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**NEW SPECIES OF *EUDALACA* VIETTE, 1950 GHOST MOTH FROM
KARKLOOF NATURE RESERVE, SOUTH AFRICA (LEPIDOPTERA:
HEPIALIDAE)**

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New species of *Eudalaca* Viette, 1950 ghost moth from Karkloof Nature Reserve, South Africa (Lepidoptera: Hepialidae)

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Abstract

Eudalaca cipollai sp. n. is described from a forest reserve in a Mistbelt forest of KwaZulu-Natal Province, South Africa. The species is characterized by a dark brown forewing with several prominent white patches. These features are distinct from all other *Eudalaca* Viette, 1950 species. Inclusion of the species within *Eudalaca* is justified by the prominent expanded blade-like structure of the distal valva in the male genitalia that is characteristic of many *Eudalaca* species and absent from other southern African genera where genitalia are described. The monophyletic status of *Eudalaca* and other southern African genera is briefly reviewed. It is suggested that the male genitalia of the monobasic *Leto* Hübner, 1820 are most similar to that of *Gorgopis* Hübner, 1820, while the male genitalia of the monobasic Chilean genus *Blanchardinella* Nielsen, Robinson & Wagner, 2000 show greater structural similarity with *Gorgopis* and *Eudalaca* than other South American genera.

Keywords

Gorgopis, morphology, taxonomy

Introduction

Southern Africa is a geographically distinct center of hepialid diversity with a total of 78 described species (Nielsen et al. 2000, Mey 2011, 2019, Eitschberger & Ströhle 2021). Most species are partitioned between just two genera: *Eudalaca* Viette, 1950 (30 species) and *Gorgopis* Hübner, 1820 (33 species). The remaining species are distributed among *Afrotheora* Nielsen & Scoble, 1986 (seven species), *Antihepialus* Janse, 1942 (four species), *Metahepialus* Janse, 1942 (two species), *Leto* Hübner, 1820 (one species) and *Neoleto* Eitschberger & Ströhle, 2021 (one species).

In this article we present a description of a new species that exhibit features that are distinct from those of any previously described southern African species. While the new species is substantiated on the basis of external and genitalic differences, its generic placement is less obvious because most genera lack phylogenetic criteria to define their monophyly by which individual species may be included or excluded. However, we were able to identify features in the male genitalia that correspond to several species of *Eudalaca*, including the type species of the genus – *E. exul* (Herrich-Schaffer, 1853). On this basis we justify the generic placement of the new species record for the southern African hepialid fauna.

Materials & Methods

The abdomen was removed and treated in a cold solution of 5% KOH. The abdominal integument was opened by a right lateral cut from the tergo-sternal bar to the genitalia which were removed and stained in Chlorazol black. Terminology follows Kristensen (2003) for wing venation, Mielke & Casagrande (2013) for the tegumen (= intermediate plate), saccus (= vinculum), and fultura inferior (= juxta), Grehan & Mielke (2018) for the fultura superior (= trulleum), Grehan & Mielke (2017) for the tergo-sternal connection, and Dumbleton (1966) for the hepialine wing pattern where Rs3

shares a common stalk with Rs2. Wing venation diagrams were drawn over photographic images using InkScape® software.

Abbreviations

FW (forewing), HW (hindwing)

Taxonomic section

Eudalaca cipollai sp. n. Ignatev & de Groof

Figs 1, 3-11

Holotype: ♂, verbatim label. Hepialidae sp., R.S.A., Kwa Zulu-Natal Prov., Karkloof, Rockwood Forest Lodge, 29°18'05"S, 30°13'17"E, +/- 1290 m, 27-11-2020. Leg. K. Larsen, A. Kingston, A. Cipolla. Holotype to be deposited in the Naturalis Biodiversity Center, Leiden, the Netherlands.

Paratype: 1♂, same data as holotype. Collection Benny de Groof (Lier, Belgium).

Etymology

Named for Alexandre Cipolla who collected the specimens and made them available to Benny de Groof. It is treated as a noun in the genitive case.

Diagnosis

A moderately small moth from eastern South Africa. The species is externally distinguished from all other southern African Hepialidae by the FW pattern. The prominent basal and central white spots on a homogeneous dark brown ground colour contrasts with the reddish-orange ground colour and white spots of *Leto*, and the pale white ground color with darker speckling of *Neoleto*, and the yellowish to grayish brown ground colour with various darker spots or patches and some with various irregular shaped transverse or/and longitudinal lines or bands in *Afrotheora*, *Antihepialus*, *Gorgopis*, and all other *Eudalaca* species.

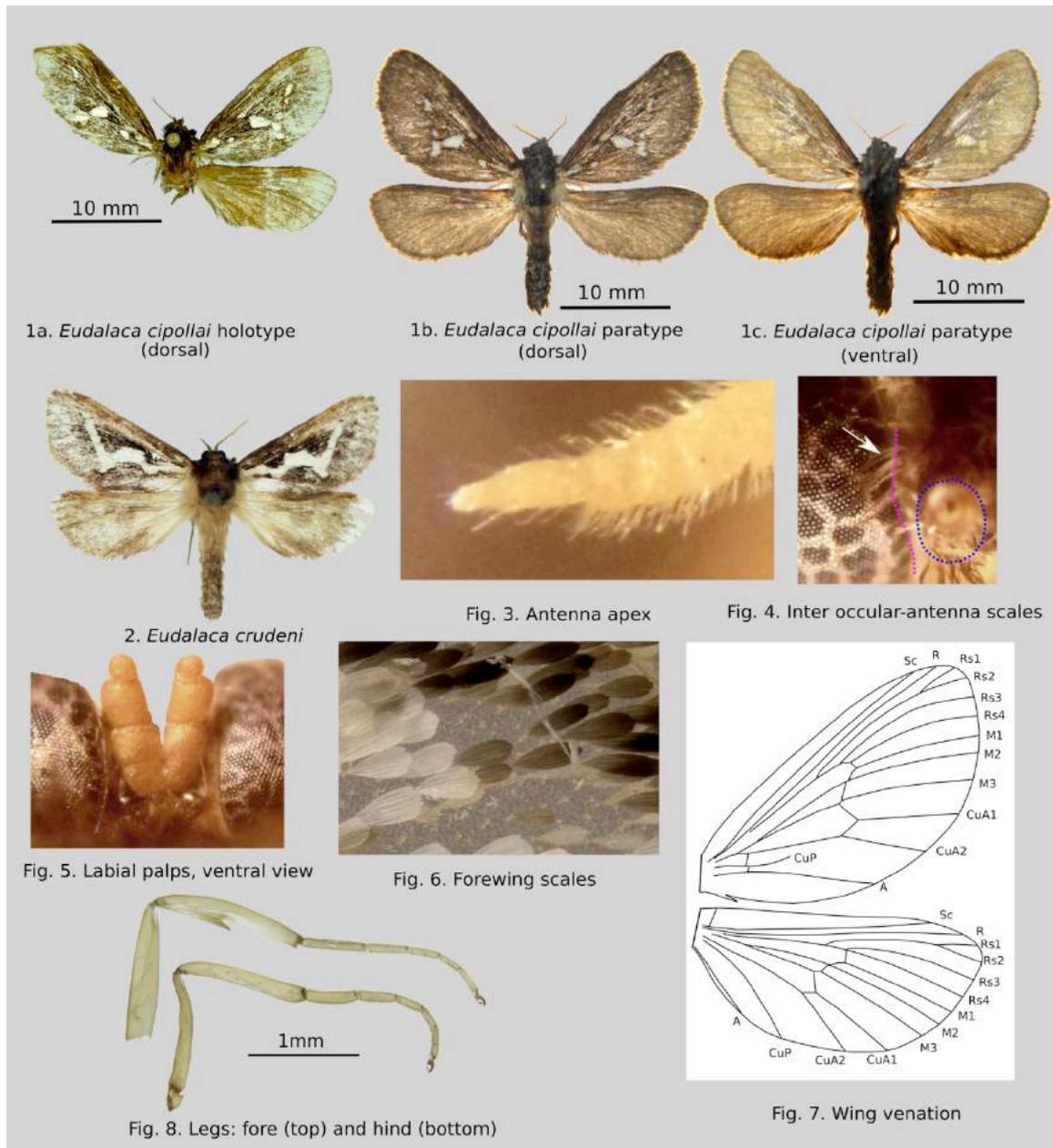
Description

♂ (Figs 1a-b). Wingspan ~28 mm, FW length: 15 mm, width: 7 mm; HW length: 13 mm, width: 6 mm.

Head: Antenna filiform, laterally flattened, flagellum 35 segments, annuli covered with numerous sensilla caetica, apical segment elongate (Fig. 3); scape barrel shaped, covered with pilose scales. Inter ocular-antennal scales present (Fig. 4). Labial palps (Fig. 5) three segmented, covered with fine, dark brown, piliform scales; labial palps with dense cover of dark brownish-black thread-like scales; short, less than diameter of eyes, first and second palpomeres subequal in length, apical segment rounded, narrower and less than half length of basal segments; prelabium short relative to length of palps, about half as long as wide. Clypeus pale brown. Frons and vertex covered with fine, dark brown piliform scales.

Thorax: Covered with dense, dark brown piliform scales. Scutum III brown, glabrous other than posterior and medial regions. Wings mostly covered by elongate lamellar scales with pointed apex (Fig. 6), anal margin with piliform scales, longer near base. FW and HW subequal in length and width, mid-costal margin of FW slightly convex, outer margin convex, curving gradually to anal margin with tornus indistinct; venation 'hepialine' (Fig. 7), Sc1 absent; FW: common stalk of Rs1 + Rs2 near apex; Sc and R widely spaced on FW and HW; dorsal ground colour black to dark brown with scattered white patches at wing base, near base of discal cell, outer posterior discal cell (largest patch), anterior discal cell, and oblique transverse post discal row of 3-4 patches between CuA2 and cell between M1 and M2. HW with long piliform scales at wing base. Dorsal HW pale brown merging to darker brown towards costal margin, scales long and thin basally, becoming shorter and rectangular towards outer margin. FW and HW ventral ground colour yellowish brown. Legs brown, femur with long piliform scales, tibia with long fine scales dorsally, and posterior surfaces with narrow lamellar scales predominating over anterior surface; tarsal segments covered with dense layer of short and apically pointed lamellar scales; arolium and epiphysis present (Fig. 8).

Pregenital abdomen: Tergites I-III covered with thin, pilose pale yellowish brown scales, remainder of abdomen darker with shorter scales. Tergosternal sclerite with narrow, elongate and curved tergosternal bar, lateral brace long relative to dorsal brace, latter not fused with the anterior ridge of tergum II (Fig.9). Tergum I length: width ratio 0.5 (Fig. 10a); tergum II rectangular with robust lateral ridge, curving latero-posteriorly (Fig. 10b); tergum VII rectangular, wider than long, tergum VIII rectangular, lateral margins angled slightly postero-medially; sternum II with

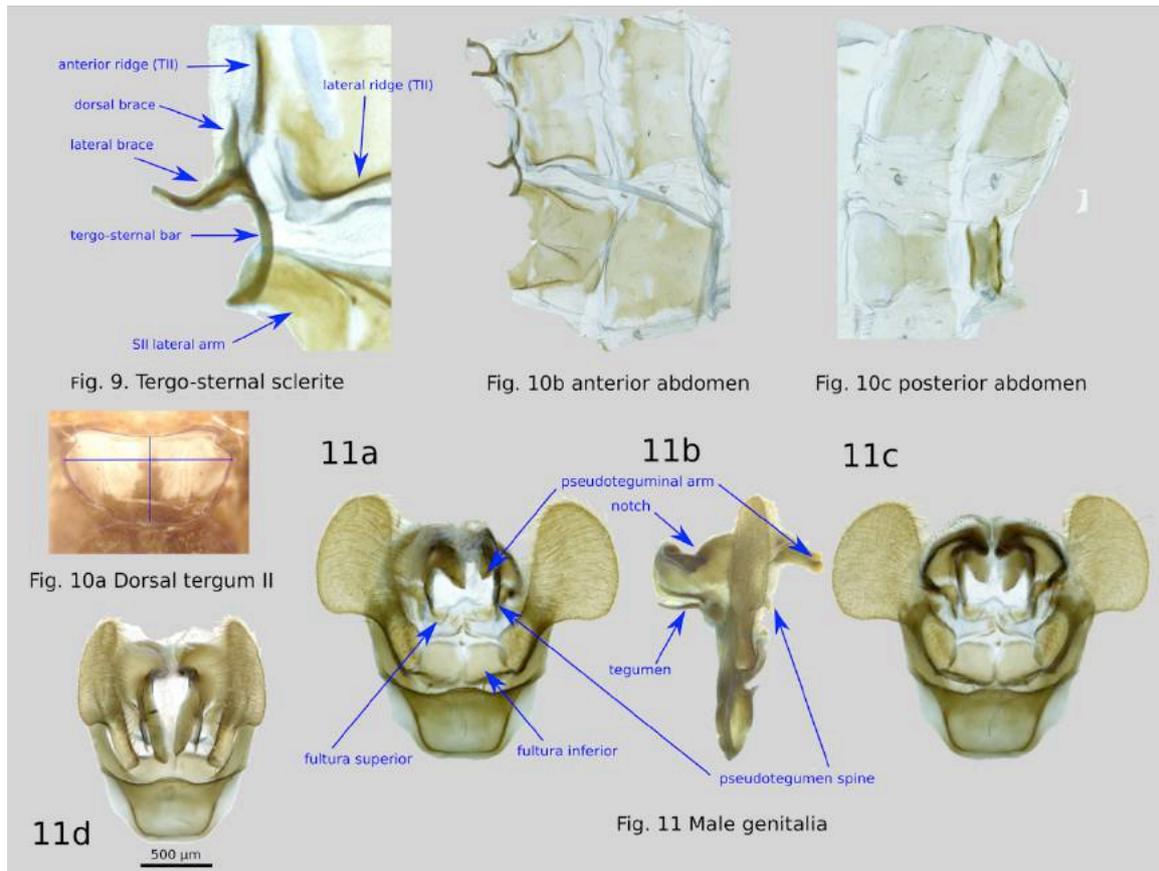


Figures 1-8. (1) *Eudalaca cipollai* sp. n. holotype dorsal (a) paratype dorsal, (b) and ventral (c). Paratype photo by Benny de Groof; (2) *Eudalaca crudeni*. South Africa, Western Cape, Breaton Bay. From Afromoths.net/species/show39 (TMSA - Ditsong Museum of Natural History (Transvaal Museum)). Photo by Jurate de Prins; (3-8) *Eudalaca cipollai* sp. n. (3) Antenna apex. Photo by John Grehan; (4) Interocular-antenna scales (white arrow) between base of antenna (blue dotted line) and medial edge of compound eye (crimson dotted line). Photo by John Grehan; (5) Labial palps, descaled, ventral view. Photo by John Grehan; (7) Wing venation; (8) Legs. Photos by Nikolai Ignatev.

prominent antero-lateral arms laterally edged with sclerotized ridge (Fig. 10b); sternum VII weakly sclerotized, anterior half about twice as wide as posterior half, sternite VIII forming a broad, longitudinally narrow sclerotized plate with anterior and posterior ridges (Fig. 10c).

Genitalia (Fig. 11): Tergal lobes membranous. Pseudotegumen dorsally unfused across median, anogenital margin notched dorsally (Fig. 11c); pseudoteguminal arms elongate, unfused at apex. Tegumen narrow, wider ventrally. Valva basally narrow, expanding distally into large subtriangular convex, setose blade, anterior and posterior edges convex towards narrow sacculus. Fultura inferior rectangular, wider than long with unsclerotized medial notch on posterior margin; fultura superior weakly sclerotized, wider than long, extends only to base of pseudotegumen at the basal pseudotegumen spine. Saccus broad, subsquare with slight medial convex margin along apodemal suture.

Female: unknown.



Figures 9-11. *Eudalaca cipollai* sp. n. holotype (9) tergo-sternal sclerite; (10) abdomen, a – dorsal view of tergum I with horizontal and longitudinal dimensions in blue lines, b – anterior (I-III), c – posterior (VII-VIII); (11) male genitalia posterior abdomen a – ventral, b – lateral, c – dorsal views, d – closed position of genitalia with posterior view of pseudotegumen.

Photo 10a by John Grehan, others by Nikolai Ignatev.

Habitat and phenology

Moths were collected from within a dense, humid primary forest near a stream within Mistbelt forest at the Karkloof Nature Reserve (Fig. 18a-c). This Reserve is located in the midlands of KwaZulu-Natal, approximately 30-km north of Howick and covers an area of 3,274 ha which combines land parcels owned, assigned, or leased by Ezemvelo KZN Wildlife, or by private individuals incorporated through the Ezemvelo KZN Wildlife Biodiversity Stewardship Programme. The Nature Reserve is a key component of the protected area system in the midlands region of KwaZulu-Natal, primarily for its role in securing indigenous Eastern Mistbelt Forest and its surrounding grassland-wetland ecosystems (KNR 2011). The climax forest of the KwaZulu-Natal Mistbelt is a mixed *Podocarpus* Forest between 1,000 and 1,500 m. These forests are located on steep, south-facing slopes that are subject to frequent mist, particularly in the summer. The

estimated original 32,000 ha area of the Karkloof Forest was reduced to about 8,100 ha by the early 1940's (Moll 1972).

The November record for the *E. cipollai* sp. n. specimens corresponds to the first month of highest monthly rainfall in the period between November and February-March. Rainfall averages 900 mm per year with the November rainfall totalling about 150 mm in the form of gentle soaking rains (KNR 2011). These conditions would provide adequate levels of humidity and moisture on the forest floor for development of eggs and early instars of Hepialidae where eggs require near saturated humidity for growth and survival.



Figure 12. Habitat and location of *Eudalaca cipollai* sp. n. (a) Vegetation and landform of the Karkloof Nature Reserve area, (b) Stream near collecting site, (c) geographic location of type locality (white circle), and *Eudalaca crudeni* at Alicedale (blue circle).

Taxonomic and systematic remarks

The status of *Eudalaca cipollai* sp. n. as a distinct species is corroborated by differences in wing pattern from all other species of southern African Hepialidae, and differences in the structure of the male genitalia compared to all other species where this structure is illustrated. No other southern African species of Hepialidae have a FW pattern comprising a few white patches or spots on a ground color of dark brown. Instead, wing patterns range from the bright reddish orange with white spots of *Leto* and the pale white with darker speckling of *Neoleto*, to a predominantly a grayish or yellowish brown ground color with scattered darker spots or patches or with various pale to white transverse or longitudinal lines or bands in other *Eudalaca* species and the genera *Afrotheora*, *Gorgopis*, and *Metahepialus*. The unique wing pattern of *E. cipollai* sp. n. was confirmed by examining photographic illustrations available for most southern African species, either posted on AfroMoths (2021) or presented in published descriptions (Janse 1942, 1948, Mey 2019, Eitschberger & Ströhle 2021). For those species for which photographs were not available, written descriptions were sufficient to exclude any pattern like that of *E. cipollai* sp. n. On the basis of this comparison, we consider the species status of *E. cipollai* sp. n. to be well corroborated.

The structure of the male genitalia of *E. cipollai* sp. n. provided evidence for the generic placement of the species even though the monophyly of *Eudalaca* and some other genera is not yet established. This lack of phylogenetic comparison (including with genera outside Africa), is problematic even for the monotypic genera. Although *Leto* is distinctive for its size, wing pattern and prominent bristle-shaped wing scales (Grehan et al. 2019), the shape of the pseudotegumen and valva of the male genitalia (Fig.13) has a general structure similar to both *Eudalaca* and *Gorgopis* species, and the pronounced elbow shape of the valva is similar to that recorded in some *Gorgopis* species (cf. Janse 1942). It is possible that *Leto* represents a morphologically divergent (autapomorphic) species that nests within one of these genera. The recently named *Neoleto* (Eitschberger & Ströhle 2021) is based on two female specimens only, and this does not allow direct comparison with most southern African species that are defined by male genitalia only.

Monophyly of *Afrotheora* was substantiated by Nielsen & Scoble (1986). The male genitalia of this genus, along with *Antihepialus*, lack fusion between the fultura superior and the pseudoteguminal apex. This is a plesiomorphic condition applicable to these and two other 'primitive' genera (Fraus Walker, 1856, *Gazoryctra* Hübner, [1820]) that comprise basal lineages within the Hepialidae. Monophyly of *Metahepialus*, *Eudalaca*, and *Gorgopis*, and the relationships between them is

unresolved. Janse (1942) originally proposed *Metahepialus* for *M. plurimaculata* (Warren, 1914) and *M. xenoctenis* (Meyrick, 1926), and subsequently *M. angustiptera* Janse, 1948 (Janse 1948). The latter species was transferred to *Gorgopis* by Mey (2011) who noted that *Metahepialus* was based on *M. plurimaculata* (Warren, 1914) which he characterized as a rather aberrant species with additional apomorphic characters that *M. angustiptera* does not exhibit, while the moderately long pectinations of the antennae and triangular scale tuft across the eyes was considered as evidence for its placement in *Gorgopis*. Janse (1942) provided a diagnostic description for *Metahepialus*, but this characterization does not provide sufficient comparative information to corroborate monophyly of the genus. Apart from external appearance, *E. cipollai* sp. n. is excluded from *Metahepialus* by differences in the male genitalia as it does not have the long, narrow saccus of *M. xenoctenis* (Janse 1942: pl. L, fig. 10) or the medial fusion and dorso-lateral projection of the pseudotegumen in *M. plurimaculata* (Janse 1942: pl. LI, fig.1). All *Antihepialus* species appear to share the presence of a basal knob or prominence on the male valva (Janse 1942) which would support monophyly of the genus. Separation and respective monophyly of *Eudalaca* and *Gorgopis* remains problematic as neither is definitively characterized as monophyletic by the presence of one or more synapomorphies (see discussion).

Monophyly of *Eudalaca* and *Gorgopis*

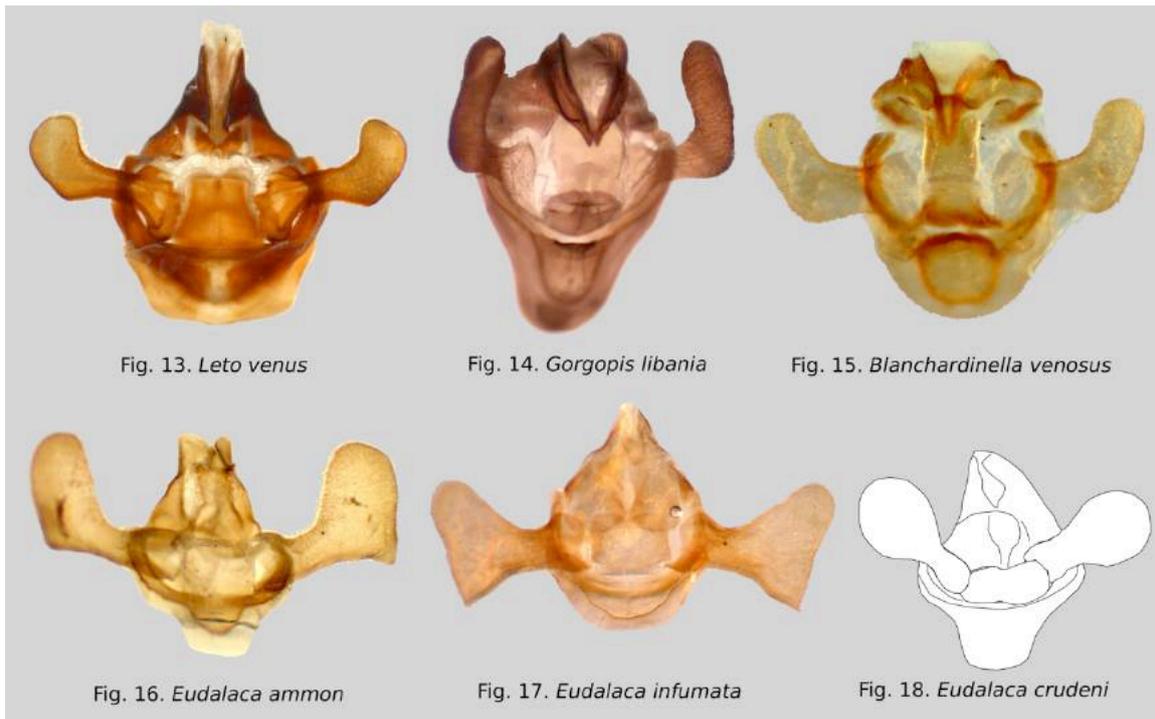
These two genera comprise many species with varied external wing patterns and male genitalia that are sometimes very similar. *Gorgopis* was characterized by Janse (1942) as having an 'eye tuft' of inter ocular-antenna scales and bipectinate antennae, but the presence of these features was not specifically verified for all species of each genus. Presence of an eye tuft appears to be a derived character state for the Hepialidae (as it has not been documented for the other hepialoid families or Mnesarchaeidae) and is therefore potentially phylogenetically informative. But the presence of an eye tuft comprising scales arising from the narrow space between the base of the antenna and the medial eye margin is recorded from other genera such as *Afrotheora* (Nielsen & Scoble 1986) and the Central-South American *Druceiella* Viette (Grehan & Rawlins 2016). This feature has also been observed in *Eudalaca orthocosma* (Janse, 1942) and *E. semicanus* (Janse, 1919) (J.R.G. pers. obs.). Another distinction illustrated by Janse (1942: plate LI, fig. 7) was the absence of CuP in the FW, but this is either an error or an aberration, as our examination of specimens in this genus show this vein to be present.

Viette (1950b) erected *Eudalaca* for all African species previously assigned to *Dalaca* Walker *sensu* Janse as the latter name was applicable to species in South America only. Since the study by Janse (1942), new species have been proposed for both *Eudalaca* and *Gorgopis*. The addition of a new species to *Eudalaca* by Viette (1950a) did not include reference to distinguishing criteria for the genus, while species listed for *Eudalaca* and *Gorgopis* by Nielsen et al. (2000) were part of a taxonomic list that did not specify generic characters. The presence of the eye tuft used in support of *G. angustiptera* being placed in *Gorgopis* by Mey (2011) is not uniquely diagnostic for the genus (as noted above), but it was also noted by Mey (2011) that the wing pattern and antennal structure is very similar to that of *G. olivaceonotata* Warren, 1914. A further two species allocated to *Gorgopis* and one to *Eudalaca* were added by Mey (2019) based on the shared presence of a bifid process on the saccus (vinculum). The two new species were considered to be closely related to *G. huntii* Janse, 1942 and *G. furcata* Janse, 1942, while also being very similar to *E. exul* (Herrich-Schaffer, 1853). As noted by Viette (1947), the valva of *Eudalaca* is similar to the monotypic Chilean *Blanchardinella* (Fig. 15). Viette (1950b) distinguished between the two genera by the length of the palpomeres although the differences were not specified.

Taxonomic placement of *E. cipollai* sp. n.

Valva morphology in *Eudalaca* ranges between species where the distal lobe is expanded into a broad subrectangular setose blade, to species where the valva forms a shallow curve without noticeable distal expansion as in *E. semicanus* (Janse, 1919) (Janse 1942). The valva in *Eudalaca* may be curved or sharply angled, and sometimes right angled. Of these, 15 species are known to

have a distinctly expanded distal blade as found for *E. cipollai* sp. n. (Janse 1942, Viette 1947, 1950a, b, Mey 2019). Some of these species have a sharp corner or point on the antero-distal edge as illustrated by *E. ammon* (Wallengren, 1860) (Fig. 16) and *E. infumata* (Janse, 1942) (Fig. 17). The lateral edge of the valva of *Gorgopis* varies in shape from curved to sharply angled (see figures in Janse 1942), as illustrated for *G. libania* (Cramer, 1781) (Fig. 14). The distal valva of *G. subrimosa* Janse, 1942 (Janse 1942, plate LII, fig. 1) is expanded into a broad blade with a sharp corner on the anterior edge and is similar in this respect to *Eudalaca*. While an expanded distal blade is a derived feature within the Hepialidae, and more frequently documented for *Eudalaca* species, it does not provide a constant difference between *Eudalaca* and *Gorgopis* with respect to species currently allocated to each.



Figures 13-18. Male genitalia in some other southern African Hepialidae and *Blanchardinella* from Chile. (13) *Leto venus* (no data), J.R. Grehan dissection M127, Peabody Museum, New Haven, USA; (14) *Gorgopis libania*, Pretoria, South Africa, J.R. Grehan dissection M176, Canadian National Collection, Ottawa, Canada; (15), *Blanchardinella venosus*, Peñalolén (Santiago), Chile, J.R. Grehan dissection M106, Carnegie Museum of Natural History, Pittsburgh, USA; (16) *Eudalaca ammon*, J.S. Dugdale dissection 598, New Zealand Arthropod Collection, Auckland, New Zealand; (17) *Eudalaca infumata*, Boma la Ngombe, Tanzania, J.R. Grehan dissection M128 (Museum of Comparative Zoology, Cambridge, Massachusetts, USA); (18) *Eudalaca crudeni*, holotype, redrawn from Janse (1942: plate XLVIII, fig. 8). Photos by John Grehan.

The anterior and posterior edges of the distal blade are rounded in *E. cipollai* sp. n., with the anterior edge slightly more angled basally. The most similar shaped valva is that of *Eudalaca crudeni* Janse, 1942 (Fig. 18) where the distal blade has rounded anterior and posterior edges with a more symmetrical shape than in *E. cipollai* sp. n. The external appearance of *E. crudeni* is similar to *E. cipollai* sp. n. with respect to having a dark brown FW with prominent white markings, but these differ from those in *E. cipollai* sp. n. by comprising an irregularly shaped, broad white band angled transversely near the cross vein of CuA1 and CuA2 (Fig. 2). The shared FW ground colour and prominent white markings may indicate a close affinity between the two species. The two species are separated by a distance of 600 km (Fig. 18c). Based on the similarly distally expanded valva of at least 15 species of *Eudalaca*, along with similar aspects of the FW pattern to *E. crudeni*, we conclude that the most probable generic assignment for the new species is *Eudalaca*. However, due to the uncertain taxonomic status of *Eudalaca* and *Gorgopis*, all generic placements for their

respective species, including *E. cipollai* sp. n., have to be treated as provisional pending future systematic evaluation of both genera.

The 0.5 length to width ratio of tergum I in *E. cipollai* sp. n. indicates that the tergite is relatively long in proportion to width. This ratio is greater than the less than 0.3 attributed to the Hepialidae sensu stricto (which includes *Eudalaca*) by Nielsen (1988). As this ratio has not been widely documented in the Hepialidae, this feature needs to be investigated further, particularly for *Gorgopis* and other *Eudalaca* species.

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