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**MORPHOLOGY AND TAXONOMIC NOTES ON *OXYCANUS
FULIGINOSA* ROTHSCHILD FROM WESTERN PAPUA, INDONESIA
(LEPIDOPTERA: HEPIALIDAE)**

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Morphology and taxonomic notes on *Oxycanus fuliginosa* Rothschild from Western Papua, Indonesia (Lepidoptera: Hepialidae)

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ABSTRACT

Details of external and genitalic morphology are described and illustrated for three male specimens of *Oxycanus fuliginosa* (Rothschild, 1915), a central highland species of Western Papua, New Guinea. Distinguishing features are documented for the genitalia and comparisons are made with other related genera. The absence of subanal sclerites in this species is of potential phylogenetic interest, and the tergo-sternal sclerite shares features with other species of *Oxycanus* Walker, 1856, and most other Old World oxycanine Hepialidae.

KEY WORDS

Morphology, phylogeny, species, systematics

INTRODUCTION

Among the most diverse genera of Hepialidae, the currently valid 73 species of *Oxycanus* Walker, 1856 is exceeded only by the 78 species of *Thitarodes* Viette, 1968. The distribution of *Oxycanus* ranges between mainland Australia, Indonesian New Guinea and Papua New Guinea (Tindale 1935, Viette 1950a, Tindale 1955). It is notably absent from New Caledonia while several closely related genera are present in New Zealand (Dugdale 1994, Brown *et al.* 1999, Grehan & Mielke 2018a). Most described *Oxycanus* species (47) occur in Australia, while of the 32 New Guinea species, 29 are recorded from only Western Papua (Indonesia) and three from only Papua New Guinea.

The Western Papua *Oxycanus* fauna represents a considerable concentration of species; most of which are poorly known, and many are similar in general appearance (Papua Insects 2021). Rothschild's (1915) description of *O. fuliginosa* (Rothschild, 1915) was limited to external body and wing colors and patterns which is insufficient for distinguishing the species, but descriptions and genitalic diagrams are available for all Western Papua species (Viette 1950a, 1956; Tindale 1955, 1968), including a diagrammatic illustration for *O. fuliginosa* by Tindale (1955) and Viette (1956) showing the structure of the pseudotegumen to be distinct from all other species, and that three specimens from the Museum Witt, Munich (Fig. 1) conform to this species. In order to begin the long-term task of further clarifying the species and taxonomy of *Oxycanus* (Beaver *et al.* 2020), we present a morphological redescription of *O. fuliginosa* with respect to three Witt Museum specimens.

METHODS AND MATERIALS

Terminology follows Kristensen (2003) for wing venation, Mielke & Casagrande (2013) for the tegumen (=intermediate plate), saccus (=vinculum), and fultura inferior (=juxta), Grehan & Mielke (2018b) for the fultura superior (=trulleum), Grehan & Mielke (2017) for the tergo-sternal connection, and Dumbleton (1966) for the oxycanine wing pattern where Rs3 shares a common stalk with Rs1+Rs2. Specimens were dissected by removing the abdomen, legs, and labial palps and macerating them in KOH. Wing venation diagrams were drawn over photographic images using InkScape® software.

Material Examined for *Oxycanus fuliginosa*

In total 3 males (Figs. 1a, 1b, 1c). Indonesia, Irian Jaya (Western Papua): 1 ♂ Camp No. 10, 10 May 2005, 3497 m, 04.03547° S, 137.70412° E., Bretschneider/Schepanski leg. Dissection GP36.315; 2 ♂ Camp No. 8, 8 May 2005, 3325m, 04.002507° S, 137.828372° E., Bretschneider/Schepanski leg. Dissection GP36.316, GP36.317. All deposited in Museum Witt, Munich, Germany.

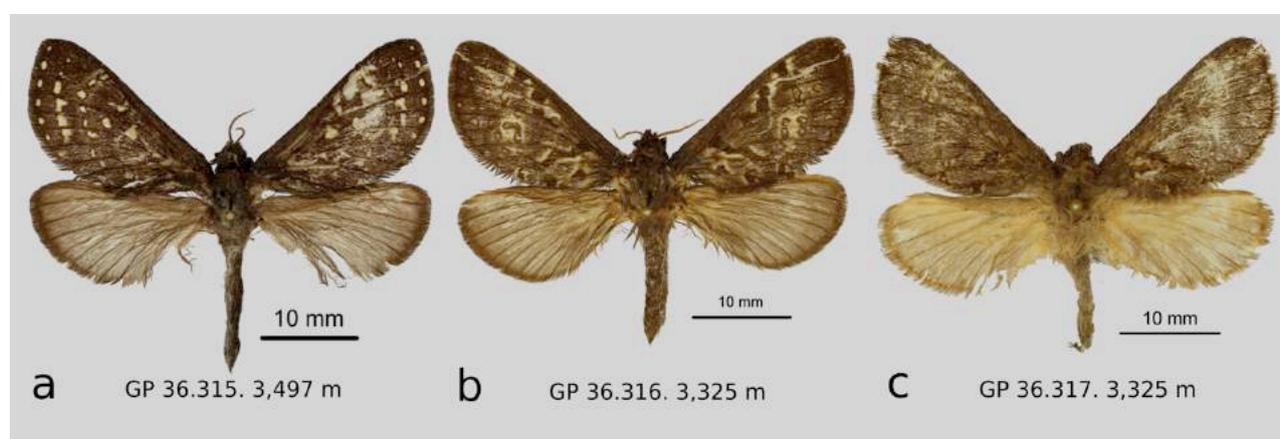


Fig. 1. Witt Museum specimens of male *Oxycanus fuliginosa* from West Papua, Indonesia: (a) Camp No. 10, (b-c) Camp No. 8. GP – dissection reference numbers.

Referenced collections for other specimens examined

CGCM Carlos Mielke Collection, Curitiba, Paraná, Brazil
 CMNH Carnegie Museum of Natural History, Pittsburgh, USA
 JRG John Grehan collection, Evans, USA

REDESCRIPTION

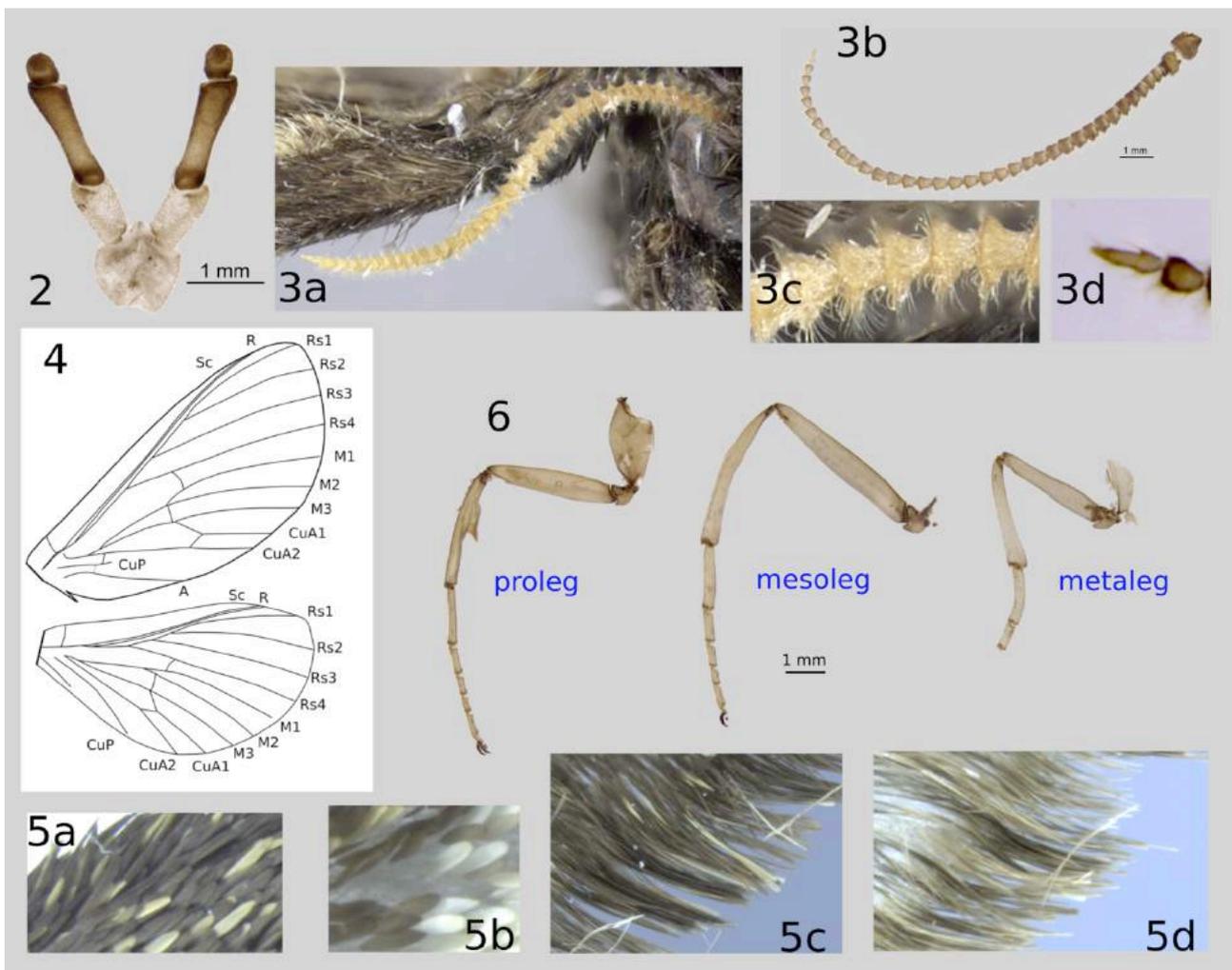
Oxycanus fuliginosa (Rothschild, 1915)

Figs. 1a-c, 2, 3a-d, 4, 5a-d, 6, 7a-c, 8a-c, 9a-b, 10a-j, 11a, 12a

Redescription male:

Head: Covered with dark brown to black piliform scales. Prelabium pentagonal with angled facets basal to palps; three palpomeres (Fig. 2), basal widest and shorter than second, distal shortest, ovoid with prominent Vom Rath's organ. Antenna filiform, covered with numerous sensilla caetica (Figs. 3a-d), 26 annuli (Fig. 3b), segments slightly longer distally, apical segment forming an elongate point (Fig. 3d).

Thorax: Covered with dark brown to black piliform scales. **Wings:** Venation oxycanine with outwardly curved Rs4-M1 cross vein, and adjacent position of Sc and R in parallel for outer half of forewing and hindwing (Fig. 4). Costal margin scales elongate (Fig. 5a), lamellar; central discal



Figs. 2-6. *Oxycanus fuliginosa* male. Head and thorax: 2, labial palps; 3, antenna: a, habitus, b, slide mount, c, annuli habitus, d, terminal segment; 4, wing venation; 5, scales: a, forewing costal margin, b, forewing outer discal cell, c, forewing outer margin, d, hindwing outer margin; 6, legs (metaleg with three tarsi missing).

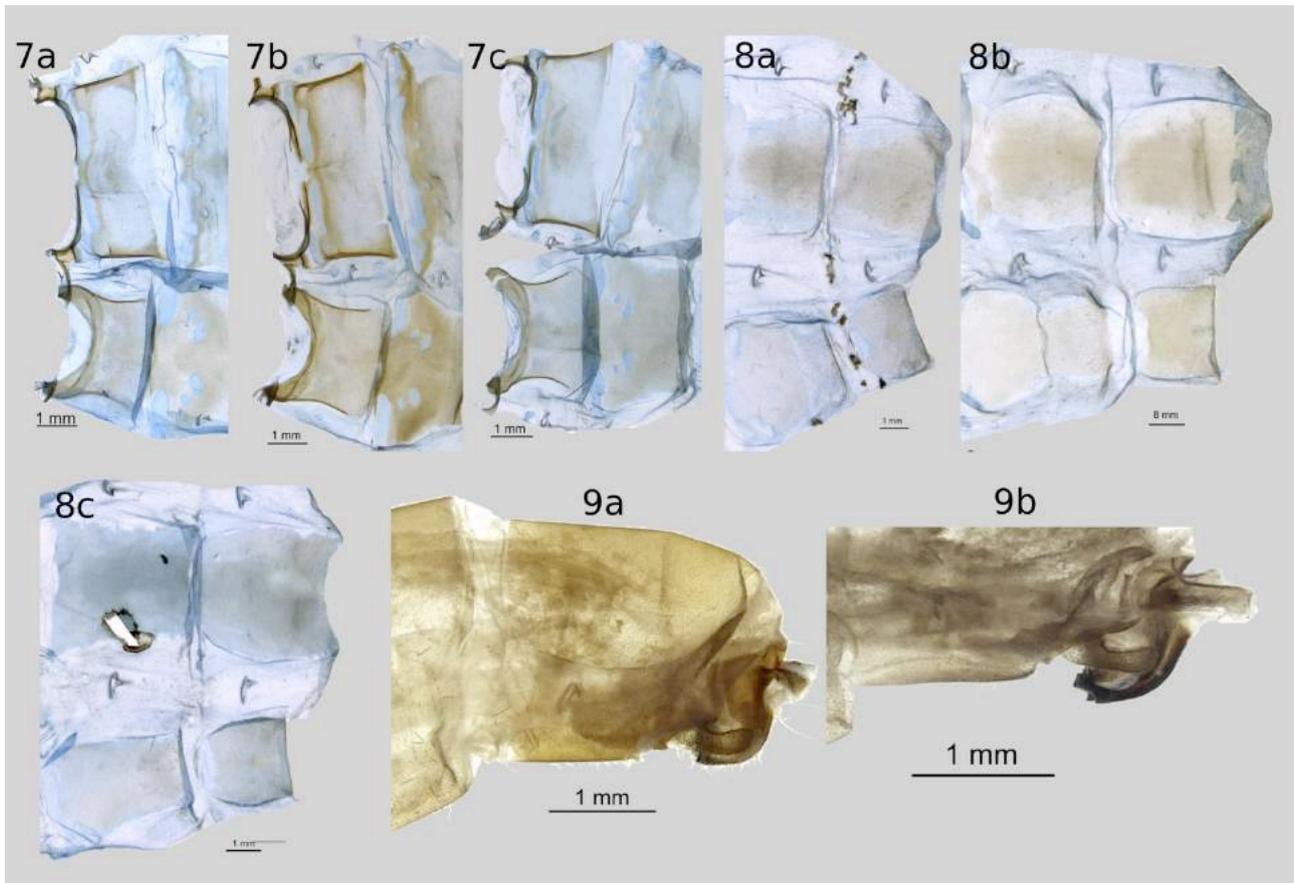
scales lamellar, pointed apically (Fig. 5b) other than white patches where scale apex more rounded (Fig. 5b); anal and outer margins with well developed fringe (Fig. 5c, d). Dorsal forewing ground colour and ventrally dark greyish brown with scattered white patches. Hindwings dorsally and ventrally greyish brown to yellowish brown without pattern. Legs dark brown dorsally and ventrally other than grey on ventral surface of tarsus. Femur and tibia with piliform scales ventrally, epiphysis broadly triangular, arolium present (Fig. 6).

Pregenital abdomen: Tergosternal sclerite with short dorsal and very short anterior brace (Fig. 12a), intermediate zone weakly sclerotized. Tergum I rectangular, prominent lateral ridge, almost straight; weakly sclerotized centrally, stronger sclerotization anteriorly and laterally, anterior ridge not fused medially (Fig. 7a-c). Sternum I sub-rectangular with broad, laterally diverging anterior lateral arms, lateral ridge convex along arms, concave posteriorly; sclerotization stronger anteriorly and on lateral arms (Fig. 7a-c). Tergum VII sub-square; tergum VIII and sternum VIII sub-rectangular, elongate; sternum VII rectangular, wider than long, posterior margin straight (Fig. 8a-c).

Genitalia (Fig. 9a-b, 10a-j): Tergal lobes unsclerotized, pseudotegumen dorsally unfused (Fig. 10h), each with an elongate twin process each side of the phallus; subanal sclerites absent; anogenital margin forming a convex curve, fused apically across the median with short, tooth-like pseudoteguminal arms each subtended by a short, subapical tooth, dorsally sometimes with short tooth near base of para-anal sclerites. Phallus membranous. Valva short, broad, strongly elbowed, narrowing to rounded apex, setose, sacculus not distinct. Fultura inferior rectangular, wider than

long, lateral edges concave; fultura superior sub-rectangular, slightly less sclerotised medially; saccus posterior margin U-shaped.

Female: syntype not examined (see Discussion).



Figs. 7-9. *Oxycanus fuliginosa* abdomen (dissections 36.314, 36.316, 36.317): 7, anterior sclerites: a, GP 36.315, b, GP 36.316, c, GP 36.317; 8 posterior sclerites: a, GP 36.315, b, GP 36.316, c, GP 36.317; 9, lateral posterior abdomen: a, GP 36.316, b, GP 317).

DISCUSSION

Rothschild (1915) described *O. fuliginosa* based on one female and one male syntype from Carstensz Peak (Puncak Jaya), [Indonesia], at 5,000-10,000' (1,524-3,048 m). Tindale (1955) thought the female specimen (NHMUK) looked like a male, although he acknowledged that this inference was made without genitalic examination. He also noted that the visible pseudotegumen of the male syntype (referred to as a “paratype”) was entirely unarmed (lacking teeth or spines) and presented a smooth convex outline in lateral view (fig. 1 in Tindale 1955). Viette (1956) examined 35 specimens in the NHMUK collection that he attributed to *O. fuliginosa*, erroneously listing a male “holotype” specimen from the type locality of Carstensz Peak. Some specimens were observed to be very dark, and one was blackish grey (corresponding to the specimens in the present article). One specimen was dissected and illustrated (Fig. 11a) but whether this was a syntype or another specimen in the series was not specified. Our redescription is therefore based on the morphology of the Witt Museum specimens corresponding to the illustrations by Tindale (1955) and Viette (1956), but final corroboration of the species would require dissection of Rothschild's two syntypes and the designation of a lectotype.

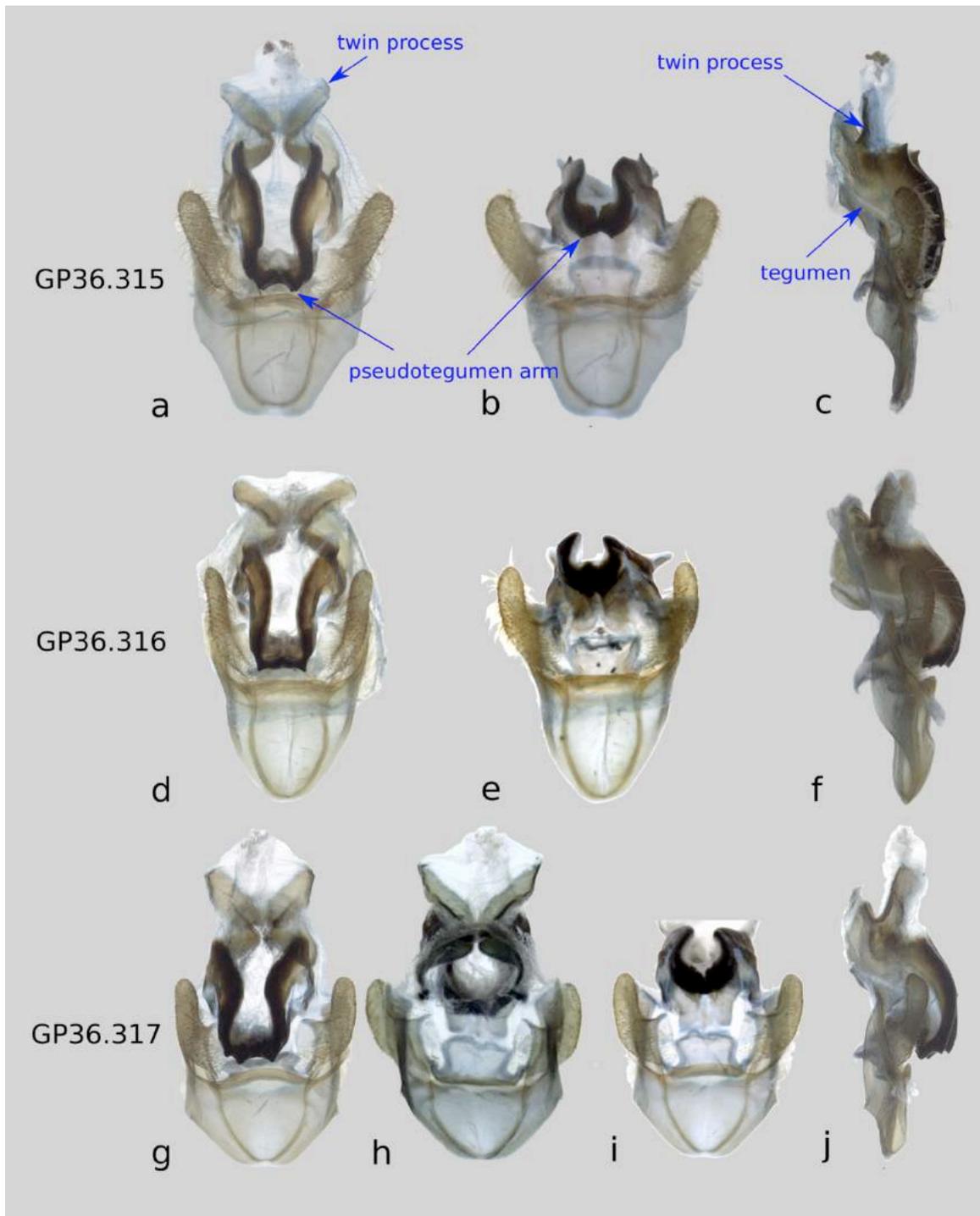


Fig. 10. *Oxycanus fuliginosa* genitalia: a, d, g, ventral closed position; b, e, i, ventral open position (fultura inferior and fultura superior visible); c,-f,-j, lateral view, h, dorsal view.

Subanal sclerites represent a derived feature within the Hepialidae and their presence is therefore potentially informative about phylogenetic relationships. The structure is present in only some species of *Oxycanus* while others, including *O. fuliginosa*, definitely lack this feature (Edwards & Green 2011, Beaver *et al.* 2020). If the subanal sclerites were present only within *Oxycanus* it would provide evidence of a close affinity for those species, but this inference is equivocal due to the feature also being present in the oxycanine genera *Parahepialiscus* Viette, 1950 (Viette 1950b), *Xhoaphryx* Viette, 1953 (Viette 1953), *Hepialiscus* Hampson, [1893] (Ueda 1988, Mielke & Grehan 2016). New Zealand species all lack this structure (Dugdale 1994). The partial presence of the subanal sclerite in *Oxycanus* may suggest that the genus, as currently defined, is non-monophyletic, or that the sclerites do not represent unequivocal evidence of monophyly for this

genus. Our description for *O. fuliginosa* is the first confirmed documentation of absence of subanal sclerites within the New Guinea *Oxycanus* fauna.

Care must be taken when observing the twin process in *Oxycanus* as they may easily be mistaken for subanal sclerites. Unlike the latter structures, twin processes are projections of the pseudotegumen at the dorsal margin of the anogenital field. Twin processes are documented for several other New Guinea *Oxycanus* by Viette (1956) and for three Australian species by Beaver *et al.* (2020). The structure appears to be a prevalent feature for other oxycanine Hepialidae, being recorded in the New Zealand oxycanines (Dugdale 1994), *Hepialiscus* (Ueda 1988), and apparently *Xhoaphryx* (Viette 1953: fig. 1), and *Parahepialiscus* (fig. 2 in Viette 1950b). A pointed 'twin process' is also present in the Eurasian genera *Hepialus* Fabricius, 1775, *Sthenopsis* Packard, 1865, and *Zenophassus* Tindale (Grehan 2012) but their homology with the twin process of oxycanines has yet to be studied in detail. A paired dorsal digitiform process in *Abantiades* Herrich-Schäffer, [1855b] (see Simonsen 2018) and *Phassodes* Bethune-Baker, 1905 represents a structure derived from the tergal lobes (Grehan & Mielke 2020).

There are 29 species of *Oxycanus* recorded from West Papua, most of which occur within, or include the central highlands. By wing ornamentation, many of these species are variable and cannot always be distinguished. Rothschild's (1915) original description of *O. fuliginosa* described the antennae as fulvous orange while the head, thorax, and forewing were characterized as sooty black, the abdomen a sooty grey, and the hindwing fuliginous (sooty) grey. These features conform to the Witt Museum specimens other than for the hindwing which varied from sooty grey to yellowish brown.

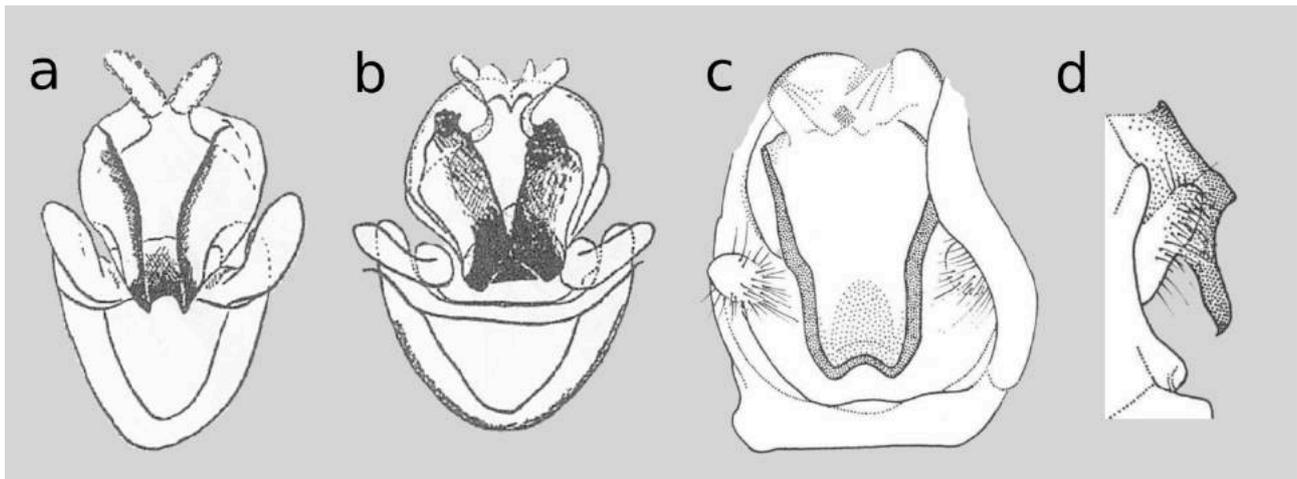


Fig. 11. Male genitalia: a, *Oxycanus fuliginosa* male (Viette 1956: fig. 2); b, *Oxycanus herbuloti* (Viette 1956: fig. 3); c, d, *Oxycanus balgooyi* (Tindale 1968: figs. 1, 2).

Tindale (1955) suggested that the shape of the pseudotegumen of *O. fuliginosa* indicated the possibility of a close relationship with the 'isolated' *O. perditus* Tindale, 1935 from southern Western Australia, but examination of genitalia of *O. perditus* by EPB found little similarity between the two species other than the absence of subanal sclerites in both. A smooth less convex profile also occurs in the Australian species *O. dirempta* Walker, 1865 (fig. 21 in Tindale 1935) and *O. waterhousei* Tindale, 1935 (fig. 22 in Tindale 1935). The pseudotegumen of *O. fuliginosa* is most similar in general shape to the *herdus-carus-silvanus-barnardi* group, and to *O. aedesima* (Turner, 1929). The latter has subanal sclerites, the former four species are without sclerites. The presence of spines on the pseudotegumen varies between species, with none on *O. barnardi* Tindale, 1935. Both *O. dirempta* and *O. waterhousei* have subanal sclerites.

The shape of the pseudotegumen, particularly the anogenital margin, is sufficiently distinct in *O. fuliginosa* to distinguish it from the male genitalia of other *Oxycanus* species. In Western Papua, the most similar genitalic morphology is found in *O. herbuloti* Viette, 1956 (Fig. 11b) which also has a smooth pseudotegumen profile along the anogenital margin (Viette 1956). The principal difference

from *O. fuliginosa* being a more extensively sclerotized surface of the pseudotegumen and sharply angled anogenital margin near the apex which has a broader blunt terminus. Tindale (1968) also noted a similarity to *O. balgooyi* Tindale, 1968 from Papua New Guinea, although the smooth anogenital margin is sharply angled (Fig. 11c-d).

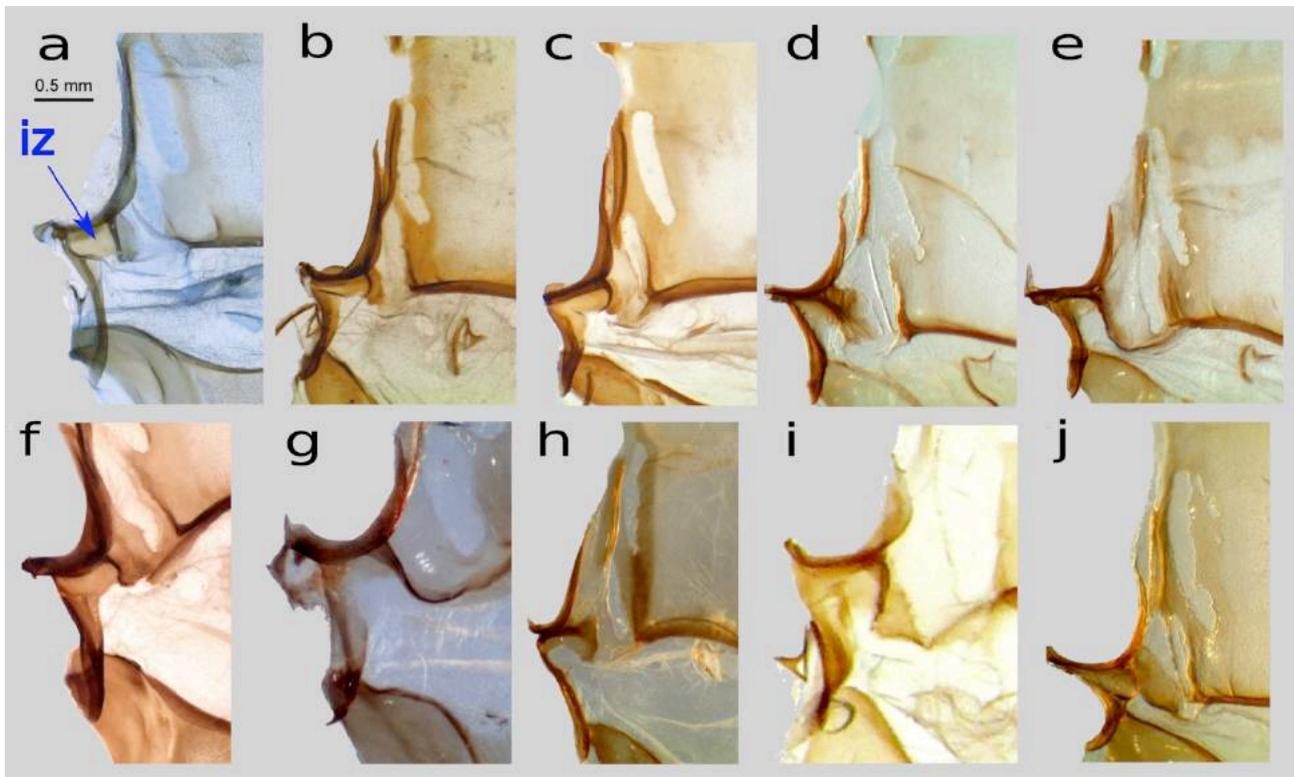


Fig. 12. Tergosternal sclerite: a, *Oxycanus fuliginosa* (GP 36.315); b, *Oxycanus rufescens* Walker, 1856 (M177, Australia, (JRG)); c, *Cladoxycanus minos* (Hudson, 1905) M127, New Zealand (JRG); d, *Dioxycanus fusca* (Philpott, 1914), M172, New Zealand (JRG); e, *Dumbletonius characterifer* (Walker, 1865) M173, New Zealand (JRG); f, *Elhamma australasiae* (Walker, 1856) M181 (CMNH); g, *Heloxycanus patricki* Dugdale, 1994 M151, New Zealand (JRG); h, *Wiseana* sp. M174, New Zealand (JRG); i, *Hepialiscus htayaungi* C. Mielke & Grehan, 2016, CGCM 33.553, Myanmar (CGCM); j, *Jeana delicatula* Tindale, 1935 M194, Australia, (JRG). IZ = intermediate zone.

The relative size and shape of the labial palpomeres can provide important diagnostic features in the Hepialidae (e.g. Nielsen & Robinson 1984, Grehan & Mielke 2018b). The palps of *O. fuliginosa* conform to the Australian species where second palpomere is longest, in contrast to the oxycanine genus *Jeana* where the basal palpomere is longest (Beaver *et al.* 2020) and the distal palpomere is narrowly subrectangular (fig. 10 in Tindale 1935). There are only two palpomeres present in the oxycanine *Elhamma* Walker, 1856 (Simonsen 2015). The small, ovoid distal palpomere of *O. fuliginosa* is also characteristic of some Australian species such as *O. rosaceus* Tindale, 1935, *O. stellans* Tindale, 1935 and *O. occidentalis* Tindale, 1935 whereas in species such as *O. sirpus* Tindale, 1935, *O. dirempta* and *O. determinata* (Walker, 1856) the distal palpomere, while still shorter than the two basal segments, is proportionally longer and narrower (figs. 14-19 in Tindale 1935). In other species such as in *O. determinata*, *O. petalous* Beaver & Moore, 2020, *O. promiscuous* Tindale, 1935, *O. armatus* Tindale, 1935, *O. poeticus* Tindale, 1935, *O. kochi* Tindale, 1955, and *O. glauerti* Tindale, 1955, the basal palpomeres is shortest (EPB *pers. obs.*).

The tergosternal sclerite connecting tergum II with sternum II is a phylogenetically significant feature in the Hepialidae (Grehan 2010, 2012). In *O. fuliginosa* the intermediate zone posterior to the junction of the tergosternal bar and lateral brace is antero-posteriorly wide and with less sclerotization (Fig. 12a). Among the Old World oxycanine genera this characteristic is also seen

Oxycanus (Figs. 12b), *Cladoxycanus* Dumbleton, 1966 (Fig. 12c), *Dioxycanus* Dumbleton, 1966 (Fig. 12d), *Dumbletonius* Dugdale, 1994 (Fig. 12e), *Elhamma* (Fig. 12f), *Heloxycanus* Dugdale, 1994 (Fig. 12g), *Wiseana* (Fig. 12h), *Hepialiscus* Hampson, 1892 (Fig. 12i), but not the Australian *Jeana* Tindale, 1935 (Fig. 12j) where the tergo-sternal bar junction extends posteriorly below the intermediate zone and the tergo-sternal bar is much shorter compared with the other oxycanines – perhaps evidence of a more distant affinity to the other oxycanine genera.



Fig. 13. Localities for *Oxycanus fuliginosa*. Dark blue circle, Witt Museum specimens; red diamond, type locality (Carstenz Peak); red circles, additional localities recorded by Tindale (1955) and Viette (1956).

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