



Description of *Walkeriella miraculosa*, gen. n. et sp. n. from South-East Peru (Lepidoptera: Hepialoidea: Hepialidae)

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Abstract

Walkeriella miraculosa gen. n. et sp. n. (Lepidoptera: Hepialoidea: Hepialidae) is based on two specimens collected from rainforest southwest of Puerto Maldonado, Tambopata, Madre de Dios department, southeastern Peru. The distinct genitalia and wing venation separate this taxon from other genera of Hepialidae although four derived characters states are shared in common with the cibyrene clade. The holotype male is deposited in the collection of the Museo de Historia Natural, Lima, Peru.

Key words: morphology, Neotropical, new genera, taxonomy

Introduction

The Hepialidae of South America include a generically diverse group referred to as the ‘cibyrene’ clade after its oldest named member genus. There is strong morphological evidence of monophyly for this group where all species share four derived character states: (i) a triangular (in lateral view) tergo-sternal bar connection with the lateral tergal brace, (ii) a postero-laterally protruding knob at or near the posterior border of the intermediate zone, (iii) an indentation, often T-shaped, on the anterior margin between the tergo-sternal bar and lateral tergal brace (Fig. 6), and (iv) a narrow or almost adjacent spacing between Sc and R on the hindwing (Grehan 2010, 2012; Grehan & Rawlins 2018). While there is good support for the monophyly of this group, the phylogenetic relationships between genera are unresolved. Based on the shared presence of these features there are 21 named cibyrene genera and over 70 species, of which eight genera are monotypic and nine genera have five or less species (Table 1). This high ratio of genera to species is an indication of the morphological diversity within the group, especially the male genitalia, and the lack of features so far discovered that might support the consolidation of species into fewer generic categories.

In this article, we describe *Walkeriella miraculosa*, gen. n. and sp. n., and discuss its morphology in comparison with other cibyrene genera. We call attention to the very useful results of collecting forays such as this one led by the third author in southern Peru.

Material and methods

Collecting activities were carried out at the Refugio Amazonas Lodge (ARA) (Fig. 1), located on the right bank of the Tambopata River (province of Tambopata, Madre de Dios department) as part of a Citizen Science program, with the mutual collaboration of the Natural History Museum (San Marcos University) and the company Rainforest Expeditions, in southeastern Peru (W 69°24'35", S 12°52'30"), at an elevation of about 230 m. The area is located at the right margin of Rio Tambopata, in a well-preserved area of typical lowland Amazonian rainforest.

Moths were collected using traditional light trapping with a single white cloth and a 250 watt mixed light bulb. The specimens were killed by alcohol injected into the thorax and they were later prepared in the laboratory.

The Köppen Climate Classification (Köppen 1948) subtype for this climate is “Af” (Tropical Rainforest Climate). The average temperature for the year in Puerto Maldonado is 25°C. The warmest month, on average, is January with 26°C and the coolest month on average is July with 22.8°C. In a year, the average rainfall is over 2,100 mm.

The abdomen and genitalia were examined with standard procedures, KOH-maceration, stained with gentian violet when necessary and preserved in glycerol. Terminology for genitalia and wings follows Mielke & Casagrande (2013) and the tergosternal connection definition follows Grehan & Mielke (2017).

The male holotype is deposited in Museo de Historia Natural, Lima, Peru along with the genitalia placed in a micro vial. The unique paratype is deposited in the collection C. Mielke, Carambeí, PR, Brazil.

TABLE 1. Genera of cibyryne Hepialidae (*Walkeriella* **gen. n.** included)

Genus	Species	Cibyryne designation source
<i>Aepytus</i> Herrich-Schäffer	5	Mielke & Grehan (2015a)
<i>Alloaepytus</i> Viette	1	Grehan (2012)
<i>Aplatissa</i> Viette	2	Grehan (2012)
<i>Cibyra</i> Walker	18	Mielke (2014, 2015), Mielke & Casagrande (2013)
<i>Druceiella</i> Viette	8	Grehan & Rawlins (2018)
<i>Gymelloxes</i> Viette	4	Grehan & Mielke (2017)
<i>Hampsoniella</i> Viette	2	Grehan (2012)
<i>Hepialyxodes</i> Viette	1	Grehan (2012)
<i>Limyra</i> C. Mielke, Dell’Erba, & Duarte	1	Mielke, Dell’Erba & Duarte (2017)
<i>Pallas</i> C. Mielke & Grehan	1	Mielke & Grehan (2015b)
<i>Philoenia</i> Kirby	8	Grehan & Mielke (2018a)
<i>Phialuse</i> Viette	1	Grehan (2012)
<i>Pseudodalaca</i> Viette	3	Grehan (2012)
<i>Pseudophassus</i> Pfitzner	2	Grehan (2012)
<i>Pseudophilaenia</i> Viette	1	Grehan (2012)
<i>Roseala</i> Viette	1	Grehan (2012)
<i>Schaefferiana</i> Viette	2	Grehan (2012)
<i>Trichophassus</i> Le Cerf	1	Grehan (2012)
<i>Tricladia</i> C. & R. Felder	4	Grehan (2012)
<i>Vietteogorgopis</i> Özdkimen	7	Grehan (2012)
<i>Yleuxas</i> Viette	2	Grehan (2012), Grehan & Mielke (2018a)
<i>Walkeriella</i> C. Mielke, Grehan & Grados	1	Present article

Taxonomic acts

Walkeriella **gen. nov.**

Type species: *Walkeriella miraculosa* **sp. nov.**, monotypic by present designation.

Diagnosis. Externally distinguished from all other Pan-American Hepialidae by a large white spot edged with dark brown at the base of each discal cell and by the large curved spot between Rs1 and M₁ at the outer anterior discal cell. *Walkeriella* **gen. n.** is also recognized by the distinctive male genitalia, particularly the valva with its concave inner (medial) surface extending from the base to the apex in contrast to either a blade-like shape or lobular shape in the other American species, and by the ‘oxycanine’ venation on the forewing and ‘hepialine’ venation (Dumbleton 1966) on the hindwing with partial fusion of Rs1+Rs2 and Rs3 at their base.

Description. *Male* (Figs 2–9). *Head.* Clypeus anteriorly glabrous and mesally projected, differentiated from the frons. Labial palpus with one tiny, rounded palpomere. Antenna lamellate.



FIGURE 1. Biotope of *Walkeriella miraculosa* **sp. nov.**

Thorax. Legs: Distitarsus without arolium. Fore- and hindwings: venation typical for cibyrene genera with Sc and R aligned very close together over much of the distal wing (Grehan & Rawlins 2018). Forewing with Sc1 and hindwing with vestigial (barely visible) Sc1 (Fig. 4).

Abdomen (Figs 6–8). Well sclerotized, tuberculate plates distinct; tergum I with lateral ridge meeting anterio-lateral tuberculate plate; anterior margin with weakly sclerotized ridge, not fused to dorsal tergal brace of tergo-sternal connection. Tergosternal connection with short dorsal and lateral brace curving together next to broad, triangular intermediate zone with prominent posterior-ventral tergal knob; upper anterior margin with small space or lacuna (Fig. 6).

Male genitalia (Fig. 9). Tegumen indistinct, likely fused to the pseudotegumen, ventral portion articulated with saccus. Saccus U-shaped anteriorly; posterior edge W-shaped with lateral expansions on either side, with indentation mesally. Tergal lobes forming narrow arch meeting anterior margin of pseudotegumen. Pseudotegumen compound of two conspicuous C-shaped lateral plates fused together on their anterior-ventral margins; its dorsal projection asymmetrical, ventral projection symmetrical with strongly sclerotized apex. Fultura inferior trapezoidal. Fultura superior comprising two reduced and narrow sclerotized longitudinal bands, one on either side. Valvae slightly curved, tapered and lightly setose. Phallus membranous.

Female. Unknown.

Etymology. This new genus is named for Francis Walker, a British entomologist, who described some Neotropical Hepialidae species in the 19th century. The name follows the tradition of *Druceiella*, *Dugdaleiella* Grehan & C. Mielke, *Hampsoniella*, *Kozloviella* Grehan & C. Mielke, and *Pfitzneriella* Viette. The gender of the name is feminine.

Remarks. The presence of *Walkeriella* **gen. n.** in southern Peru, a relatively well surveyed country, is surprising since no other similar taxon is so far known from the Neotropical region. The presence of a strongly developed posterior lateral knob, a broad intermediate connection between the tergo-sternal bar and the lateral ridge and a broken anterior margin at the tergo-sternal connection, along with a very close parallel position between the outer hindwing Sc and R veins support inclusion of *Walkeriella* **gen. n.** within the ‘cibyrene’ cluster of genera (Grehan 2012). The

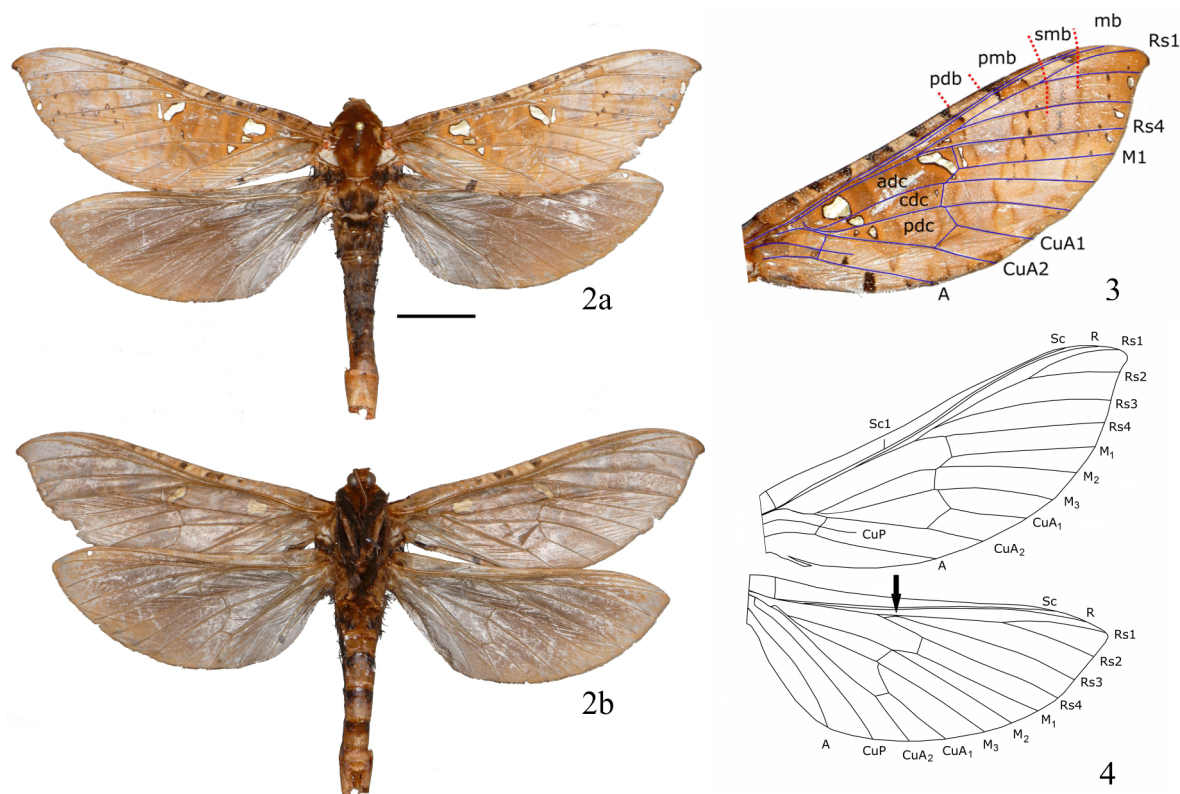
configuration of Rs1+Rs2 and Rs3 is unique among all Hepialidae genera and this is the first case that both hepialine and oxycanine venations are found in the same species. In the holotype the left forewing has an oxycanine arrangement (Rs3 joining the common stalk of Rs1+Rs2) whereas the right wing has a hepialine arrangement with Rs3 joining the base of Rs4. The hindwing arrangement is hepialine on both sides. The paratype has oxycanine venation on both forewings and hepialine venation on both hindwings. Further investigation will be necessary for a better understanding of this pattern.

***Walkeriella miraculosa* sp. nov.**

(Figs 2–9)

Diagnosis. The single known species may be recognized using diagnostic attributes of the genus. The male genitalia show the most important diagnostic features: (i) asymmetrical projection of the pseudotegumen; (ii) valva with a ventral expansion; and (iii) phallus long and narrow, tapering to apex.

Description. *Male* (Figs 2–9). Forewing length: 38–43 mm; wingspan: 80–90 mm.

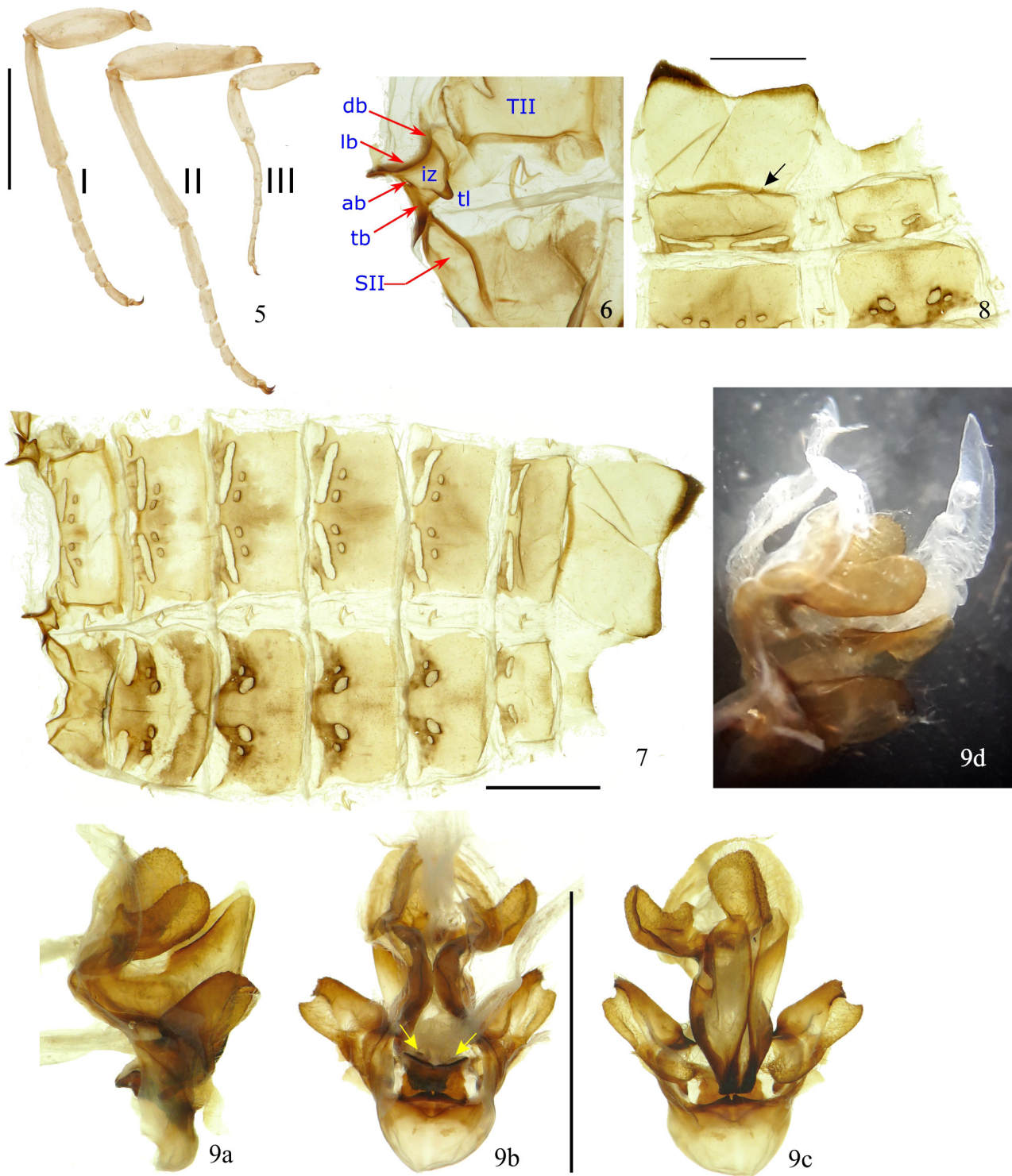


FIGURES 2–4. *Walkeriella miraculosa* sp. nov., male holotype habitus. 2, Dorsal view (a), ventral view (b). Scale bar = 1 cm. 3, Forewing ornamentation (adc = anterior discal cell, cdc = central discal cell, mb = marginal band, pdb = postdiscal band, pdc = posterior discal cell, pmb = premarginal band, smb = submarginal band). 4, Wing venation. Arrow indicates the fusion of Rs1 + Rs2 and Rs3.

Head. Frons dark orangish-brown. Antenna with about 40 antennomeres.

Thorax. Coloured as the head. Forewing costal margin straight, slightly concave midway, apex produced and falcate; outer and inner margins convex without distinct tornus. Dorsal ground colour light orangish-brown; costal margin with interspersed dark and light brown spots; basoproximal, basodistal, postdiscal and submarginal bands concolourous, lighter than other bands and edged with orangish-brown scales; basoproximal band with a pronounced dark rectangular spot at the margin; basocentral and central patch darker, the first with three bright pale yellow spots edged with dark brown, anterior spot largest, the latter with a stigma, concolourous with spots of basocentral area, comprising a main bar and some tiny surrounding dots and bars; premarginal and marginal bands with several tiny dark dots, the latter with pale tiny dot between veins from apex to intervenular space between Rs4 and M₁. Hindwing dorsally dark brown proximally, lighter distally. Forewing and hindwing ventrally uniformly coloured, light brown without any markings. Legs densely covered by porrect piliform scales (Fig. 5). Epiphysis absent.

Abdomen (Figs 6–8). Coloured dorsally as for thorax, distal portion lighter as ventrally. Tergum VII with single spine-like posterior projection each side on the posterior margin (Fig. 8); tergum VIII wider and longer than other segments, distally folded with concave posterior edge. Sternum VIII rectangular, about 1/3 width of sternum VII.



FIGURES 5–9. *Walkeriella miraculosa* sp. nov., male holotype morphological features. 5, Legs. Scale bar = 0.5 cm. 6, Tergosternal connection (ab = anterior break, db = dorsal brace, iz = intermediate zone, lb = lateral brace, SII = sternum II, TII = tergum II, tb = tergosternal bar, tl = tergal lobe). 7, Abdomen upper dorsal, lower ventral view. Scale bar = 0.5 mm. 8, Tergum (left) and sternum (right) VII and VIII. Arrow indicates the projections of tergite VII. Scale bar = 0.5 mm. 9, Genitalia: lateral view (9a), ventral view (9b; arrows indicates the futura superior), anterior view (9c), phallus everted (9d). Scale bar = 0.5 mm.

Male genitalia (Fig. 9). Right dorsal projection of pseudotegumen smaller compared to left projection, but with single process on its internal edge. Ventral projection of pseudotegumen angled posteriorly and supporting phallus dorsally. Valva rectangular, tapered with apex densely sclerotized, curved and pointed, distal portion with tiny spines on dorsal and ventral edges; ventro-laterally with an expansion of almost same length of main portion. Fultura inferior laterally compressed, fultura superior comprising two reduced and narrow sclerotized longitudinal bands, each either side of the median. Phallus long and narrow, tapering to apex, angled dorsally, cornutus absent.

Female. Unknown.

Distribution. *Walkeriella miraculosa* **sp. n.** is known from the type locality, about 40 Km southwest of Puerto Maldonado, Tambopata, Madre de Dios department, Peru at 230 m. (Fig. 10).

Ethology. All specimens at the type locality were attracted to light at dusk.

Host plant. Unknown.

Etymology. The species name *miraculosa* is a feminine Latin noun in singular nominative meaning wonderful.

Type material. Holotype male with the following labels (separated by forward slashes): /HOLOTYPUS, *Walkeriella miraculosa* C. Mielke, Grehan & Grados des. 2019/ Peru, MD [Madre de Dios], Albergue, Refugio Amazonas, 12°52'30"[S], 69°24'35"[W], 235 m 08.iv.2017, D. Couceiro [*leg.*] (deposited in Museo de Historia Natural, Lima, Peru).

Paratype. 1 male, same location as the holotype, 22.X.2016, J. Grados *leg.* (CGCM 39.415; Coll. C. Mielke, Carambeí, PR, Brazil).

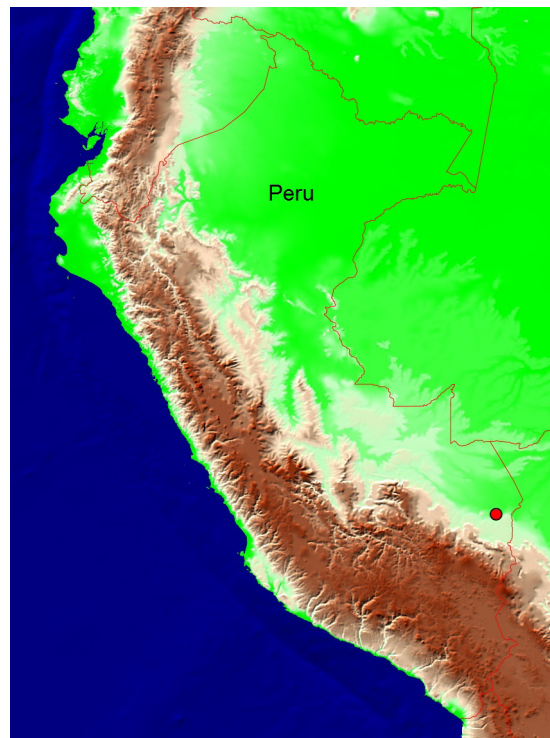


FIGURE 10. Geographical distribution of *Walkeriella miraculosa* **sp. nov.** in southern Peru (red dot).

Taxonomic and systematic remarks

The new species includes the four characteristics that define the cibyrene clade of Hepialidae. Three features are involved in the connecting sclerite between the sternum and tergum of the second abdominal segment – (i) a triangular tergo-sternal bar connection, (ii) an indentation on the anterior margin, and (iii) a knob at or near the posterior border of the intermediate zone (Fig. 6). The first two features are unique to cibyrenes while a similarly positioned knob is recorded in *Phassodes* Bethune-Baker (Fiji, Samoa, Solomon Islands) and *Abantiades* Herrich-Schäffer (Australia)

which may indicate a broader affinity (Grehan 2012). The fourth feature also present in *Walkeriella* **gen. n.** is a very narrow or almost absence of spacing between Sc and R on the hindwing for much of their length. An objective demarcation of ‘narrow’ spacing has not been defined so it is possible that the feature is not unambiguous for recognizing the cibyryne group, and narrow spacing occurs in some *Aenetus* Herrich-Schäffer species (cf. Dugdale 1994; Simonsen 2018). Since all four features are present in *Walkeriella* **gen. n.** and we have not found features to suggest affinity with other groups of Hepialidae we are confident to include *Walkeriella* **gen. n.** within the cibyryne clade.

With respect to the features we were able to examine we did not find evidence supporting any particular relationship between *Walkeriella* **gen. n.** and other genera within the cibyryne group. The wings are relatively narrow like many other cibyryne genera, but the falcate tip of the forewing is rarely observed in the group, being otherwise present only in *Trichophassus*. However, the presence or absence and the degree of prominence of falcate wing tips is variable among the Hepialidae. The pale yellowish brown shading and indistinct transverse banding also occurs in many other cibyrynes but there is considerable variability between and within genera. The large discal spots contrasts with the much smaller and less prominent spots present in many other cibyryne genera, so there is no immediate comparability of this feature to other genera. The morphology of tergite II is similar to many Hepialidae, but sternite II is most similar to many other cibyrynes and to the non-cibyryne *Andeabatis* Nielsen & Robinson with respect to the ovoid shape of the antero-lateral branch and the presence of an anterior and posterior marginal ridge. Within the cibyrynes this feature is most noticeably present in *Druceiella*, *Alloaepytus*, *Gymelloxes*, *Pseudodalaca*, and *Trichophassus* (Grehan 2012). In the posterior abdomen, the presence of a subdorsal tooth along the posterior margin of tergite VII represents a previously unrecorded feature in the Hepialidae. The reduction of tergite VIII compared to tergite VII (Fig. 8) occurs to various degrees within the cibyryne group and within the Hepialidae in general. The slightly bifurcated posterior margin of tergite VIII in *Walkeriella* **gen. n.** is also a feature found in *Hampsoniella equatorialis* (Viette) (JRG pers. obs.). The male genitalia of *Walkeriella* **gen. n.** differs from other cibyrynes (and Hepialidae in general) in the shape of the pseudotegumen with the very large and rounded dorsal ‘twin processes’ and the acutely pointed lobe of the ventral pseudotegumen. The presence of a ‘twin process’ occurs in various genera of Hepialidae (Dugdale 1994; Grehan 2012), but with different morphological configurations so the structure may be found to be phylogenetically uninformative once tested by degree of congruence with other derived character states. The presence of a twin process is not recorded from other cibyrynes. The elongate ventral region of the pseudotegumen and its apical fusion is a feature also present in *Hampsoniella* and *Pseudophassus* as also is the strongly sclerotized and slightly dentate and centrally notched posterior margin of the saccus that would articulate with the pseudotegumen apex. The shape of the valva in *Walkeriella* **gen. n.** is also unique, but the blunt distal edge of the valva in *Walkeriella* **gen. n.** is shared with *Hampsoniella equatorialis*. The lack of a detailed comparative morphology of male genitalia in the cibyrynes precludes any definitive conclusions at this time, but at least three genitalia features appear to be more similar between *Walkeriella* **gen. n.** and *Hampsoniella*. The latter genus is not yet well defined and requires further phylogenetic assessment.

The presence of ‘oxycanine’ venation in the forewings is of potential phylogenetic interest. Oxycanine venation involves Rs3 connecting with the common stalk of Rs1+Rs2 rather than with the Rs4 (usually near the base). The oxycanine pattern was originally identified for several Australasian genera that were placed in the subfamily Oxycaninae while the remainder of the family was placed in the Hepialinae (Dumbleton 1966). While there is some evidence supporting the monophyly of Australasian genera with oxycanine venation (see references in Grehan & Mielke 2018b) there is no comprehensive assessment involving the other Old World genera *Hepialiscus* Hampson, *Parahepialiscus* Viette, *Napialus* Chu & Wang and *Neohepialiscus* Viette that also share oxycanine venation. The oxycanine pattern is also present in the South American genera *Aepytus*, *Roseala*, *Tricladia*, and *Vietteogorgopis*. As these genera exhibit cibyryne characters along with other external and genitalic similarities with other cibyrynes, the presence of oxycanine venation does not unambiguously denote a monophyletic group (Nielsen & Robinson 1983; Dugdale 1994). Whether the shared oxycanine venation within the cibyryne group supports a suclade has yet to be assessed. The oxycanine pattern in *Walkeriella* **gen. n.** involves a very acute angle in the junction between Rs3 and Rs1+Rs2 whereas the Old World junction appears to be wider. The posterior edge of Rs3 in *Walkeriella* **gen. n.** also curves continuously to the junction with Rs4 in contrast to other genera where the appearance is of Rs3 intersecting Rs1+Rs2 at a distinct distance from the junction with Rs4. Although the hindwings have the hepialine pattern, the junction between Rs3 and Rs4 is very close to the base of R1+Rs2, and the base of Rs3 curves anteriorly at the base so as to partially obscure its separation from Rs1+Rs2.

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