A new species of the genus *Euxaldar* Fennah, 1978 (Hemiptera, Fulgoromorpha, Issidae) from China and revision on the molecular phylogeny of the family

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Abstract

A new species *Euxaldar daweishanensis* Yang, Chang & Chen, *sp. nov.*, is described and illustrated from southwestern China. The female genitalia of the genus *Euxaldar* is described and presented for the first time. A checklist and key to the known species of the genus are provided. A revised molecular phylogenetic analysis of the family Issidae based on combined partial sequences of 18S, 28S, COI, and Cytb is provided using both Maximum likelihood and Bayesian inference analyses.

Keywords

Checklist, DNA sequence, Hemisphaeriini, identification key, morphology, planthopper, taxonomy

Introduction

The planthopper genus *Euxaldar* Fennah, 1978 is a small group in the Issidae tribe Hemisphaeriini Melichar, 1906, established for a single species *E. jehucal* Fennah, 1978, recorded from Ninh Binh, Ha Noi, Vinh Phuc, Hoa Binh, and Haiphong Province in northern Vietnam (Fennah 1978; Gnezdilov and Constant 2012). Recently
Gnezdilov et al. (2017a) reviewed the genus and described *E. lenis* Gnezdilov, Bourgoin & Wang, 2017 from Lam Dong Province (Da Lat) of southern Vietnam. Later, Zhang et al. (2018) recorded the genus for the first time from southeastern China and described *E. guangxiensis* Zhang, Chang & Chen, 2018 from Guangxi Province. Previously, Gnezdilov placed *Euxaldar* into the tribe Issini Spinola, 1839 (Gnezdilov 2013). However, Wang et al. (2016) moved it to Hemisphaeriini Mongolianina. Recently, this genus was placed in subgroups of Mongolianina: *Mongoliana + (Euxaldar + Macrodaruma)* by Zhao et al. (2019), but as shown in this study it is better placed in the subgroup (*Retaldar + (Clypeosmilus + Eusudasina)*) because all genera in this subgroup have the same characteristic protruded clypeus.

Below, we describe and illustrate a new species of *Euxaldar* from Yunnan Province in China, provide a checklist and key to *Euxaldar* species, and describe and photograph the female genitalia of the new species. The partial DNA sequences (*16S, 28S* (d6-d7), *COI, Cytb*) of the new species are briefly analyzed. A revised molecular phylogeny is analyzed by Bayesian and Maximum likelihood based on seven sequences of four genes (*18S, 28S, COI and Cytb*), providing molecular evidence of phylogenetic relationships within the Issidae and enabling a revaluation of the current classification of the family Issidae by Wang et al. (2016), Zhao et al. (2019) and Gnezdilov et al. (2020).

**Materials and methods**

The morphological terminology used for body appearance follows Chan and Yang (1994) and Anufriev and Emeljanov (1988). Forewing venation pattern follows Bourgoin et al. (2015). The terminologies of male and female genitalia follow Bourgoin (1987, 1993) and Chang et al. (2015). Body length (included forewings) is given in millimeters (mm).

The genital segments of the specimens were macerated in a boiling solution of 10% NaOH for about 5 minutes, washed in distilled water, then immersed in glycerine for observation, dissection, drawing, and photography. They were stored in a micro vial in glycerol for further examination. A Leica MZ 12.5 stereomicroscope was used for illustrations. A KEYENCE VHX-1000C was used to acquire photographs. All specimens studied are deposited in the Institute of Entomology, Guizhou University, Guiyang, China (*GUGC*).

The molecular phylogenetic study included 71 species belonging to 48 genera as ingroups from Issidae (Wang et al. 2016; Zhao et al. 2019; Gnezdilov et al. 2020) and five species as outgroups from the families Cixidae, Caliscelidae, Delphacidae, Dictyopharidae, Tropiduchidae. Data for the 71 included species were downloaded from NCBI. Five ingroup species including the new species were newly sequenced, for which total DNA was extracted using the Animal Tissue Genomic DNA Kit (Tiangen Biotech Company, Beijing, China). Primers and PCR procedures are listed in Tables 1, 2 and carried out in 30 μl volume reaction. Accession numbers for species used in the phylogenetic analysis are shown in Table 4.
A new species of the genus *Euxaldar* Fennah, 1978 from China

### Table 1. Primers used for amplification and sequencing.

| Gene | Primer | Sequence (5’–3’) |
|------|--------|-----------------|
| COI  | COI (LCO18)-PF | GGTCAACAAATCATAAAGATATTG |
|      | COI (HCO29)-PR | TAAACTTCAGGGTGACCAAAAAAT |
| 16S  | 16S-PF | GCCTGTTATCAAAAAACAT |
|      | 16S-PR | CGGTCGTGAACTGAGATCA |
| Cytb | Cytb-PF | TATGACTACCAGGACAAATATC |
|      | Cytb-PR | ATCTTAATGCAAATCCTC |
| 28S  | 28S EE | CGCCTAAGGACTGTGTAAG |
|      | 28S MM | GAAGTTGAGGTCTTARTTTG |
|      | 28S d3–d5 | GACCCGCTTGGAAACACG |
|      | 28S D4D5r | GTTACACACTCCTTAGCGGA |

### Table 2. PCR procedures.

| Gene | COI  | 16S  | Cytb | 28S d3–d5 | 28S d6–d7 |
|------|------|------|------|----------|----------|
| Initial denaturation | 94 °C 5 min | 95 °C 7 min | 94 °C 5 min | 94 °C 3 min | 94 °C 3 min |
| 95 °C 7 min | 94 °C 50 sec | 95 °C 50 sec | 94 °C 1 min | 94 °C 1 min | 94 °C 1 min |
| Annealing | 55 °C 1 min | 50 °C 1 min | 47 °C 1 min | 54 °C 1 min | 55 °C 1 min |
| Extension | 72 °C 1 min | 72 °C 1 min | 72 °C 1 min | 72 °C 1 min | 72 °C 1 min |
| Cycles | 35 Cycles | 35 Cycles | 35 Cycles | 35 Cycles | 40 Cycles |
| Annealing | 72 °C 10 min | 72 °C 10 min | 72 °C 10 min | 72 °C 10 min | 72 °C 10 min |

### Table 3. Nucleotide gene composition of *Euxaldar daweishanensis* Yang, Chang & Chen, sp. nov.

| Gene | A% | T% | G% | C% | A+T% |
|------|----|----|----|----|------|
| COI  | 33.2 | 36.3 | 17.8 | 12.7 | 69.5 |
| 16S  | 27.4 | 48.6 | 14.9 | 9.1 | 76.0 |
| Cytb | 35.3 | 34.5 | 11.6 | 18.6 | 69.8 |
| 28S d6–d7 | 20.4 | 18.9 | 33.7 | 27.0 | 39.2 |

The DNA sequencing was performed at Sangon Company (Shanghai, China). Sequence chromatograms were checked and assembled by Seqman from the package DNASTar v5.01 (www.dnastar.com), calculated by MEGA 6.06 and Notepad 7.6.2. The Maximum likelihood (ML) phylogenetic analysis was performed by IQtree v1.6.7 and visualized by Figtree v1.1.2. A Bayesian estimation search (BI) was performed using MrBayes (Ronquist et al. 2011) on the CIPRES Science Gateway V3.1 Portal (https://www.phylo.org/portal2/home.action). Best partitions and models were chosen by PartitionFinder 2 (Lanfear et al. 2017), running conditions as described in Appendix 1.

### Taxonomy

**Genus *Euxaldar* Fennah, 1978**

*Euxaldar* Fennah, 1978: 267.

**Type species.** *Euxaldar jehucal* Fennah, 1978, by monotypy.

**Diagnosis.** Coryphe transverse, 2–3 times as wide as long. Metope flat and elongate, disc smooth or densely covered by pustules. Anteclypeus with distinct median
### Table 4. Species used in the phylogeny analysis with accession number. “*” denotes new added sequences in this study.

| Species                                               | COI          | Cyto     | Gene 18S (A2–9R) | Gene 28S (D3–D5) | Gene 28S (D6–D7) | Collection |
|-------------------------------------------------------|--------------|----------|-------------------|-------------------|-------------------|------------|
| Agalinatium flavescens (Oliver, 1791)                 | MN194180     | MN191521 | MN165781          | MN266987          | MN266956         | Russia     |
| Anapalolus musculus Dlabola, 1982                     | MN194181     | –        | MN165782          | MN266988          | MN266957         | Turkey      |
| Baldiaza ana (Bell, 1910)                            | –            | MN191522 | MN165783          | MN266989          | MN266958         | Mexico      |
| Bootboca taurus (Osharin, 1870)                       | MN194182     | MN191523 | MN165784          | MN266990          | MN266959         | Bulgaria    |
| Buchaia jojini Dlabola, 1980                          | MN194182     | –        | MN165785          | MN266991          | MN266960         | Bulgaria    |
| Buchiaia sp.                                          | –            | MN191524 | MN165786          | MN266992          | MN266961         | Greece      |
| Cadinella waangraithi Stål, 1863                      | KX702956     | KX702901 | KX702855          | KX761436          | KX702877         | China       |
| Clytusphaera quadrupra Meng & Wang, 2012              | KX702919     | KX702906 | KX761576          | KX761444          | KX702806         | China       |
| Ceratogergithus pseudotessellatus (Che, Zhang & Wang, 2007) | KX761502     | KX761513 | KX761491          | KX761532          | KX761521         | China       |
| Ceratogergithus spinosus (Che, Zhang & Wang, 2007)    | KX761502     | KX761513 | KX761491          | KX761532          | KX761521         | China       |
| Chionagrus longipes Zhang, Wang & Che, 2006            | KX761460     | –        | KX650620          | KX761450          | KX702810         | China       |
| Ciazi sp.                                             | KR343731     | KX702891 | JQ982514          | KX761413          |                   | France      |
| Chyphopinus centrodemus Gnezdilov & Souls-Derfler, 2017 | KX761470     | KX61474  | KX615753          | –                 | –                 | Vietnam     |
| Conocephalus coelatus Mulsant & Rey, 1855             | MN194185     | MN191526 | MN165787          | MN266995          | MN266962         | France      |
| Dicranotropis bartoni (Boeheman, 1847)                | KX76146      | –        | KX702837          | KX761409          | –                 | Austria     |
| Diephagra europaea (Linnæus, 1767)                     | KJ911190     | KX702896 | KX702851          | KX761427          | –                 | Russia      |
| Eucnemus vayssieri (Bonhôte, Anie & Reynaud, 2001)    | –            | –        | MN165789          | MN266995          | MN266964         | China, Reunion |
| Exuadina sinontensis Yang, 1994                        | HM052838     | HM452266  | –                 | –                 | –                 | China       |
| ExCoalda daweiensis sp. nov.*                         | MK441660     | MK441661 | –                 | –                 | –                 | China       |
| ExCoalda lena Gnezdilov, Bourgoin & Wang, 2017        | –            | –        | KX761565          | KX761412          | –                 | Vietnam     |
| Falctidus limbatus (A. Costa, 1864)                    | MN194185     | –        | MN165790          | MN266996          | MN266965         | Italy       |
| Flavina batuana (Wang & Wang, 1999)                   | –            | KX702912 | KX702824          | KX761453          | MN381846         | China       |
| Fornisia sp.                                          | KX761498     | KX61509  | KX761487          |                   | KX761518         | China       |
| Gergithoides carinatifrons Schumacher, 1915           | KX761555     | KX702905 | KX761538          | –                 | KX702805         | China       |
| Gergithoides caulipinnus Chen, Zhang & Chang, 2014*   | MN171521     | MW233581 | –                 |                   | MW228374         | China       |
| Gergithoides rugulosus (Melichar, 1906)               | HM052835     | HM452279  | –                 | –                 | –                 | China       |
| Gergithius frontilongus Meng, Webb & Wang, 2017*      | MN171522     | MW233582 | –                 |                   | MW228375         | China       |
| Gergithus paralides Che, Zhang & Wang, 2007*          | MN171525     | MW233583 | –                 |                   | MW228376         | China       |
| Gergithus yunnanensis Che, Zhang & Wang, 2007*        | KX702924     | KX702915 | KX702831          | KX761456          | MN381848         | China       |
| Gnezdilovius sp.*                                     | MN171524     | –        | –                 |                   | MW228577         | China       |
| Hemisphaerius coccinelloides (Burmeister, 1834)       | KX702934     | KX702884 | KX702834          | KX761405          | KX702861         | Philippines |
| Hemisphaerius fuscus Fennah, 1978                     | KX702933     | KX702883 | KX702835          | KX761404          | KX702860         | Vietnam     |
| Hemisphaerius palmeroni Fennah, 1978                  | KX761497     | KX61508  | KX761486          | KX761526          | KX761517         | China       |
| Hemisphaerius refraueri Walker, 1858                  | KX702923     | KX702913 | KX702825          | KX761454          | KX702812         | China       |
| Hemisphaerius sp.                                     | KX761536     | KX702885 | KX702855          | KX761406          | KX702862         | Laos        |
| Hemisphaerius tateaeus Distant, 1906                  | HM052831     | HM452258  |                   |                   |                   | China       |
| Hypotermum dolichotum Gnezdilov & Mazzoni, 2004       | –            | –        | MN165791          | MN266977          | MN266966         | France      |
| Issu coleotatus (Fabricius, 1781)                      | KX702932     | KX61505  | KX761568          | KX761403          | KX761560         | France      |
| Issu lauri Ahrens, 1814                                | –            | MN191528 | MN165793          | MN266999          | MN266908         | Italy       |
| Kerriaea omeiporta (Spinola, 1839)                    | MN194187     | MN191529 | MN165794          | MN267009          | MN266909         | Italy, 1839 |
| Kordaniella bic Testamentum Fennah, 1956              | KX761458     | KX702902 | KX702814          | KX761441          | KX702802         | China       |
| Kordaniella intonum Wing, Bourgoin & Zhang, 2017      | –            | KX761472 | KX761476          | KX761480          | KX761482         | China       |
| Laternatium latifrons (Hieber, 1877)                  | MN194188     | MN191530 | MN165795          | MN267001          | MN266970         | Bulgaria    |
A new species of the genus *Euxaldar* Fennah, 1978 from China

| Species | COI | Cytb | Gene 18S (A2–9R) | Gene 28S (D3–D5) | Gene 28S (D6–D7) | Collection |
|---------|-----|------|------------------|------------------|------------------|------------|
| *Laticia antalyica* (Dlabola, 1986) | – | MN191531 | MN165796 | MN267002 | MN266071 | Greece |
| *Laticia dilatata* (Fourcroy, 1785) | – | MN191532 | MN165797 | MN267003 | MN266072 | Greece |
| *Macrodaruma pertinax* Fennah, 1978 | KX702931 | KX702882 | KX702832 | KX761402 | KX702859 | Vietnam |
| *Macrodaruma* sp. | KX702927 | KX702881 | KX702828 | KX761399 | KX702857 | China |
| *Maculergithus* multipunctatus (Che, Zhang & Wang, 2007) | KX702918 | KX702904 | KX702816 | KX761443 | KX702804 | China |
| *Maculergithus* nonomaculatus (Meng & Wang, 2012) | KX761503 | KX761514 | KX761492 | KX761535 | KX761522 | China |
| *Mongoliana* serrata Che, Wang & Chou, 2003 | HM052830 | HM452272 | – | – | – | China |
| *Mongoliana* sinuata Che, Wang & Chou, 2005 | KX761459 | KX702908 | KX702820 | KX761448 | – | China |
| *Mongoliana* sp. 2 | – | KX761566 | KX761534 | MN381849 | China |
| *Mongoliana* sp.1 | – | MN332233 | MN422135 | MN381854 | Thailand |
| *Mongoliana triangulalis* Che, Wang & Chou, 2003 | – | KX761510 | KX761561 | KX761528 | – | China |
| *Mulsantereum* maculifrons (Mulsant & Rey, 1855) | KX702928 | KX761551 | KX761569 | KX761400 | MN381847 | France |
| *Mycterodus* drosopoulosi Dlabola, 1982 | MN194189 | MN191533 | MN165798 | MN267004 | MN266073 | Greece |
| *Mycterodus* goricus (Dlabola, 1958) | MN194190 | MN191534 | MN165799 | MN267005 | MN266074 | Greece |
| *Neodurium* hamatius Wang & Wang, 2011 | KX702920 | – | KX702818 | KX761446 | MN381844 | China |
| *Neogergithoides* tubercularis Sun, Meng & Wang, 2012 | KX761558 | KX702910 | KX702822 | KX761451 | MN381845 | China |
| *Opthalmosphaerius* trilobulus (Che, Zhang & Wang, 2006) | KX761462 | KX702914 | KX702826 | KX761455 | KX702813 | China |
| *Palmallorcus* punctulatus (Rambur, 1840) | KX761462 | KX702914 | MN165800 | MN267006 | MN266075 | Greece |
| *Proteinia* bilimeki Fowler, 1904 | MN194195 | MN191557 | MN165803 | MN267009 | MN266078 | Greece |
| *Rhombiscus* sp. | MN381857 | MN332232 | MN381856 | MN381855 | MN381851 | China |
| Sarina bifurca Meng & Wang, 2016 | MN332231 | MN381852 | MN381855 | MN381850 | China |
| Scrobipalpus tepatapaturium Minjaev, 1971 | – | – | – | MN267010 | MN266079 | Kazakhstan |
| Scorophyllum discolus (Germar, 1821) | – | – | MN165804 | MN267011 | MN266080 | Bulgaria |
| Serrumica sp. | KX702922 | KX702909 | KX702821 | KX761449 | KX702809 | China |
| *Talnichius* ophiolus (Linnarsson, 1787-1840) | MN194194 | MN191538 | MN165805 | MN267012 | MN266081 | Turkey |
| *Tingia* guadarramensis (Malach, 1906) | KX702935 | KX702886 | MN165806 | MN267015 | MN266082 | Portugal |
| *Trypetimorpha* fulvus Meetall, 1923 | MN194195 | MN191539 | MN165807 | MN267014 | MN266083 | Mexico |
| *Zopherisca* penelea (Felt, 1923) | – | KX761546 | KX761437 | – | – | Kazakhstan |
| *Zopherisca* penelea (Dlabola, 1974) | KX702957 | – | KX761546 | – | – | Kazakhstan |

**Distribution.** China, Vietnam.

**Checklist of *Euxaldar* species**

*E. daweishanensis* sp. nov. (Southwestern China: Yunnan Province)
Key to male species of *Euxaldar*

Modified from Gnezdilov et al. (2017a) and Zhang et al. (2018).

1 Metope smooth. Forewings without coloured bands or spots (Gnezdilov et al. 2017a: fig. 23) ................................................................. *E. lenis*

   – Metope with a row of distinct pustules along lateral margins. Forewings with coloured bands or spots (Figs 9, 11; Zhang et al. 2018: fig. 5; Gnezdilov et al. 2017a: figs 20, 33) ......................................................... 2

2 Metope without median carinae. Metopoclypeal suture incomplete medially. Hind wings rudimentary, shorter than half length of forewings (Zhang et al. 2018: fig. 5) ...................................................................................... *E. guangxiensis*

   – Metope with weak median carinae running from upper margin to middle. Metopoclypeal suture complete, straightly, or weakly concave. Hind wings developed, longer than half length of forewings (Gnezdilov et al. 2017a: figs 20, 33) .................................................................................................. 3

3 Coryphe about 3 times as wide as long in the middle. Male anal tube enlarging from base to apical margin and deeply concave at posteromedial part in dorsal view (Gnezdilov et al. 2017a: fig. 6) ........................................................................... *E. jehucal*

   – Coryphe about 4 times as wide as long in middle. Male anal tube elongated in dorsal view, enlarging from base to apical fourth and narrowing at apical part, lateral margins with a triangular process in the upper half on each side (Figs 8, 13) ......................................................... *E. daweishanensis* sp. nov.

*Euxaldar daweishanensis* sp. nov.

http://zoobank.org/663A901A-6FF8-4BC9-A6B9-C9D1244AAB5B

Figs 1–26

**Type material.** Holotype: ♂, China: Yunnan Province, Pingbian County, Mt: Daweishan National Nature Reserve (23°07’ N, 103°20’ E), 8 August, 2017, Qiang Luo, Nian Gong, Y.-J Sui, Yan Zhi. Paratypes: 7♂♂ 36♀♀, same data as holotype.

**Measurements.** Total length (from apex of coryphe to tip of forewing): male 4.1–4.3 mm (*N* = 6), female 4.6–4.9 mm (*N* = 10); forewing length: male 3.8–4.0 mm (*N* = 7), female 4.2–4.4 mm (*N* = 10).

**Diagnosis.** This species differs from other *Euxaldar* species by the following characters: (1) coryphe about 2.3 times wider than long (less, or more than 2.3 times as wide as long in other species of *Euxaldar*); (2) first metatibiotarsal of hind leg with 8 intermediate spines (other species of *Euxaldar* with first metatarsomere of hind leg
A new species of the genus *Euxaldar* Fennah, 1978 from China

Coloration. Male body brown yellowish, with irregular dark brown bands on forewings. Coryphe brown (Fig. 8). Metope with all margins, pustules, and median carinae pale yellow, disc dark brown (Fig. 9). Metopoclypeal suture light yellow. Anteclypeus straw yellow. Postclypeus pale yellow (Figs 9, 10). Rostrum and antenna straw yellow (Fig. 10). Eyes dark brown (Figs 8–10). Pronotum straw yellow. Mesonotum dark brown (Fig. 8). Forewings slightly hyaline, with 2 irregular brown bands (Figs 1, 2, 11): a large one derived from costal margin to almost C2 of radial cell, small one derived from apical half of median cell, extended to areola postica (anterior cubital area). Legs (Figs 2, 4) light brown. Abdomen brown, male genital segment light straw yellow. Females generally darker than males (Figs 3, 4).

Head and thorax. Coryphe transverse, about 2.3 times wider than long, anterior margin weakly prominent in the middle, posterior margin angularly concave (Fig. 8). Metope flat, median carinae weak, running from upper margin and reaching middle, with a row of distinct pustules along lateral margins, disc with weak pustules (Fig. 9). Metopoclypeal suture complete (Fig. 9). Anteclypeus with distinct median carinae (Figs 9, 10). Pronotum with disc depressed (Fig. 8). Mesonotum about 2.1 times longer than pronotum. Forewings (Figs 1–4, 11) with distinct claval suture and CuP venation, the other venation reticulate, poorly recognizable. Hind wings about 0.7 times as long as forewings, venation reticulate (Fig. 12). Hind tibiae with 2 lateral teeth. Metatibiotarsal formula (9–8)–8–2.

Male genitalia. Anal tube (Fig. 13) enlarging from base to apical fourth in dorsal view, narrowing to apex, apical margin convex in the middle, laterally with 2 small triangular processes in apical fourth. Pygofer with hind margin distinctly convex (Figs 5, 14). Gonostyli triangular, hind margin convex, caudo-dorsal angle rounded (Fig. 14). Capitulum of gonostyli style with wide and short neck, with a wide lateral tooth and 2 apical teeth (Figs 14, 15). Corpus of connective rod-like (Figs 5–7, 16, 17), curved, cuticularized, reaching middle of periandrium; tectiductus of connective cup-shaped, third ventral part separated from corpus (Fig. 14). Periandrium asymmetrical (Figs 6, 7, 16, 17), suspensorium V-shaped in dorsal view, membranaceous in the middle; base with process claval (Figs 16, 17, bp), dorsal periandrium lobe with 2 ribbon-like processes in center near right edge (Figs 16, 17, pp), directed dorsad, respectively curved caudad and cephalad; dorsal lobe in left lateral view with 2 subapical processes near apex (Fig. 16, sap): one crescent-shaped, above base with another process shortly sword-shaped, directed caudad; in right lateral view (Fig. 17, sap) with two subapical processes derived from apical third, directed apically, one process base movable, sword-shaped, below base another process crutch-like and sclerotized. Ventral periandrium lobe (Fig. 18, vlp) with apical margin convex, shorter than dorso-lateral lobe of periandrium (Figs 16, 17, dllp, 18) in ventral view. Aedeagus (Figs 16, 17, aed) with dagger-shaped process, base slightly movable, directed dorsad, slightly inclined caudad (Figs 16, 17, paed).
**Female genitalia.** Anal tube ovate in dorsal view, about 1.3 times longer than maximal width at second part (Fig. 19). Anal style long, located at basal fifth of anal tube. In ventral view, Sternite VII with hind margin convex medially, without any process in ventral view, disc arched ventrad (Fig. 20). Anterior connective lamina of gonapophysis VIII nearly rectangular, with 3 or 4 apical teeth on inner lateral margin and 3 lateral teeth bearing 3 keels on outer lateral margin (Figs 21, 22); endogonocoxal
A new species of the genus *Euxaldar* Fennah, 1978 from China

Figures 8–18. *Euxaldar daweishanensis* sp. nov. (male adult) 8 head and thorax, dorsal view 9 face, front view 10 head and thorax, lateral view 11 forewings 12 hind wing 13 anal tube, dorsal view 14 pygofer, anal tube and genital style, lateral view 15 capitulum of gonostyli, dorsal view 16 penis, lateral view (left) 17 penis, lateral view (right) 18 penis, ventro-apical view. Abbreviations: aed—aeadeagus; bp—basal process of the periantrium; dllp—dorso-lateral lobe of periantrium; paed—process of aedeagus; pp—process of periantrium; sap—subapical processes of periantrium; vlp—ventral lobe of periantrium. Scale bars: 0.5 mm

lobe developed, membranous in distal part (Figs 21, 22). Posterior connective lamina of gonapophyses IX triangular in dorsal view (Fig. 23), narrowing; median field with leaf-like process bearing apical margin, deeply incised in the middle (Fig. 23, mdp);
Figures 19–26. *Euxaldar daweishanensis* sp. nov. (female adult) 19 female anal tube, dorsal view 20 sternite VII, ventral view 21, 22 gonocoxa VIII and gonapophysis VIII, ventral view 23 gonapophysis IX and gonaspiculum bridge, dorsal view 24 gonapophysis IX and gonaspiculum bridge, lateral view 25 gonoplacs, lateral view 26 gonoplacs, dorsal view Abbreviations: lf—lateral field of posterior connective lamina of gonapophyses IX; mdp—medial dorsal process; mf—medial field of posterior connective lamina of gonapophyses IX; pvd—posterior ventral lobes; slf—sublateral field of posterior connective lamina of gonapophyses IX. Scale bars: 0.5 mm.

Lateral field (Fig. 23, lf) without obvious process; distal parts of laminae (Fig. 23, slf) with tooth-like process on each lateral margin; posterior ventral lobes bent at slender angle (Figs 23, pvd, 24). Gonoplacs in lateral view irregularly elliptical (Fig. 25), without carinae, with apical half fused, apical margin membranous (Fig. 26).
A new species of the genus *Euxaldar* Fennah, 1978 from China

**Etymology.** This new species is named after the type locality, Mt. Daweishan National Nature Reserve, Yunnan Province, China.

**Distribution.** China (Yunnan Province)

**Remark.** This new species resembles *Euxaldar jehucal* but differs from the latter by the following combined features: Anal tube with apical margin convex in the middle, lateral margin with a small triangular process in each side (anal tube wide, apical margin deeply concave medially in *E. jehucal*); periandrium with two asymmetrical subapical processes sword-shaped in apical half (periandrium with subapical processes not as sword-shaped in *E. jehucal*); aedeagus with one medial dagger-like process on lateral margins (aedeagus without any processes on lateral margins in *E. jehucal*).

**Phylogenetical analysis.** Four gene fragments of *Euxaldar daweishanensis* sp. nov. were sequenced and registered in GenBank with the accession numbers as follows: MK441660 (*COI*), MK426664 (*16S*), MK441661 (*Cytb*), MK441662 (*28S d6-d7*). Nucleotide compositions are listed in Table 3. A+T content of *16S* is the highest (76.0%) and *28S* (d6-d7) is the lowest (39.2%).

This study deals with more molecular markers from Oriental and Western Palearctic, Nearctic and Neotropical regions than previous reviews by Wang et al. (2016) and Gnezdilov et al. (2020). BI (Fig. 27) and ML (Fig. 28) topologies were mostly congruent, and the monophyly of Issidae was reconfirmed. The Issidae had lower support in the ML tree (BS: 47) than Gnezdilov et al. (2020) and Wang et al. et al. (2016) and higher support in the BL analysis (PP: 88). Subfamilies Hysteropterinae Melichar,
1906 sensu (Gnezdilov et al. 2020) and Issinae Spinola, 1839 sensu (Gnezdilov et al. 2020) are both recovered (nodes 1 and 2: ML: 47, 67; BI: 88, 89, respectively).

Node 1 includes almost all tribal level genera group of the subfamily Hysteropterinae sensu Gnezdilov (2016a, b, 2020) and the tribe Thioniini Melichar, 1906 sensu (Gnezdilov 2018): 1) Node 4 (ML: 75, BI: 100) corresponds to the subtribe Thioniina sensu Gnezdilov (2018) with the inclusion of American taxa, characterized by hind wings reduced or rudimentary, A2 vein branched; 2) Nodes 5 and 6 corresponds to the monophyletic *Kervillea*, and *Mycterodus* genera group sensu Gnezdilov (2016 a, b); monophyly of the *Hysteropterum* genera group was not supported by this analysis (node 3).

Node 2 (ML: 67, BI: 89) includes five monophyletic tribes (nodes 7–11): Issini, Kodaianellini and Hemisphaeriini sensu (Gnezdilov 2020), Parahiraciini, and Sarimini sensu (Wang et al. 2016), while the monophyly of Sarimini and Parahiraciini was not supported by Gnezdilov (2020).

**Discussion**

According to our analysis, the tribe Thioniini was recovered as monophyletic, split from the subfamily Issinae sensu Gnezdilov et al. (2020), and placed in the subfamily
Hysteropterinae sensu Gnezdilov et al. (2020). Herein, we suggest that the subtribe Thioniina sensu Gnezdilov et al. (2020) should be a tribe of Hysteropterinae (Thioniini + tribal level groups of genera (Gnezdilov 2016a, b)), sharing the common characteristic of this subfamily: hind wings reduced or rudimentary. Conversely, most taxa of the subfamily Issinae Spinola, 1839 sensu Gnezdilov et al. (2020) have developed hind wings. The Issinae, including five tribes distributed in the Oriental Region, is recovered and well supported in the following topology (node 2): [(Koaianellini, Issini) + (Sarimini, Parahiracini) + Hemisphaeriini)].

The monophyletic tribe Hemisphaeriini Melichar, 1906 is confirmed by our data, characterized by hemispherical forewings and single-lobed or rudimentary hind wings (Gnezdilov et al. 2020). The monophyly of the subtribes Hemisphaeriina and Mongolianina Wang et al. (2016) is not supported: the genus Gergithus shows a sister relationship with (Hemisphaeriina + Mongolianina) in this analysis (ML: 97, BI: 89).

*Mongoliana serrata* Che, Wang & Chou, 2003 is isolated from *Mongoliana* Distant, 1909 (ML:58, BI:89), confirming the hypothesis of Meng et al. (2017) that the genus *Mongoliana* could be divided into two species groups. It probably contains two different genera: one of them *M. serrata* is a new genus with the smooth frons, pale brown tegmina having dark fasciae and spots and the ventral hooks of the aedeagus variable in shape and usually unparallel. *Gergithus yunnanensis* and *G. parallelus* show a sister relationship with *Ophthalmosphaerius* Gnezdilov, 2017, probably belonging to a new genus with *Ophthalmosphaerius*; this finding agrees with Gnezdilov (2017c) and Zhao et al. (2019), but we still consider it incertae sedis until more evidence is presented.

The third lineage of Mongolianina (Zhao et al. 2019) is recovered only in our ML analysis. *Euxaldar daweishanensis* sp. nov. and *E. lenis* are grouped into a different cluster in our research: the genera of the cluster ((*E. daweishanensis* sp. nov. + Retaldar) + (Clypeosmilus + Eusudasina)) share a protruded clypeus, and forewings CuP clear; another cluster (*E. lenis* + Macrodaruma) recovered by Zhao et al. (2019) share a smooth metope without pustules, and sexual dimorphism. *Euxaldar lenis* probably belongs to a new genus.

*Euxaldar* is similar to the genus *Paramongoliana* Chen, Zhang & Chang, 2014 which is here formally placed in the subtribe Mongolianina according to Wang et al. (2016), but differs by the following characters: metope smooth or with pustules (metope roughly corrugated, without pustules in *Paramongoliana*, see Chen et al. 2014: figs 2–33E); forewings with CuP distinct (forewings with CuP poorly recognizable in *Paramongoliana*, see Chen et al. 2014: figs 2–33A, B, F); anal tube with apical margin not straight (anal tube nearly quadrilateral, apical margin straight in *Paramongoliana*, see Chen et al. 2014: figs 2–33H).

The genus *Euxaldar* is also similar to the genus *Clypeosmilus* (Gnezdilov et al. 2017b) in having forewings with reticulate venation and a distinct claval suture, but can differ from the latter in the following characters: postclypeus with complete median carina and anteclypeus with distinct median carina (*Clypeosmilus* with postclypeus large, flattened laterally, bearing a thick chisel-like median carina); periantrium asymmetrical (periantrium symmetrical, with pair of long and narrow subapical processes directed apically).
Euxaldar daweishanensis sp. nov., E. jehucal, and E. guangxiensis share several compelling characters: 1) E. daweishanensis sp. nov., E. jehucal, and E. guangxiensis share a metope disc with relatively weak pustules distributed in a row along the lateral margins; and 2) E. daweishanensis sp. nov. and E. guangxiensis have an anal tube with a triangular process on each lateral margin (Fig. 13; Zhang et al. 2018: figs 12, 13). Other noteworthy characters: 1) E. guangxiensis exhibits a vestigial hind wing; 2) E. lenis has a smooth metope without pustules, and sexual dimorphism. All species of this genus probably belong to different species groups or even different genera. More molecular data and other convincing morphological evidence are expected in the future, enabling further discussion of the taxonomic status of Euxaldar.

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References

Anufriev GA, Emeljanov AF (1988) Cicadinea (Auchenorrhyncha). In: Lehr PA (Ed.) Key to the insects of the Far East of the USSR, 2. Leningrad, Nauka, 12–495.
Belshaw R, Quicke DLJ (2002) Robustness of ancestral state estimates: evolution of life history strategy in ichneumonoid parasitoids. Systematic Biology 51: 450–477. https://doi.org/10.1080/10635150290069896
Bourgoin T (1987) A new interpretation of the homologies of the Hemiptera male genitalia, illustrated by the Tettigometridae (Hemiptera, Fulgoromorpha). Proceedings of the 6th Auchenorrhyncha Meeting, Turin (Italy), September 1987, 113–120.
Bourgoin T (1993) Female genitalia in Hemiptera Fulgoromorpha, morphological and phylogenetic data. Annales de la Société Entomologique de France 29(3): 225–244.
Bourgoin T, Steffen-Campbell JD, Campbell BC (1997) Molecular phylogeny of Fulgoromorpha (Insecta, Hemiptera, Archaeorrhyncha) the enigmatic tettigometridae: evolutionary affiliations and historical biogeography. Cladistics-the International Journal of the Willi Hennig Society 13(3): 207–224. https://doi.org/10.1111/j.1096-0031.1997.tb00316.x
Bourgoin T, Wang RR, Asche M, Hoch H, Soulier-Perkins A, Stroiński A, Yap S, Szvedo J (2015) From micropterism to hyperpterism: recognition strategy and standardized homol-
ogy driven terminology of the forewing veins patterns in planthoppers (Hemiptera: Fulgoromorpha). Zoomorphology 134(1): 63–77. https://doi.org/10.1007/s00435-014-0243-6
Chan ML, Yang CT (1994) Issidae of Taiwan (Homoptera: Fulgoroidea). Chen Chung Book, Taichung, 188 pp.
Chang ZM, Yang L, Zhang ZG, Chen XS (2015) Review of the genus Neotetricodes Zhang et Vhen (Hemiptera: Fulgoromorpha: Issidae) with description of two new species. https://doi.org/10.11646/zootaxa.4057.3.2
Clary DO, Wolstenholme DR (1985) The mitochondrial DNA molecule of Drosophila yakuba: nucleotide sequence, gene organization, and genetic code. Journal of Molecular Evolution 22(3): 252–271. https://doi.org/10.1007/BF02099755
Chen XS, Zhang ZG, Chang ZM (2014) Issidae and Caliscelidae (Hemiptera: Fulgoroidea) from China. Guizhou Science and Technology Publishing House, Guiyang, 242 pp.
Cryan JR, Wiegmann BM, Deitz LL, Dietrich CH (2000) Phylogeny of the treehoppers (Insecta: Hemiptera: Membracidae): evidence from two nuclear genes. Molecular Phylogenetics & Evolution 17(2):317–334. https://doi.org/10.1006/mpve.2000.0832
Fennah RG (1978) Fulgoroidea (Homoptera) from Vietnam. Annales Zoologici 34(9): 207–279.
Gnezdilov VM (2003) Review of the family Issidae (Homoptera, Cicadina) of the European fauna, with notes on the structure of ovipositor in planthoppers. Chteniya pamyati NA Kholodkovskogo [Meetings in memory of NA Cholodkovsky], St. Petersburg 56(1): 1–145. [In Russian with English summary]
Gnezdilov VM, Constant J (2012) Review of the family Issidae (Hemiptera: Fulgoromorpha) in Vietnam with description of a new species. Annales Zoologici 62(4): 571–576. https://doi.org/10.3161/000345412X659632
Gnezdilov VM (2013) Modern classification and the distribution of the family Issidae Spinola (Homoptera, Auchenorrhyncha, Fulgoroidea). Entomologicheskoe obozrenie 92(4): 724–738. [English translation published in Entomological Review 94(5): 687–697.] https://doi.org/10.1134/S0013873814050054
Gnezdilov VM (2016a) Planthoppers of the family Issidae (Hemiptera, Fulgoroidea) of Western Palaearctic. Thesis of Doctoral Dissertation (Dr. Sci. habilitation), St.-Petersburg, 44 pp. [In Russian]
Gnezdilov VM (2016b) Notes on phylogenetic relationships of planthoppers of the family Issidae (Hemiptera, Fulgoroidea) of the Western Palaearctic fauna, with description of two new genera. Entomologicheskoe Obozrenie 95(2): 362–382. [In Russian] [English translation published in Entomological Review (2016) 96(3): 332–347] https://doi.org/10.1134/S0013873816030106
Gnezdilov VM, Bourgoin T, Wang ML (2017a) Revision of the Genus Euxaldar Fennah, 1978 (Hemiptera: Fulgoroidea: Issidae). Annales Zoologici 67(1): 13–20. https://doi.org/10.3161/00034541ANZ2017.67.1.002
Gnezdilov VM, Soulier-Perkins A (2017b) Clypeosmilus centrodasus gen. et sp. nov., a new genus and species of family Issidae (Hemiptera: Fulgoroidea) from Northern Vietnam. Proceedings of the Zoological Institute RAS 321(1): 25–31.
Gnezdilov VM (2017c) Addenda to the revisions of the genera Gergithus Stål and Hemisphaerius Schaum (Hemiptera, Auchenorrhyncha, Fulgoroidea, Issidae). Entomological Review 97(9): 1338–1352. https://doi.org/10.1134/S0013873817090123

Gnezdilov VM (2018) To the revision of the genus Thionia Stål (Hemiptera, Fulgoroidea, Issidae), with description of new genera and new subtribe. Zootaxa 4434(1): 158–170. https://doi.org/10.11646/zootaxa.4434.1.10

Gnezdilov VM, Konstantinov FV, Bodrov SY (2020) New insights into the molecular phylogeny and taxonomy of the family Issidae (Hemiptera: Auchenorrhyncha: Fulgoroidea). Proceedings of the Zoological Institute RAS 324(1): 146–161. https://doi.org/10.31610/trudyzin/2020.324.1.146

Lanfear R, Frandsen PB, Wright AM, Senfeld T, Calcott B (2017) PartitionFinder 2: New Methods for Selecting Partitioned Models of Evolution for Molecular and Morphological Phylogenetic Analyses. Molecular Biology and Evolutionary 34(3): 772–773. https://doi.org/10.1093/molbev/msw260

Ronquist F, Huelsenbeck J, Teslenko M (2011) MrBayes version 3.2 Manual: Tutorials and Model Summaries. http://mrbayes.sourceforge.net/mb3.2_manual.pdf

Wang ML, Zhang Y, Bourgoin T (2016) Planthopper family Issidae (Insecta: Hemiptera: Fulgoromorpha): linking molecular phylogeny with classification. Molecular Phylogenetics and Evolution 105: 224–234. https://doi.org/10.1016/j.ympev.2016.08.012

Meng R, Webb MD, Wang YL (2017) Nomenclatural changes in the planthopper tribe Hemisphaeriini (Hemiptera: Fulgoromorpha: Issidae), with the description of a new genus and a new species. European Journal of Taxonomy 298: 1–25. https://doi.org/10.5852/ejt.2017.298

Zhang ZG, Chang ZM, Chen XS (2018) A new species of the genus Euxaldar Fennah, 1978 from China (Hemiptera, Fulgoroidea, Issidae). ZooKeys 781: 51–58. https://doi.org/10.3897/zookeys.781.27059

Zhao S, Bourgoin T, Wang M (2019) The impact of a new genus on the molecular phylogeny of Hemisphaeriini (Hemiptera, Fulgoromorpha, Issidae). ZooKeys 880: 61–74. https://doi.org/10.3897/zookeys.880.36828

**Appendix 1**

Partitions and models used for the Maximum likelihood tree in IQtree and Bayesian 50% consensus tree.

#nexus
begin sets;
  charset Subset1 = 1–1899;
  charset Subset2 = 1900–2617;
  charset Subset3 = 2618–3473;
  charset Subset4 = 3474–4194;
  charset Subset5 = 4195–4861;
charpartition PartitionFinder = GTR+I+G: Subset1, GTR+I+G: Subset2, GTR+I+G: Subset3, GTR+G: Subset4, GTR+I+G: Subset5;
end;

begin mrbayes;
log start filename = log.txt;
outgroup Caliscelis wallengreni;
outgroup Cixius sp;
outgroup Dicranotropis hamata;
outgroup Dictyophara europaea;
outgroup Trypetimorpha occidentalis;
charset Subset1 = 1–1941;
  charset Subset2 = 1942–2732;
  charset Subset3 = 2733–3576;
  charset Subset4 = 3577–4302;
  charset Subset5 = 4303–4929;

partition PartitionFinder = 5: Subset1, Subset2, Subset3, Subset4, Subset5;
set partition = PartitionFinder;

lset applyto = (1) nst = 6 rates = invgamma;
  lset applyto = (2) nst = 6 rates = invgamma;
  lset applyto = (3) nst = 6 rates = invgamma;
  lset applyto = (4) nst = 6 rates = invgamma;
  lset applyto = (5) nst = 6 rates = invgamma;

prset applyto = (all) ratepr = variable revmatpr = dirichlet (1, 1, 1, 1, 1, 1) statefreqpr
  = dirichlet (1, 1, 1, 1, 1);
unlink statefreq = (all) revmat = (all) shape = (all);
mcmc ngen = 30000000 nrns = 2 relburnin = yes burninfrac = 0.25 printfreq =
  1000 samplefreq = 1000 nchains = 4 savebrlens = yes;
mcmc;
sumt;;
end;