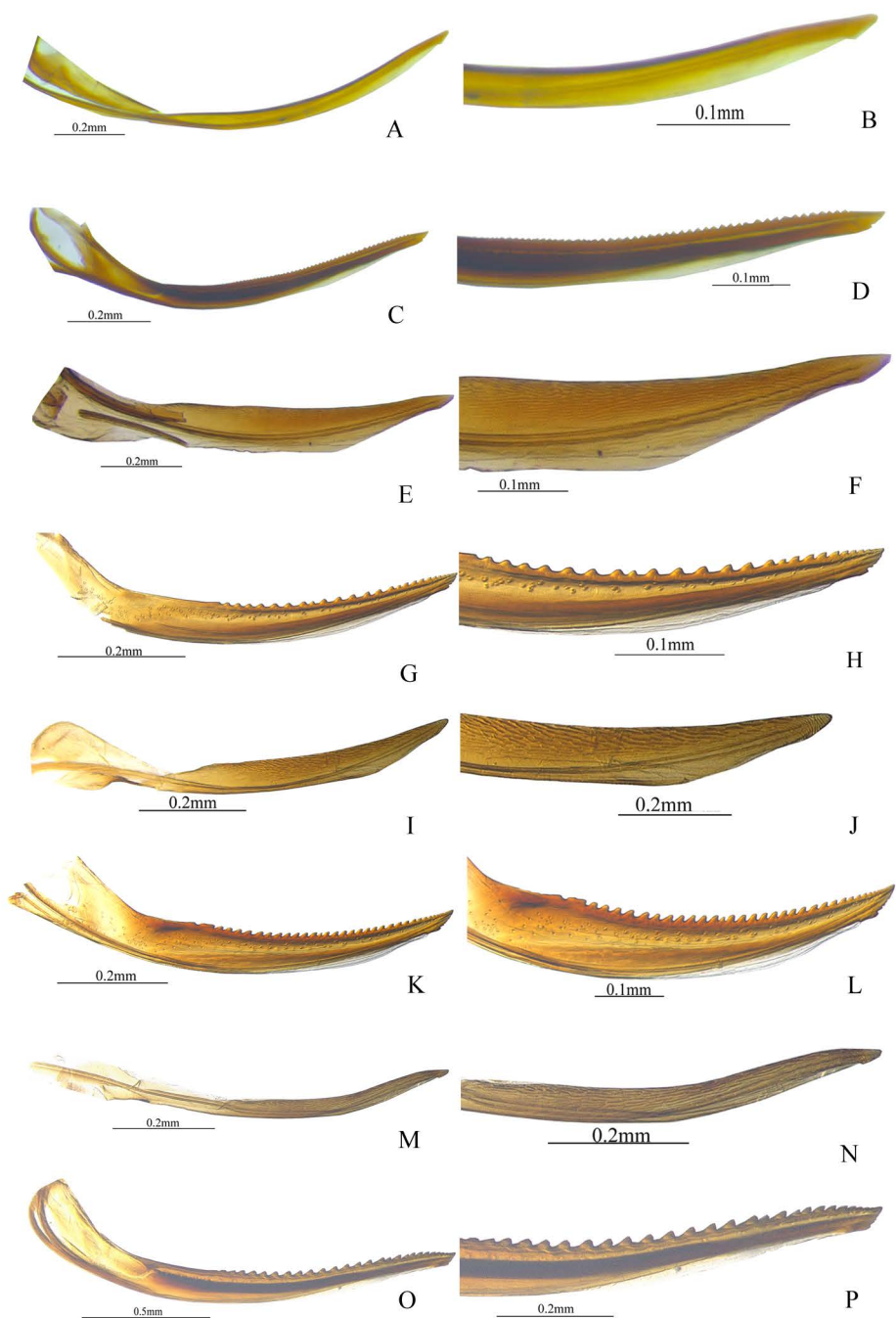


Fig. 56. Species of Delphacini: Female valvulae I and II. *Mahmuktashgaria liboenis* (Chen): A and B. Valvula I; C and D. Valvula II. *Metadelphax propinqua* (Fieber): E and F. Valvula I; G and H. Valvula II. *Nilaparvata lugens* (Stal): I and J. Valvula I; K and L. Valvula II. *Nycheuma nilotica* Linnavuori: M and N. Valvula I; O and P. Valvula II.



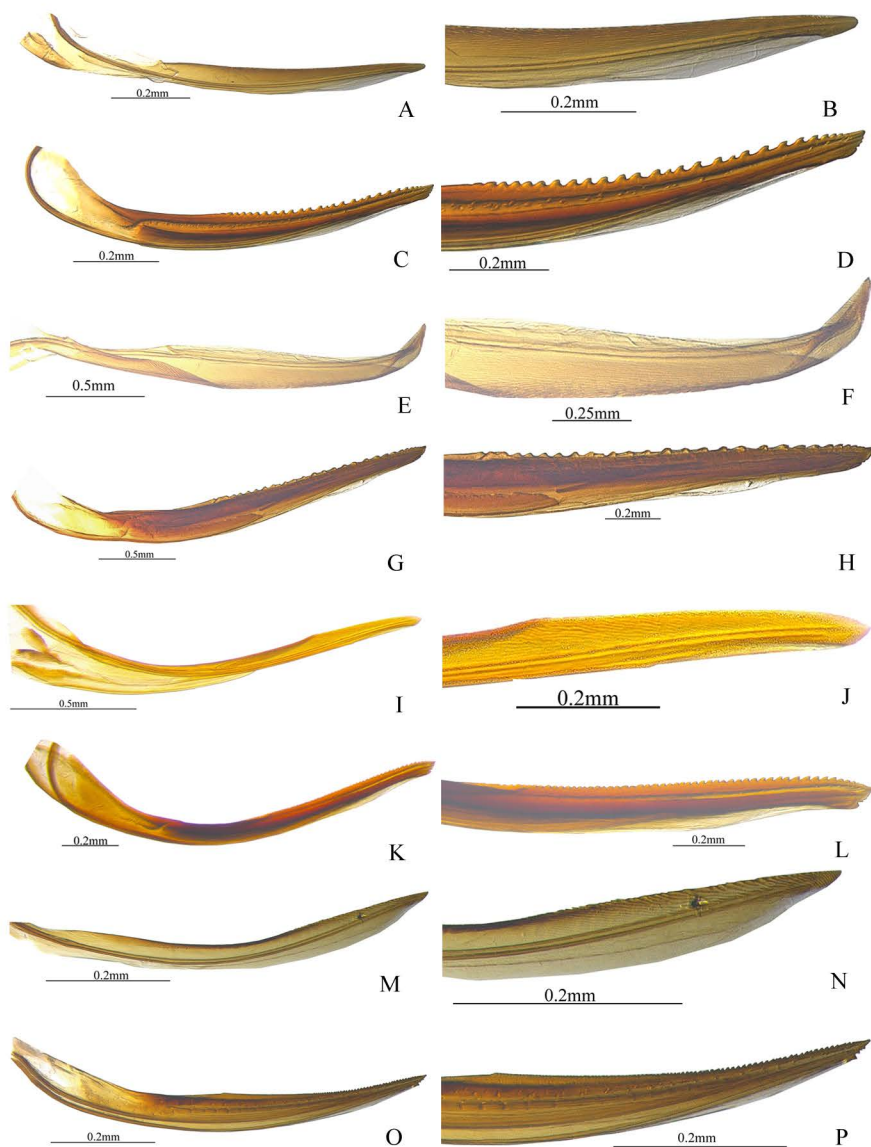


Fig. 57. Species of Delphacini: Female valvulae I and II. *Peregrinus maidis* (Ashmaed): A and B. Valvula I; C and D. Valvula II. *Perkinsiella insignis* Kirkaldy: E and F. Valvula I; G and H. Valvula II. *Perkinsiella sinensis* Kirkaldy: I and J. Valvula I; K and L. Valvula II. *Phyllodinus* sp. nov. 4: M and N. Valvula I; O and P. Valvula II.

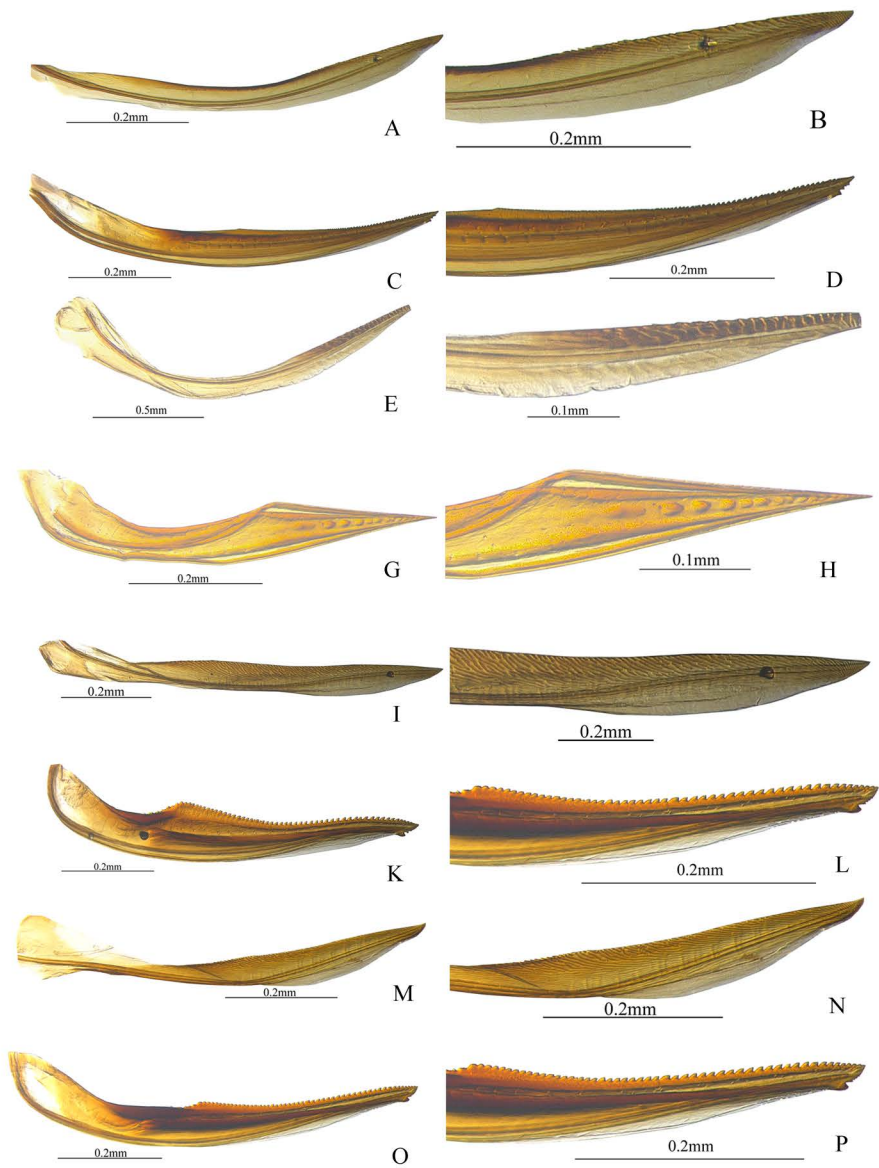


Fig. 58. Species of Delphacini: Female valvulae I and II. *Sardia rostrata* Melichar: A and B. Valvula I; C and D. Valvula II. *Sogata* sp. nov. 5: E and F. Valvula I; G and H. *Sogatella furcifera* (Horvath): I and J. Valvula I; K and L. Valvula II. *Sogatella kolo-phon* (Kirkaldy): M and N. Valvula I; O and P. Valvula II.



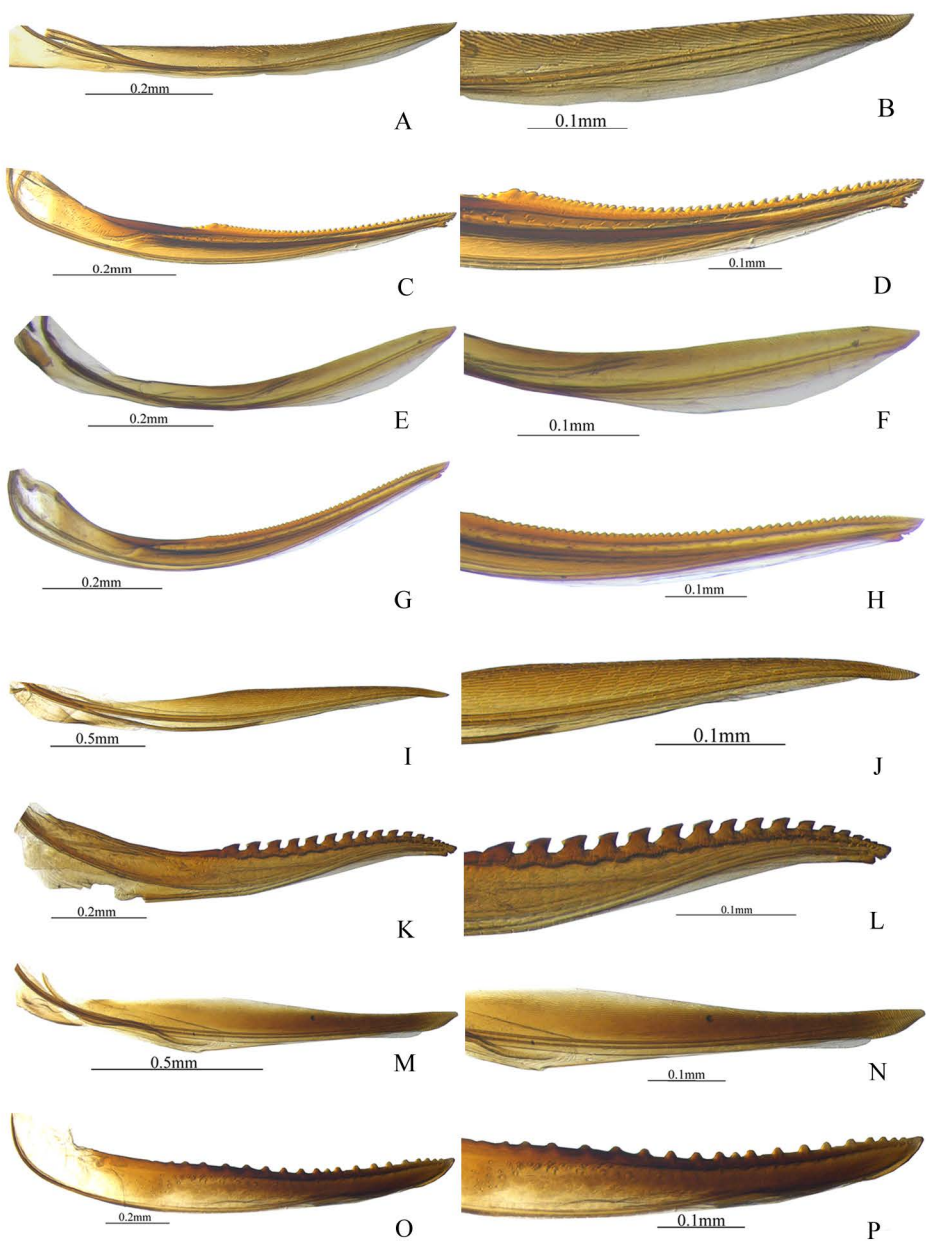


Fig. 59. Species of Delphacini; A-F. Species of Tropidocephalini; I-P: Female valvulae I and II. *Sogatella vibix* (Haupt): A and B. Valvula I; C and D. Valvula II. *Tagosodes pusanus* (Distant): E and F. Valvula I; G and H. Valvula II. *Arcofacies securisus* sp. nov. 6: I and J. Valvula I; K and L. Valvula II. *Arcofaciella sinuata* sp. nov. 7: M and N. Valvula I; O and P. Valvula II.

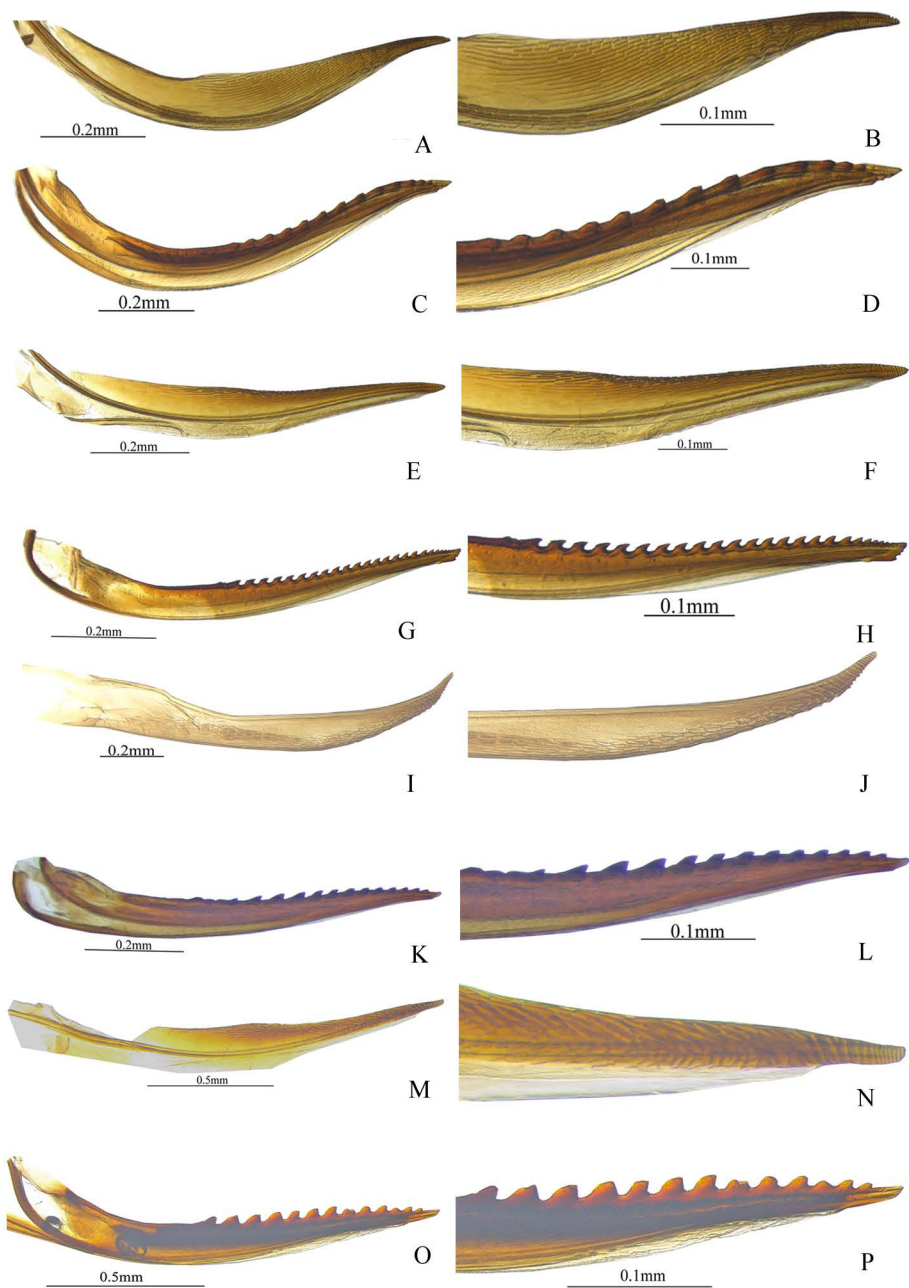


Fig. 60. Species of Tropidocephalini: Female valvulae I and II. *Bambusiphaga* sp. nov. 9: A and B. Valvula I; C and D. Valvula II. *Purohita taiwanensis* Muir E and F. Valvula I; G and H. Valvula II. *Tropidocephala festiva* (Distant): I and J. Valvula I; K and L. Valvula II. *Tropidocephala tuberipennis* (Mulsant and Rey). M and N. Valvula I; O and P. Valvula II.

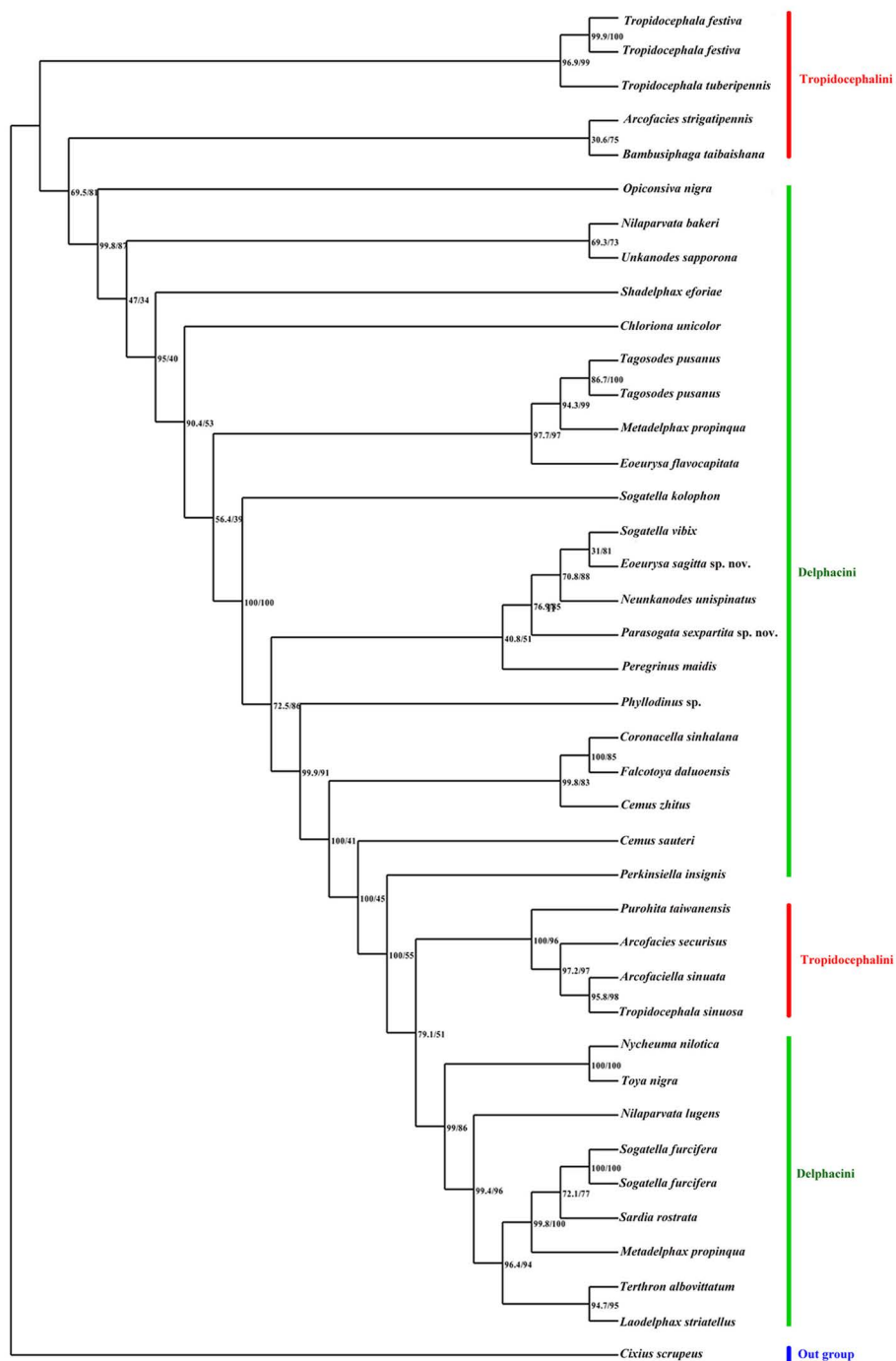


Fig. 61. Phylogram of Delphacinae: Maximum-Likelihood (ML) tree estimated from combined dataset. At each node, values indicate ML support: SH-like approxi-