Description of Two Species of Family Cydnidae Billberg, 1820 (Hemiptera: Heteroptera) from Sindh, Pakistan

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Abstract

Burrowing bugs (the family Cydnidae [Hemiptera: Heteroptera]) are important members of agricultural ecosystems. These insects display a range of feeding behaviors, as some species can be pests, whilst others promote soil aeration and the breakdown of organic matter. Herewith is the first comprehensive taxonomy description of two species within the family Cydnidae Billberg, 1820. This includes morphological observations and imaging of true bugs from Sindh, Pakistan. It provides information on the structural, ecological, and geographical characteristics of Macrocytus brunneus (Fabricius, 1803) along with Formundus pygmaeus (Dallas, 1851). Field investigations have shown that these species are fossorial and participate in soil nutrient cycling. The potential impact of these specimens on agroecosystems has been assessed through their collection from different agricultural fields in Sindh. Macrocytus brunneus has a large oval body and prominent hind femoral spines, while Formundus pygmaeus is of moderate compactness and oblong, covered in characteristic dotted markings. By indicating their role in phylogenetics and ecology, the data generated in this study emphasize the taxonomical and ecological significance of these organisms as potential bioindicators of soil health.

Keywords: Cydnidae, Hemiptera, Taxonomy, Macrocytus brunneus, Formundus pygmaeus

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Introduction

Cydnidae (burrowing bugs) consists of 334 species and is are most diverse group in Hemiptera, which are common in Sindh, Pakistan. The structure of these family members has morphological adaptations for soil-dwelling, these being convex, ovoid bodies 2 to 20 mm in size (Santacruz & Martínez, 2016; Lis, 2006). The Cydnidae are diverse in agricultural landscapes where they can perform a range of ecosystem services; some species are root-feeding pests, while others contribute to soil aeration through burrowing activity. Depending on their feeding and population dynamics, some species can increase and others can decrease soil fertility (Souza et al., 2019). Given the biogeographical data available on such insects, their synergistic interactions, and their contribution to the agricultural ecosystems, particularly in Sindh, the practical aspect of such studies must be emphasized.

The evolutionary history of the Cydnidae suggested complex evolutionary trajectories for this family. The family can be subdivided into two or more subfamilies, Cydninae and Amnestinae, which have varying degrees of monophyly and taxonomic treatment (Froeschner, 2019; Grazia et al., 2008). Molecular techniques have offered recent advances in understanding the relationships of Cydnidae and the evolutionary history and possible adaptation to different environmental niches (Dias et al., 2019; Grazia et al., 2008).

According to previous reports, species that belong to the family Cydnidae are mostly found in tropical and wet ecosystems (Lis, 2006; Santacruz & Martínez, 2016). Considering Sindh's agro-climatic conditions, it is anticipated that these species will add to the regional diversity. Cydnidae have no records in Tanzania; true to this, Cydnidae species worldwide only occur in humid and tropical environments and habitats (Lis 2006; Santacruz & Martínez 2016). Nevertheless, due to the eco-climatic conditions and agricultural practices of the Sindh region in Pakistan, it is anticipated that our region, as well as the whole of Pakistan, possesses a high diversity of Cydnidae species. Therefore, this study is essential to provide insights into the structure and ecological role of these neglected in the agricultural ecosystems of Sindh. Furthermore, the potential usage of Cydnidae as bioindicators of soil health and ecosystem stability remains a subject for further investigation (Souza et al., 2019; Eger, 2008).

From Indo-Pakistan, Moizuddin metathoracic scent glands and male and female genitalia. The assessment of *Macrocytus brunneus* and *Formundus pygmaeus* with detailed taxonomic status is reported for the first time, with Sindh, Pakistan, being their collecting locality. In this study, we provide a comprehensive investigation on the morphological characterization, species distribution, and ecological role of Cydnidae to increase knowledge of regional biodiversity and data source for future research on the agricultural and environmental importance of Cydnidae in the Indo-Pakistan context.

Materials and Methods

Collection: The research material for this study was collected using various methods tailored to the habits and habitats of the Cydnidae species. These methods ensured a comprehensive sampling of specimens from diverse environments.

Preservation: Specimens were killed from the specimens that had been collected using ethyl acetate vapors or 70% ethyl alcohol and preserved dry. Triangular hard paper points with smaller bugs mounted and larger specimens pinned to the right side of

the scutellum. Collection details (location, date, and name of collector) were documented with the attached labels. Following identification, the specimens were then labeled with complete scientific names and author information.

Slide Preparation: The dissection of genital structures was followed by removal from fresh tissue and overnight treatment in 10% KOH. Detailed visualization was observed and altered under different lighting conditions.

Illustrations: Microscopes, including HT (40X), Kyowa Medilux 20, were used to examine the specimens. Then, pencil sketches were first made that were later finalized in ink upon quality tracing paper and converted through Adobe Illustrator.

Measurements: Body length, body width, pronotal length, and pronotal width were measured in millimeters.

Specimens were examined carefully, dissected, and observed and dissected for close study of the morphological features and genitalia. Taxonomic literature was used to identify.

Results

The research results provide comprehensive descriptions of two species of the Cydnidae collected from Pakistan, Sindh, *Macrocytus brunneus* and *Formundus pygmaeus*. The large, oval body with well-developed spines on the hind femora and the peculiar punctation pattern characterize *M. brunneus*. In contrast, *F. pygmaeus* has a medium-sized, oblong body with well-defined pigmentation and structural character. Detailed morphological observations are provided, including body length, width, and pronotal measurements. In addition, dissections and illustrations of male and female genitalia are included to assist in correct species identification. The ecological and geographical distribution of these species is also discussed, with stress on the fact that these species can be found in agricultural ecosystems. The findings are also important to fill the gaps in the taxonomic understanding of the Cydnidae family and to evaluate the biodiversity of the area. This research demonstrates some of the importance of these species in agroecosystems and as bioindicators of soil health and ecosystem stability.

Key to the genera of the family Cydnidae

1. Body large, oval-shaped, head without hairs, hind femora with spine beneath……*Macrocytus* Fieber, 1860

- Body medium-sized, oblong shape, head with hairs, hind femora without spine…….*Formundus* Distant, 1901

Genus Macrocytus Fieber, 1860

Macrocytus Fieber, 1860: 83. Monotypic by subsequent designation (Fieber 1861: 362): *Cydnus brunneus* Fabricius, 1803.

Hahnia Ellenrieder, 1862: 139, name preoccupied by Hahnia Koch, 1841 (in Aranea) (syn. by Lis 1994a: 209). Type species by monotypy: *Hahnia gibbula* Ellenrieder, 1862.

Philapodemus Kirkaldy, 1910: 8 (new name for *Hahnia* Ellenrieder,1862 (syn. by Lis 1994a: 209). Type species by original designation: *Hahnia gibbula* Ellenrieder, 1862.

Generally large, oval body, weakly punctate dorsally; head anteriorly sub-round, distinctly broader than long; antennae with third segment shorter than fourth segment; pronotum broader than long, levigate spots absent, pronotal surface nodulate posteriorly; scutellum weakly punctate, reaching to apices of clavi; metathoracic scent gland with ostiole oval, evaporatoria greatly developed; legs with posterior femora bearing well-developed spines. Abdomen with sternites slightly convex.

Macrocytus brunneus (Fabricius, 1803)

Cydnus brunneus Fabricius, 1803: 185. *Macroscytus brunneus*: Fieber 1861: 362.

Cydnus proximus Rambur, 1839: 112 (syn. by Amyot 1845: 427). *Aethus opacus* Stal, 1854: 214 (syn. by Signoret 1881: 644). *Macroscytus scutellaris* Horváth, 1919: 238 (syn. by Linnavouri 1993: 25). *Macroscytus exiguus* Horváth, 1919:238 (syn. by Linnavouri 1993: 25). *Macroscytus subaeneus,* not Dallas: Ahmad & Moizuddin 1977: 76; Ahmad et al. Moizuddin & Ahmad 1985: 163, 1990: 325 & 326; 1979: 15 & 18.

Measurement: Male length 8.00 mm

Description: Body black entire, ocelli piceous red, eyes castaneous brown, legs and sternum piceous brown, corium, connexion light brown. Head medium-sized, frons broader, surface rough at the middle, shiny with irregular ridges near eyes, two reddish ocelli just behind eyes, eyes lobately produced, clypeus semicircular with setigerous marking at inner margin, vertex convex, narrower posteriorly. Pronotum broader than long, anterior margin well angulate medially, lateral angles bluntly produced, disc rough, with scarce fine punctures, lateral margins scarcely oblique, hind angles blunt; scutellum triangular shaped, with narrow lobulated apex, piceous black with deep but scarce punctures; clavus narrow but elongated with more grooves, corium broad at the base, darker than clavus, covered with deep and dense punctures, membrane fuscous white. Abdomen black, shiny, without punctures.

Material examined: 4 females and two males, Pakistan, Sindh Province, Tandojam, 24. vii.2022, leg. Soomro A.P. 3 males, Pakistan, Sindh Province, District Tando M Khan, village Sheikh Bhirkio, 8.vii.2016, leg. Mir Sohail.

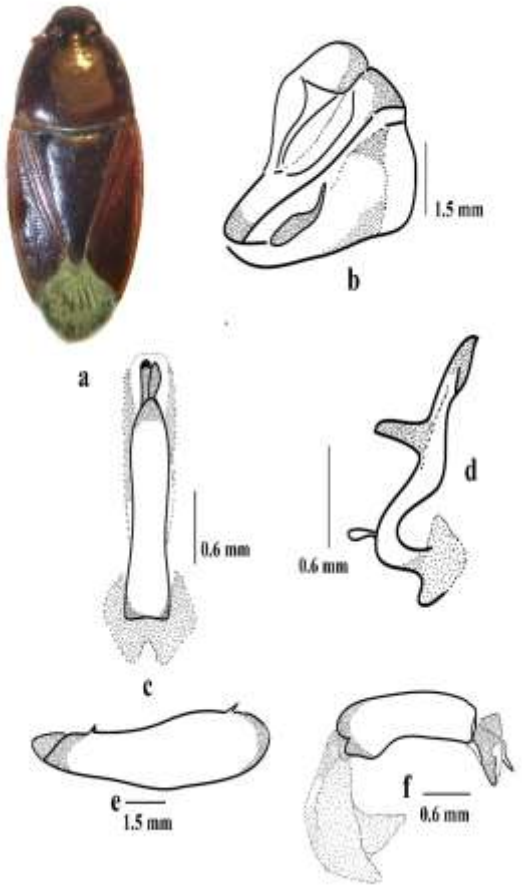


Plate 01. *Macrocytus brunneus* (Fabricius, 1803) a) Habitus b) Osteolar peritreme c) Phallus dorsal d) paramere e) hind femora f) phallus lateral

Genus Formundus Distant, 1901

Fromundus Distant, 1901a: 582. Type species by monotypy: *Fromundus opacus* Distant, 1901.*Alamprella* Horváth, 1904: 254 (syn. by Lis, 1996d: 100). Type species by monotypy: *Alamprella singularis* Horváth, 1904. *Brachysolen* Horváth, 1919: 269 (syn. by Lis, 1994a: 173). Type species by original designation: *Brachysolen opacus* Horváth, 1919 (=*Fromundus opacellus* Lis, 1994).

Medium-sized (3.84-6.84) to nearly oblong, margin hairy; head sub-round at front, wider than long; antennae third segment distinctly shorter than fourth segment; labium short, reaching to mid coxae; Pronotum as long as wide, anterior pronotal surface medially with or without

two levigate spots, pronotal surface laterally very poorly nodulate posteriorly; scutellum sparingly or coarsely punctate, always slightly extending beyond tips of clavi; legs posterior femora unsplit.

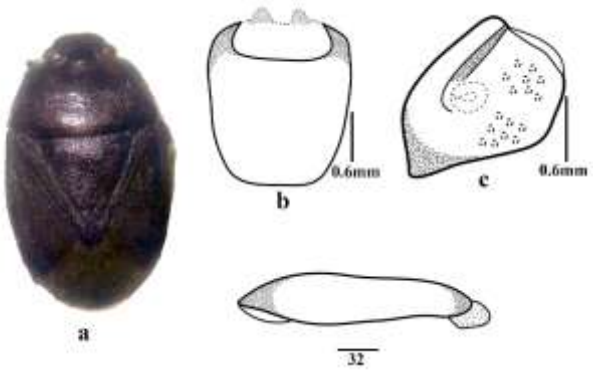
Formundus pygmaeus (Dallas, 1851)

Aethus pygmaeus Dallas, 1851: 120. *Fromundus pygmaeus*: Lis, 1994a: 181.

Measurement: Female length 4.2mm

Generally brown to piceous brown. Head small, with deep and dense punctures; eyes depressed, convergent scarce; clypeus almost or scarcely shorter than paraclypeus, margin rugosely punctured, two ocelli pale orange, vertex narrow posteriorly; labium passing fore coxae. Pronotum broad, anterior margin medially well angulate, lateral angles obsolete, lateral margin uniformly subrounded, disc convex; anterior part covered with coarse, deep punctures, a median broad brick-red patch present; lateral margin with deep and dense punctures; scutellum broadly triangular with narrow lobulated apex, piceous at base, dark brown in the middle, covered with coarse and deep punctures; clavus narrow, corium large, broadened at base, with coarse and deep punctures, membrane not hyaline, fuscous with white texture' sternum castaneous brown, coxae very broad. Abdomen piceous brown, with scattered punctuation.

Material examined: 6 females, three males, Pakistan, Sindh Province, Tandojam, 4. viii.2013, leg. Soomro, A.P.



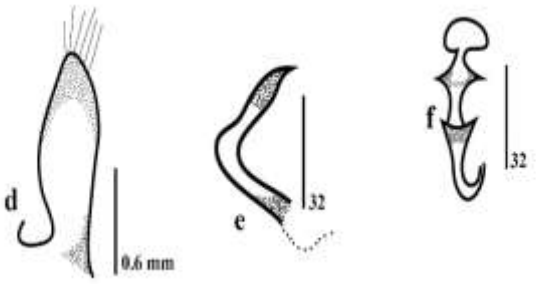


Plate 02. *Formundus pygmaeus* (Dallas, 1851): **a)** Habitus, b) pygofer capsule, c) Osteolar peritreme, d) apex of phallus, e) paramere, f) female terminalia with bulb**.**

Discussion

The ecological significance of these species extends beyond taxonomy; their interactions with crop systems and their potential as bioindicators of soil health make them essential subjects for future biodiversity research. A recent study by Gapon (2023) provided a detailed morphological analysis of male and female terminalia in the genus *Canthophorus*, offering new insights into the structural diversity and taxonomic classification of burrowing bugs. Similarly, Lis & Lis (2023) examined the evolution of coxal combs in Cydnidae, emphasizing their independent morphological origins and adaptations. The study represents a continuation of the work of Moizuddin and Ahmad (1990), who revised the family Cydnidae in the Indo-Pakistan region and described several new species in *Geotomus* and *Macrocytus*. Another important revision consists of the synonymisation of *Geotomus macroevaporatorius* Moizuddin & Ahmad (1982) with *Formundus pygmaeus* (Dallas) Lis (1999). It, therefore, underscores the dynamic nature of taxonomic classifications as new compositions in morphological and molecular evidence become available. These revisions correspond to our findings, which offer detailed morphological descriptions and measurements of *Macroskytus brunneus* and *Formundus pygmaeus* and confirm their

taxonomic placement. The ecological roles of Cydnidae are highlighted, including interaction with crops and potential use as bioindicators of soil health, in the study. The results also underscore the need for regional biodiversity assessments in Sindh, Pakistan, and across agricultural ecosystems that are strongly impacted by these burrowing bugs. Further taxonomic ambiguities are to be resolved in the future by integrating molecular data.

Conclusion

Morphological descriptions and illustrations presented in this study enhance taxonomic knowledge and facilitate future research on sustainable agriculture and biodiversity conservation. An integrated taxonomic account of Macrocytus brunneus and Formundus pygmaeus and their ecological importance in Sindh, Pakistan. These species provide provisioning ecosystem service in terms of soil health through nutrient cycling and burrowing activity, with potential regulatory ecosystem service in terms of the effect on crops. Morphological descriptions and illustrations fill knowledge gaps in the regional biodiversity assessment and enhance taxonomic knowledge. This work facilitates research on sustainable agriculture and biodiversity conservation.

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