



Discovery of *Goniozus apoderophagus* n. sp. (Hymenoptera: Bethylidae) an ectoparasitoid of *Apoderus tranquebaricus* (Coleoptera: Attelabidae) from India

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Received: 26 June 2024 / Accepted: 6 August 2024
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Abstract We describe and illustrate *Goniozus apoderophagus* Gupta & Azevedo n. sp. (Hymenoptera, Bethylidae), an ectoparasitoid of *Apoderus tranquebaricus* Fabricius (Coleoptera, Attelabidae) associated with leaf rolls of *Grewia abutilifolia* Vent. ex Juss. from Karnataka, India. The new species is compared with all the possible closely allied species from the Oriental region.

Introduction

The flat wasp Bethylidae genus *Goniozus* Förster, 1856 is one of the most speciose genera of Bethylidae with 174 worldwide species (Azevedo et al., 2018). This genus was initially defined to include those bethylines with the antennae with 11 flagellomeres and the forewing with three closed cells combined with the Rs+M vein not closing the first medial cell. However, Evans (1978) synonymized *Parasierola* Cameron, 1883 under *Goniozus*, so that its concept was

broadly expanded to accommodate the species with closed first medial cell in the forewing. This synonymy had already been considered by host similarity (Evans, 1964; Gordh & Evans, 1976).

This genus has been recovered as a paraphyletic by Ramos & Azevedo (2020), who retrieved *Afrobethylus* Ramos & Azevedo, 2016, *Bethylus* Latreille, 1802 and *Sierola* Cameron, 1881 nested inside *Goniozus* in analysis based on morphological characters. On the other hand, Magnacca (2024) retrieved *Odontepyris* Kieffer, 1904 nested inside *Goniozus* in analysis performed with COI sequences.

Goniozus is known for attacking larvae of several families of Lepidoptera (Azevedo et al. 2018), and is known to be an important biocontrol agent of various lepidopteran pests in agricultural ecosystems (Gordh, 1988; Gordh & Evans, 1976; Gordh & Hawkins, 1981; Gordh & Medved, 1986; Gordh et al., 1993; Gordh et al. 1999). However, there are also a few records of *Goniozus* associated with larvae of Coleoptera, Hymenoptera and Diptera, *Goniozus gestroi* Kieffer, 1904 attacking Ptinidae, *G. inauditus* Santhosh, 2015 was found in galls with thrips and Staphylinidae, *G. microstigma* Evans, 1993 attacking Crabronidae, and *Goniozus morindae* Kurian, 1952 was found in Cecidomyiidae galls (Kurian, 1952; Richards, 1955; Melo & Evans, 1993; Santhosh & Ranjith, 2015). It is necessary to emphasize *Goniozus* reared from galls does not mean that they use the inquilines as hosts. The hosts of this genus are semi-concealed, not so cryptic as usual for bethylids, and

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there are vast data of observation of its lifestyle in the literature. This makes *Goniozus*, the genus of Bethyliidae with more biological information, and with the broadest range of hosts.

The fauna of Oriental *Goniozus* is currently composed by 51 species. Many of them are from India and were described by Kurian (1952, 1954, 1955). The main goal of this contribution is to describe and illustrate a new ectoparasitoid species of the beetle *Apoderus tranquebaricus* (Coleoptera: Attelabidae) from India.

Materials and methods

In the present study, leaf rolls of *Grewia abutilifolia* Vent. ex Juss. were collected from Karnataka, India. The leaf rolls were kept in rearing cages in the National Insect Museum (NIM) at $25 \pm 2^\circ\text{C}$ and $50 \pm 10\%$ relative humidity for observation. Unparasitised hosts (*Apoderus tranquebaricus*, Coleoptera, Attelabidae) were reared to adulthood for host confirmation.

The wasp images were taken using Leica M 205 A stereozoom microscope with Leica DC 450 C inbuilt camera using automontage software (version 3.8). The images of the leaf rolls were taken with Nikon D7000 with Nikkor 105 mm macro lens. Both the types of the new species are housed in the NIM located in Indian Council of Agricultural Research-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru, India.

To identify the parasitoid wasps we compared it with all 51 other Oriental species of *Goniozus* based on literature and on the Azevedo's personal image database. Terminology follows Azevedo et al. (2018).

Order Hymenoptera Linnaeus, 1758

Family Bethyliidae Haliday, 1839

Genus *Goniozus* Förster, 1856

Goniozus apoderophagus Gupta & Azevedo **n. sp.**

Type-material: Holotype, one female on card, 18.viii.2016, coll. A. Gupta. Deposited in the NIM (ICAR-NBAIR), Bangalore under accession number NIM/NBAIR/Beth/Gon/180816. Paratype, one female on card, with same data as for the holotype (NIM/NBAIR/Beth/Gon/180816). (Figs 1 & 2)

Type-locality: Karnataka, Chikkaballapur, Nandi hills (13.38N,77.70E), India.

Type-host: Leaf rolls of *Apoderus tranquebaricus* Fabricius (Coleoptera: Attelabidae) on the host plant *Grewia abutilifolia* Vent. ex Juss. (Fig. 3)

ZooBank registration: To comply with the regulations set out in article 8.5 of the amended 2012 version of the International Code of Zoological Nomenclature (ICZN, 2012), details of the new species have been submitted to ZooBank. The Life Science Identifier (LSID) for *Goniozus apoderophagus* **n. sp.** is [to be establish later].

Etymology: The specific name 'apoderophagus' is given based on its host.

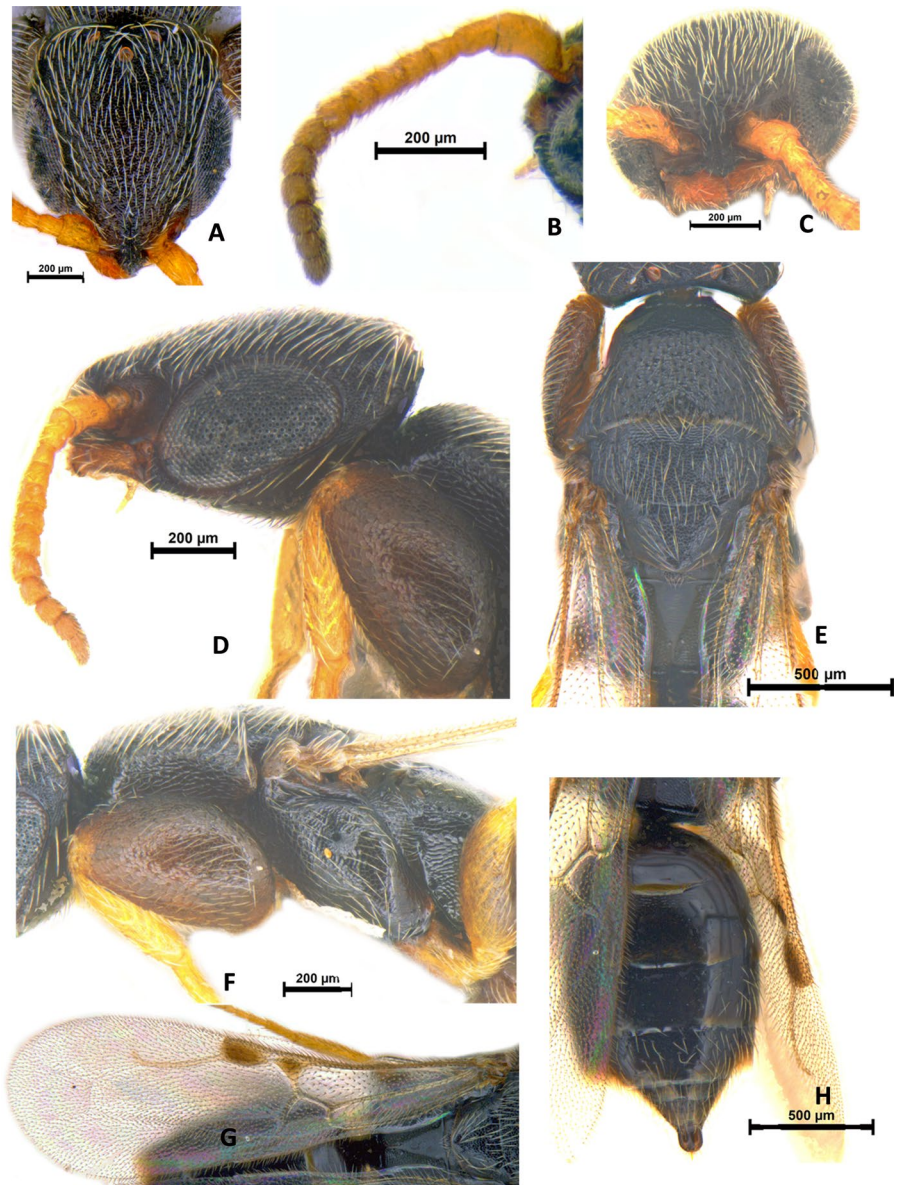
Description (Fig. 1). **Female.** Body 2.25 mm long; forewing 2.3 mm long.

Color. Head and mesosoma black, metasoma varying from black to dark castaneous at apical margins of tergites and its lateral corners; mandible dark castaneous; antenna testaceous-castaneous; palpi light castaneous; eye black and ocelli testaceous-castaneous; legs with coxae varying castaneous to dark castaneous, profemur evenly dark castaneous, meso- and metafemora varying castaneous to dark castaneous, trochanters, tibiae and tarsi castaneous, claws black; tegula dark castaneous, lighter distally; wings hyaline, veins castaneous to dark castaneous.

Pubescence. General body setation whitish-yellowish, soft, dense and long, arising from punctures. Metascutellum setose only medially. Mesosternum covered with short setae. Metanotal and metapectal-propodeal disc almost fully glabrous, with just few setae on antero-lateral corners. Metasoma with segment I glabrous, segment II with some lateral setae, segment III with few dorsal setae and some lateral ones, remaining segments progressively more setose dorsally. Ventrally segment II with long setae medially, segment III, IV and V with setae present on apical margins, medially and laterally. Setation on eye denser but shorter. Flagellar pubescence appressed, dense and about half as long as flagellar width. Setation on legs more delicate. Wing setation testaceous-castaneous, hard, dense, short, setae on veins slightly longer and conspicuous. Setation on R and 1Cu moderately setose.

Head. Mandible about evenly wide across its length, short, $2 \times$ as long as wide, one slightly overlaps the other, very thick, ventral margin straight, with four small apical teeth. Palpal formula 5:3.

Fig. 1 *Goniozus apoderophagus* n. sp. Female. **A**, Head in dorsal view; **B**, Antenna in ventral view; **C**, mandible in anterior view; **D**, Head in lateral view; **E**, Mesosoma in dorsal view; **F**, Mesosoma in lateral view; **G**, Forewing in dorsal view; **H**, Metasoma in dorsal view



Median clypeal lobe longer than wide, angulate, median carina conspicuous and complete, arched in lateral profile. Antenna moniliform, with 11 flagellomeres, short, slightly surpassing head posteriorly, median length of scape $1.65 \times$ longer than its apical width, pedicel $1.4 \times$ longer than wide, flagellomeres I–X about as long as wide, flagellomeres XI distinctly longer than wide. Head $1.1 \times$ as long as wide, wider at eye level, sides of head converging both anterad and posterior, vertex crest broadly straight when seen in full dorsal view, but slightly incurved when seen in posterior view. Head

subtriangular in lateral view. Eye very large, $2.15 \times$ as long as its distance to vertex crest, and fully placed laterally on head, almost touching dorsal mandibular condyle, so that malar space is minimal. Eye subhorizontal in lateral view. Ocellar triangle far posterior to supra-ocular line and almost touching vertex crest when seen in full dorsal view, its anterior angle clearly obtuse, its width slightly greater than distance of posterior ocelli to eye. Frons $0.6 \times$ as wide as head, and $1.05 \times$ as wide as eye length, strongly coriaceous, punctures small, but dense. Occipital carina not visible in dorsal

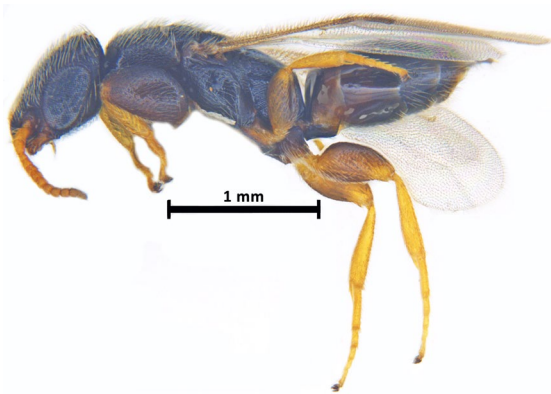


Fig. 2 *Goniozus apoderophagus* n. sp. Female (habitus)



Fig. 3 Host insect damage symptoms and habitus view. **A**, Leaf knots on the host plant *Grewia abutilifolia* Vent. ex Juss.; **B**, Coleoptera: Attelabidae *Apoderus tranquebaricus* Fabricius; **C**, Pupae of *Goniozus apoderophagus* n. sp. inside the leaves rolled

view. Vertex broadly straight with rounded corners, carinate but not notched between ocelli.

Mesosoma. Thorax strongly coriaceous at pronotum, mesoscutum and mesoscutellum, mesopleuron somewhat imbricate anteriorly otherwise coriaceous. Dorsal pronotal area ecarinate, progressively wider posterad, about $1.3 \times$ as long as mesoscutum. Notauli absent, parapsidal signum complete, narrow, straight anteriorly and curved mesad posteriorly. Mesoscutoscutellar sulcus absent, mesoscuto-scutellar foveae

subelliptical, its anterior margin rounded, but posterior margin sharp. Metascutellum much wider than long, separating metapectal-propodeal disc from posterior margin of mesoscutellum. Metapectal-propodeal disc imbricate medially in basal triangle, lateral surface of metapectal-propodeal complex imbricate-areolate, metapectal-propodeal disc $0.48 \times$ as long as wide medially. Basal triangle smoothly transforming into metapostnotal median carina, elevated, polished, well outlined but margins not sharp, about $1.33 \times$ longer than wide, metapostnotal median carina only present posteriorly, lateral marginal carina of basal triangle well defined, propodeal spiracle elliptical, inclined fully placed on dorsal surface, transverse posterior carina missing medially. Propodeal declivity subtle. **Forewing.** Prestigmal abscissa of R1 extremely dilated into triangular prestigma, M vein almost twice as long as Rs vein, Rs+M slightly evenly curved, 2r-rs and Rs arising from postero-apical corner of pterostigma, its apex slightly angled anterad, far from distal margin of wing. **Legs.** Profemur very robust, about $0.57 \times$ as wide as long.

Metasoma. Shining and polished, clearly shorter than mesosoma.

Discussion

In general, the configuration of head varies a lot and constitutes the structure more useful in the taxonomy of *Goniozus*. The mainly useful characters to recognize them are present in the head, metapectal-propodeal disc and in the forewing. The shape of the head is determined by the curvature of the vertex crest and the sides. The vertex crest is shortly or broadly straight or slightly outcurved or incurved, but this latter pattern is not found in Oriental species. The anterior profile of the head is always convergent anterad. However, the temple profile is parallel or convergent posterad, the former is usually found in species with small eyes. So, the first case the head assumes a pentagonal aspect and in the second a subrounded feature.

The eye length and its relative length in relation to the vertex-ocular line attracts a lot of attention because it causes a huge impact on the head configuration making them determinative to species delimitation in *Goniozus*. The longer are the eyes the shorter is the vertex-ocular line and closer to ocelli as well.

The ocellar triangle is usually located very close to vertex crest when seen on dorsal view, or separated from the vertex crest by no more than the diameter of anterior ocellus, however when both the eyes and ocelli are small this distance is more accentuated, such as in *G. indicus* Ashmead, 1903. Its anterior angle is slightly acute, right or more frequently obtuse.

The shape of median clypeal lobe does not vary too much, it is long and angulate in the great majority of the Oriental species, but few species such as in *G. stomopterycis* Ram & Subba Rao, 1967, the lobe is wider, shorter and rounded (Ram & Subba Rao, 1967).

The relative length of antennomeres does not vary too much, and the pedicel is always at least slightly longer than wide. However, its relative length compared to flagellomeres can provide some taxonomic utility, varying from about as long as or clearly longer.

In *Goniozus*, the metapectal-propodeal disc has a polished elevated triangular area located in the antero-medially in the disc. In a few cases, this basal triangle is very elevated with sharp margins, so that it is well outlined, as in *G. hybleae* Kurian, 1955 (Singh et al., 2021), but it is frequently only slightly elevated with smooth margins, so that it is not sharply outlined from the remain discal surface. Posterior to the basal triangle, some species have the metapostnotal median carina, which can be complete. This carina can be ill defined, so that it seems sometimes interpreted as a continuation of the basal triangle. However this carina is normally absent. Although the transverse posterior carina is complete, incomplete medially or occasionally nearly absent (Evans, 1964), in the Oriental fauna, most of the species have this carina complete, despite the fact that is customarily weak.

In the forewing, the First Medial (1M) cell is closed in the majority, but in 12 species it is closed following the old sense of *Parasierola*. When this cell is opened, the shape and length Rs+M vein becomes an important character to distinguish species. It can be straight or slightly curved, and it is usually as long as M vein, but in few species it is shorter. The curvature of 2r-rs&Rs vein provides good information for species recognition in two different ways. The whole vein can be more strongly or weakly curved, the apex also varies from smoothly curved to angled in several degrees.

Goniozus apoderophagus is very similar to the following species by having the anterior angle of the ocellar triangle obtuse, the median clypeal lobe angulate and long, the eyes large, occupying most area of sides of the head. The new species resembles *G. armigerae* Santhosh & Narendran, 2009, but the latter has the 2r-rs&Rs vein of the forewing less curved, the ocellar triangle touching the vertex crest in dorsal view, the vertex crest more rounded off, and the metapostnotal median carina fully missing. It also resembles *G. borneanus* Cameron, 1910, but the latter has the head more converging and more produced anterad, the metapostnotal median carina fully missing, and the 2r-rs&Rs vein of the forewing more angled. It is very similar to *G. lygropiae* Kurian, 1955, but the latter has the metapectal-propodeal disc about as long as wide, and the metapostnotal median carina fully missing. It is very similar to *G. marasmi* Kurian, 1955, but that species has the scape $2.0 \times$ longer than pedicel, the pedicel shorter than flagellomere I, flagellomere I longer than wide, flagellomere III less transverse, the metapostnotal median carina of the metapectal-propodeal disc fully missing, the profemur less robust, and the 2rs-r&Rs vein of the forewing shorter, with distance to apical margin about $1.42 \times$ its length. It resembles *G. philippinensis* Ashmead, 1904, but the latter has the head slightly wider, the vertex crest less broadly straight, the dorsal pronotal area shorter, and the 2rs-r&Rs vein of the forewing less angled, and cells R and Cu1 with two rows of setae. It resembles *G. williamsi* Bridwell, 1919, but that species has the vertex crest sinuate around the ocelli in dorsal view, the eyes slightly smaller, the metapostnotal median carina is also indistinct posterior of the polished area, the 2rs-r&Rs vein of the forewing less curved, and cell Cu1 with only one row of setae.

However, the most bizarre difference of *G. apoderophagus* is comparison to the other Oriental congeneric species is its lifestyle. It is found to be an ectoparasitoid of the leaf rolls beetle family Attelabidae *Apoderus tranquebaricus* Fabricius on the host plant *Grewia abutilifolia* Vent. ex Juss. (Fig. 3). As aforementioned, the majority species of *Goniozus* attack lepidopteran larvae. Gordh (1986) summarized the host of the Indian *Goniozus*. Most species attack the Lepidoptera families Crambidae and Pyralidae, but some species attack Blastobasidae,

Hyblaeidae, Gelechiidae, Geometridae, Tortricidae and Xyloryctidae.

Gordh et al. (1993) reported an interesting case of the Vietnamese species *Goniozus hanoiensis* Gordh, 1993, which parasites the rice leaf roller Lepidoptera family Crambidae *Cnaphalocrosis medinalis* Guenné. This data emphasizes the role that *Goniozus* plays in nature by attacking leaf roller as our new species.

Acknowledgements AG and SNS are grateful to the Indian Council of Agricultural Research, New Delhi and ICAR–NBAIR for research facilities. AG gratefully acknowledges financial assistance from the Science and Engineering Research Board, Department of Science and Technology, New Delhi under the scheme: CRG/2021/001523 for undertaking present study. COA is supported by FAPES PRONEX Program Grant #980/2022, and CNPq Grant #302613/2022-6. We also thank the subject editor and the anonymous reviewers who helped us to improve the quality of the contribution.

Author Contribution AG undertook surveys, rearing, specimen examination, writing description, imaging, figure plates preparation and writing manuscript; SNS - facilitating insect surveys, arranging funds for specimen curation, manpower, transportation etc. and COA- writing description, literature, comparative analysis with all *Goniozus* species from the Oriental region on Azevedo's personal image database, writing manuscript. All authors reviewed the manuscript.

Funding Funding was provided by Science and Engineering Research Board (CRG/2021/001523), Indian Council of Agricultural Research (Institute MI), and FAPES PRONEX Program (#980/2022).

Data Availability No datasets were generated or analysed during the current study.

Competing interests The authors declare no competing interests.

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