A new species of *Diplatys* (Insecta, Dermaptera, Diplatyidae) earwig from the Western Ghats of India

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Abstract

To explore diversity of earwigs (Dermaptera) in different agricultural ecosystems of South India, an extensive taxonomic survey was conducted in 2020 during which an undescribed species of *Diplatys* was collected. Twenty-one species of the genus *Diplatys* (Diplatyiidae, Diplatyinae) have been reported to date from India, of which six species are known from Karnataka, South India. Based on a male specimen collected from a sugarcane field in Karnataka, a new species, *Diplatys sahyadriensis* sp. nov., is described as the twenty-second species of this genus from India. A revised key to the males of *Diplatys* species from India and Sri Lanka is provided. This new record adds to the known species diversity in the Sahyadri Ranges of the Western Ghats in Shivamogga District, Karnataka, part of the Southern Plateau and Hills agro-climatic region of India.

Keywords

*Diplatys sahyadriensis* sp. nov., Karnataka, Sri Lanka, sugarcane

Introduction

Earwigs are a moderately diversified group of insects which comprise approximately 1,900 species distributed mainly in tropical and subtropical parts of the world (Hopkins et al. 2018). The previous taxonomic study by Srivastava (2013) reported 284 species...
from India. Although the taxonomy is unstable and unsettled, the genus *Diplatys* (Diplatyidae), in a broad sense, is species rich with approximately 70 described species from the Ethiopian and Oriental regions (Hopkins et al. 2018). According to the system of Srivastava (1988, 2013), 25 species of *Diplatys* have been reported from India and Sri

Table 1. Distribution and subgeneric classification of *Diplatys* species recorded from India and Sri Lanka.

| Species                               | Subgenus by Steinmann (1986b) | Distribution                      | Sri Lanka                  |
|---------------------------------------|-------------------------------|----------------------------------|----------------------------|
|                                       |                               | Highland (Himalayas & N.E. mountains) | Humid Subtropical | Tropical Wet and Dry | Arid | Semiarid | Tropical Wet |
| *D. adjacen* Hincks, 1955             | (Syndiplatys)                 | Uttarakhand¹, Madhya Pradesh¹    | Madhya Pradesh¹          |                      |      |          |              |
|                                       |                               | Tamils                           |                           |                      |      |          |              |
| *D. anamalensis* Srivastava, 1970     | (Syndiplatys)                 | Central Himalaya¹                | West Bengal²,³           |                      |      |          |              |
| *D. carinatus* Srivastava, 1988       | Not assigned                  | Karnatak¹                        | Karnatak¹                 |                      |      |          |              |
| *D. carli* Srivastava, 1988           | Not assigned                  | Tamil Nadu¹                      |                           |                      |      |          |              |
| *D. chopardi* Hincks, 1955            | (Neodiplatys)                 | Karnatak¹                        | Tamil Nadu¹               |                      |      |          |              |
| *D. chowdharvii* Srivastava, 1989     | Not assigned                  | Tamil Nadu¹                      | Odisha²                   |                      |      |          |              |
| *D. coelebs* Hincks, 1955             | (Syndiplatys)                 | Maharashtra¹, Tamil Nadu¹         | Karnataka¹, Kerala¹       |                      |      |          |              |
| *D. confusus* Hincks, 1955            | (Syndiplatys)                 | Tamil Nadu¹                      | Tamil Nadu¹               |                      |      |          |              |
| *D. devlinii* Srivastava, 1974        | (Hydrodipalytys)              | Tamil Nadu¹                      |                           |                      |      |          |              |
| *D. daleni* Hincks, 1957              | (Neodiplatys)                 | Maharashtra¹                     |                           |                      |      |          |              |
| *D. ernesti* Burr, 1910               | (Syndiplatys)                 |                                  |                           |                      |      |          |              |
| *D. exciden* Hincks, 1954             | (Neodiplatys)                 | Karnatak¹                        |                           |                      |      |          |              |
| *D. fletcheri* Burr, 1910             | (Hydrodipalytys)              | Madhya Pradesh¹                  | Tamil Nadu¹               |                      |      |          |              |
| *D. greeni* Burr, 1904                | (Syndiplatys)                 |                                  |                           |                      |      |          |              |
| *D. jawalagriensis* Kapoor, 1971       | (Diplatyistis)                | Karnatak¹                        | Tamil Nadu¹               |                      |      |          |              |
|                                       |                               | Tamil Nadu¹                      | Karnatak¹                 |                      |      |          |              |
| *D. lefroyi* Burr, 1910               | (Neodiplatys)                 | Karnataka¹                       |                           |                      |      |          |              |
| *D. menoni* Kapoor & Bharadwaj, 1968  | (Diplatyistis)                | Maharashtra¹                     |                           |                      |      |          |              |
| *D. nathani* Hincks, 1960             | (Diplatyistis)                | Madhya Pradesh¹                  |                           |                      |      |          |              |
| *D. nigirienis* Hincks, 1955          | (Syndiplatys)                 | Karnataka¹                       | Tamil Nadu¹               |                      |      |          |              |
| *D. papori* Bey-Bienko, 1959          | (Neodiplatys)                 | Tamil Nadu¹                      |                           |                      |      |          |              |
| *D. propinquus* Hincks, 1955          | (Syndiplatys)                 | Meghalaya¹                       |                           |                      |      |          |              |
| *D. sahyadrisps* nov.                 | Not assigned                  | Karnataka¹                       |                           |                      |      |          |              |
| *D. santishti* Srivastava, 1975       | (Syndiplatys)                 |                                  |                           |                      |      |          |              |
| *D. sinuatus* Hincks, 1955            | (Syndiplatys)                 | Himachal Pradesh¹, Odisha¹, West Bengal² |                           |                      |      |          |              |
| *D. tikaderi* Srivastava, 1988        | Not assigned                  | Odisha¹                          |                           |                      |      |          |              |

1. Srivastava (1988), 2. Srivastava (1989), 3. Deepak and Ghosh (2018), 4. Srivastava (1993a)
Lanka, of which four species are endemic to Sri Lanka (Srivastava 1988, 1989, 2013; Table 1); clearly these two countries represent the centre of Diplatys diversity.

To explore the diversity of earwigs in different agricultural ecosystems of South India, we conducted an extensive taxonomic survey in agricultural and horticultural crop fields. Here we report a new species, *D. sahyadriensis* sp. nov., based on a male specimen collected from a sugarcane ecosystem. The possible relationships of the new species with other Diplatys recorded from India and Sri Lanka and the diversity of this genus in this region are also discussed.

**Materials and methods**

The specimen was collected by hand from a sugarcane field in Shivamogga District, Karnataka, India, and preserved in 70% ethanol. For the morphological identification, the specimen was examined under a Stemi 508 stereozoom microscope (Carl Zeiss Microscopy GmbH, Jena, Germany). Photographs of the habitus and external body parts were taken under an M205C stereozoom microscope attached with a DFC450 camera (Leica, Wetzlar, Germany). The male genitalia were removed by gently lifting the penultimate abdominal sternite, pulling out from the genital chamber with forceps, and cutting at the site of attachment to the ejaculatory ducts. The genitalia were processed by submersion in 5% KOH for two days for clearing tissues and mounted on a glass slide with glycerol. Photographs of dissected genitalia were taken an M205C stereozoom microscope attached with a DFC450 camera. Based on the photographs, the genitalia were illustrated using Adobe Illustrator CS6. The specimen, with voucher number UAHSE19K, is deposited in the Insect Systematics and Vector Biology Laboratory, Department of Entomology, College of Agriculture, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga. The terminology of Kamimura (2014) was adopted to describe male genital structures.

**Taxonomy**

Order Dermaptera de Geer, 1773  
Infraorder Protodermaptera Zacher, 1910  
Family Diplatyidae Verhoeff, 1902  
Subfamily Diplatynae Verhoeff, 1902  
Genus *Diplatys* Audinet-Serville, 1831

*Diplatys sahyadriensis* Karthik, Kamimura & Kalleshwaraswamy, sp. nov.  
http://zoobank.org/3E7D2B09-09B4-437B-93B1-280FEBD35207  
Figs 1, 2, Table 2

**Material examined.** *Holotype* (♂), INDIA: Karnataka, Hosanagara-Shivamogga Road, Galigekola, 13°59'52.854"N, 75°22'42.576"E, 6.xi.2020, C.M. Karthik leg., ex. sugarcane.
**Diagnosis.** Male has simple forceps, and is easily discriminated from that of other *Diplatys* species by the unique morphology of the virga: paired portion with developed flanges and a whip-like process at each tip. Flanged virgae have been reported in this genus only for *D. jawalagiriensis* Kapoor, Bharadwaj & Banerjee, 1971. However, almost no unpaired part is present at the base of each virga in *D. jawalagiriensis*, with no associated large sclerites in the penis lobe (vs short but conspicuous unpaired part and characteristic associated sclerites are present in *D. sahyadriensis* sp. nov.).

**Description.** Male (holotype: Figs 1, 2). Measurements of body parts are shown in Table 2. Body generally dark brown. 2nd antennal segment and beyond light brown. Coxa, trochanter, basal third of femur, distal half of tibia, tarsi, base of tegmina, wings (excluding fustis), lateral and posterior margins of pronotum, and base of forceps whitish brown (Fig. 1a–f). Abdomen and forceps densely pubescent (Fig. 1a, f).

Head (Fig. 1a) slightly wider than long, widest in eye region; frons tumid but weakly depressed at apex; occiput strongly and widely depressed; transverse and median sutures visible but not conspicuous; posterior margin strongly emarginated in middle. Eyes prominent, distinctly longer than the post-ocular length. Antennae (Fig. 1a, d) 17 segments or more (in holotype 15 left segments and 17 right segments remain), 1st expanded apically, slightly shorter than the combined length of 2nd to 4th; 2nd minute, shorter than width; 3rd long and slender; 4th slightly shorter than 3rd; 5th onwards segments gradually increasing in length and thinning up to 13th and 14th. Pronotum (Fig. 1b) longer than broad, narrowed posteriorly, anteriorly convex, sides almost straight, hind margin subrotundate, median sulcus distinct, prozona tumid and well differentiated from flat metazona. Tegmina (Fig. 1b) well developed, humeral angles weak, costal margin straight, posterior margin obliquely convex, axillary angles weak, showing a broad triangular scutellum. Wings (Fig. 1b) well developed.

Prosternum (Fig. 1c) elongate, with a constriction at the point of attachment of forelegs. Mesosternum (Fig. 1c) broader than prosternum, more or less rounded, deeply constricted at the point of attachment of the midlegs, truncated posteriorly. Metasternum (Fig. 1c) hexagonal, constricted at point of attachment of hindlegs, emarginate posteriorly.

Abdomen (Fig. 1a) long, cylindrical, greatly enlarging from 7th tergite onwards. Penultimate sternite (Figs 1f, 2a), relatively long, posterior margin weakly emarginated at middle. Ultimate tergite (Fig. 1a) transverse with two small, bifid, undulate depressions. Forceps (Fig. 1a, f) about as long as the ultimate tergite, trigonal with ridge only present in basal two-thirds, branches tapering apically with pointed tip and without curving.

Parameres (= external parameres; Figs 1g, 2b) with an internal tooth at apical one-quarter and a small, deep concavity distal to it. Penis lobes (Figs 1g, 2c) slightly shorter than the parameres, each with a denticulated sclerite (= outer denticulated sclerite; ods), two differently shaped, serrated sclerites (mid serrated sclerite [mss] and inner serrated sclerite [iss]), a disc-shaped sclerite (ds), and a bifurcated virga. Virga (Figs 1g, 2c) with very short, unpaired part, and long paired part. Each branch of paired part convoluted, slender, but with well-developed flange, and tips widened with a whip-like distal process (wdp).
A new earwig from India

Female. Unknown.

Etymology. The specific epithet *sahyadriensis* refers to the type locality: the specimen was collected from the Sahyadri Ranges, which is a gateway to the Western Ghats of Karnataka.

Distribution. Only known from Shivamogga, Karnataka, India.
Bioecology. The male specimen (holotype) was collected from whorls of sugarcane *Saccharum officinarum* L. (Angiospermae, Gramineae). The collection site is in a mixed area of sugarcane and paddy fields. Faecal pellets were seen on the leaves of sugarcane, suggesting that specimen had been in that place for some time, possibly taking advantage of this shaded spot.

![Figure 2. *Diplatys sahyadriensis* sp. nov. (male holotype) a posterior half of penultimate sternite b left paramere c left penis (in repose), virga with whip-like distal processes (wdp), and associated sclerites (ds, disc-shaped sclerite; iss, inner serrated sclerite; mss, mid serrated sclerite; ods, outer denticulated sclerite).](image)

| Table 2. Measurements (mm) of the male holotype of *Diplatys sahyadriensis* sp. nov. |
|----------------------------------|----------------------------------|
| **Length**                       | **Measurement (mm)**             |
| Body without forceps             | 11.12                            |
| Head                             | 1.55                             |
| Pronotum                         | 1.22                             |
| Tegmen                           | 3.00                             |
| Forceps                          | 1.30                             |
| **Width**                        |                                  |
| Head                             | 1.57                             |
| Pronotum                         | 1.22                             |
| Tegmen                           | 1.00                             |
| Ultimate tergite                 | 1.25                             |
Key to *Diplatys* species known from India and Sri Lanka (males only)

(Adopted from Srivastava 1988; * = species known only from Sri Lanka)

| Step | Description | Species |
|------|-------------|---------|
| 1    | Virga much reduced, represented by dots; instead, a long chitinous rod projects from penis lobe (According to Srivastava 1989) | *Diplatys chowdhuryi* Srivastava, 1989 |
|      | – Bifurcated virga present |  |
| 2    | Virga paired throughout its entire length | *Diplatys confusus* Hincks, 1955; *Diplatys coelebs* Hincks, 1955; *Diplatys jawalagiriensis* Kapoor, Bharadwaj & Banerjee, 1971; *Diplatys nathani* Hincks, 1960; *Diplatys dolens* Hincks, 1957; *Diplatys tikaderi* Srivastava, 1988; *Diplatys lefroyi* Burr, 1910; or *Diplatys menoni* Kapoor & Bharadwaj, 1968; see couplets 12–25 in the key by Srivastava (1988) |
|      | – Virga unpaired at base, sometimes forming a rounded vesicle or small protuberance; its length variable in relation to paired portion |  |
| 3    | Unpaired portion of virga about as long as or longer than the paired portion | *Diplatys propinquus* Hincks, 1955*; *Diplatys ernesti* Burr, 1910*; *Diplatys adjacens* Hincks, 1955; *Diplatys sinuatus* Hincks, 1955; *Diplatys santoshi* Srivastava, 1975*; *Diplatys nilgiriensis* Hincks, 1955; or *Diplatys carinatus* Srivastava, 1988; see couplets 37–48 in the key by Srivastava (1988) |
|      | – Unpaired basal portion of virga very short to one-third of the paired portion |  |
| 4    | Parameres internally with a sharp tooth at about the middle, apical half narrow and points externally. Unpaired part of virga short but dilated, forming an oval vesicle | *Diplatys brindlei* Steinmann, 1974 |
|      | – Outer margin of parameres almost straight, apical half not obliquely pointing outward. Unpaired part of virga not forming a conspicuous oval-shaped vesicle |  |
| 5    | Posterior margin of penultimate sternite with a pair of conspicuous projections and emarginate between these projections | *Diplatys popovi* Bey-Bienko, 1959 |
|      | – Posterior margin of penultimate sternite almost truncate, emarginate, or sinuate, but without conspicuous projections |  |
| 6    | Posterior margin of penultimate sternite almost truncate, or only feebly undulate |  |
| 7    | Virga as long as parameres | *Diplatys devlensis* Srivastava, 1974 |
| 8    | Virga longer than parameres, sometimes exceeding base of genitalia | *Diplatys fletcheri* Burr, 1910 |
8. Posterior margin of penultimate sternite emarginate at middle or bisinuate. Virga very long, extending beyond base of genitalia.................................9

− Penultimate sternite posteriorly emarginate at middle. Virga short or long, but not extending beyond base of genitalia .......................................10

9. Penultimate sternite posteriorly bisinuate. Virga very long, extending beyond base of genitalia, paired part not flanged ...Diplatys chopardi Hincks, 1955
− Penultimate sternite weakly emerged at middle posteriorly. Paired part of virga convoluted and laterally provided with flange, each apex with a whip-like process..............................................................

Diplatys sabhadiensis Karthik, Kamimura & Kalleshwaraswamy, sp. nov.

10. Virga apparently longer than penis lobe ......Diplatys excidens Hincks, 1954
− Virga shorter than or almost as long as penis lobe ....................................11

11. Virga much shorter than 1/2 of penis lobe; paired part stout and swollen ..... ..............................................................................

− Virga longer than 1/2 of penis lobe; paired part slender ................................12

12. Inner pre-apical tooth of parameres strongly hooked........................................

.................................................................Diplatys carli Srivistava, 1988
− Inner pre-apical tooth of parameres normal, not strongly hooked ............. ............................................................

..................................................................Diplatys greeni Burr, 1904

Discussion

In the present study, we follow Srivistava’s (1988, 2013) classification of Diplatyinae, except for the treatment of Haplodiplatys Hincks, 1955, which is considered the sole genus of the family Haplodiplatyiidae (Engel et al. 2017). Based mainly on the parameric characters, Steinmann (1974, 1986b) proposed to classify Diplatys sensu Hincks (1955) into four genera (Diplatys, Schizodiplatys Steinmann, 1974, Lobodiplatys Steinmann, 1974, and Circodiplatys Steinmann, 1986). Although Steinmann (1974) placed Diplatys conradti Burr, 1904 in Lobodiplatys, Zacher (1910) erected subgenus Paradiplatys Zacher, 1910, treating this species as its type. According to the Principle of Priority, Sakai (1982) resurrected the subgenus Paradiplatys as a full genus and synonymised Lobodiplatys with it. Engel and Haas (2007), who omitted to cite Sakai (1982), made the same proposal. This view was followed by Srivistava (1988, 2013) in classifying the Indian species of Diplatyinae into three genera: Diplatys, Paradiplatys, and Nannopygia Dohrn, 1863; Srivistava (1993b) considered Nannopygia a senior synonym of Schizodiplatys. Males of Diplatys possess a pair of elongate parameres with unarmed external margins (vs armed with a single movable epimerite in Paradiplatys), but with internal margins armed with one or two teeth, which are sometimes separated by a concavity. Occasionally, a concavity preceding or succeeding the pre-apical tooth is also present but parameres are not divided into two lobes with a cleft (vs cleft in Nannopygia). The elongate parameres of the new species, each with an internal tooth but without deep clefts or articulated structures, clearly indicate that the species is a member of Diplatys.
Steinmann (1986b) proposed a subgeneric classification system for *Diplatys* (Table 1), mainly based on the relative lengths of virgal regions (paired and unpaired parts), especially those included in the penis lobe. However, some apparently closely related species can be classified into different subgenera according to this system (Gorokhov and Anisyutkin 1994). Therefore, we do not assign *D. sahyadriensis* sp. nov. to any subgenus, as done for some other *Diplatys* species described since Steinmann (1986b) (Table 1).

The male genitalia of *D. sahyadriensis* sp. nov. are unique in the genus in having several elaborations: a well-developed flange on the paired part of virgae, three differently shaped sclerites with serration (or denticulation) on the penis lobe, and a filament-like appendage at each virgal tip. *Diplatys jawalagiriensis*, which has been recorded from Karnataka and Tamil Nadu, also possesses flanged virgae (Kapoor et al. 1971; Srivastava 1988), which indicates a possible relationship with *D. sahyadriensis* sp. nov. According to the descriptions by Kapoor et al. (1971) and Srivastava (1988), however, no conspicuous associated sclerite is present in the penis lobe of this species.

*Diplatys propinquus* is a Sri Lankan *Diplatys* species possibly close to the new species. According to the descriptions and illustrations by Hincks (1955) and Srivastava (1988), each penis lobe includes three different, serrated or denticulated sclerites, which are very similar to those of *D. sahyadriensis* sp. nov. Little is known of the functions of sclerites observed on the penis lobe of earwigs. However, males of the ovoviviparous spongiphorid *Marava arachidis* (Yersin, 1860) possess a pair of triangular sclerites (genital hooks) on the penis lobe (Kamimura et al. 2016), and during copulation, the sclerites are firmly pressed against the opening region of the spermatheca, frequently resulting in wounds (Kamimura et al. 2016). At the same time, another spatula-shaped sclerite is shallowly inserted into the spermatheca (female sperm storage organ), supporting the insertion of the narrow (<10 μm in diameter) but highly elongate (ca 20 mm) virga (Kamimura et al. 2016). A similar division of roles among differently shaped accessory sclerites has been reported for another spongiphorid, *Paralabellula dorsalis* (Burmeister, 1838) (Briceño 1997; Kamimura and Ferreira 2017). Different types of denticulated or serrated accessory sclerites have also been reported for several other diplatyids (Hincks 1955; Sakai 1985; Steinmann 1986a; Srivastava 1988). Males of *Diplatys flavicollis* Shiraki, 1907 possess three different types of denticulated sclerites (saber-shaped, rod-shaped, and U-shaped) on each penis lobe (Kamimura 2004). During genital coupling, two lateral pockets in the female genital chamber receive the U- and rod-shaped sclerites, while the saber-shaped sclerite contacts the female subgenital plate (Kamimura 2004). The accessory sclerites of *D. sahyadriensis* sp. nov. may have similar functions in securely holding a female during copulation.

The filament with long spines at each virgal tip represents another characteristic structure of *D. sahyadriensis* sp. nov. In *Diplatys*, the Cameroonian *D. longipennis* Brindle, 1969 also possesses many spines, like bars, but directly on each tip of the thin, highly elongate paired part of the virgae (Brindle 1969). These barb-like structures may be for the removal of rival sperm from female sperm storage organ(s), as known in several
insect groups (Waage 1979). Males of the anisolabidid, *Euborellia plebeja* (Dohrn, 1863) also use their highly elongate virga, which is usually longer than the entire body, for removing rival sperm from the tubular spermatheca of mates (Kamimura 2000). However, in this species, a recurved flange at the virgal tip is considered responsible for sperm removal (Kamimura 2000). Although males of most earwig species directly insert a virga into the female spermatheca for transferring sperm during copulation (Kamimura 2014; Kamimura et al. 2019), *D. flavicollis* is an exception: the virgal tips are much wider than the spermathecal openings and ducts, indicating that physical removal of stored sperm by a virga is not feasible (Kamimura 2004). However, as in males, female genitalia are quite variable among diplatyid species (Popham 1965; Klass 2003). Future studies on the female genital structures and reproductive biology are warranted for *D. sahyadriensis* sp. nov. and other, related species.

Based on temperature and precipitation, India is divided into six regions: highland, humid subtropical, tropical wet and dry, arid, semi-arid, and tropical wet zones (Senapati et al. 2013). *Diplatys* is most species rich in the tropical wet and dry zone (Table 1), which occupies a large part of the southern Indian peninsula. The tropical, rainy climate is responsible for the persistent warm or hot temperature, which normally does not fall below 18°C. India hosts two climatic subtypes, the tropical monsoon climate and the tropical wet and dry climate. The most humid is the tropical monsoon climate, also known as tropical wet climate, which extends over a strip of south-western lowlands abutting the Malabar Coast, the Western Ghats, and southern Assam. These regions are characterised by moderate to high year-round temperatures, even in the foothills, and rainfall which is seasonal but heavy and typically more than 2,000 mm per year (Senapati et al. 2013). Most rainfall occurs between May and November, and this moisture is enough to sustain lush forests and other vegetation for rest of the year. The heavy monsoon rains are responsible for the exceptionally higher biodiversity of earwigs.

The new species of earwig, *D. sahyadriensis* sp. nov. described from sugarcane ecosystem in Western Ghats gives insight into the possible substantial diversity of this genera in India. There is a need to study its distribution, status, and role in agricultural and horticultural ecosystems.

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References

Briceño RD (1997) Genitalic structure and copulation in *Paralabella dorsalis* (Dermaptera: Labbidae). Revista de Biología Tropical 45: 1107–1116.

Brindle A (1969) Récoltes de Ph. Bruneau de Miré au Cameroun (Dermaptera). Bulletin de l’Institut Français d’Afrique Noire 31: 58–71.

Deepak CK, Ghosh D (2018) Insecta: Dermaptera. In: Zoological Survey of India (Ed.) Faunal Diversity of Indian Himalaya. Zoological Survey of India, Kolkata, 265–272.

Engel MS, Haas F (2007) Family-group names for earwigs (Dermaptera). American Museum Novitates 3567(1): 1–20. https://doi.org/10.1206/0003-0082(2007)539[1:FNFED]2.0.CO;2

Engel MS, Huang D, Thomas JC, Cai C (2017) A new genus and species of pygidicranid earwigs from the Upper Cretaceous of southern Asia (Dermaptera: Pygidicranidae). Cretaceous Research 69: 178–183. https://doi.org/10.1016/j.cretres.2016.09.009

Gorokhov AV, Anisyutkin LN (1994) To the knowledge of Vietnam earwigs from the family Diplatyidae (Dermaptera). Trudy Zoologicheskogo instituta (Akademiia Nauk SSSR) 257: 59–71.

Hincks WD (1955) A systematic monograph of the Dermaptera of the world. Part I. Pygidicranidae: Diplatyinae. British Museum (Natural History), London, 132 pp.

Hopkins H, Maehr MD, Haas F, Deem LS (2018) Dermaptera Species File. Version 5.0/5.0. http://dermaptera.speciesfile.org [Accessed on 2022-2-21]

Kamimura Y (2000) Possible removal of rival sperm by the elongated genitalia of the earwig, *Euborellia plebeja*. Zoological Science 17(5): 667–672. https://doi.org/10.2108/zsj.17.667

Kamimura Y (2004) Mating behaviour and insemination in *Diplatys flavicollis*, an earwig with double-barreled penises and a variable number of female sperm-storage organs. Journal of Zoology 262(1): 37–46. https://doi.org/10.1017/S0952836903004370

Kamimura Y (2014) Pre- and postcopulatory sexual selection and the evolution of sexually dimorphic traits in earwigs (Dermaptera). Entomological Science 17(2): 139–166. https://doi.org/10.1111/ens.12058

Kamimura Y, Ferreira RL (2017) Earwigs from Brazilian caves, with notes on the taxonomic and nomenclatural problems of the Dermaptera (Insecta). ZooKeys 713: 25–52. https://doi.org/10.3897/zookeys.713.15118

Kamimura Y, Tee HS, Lee C-Y (2016) Ovoviviparity and genital evolution: A lesson from an earwig species with coercive traumatic mating and accidental breakage of elongated intromittent organs. Biological Journal of the Linnean Society. Linnean Society of London 118(3): 443–456. https://doi.org/10.1111/bij.12755

Kamimura Y, Yang CCS, Lee C-Y (2019) Fitness advantages of the biased use of paired laterally symmetrical penises in an insect. Journal of Evolutionary Biology 32(8): 844–855. https://doi.org/10.1111/jeb.13486

Kapoor VC, Bharadwaj RK, Banerjee SK (1971) Some new species of Dermaptera. Bulletin of Entomology 12: 28–40.

Klass KD (2003) The female genitalic region in basal earwigs (Insecta: Dermaptera: Pygidicranidae s.l.). Entomologische Abhandlungen 61: 173–225.
Popham EJ (1965) The functional morphology of the reproductive organs of the Common earwig (*Forficula auricularia*) and other Dermaptera with reference to the natural classification of the order. Journal of Zoology 146: 1–43. https://doi.org/10.1111/j.1469-7998.1965.tb05198.x

Sakai S (1982) A new proposed classification of the Dermaptera with special reference to the check-list of the Dermaptera of the world. Bulletin of Daito Bunka University 20: 1–108.

Sakai S (1985) Dermapterorum Catalogus XVI–XVIII: Iconographia I–III. Pygidicranidae and Diplatyidae. Daito Bunka University, Tokyo, 1080 pp.

Senapati MR, Behera B, Mishra SR (2013) Impact of climate change on Indian agriculture & its mitigating priorities. American Journal of Environmental Protection 1(4): 109–111. https://doi.org/10.12691/env-1-4-6

Srivastava GK (1988) Fauna of India and the Adjacent Countries, Dermaptera Part I: Pygidicranoida. Zoological Survey of India, Kolkata, 268 pp.

Srivastava GK (1989) Zoological Survey of India. State Fauna Series 1: Fauna of Orissa (Part 2): 147–170.

Srivastava GK (1993a) Zoological Survey of India. State Fauna Series 3: Fauna of West Bengal (Part 4): 369–459.

Srivastava GK (1993b) Taxonomic status of certain genera of Pygidicranidae (Demiaptera). Records of the Zoological Survey of India 92: 41–51.

Srivastava GK (2013) Fauna of India and the Adjacent Countries, Dermaptera Part III: Apachyoidea and Forficuloidea. Zoological Survey of India, Kolkata, 268 pp.

Steinmann H (1974) A new generic classification of the species group of *Diplatys* Serville (Dermaptera, Pygidicranidae). Acta Zoologica Hungarica 20: 187–205.

Steinmann H (1986a) Dermaptera. Catadermaptera I. Das Tierreich 102: 1–343.

Steinmann H (1986b) A new generic classification for the *Diplatys* species-groups (Dermaptera: Pygidicranidae). Acta Zoologica Hungarica 32: 169–179.

Waage JK (1979) Dual function of the damselfly penis: Sperm removal and transfer. Science 203(4383): 916–918. https://doi.org/10.1126/science.203.4383.916

Zacher F (1910) Beitrag zur Kenntnis der Pygidicraniden und Diplatyiden (Dermaptera). Entomologische Rundschau 27: e105.