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### **Bicentenary of Ludwig Leichhardt: Contributions to Australia's Natural History in honour of his scientific work exploring Australia**

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PO Box 3300, South Brisbane 4101, Australia  
Phone 06 7 3840 7555  
Fax 06 7 3846 1226  
Email [qmlib@qm.qld.gov.au](mailto:qmlib@qm.qld.gov.au)  
Website [www.qm.qld.gov.au](http://www.qm.qld.gov.au)

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# A new species of *Pseudotyranochthonius* Beier (Pseudoscorpiones: Pseudotyranochthoniidae) from the Warrumbungle Range, New South Wales

Danilo HARMS

School of Animal Biology, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia. Email: d.harms01@googlemail.com; Department of Terrestrial Zoology, Western Australian Museum, Locked Bag 49, Welshpool DC, WA 6986, Australia.

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## ABSTRACT

A new species of the pseudoscorpion genus *Pseudotyranochthonius* (family Pseudotyranochthoniidae) is described from Warrumbungle Range in New South Wales based on morphological features of both males and females. *Pseudotyranochthonius leichhardti* sp. nov. is the fourth described species from New South Wales and known only from the type locality. It represents the most inland record of any *Pseudotyranochthonius* in Australia. □ *false scorpion, Ludwig Leichhardt, pseudoscorpion, taxonomy, Warrumbungle National Park.*

The Pseudotyranochthoniidae are a family of medium-sized to large chthoniid pseudoscorpions (body length 1–3 mm) with 48 described species occurring on five continents across the Northern (Asia and USA) and Southern (Australia, Chile, Southern Africa) hemispheres (Harms & Harvey 2013; Harvey 2011; Harvey & Stáhlavský 2009). Only the nominate genus, *Pseudotyranochthonius* Beier, occurs in Australia and 11 species have been described from mesic forests and caves in eastern Australia (8 species), southwestern Australia (1 species) and Tasmania (2 species) (Harms & Harvey 2013; Harvey 1985, 2011). All species are slender chthoniid pseudoscorpions with prominent chelicerae and a unique arrangement of the pedipalpal trichobothria. *Pseudotyranochthonius* live in moist leaf litter, low vegetation and the topsoil layer, although the cave-dwelling species demonstrate a capacity to colonise subterranean habitats (Beier 1968, 1969, 1971; Chamberlin 1962; Dartnall 1970; Harms & Harvey 2013).

Despite the small number of described species, *Pseudotyranochthonius* is widespread and represents the dominant pseudoscorpion

group in rainforests and wet sclerophyll forest communities across temperate Australia, with numerous new species awaiting formal description (Harms & Harvey 2013). The fauna of New South Wales is no exception and the only species currently described are *P. australiensis* Beier, 1966 from a single forest locality near Edith, plus two karst endemics: *P. eberhardi* Harms and Harvey, 2013 from the Stockyard Creek Karst and *P. jonesi* (Chamberlin, 1962) from the Jenolan Karst (Harvey 1985, 2011; Harms & Harvey 2013). Museum records, however, indicate a much wider distribution of *Pseudotyranochthonius* in this state, with epigeal records representing many different putative species in most forest systems with a well-balanced supply of moisture (Fig. 1).

This paper has two aims: firstly to describe a new species of *Pseudotyranochthonius* from the Warrumbungle National Park in the Orana region of New South Wales and present the first digital images of an epigeal species belonging to this genus. Secondly to establish the most inland record of *Pseudotyranochthonius* in Australia: frontier country for a moisture-loving invertebrate lineage with a Gondwanan

heritage. I also report the distributional limits of this group on the world's driest inhabited continent.

In naming *Pseudotyranochthonius leichhardtii* sp. nov., I wish to honour Ludwig Leichhardt, a man who loved to explore frontier country outback, pushed the limits of established knowledge, and offered scientific insights into wildlife and biodiversity at a time when Australia was largely *terra incognita*.

## MATERIAL AND METHODS

All specimens examined are lodged at the Australian Museum Sydney (AMS). Terminology and measurements follow Chamberlin (1931), except for modifications to the nomenclature of the segments of the pedipalps and legs (Harvey 1992), the trichobothria (Edward & Harvey 2008; Harvey 1992) and chelal teeth morphology (Harvey 2009). The term 'rallum' is used for the cheliceral blades (Judson 2007) and the term 'coxal blades' (Harms & Harvey 2013) for the grooming organs on the first coxae. The abbreviation *dt* is used for the chelal duplex trichobothria in Pseudotyranochthoniidae rather than *xs* (Edward & Harvey 2008) to avoid homology implications amongst families in the absence of a phylogenetic framework for Chthonioidea.

Specimens used for morphological examination were preserved in c. 70–75% ethanol. General morphological examinations were carried out using a Leica MZ16A stereomicroscope and digital images were taken using a Leica DFC500 digital camera attached to a Leica MZ16A stereomicroscope, using the Leica Application Suite Version 3.6.0 software. This program allows the alignment of images taken at different focal planes (here 20–40 images, depending on size of the imaged structure) and combines them into a single image (Harms & Harvey 2013). Fine structures, such as the genital plates and coxal blades, were examined using an Olympus BH-2 compound microscope under 100–200 times magnification. For this purpose, specimens were immersed in 100% glycerol and temporarily mounted on microscope glass slides with 12 mm coverslips supported by

microneedles (diameter according to size of specimen). Glass genitalia microvials (BioQuip Products, Inc.) were used to store the dissected structures (Edward & Harvey 2008).

Line drawings were made on tracing paper using printed auto-montage images and rechecked against the respective structures to assure accuracy. In contrast to some recent taxonomic papers on chthonioid pseudoscorpions (Edward & Harvey 2008; Harvey 2009), only the external male genitalia are illustrated here because the internal genitalia appear to be of limited diagnostic value. All images were edited and formatted in Adobe Photoshop Version CS5 and distribution maps were produced using ESRI ArcGIS 9.3.1 software with improvements made in Adobe Photoshop Version CS5.

Measurements were taken with an ocular graticule at the highest possible magnification and are expressed in millimetres. All measurements were taken in dorsal view, except those of the coxae, trochanters and manducatory process that were taken in ventral view. Total length measurements of the body exclude the legs and chelicerae. Precipitation data for the Warrumbungle National Park are from the Office of Environment & Heritage, NSW National Parks & Wildlife Service (online at <http://www.environment.nsw.gov.au/NationalParks/>) and those for the surrounding areas from the Bureau of Meteorology, Melbourne, Australia (online at <http://www.bom.gov.au/>).

## SYSTEMATICS

### Family Pseudotyranochthoniidae Beier, 1932

#### Genus *Pseudotyranochthonius* Beier, 1930

*Pseudotyranochthonius* Beier, 1930: 207–208.

*Tubbichthonius* Hoff, 1951: 10–11 (synonymised by Beier 1966, p. 285).

*Spelaeochthonius* Morikawa, 1954: 83–84 (synonymised by Muchmore 1967, p. 134).

**Type species.** *Chthonius* (*Chthonius*) *silvestrii* Ellingsen 1905, by original designation.

**Diagnosis and description.** See Harms & Harvey (2013).

***Pseudotyrannochthonius leichhardti* sp. nov.**

(Figs 1–4)

**Common name.** Leichhardt's pseudoscorpion.**Etymology.** The specific epithet is a patronym in honour of the naturalist and explorer Ludwig Leichhardt (1813–c. 1848) for his scientific legacy and contributions to Australian natural history.**Material.** Holotype ♀: Australia, New South Wales, Warrumbungle National Park, Siding Springs Road, 0.9 km from Siding Spring Observatory, 31.16°15'S 149.04°31'E, 10–24 Nov 2001, c. 1060 m, pitfall traps, M.R. Gray, G.A. Milledge and H.M. Smith (AMS KS 75442). Paratypes: 1 ♀ (AMS KS 119839) and 1 ♂ (AMS KS 119840), same data as holotype.**Diagnosis.** The species can be distinguished from *Pseudotyrannochthonius australiensis* Beier, 1966, the only other described epigeal species from New South Wales, by details of the chelal fingers: both fingers strongly curved (slightly curved in *P. australiensis*), movable finger 4/5 as long as fixed finger (movable finger almost as long as fixed finger), movable finger with 9 broad teeth (5 acute teeth), fixed finger with 20 reclinate teeth (23 acute teeth), retrolateral side of chelal palm with c. 9 setae (c. 12 setae), trichobothrium *sb* shifted proximally and much further apart from *b* than *t* (*sb*, *b* and *t* spaced equally); tergal chaetotaxy 2: 4: 4: 4 (2: 4: 6: 6), cheliceral palm retrolateral with 5–6 setae (8 setae), and 11–12 coxal blades (9–10 blades).**Description.** *Adult female* (holotype, AMS KS 75442). **Colour** (in ethanol): pedipalps, chelicerae and legs light brown, cephalothorax brown, chelal fingers and soft body parts pale yellow (Figs 2F, 3E).**Chelicerae** (Figs 2H, I). Cuticle of palm squamate, with 5 acuminate setae, 1 lyrifissure in prolateral position to most dorsal row of setae on palm; movable finger with 1 seta in medial position, with 14 continuous serrations, medial serrations sharply pointed and proclinate, galea absent; fixed finger with 1 seta in subproximal position, 1 lyrifissure at the base, 2 large teeth situated medially and distally, 5 smaller teeth between large teeth, all teeth acuminate; rallum with 12 blades arising from a slit-shaped depression and distally increasing in size, proximal and distal blades not paired, other blades arranged

in pairs, all blades pinnate except anterior blade slightly serrate; serrula exterior with c. 20 visible blades, serrula interior with c. 16 blades.

**Pedipalp** (Figs 3E; 4A). All setae acuminate; trochanter 1.6, femur 6.9, patella 1.7, chela 4.6, palm 1.6 x longer than broad, fixed finger 1.9 x and movable finger 1.6 x longer than palm, without large basal apodeme, femur without tactile setae; chelal palm retrolateral with 9 setae, setae not arranged in rows; movable finger 0.8 x as long as fixed finger, both fingers strongly curved in lateral view, homodontate, distal sections of fingers strongly bent and crossing over in dorsal view, intercalary and accessory teeth absent, microsetae absent but distolateral setae at base of fixed finger short and thick, external and internal chelal condyles small and rounded, venom apparatus absent; fixed finger with 1 large lyrifissure at base, with 20 large and erect diastemodontate teeth, slightly reclinate, teeth largest medially and decreasing in size distally and proximally; movable finger with c. 9 strongly reclinate, broad and slightly juxtadentate teeth in distal third, teeth proximally decreasing in size and forming a row of continuous reclinate serrations that extends towards base of finger; *trichobothria ib* and *isb* distally on dorsum of palm, fixed finger with 8 *trichobothria*, *esb*, *ist* and *eb* form an oblique row sublaterally to dorsally at base of fixed chelal finger, it and *est* in distomedial position and paired, it slightly more distal than *est*, *et* subdistal and duplex *trichobothria dt* distal, distance between *dt* and *et* c. 3 times diameter of *dt*, *dt trichobothria* shorter than other *trichobothria*; movable finger with 4 *trichobothria*, *st* situated sub-proximal and in medial position on finger, triplet *sb*, *b* and *t* distomedial to distal, distance between *sb* and *b* 5 times distance between *b* and *t*, *sb* in subventral position, *b* medial and *t* subdorsal.**Cephalothorax** (Figs 2G; 3A, B). Subquadrate, 1.05 x longer than broad, without furrows, lateral margins constricted posteriorly; two pairs of eyes well developed and pigmented, posterior eyes less well defined than anterior eyes, eye region convex in dorsal view (Fig. 2G); with 20 setae arranged 8: 4: 4: 2: 2, postocular setae reclinate, preocular setae proclinate, interocular

setae situated at anterior margin of posterior eyes (Figs 3A,B); with 2 pairs of lyrifissures (Fig. 3B), first pair between anterior and ocular row of setae, second pair situated posterolateral to setae of posterior row, anterior pair larger than posterior pair; epistome convex, in a shallow groove, small but well sclerotised, strongly denticulate (Fig. 2A).

**Abdomen** (Figs 2D, E, F). Pleural membrane papillostriae, tergites and sternites undivided, setae uniserrate and acuminate; tergal chaetotaxy (Fig. 2E): 2: 4: 4: 4: 6: 6: 6: 7: 5: 4: 4: 0 sternal chaetotaxy (Fig. 2D): 10: 12: 12: 10: 9: 9: 8: 6: 4: –: 2.

**Genital region** (Figs 2D; 3C). Genital opening slit-like, with 10 setae proximal to opening, arranged in two oblique rows 4: 4 plus a pair 1: 1 in medial position, all setae forming a subtriangular figure, two oblique lyrifissures present anterolateral to genital opening (Fig. 4C).

**Coxae** (Figs 3C, D). Manducatory process with 2 acuminate distal setae, apical seta straight, about 3 times longer than subapical seta and extending to about half of the rallum, subapical seta dwarfed and bent towards interior margin; pedipalpal coxa with 3 setae, two at distal margin and one more medial near interior margin, with 1 medial lyrifissure; coxae I with 11 terminally trifurcate coxal blades in an oblique row (Figs 2B; 3D), arranged in four distinct groups: 2: 2: 3: 4, blades that belong to a common group basally fused, distal blades largest and on a common palm-shaped, spatulate base; apical process of coxa I broadly rounded, total number of setae on coxae: I(3): II(4): III(5): IV(5) (Fig. 3D), each coxa with one small lyrifissure in distoapical position near margin; intercoxal tubercle pronounced and tear-drop shaped, bisetose (Fig. 3D).

**Legs** (Figs 2C, F; 3E). Heterotarsate; femora I and II longer than patellae I and II; femur and patella of leg IV 4.1 x longer than broad; metatarsi III and IV with two tactile setae in submedial position, tarsi III and IV with two tactile setae in subbasal and subterminal position; tarsus III with 3–4 terminal setae, tarsi IV and V terminally with 4–5 long setae; setae on femora I–IV: I(4), II(3), III(2), IV(2); subterminal tarsal setae not

distally serrate, arolium slightly shorter than claws and not divided, all claws simple.

**Dimensions** (in mm). Body length 2.40; pedipalps: trochanter 0.28/0.18, femur 0.97/0.14, patella 0.30/0.18, chela 1.37/0.30, palm length 0.47, fixed finger length 0.89, movable finger length 0.73; chelicera total 0.60/0.29, fixed finger length 0.26, movable finger length 0.33; cephalothorax 0.65/0.62 (anterior)/0.55 (posterior); leg I: femur 0.46/0.11; patella 0.52/0.09; tibia 0.34/0.08; tarsus 0.56/0.05; leg IV: femur 0.25/0.19; patella 0.53/0.19; tibia 0.54/0.12; metatarsus 0.31/0.90; tarsus 0.58/0.06.

**Adult male** (AMS KS 119840). As for female except as follows: *Chelicerae*: with 6 setae; movable finger with 15 continuous serrations; fixed finger with 4 large teeth, distal tooth largest.

**Pedipalp** (Fig. 4B). Trochanter 1.5, femur 6.14, patella 1.87, chela 4.95, palm 1.8 x longer than broad, movable finger 1.6 x longer than palm; palm 0.77 x as long as palm of female and more slender; fixed finger with 21 large and erect diastemodontate teeth; movable finger with 8 teeth in distal third.

**Cephalothorax**. 1.02 x longer than broad; epistome less pronounced than in female.

**Abdomen**. Sternal chaetotaxy 12: 26 [8+5]: 8: 10: 8: 8: 8: 6: 4: –: 2. **Genital region** (Fig. 4D): sternite II with 13–14 reclinate genital setae; sternite III with U-shaped genital opening and two valves, each genital valve with 8 proclinate valvular genital setae.

**Coxae**. Coxae I with 11–12 blades arranged in four distinct groups: 2: 2: 3(2): 5. **Legs**: setae on femora I–IV: I(4), II(3), III(2), IV(2).

**Dimensions** (in mm). Body length 1.80; pedipalps: trochanter 0.21/0.14, femur 0.86/0.14, patella 0.28/0.15, chela 1.14/0.23; fixed finger length 0.77; palm length 0.41; movable finger length 0.67; cephalothorax 0.55/0.54 (anterior)/0.45 (posterior); chelicera total 0.42/0.24, fixed finger length 0.18, movable finger length 0.23.

**Distribution**. Known only from the type locality in the Warrumbungle National Park (Fig. 1). Most species of *Pseudotyrannochthonius*

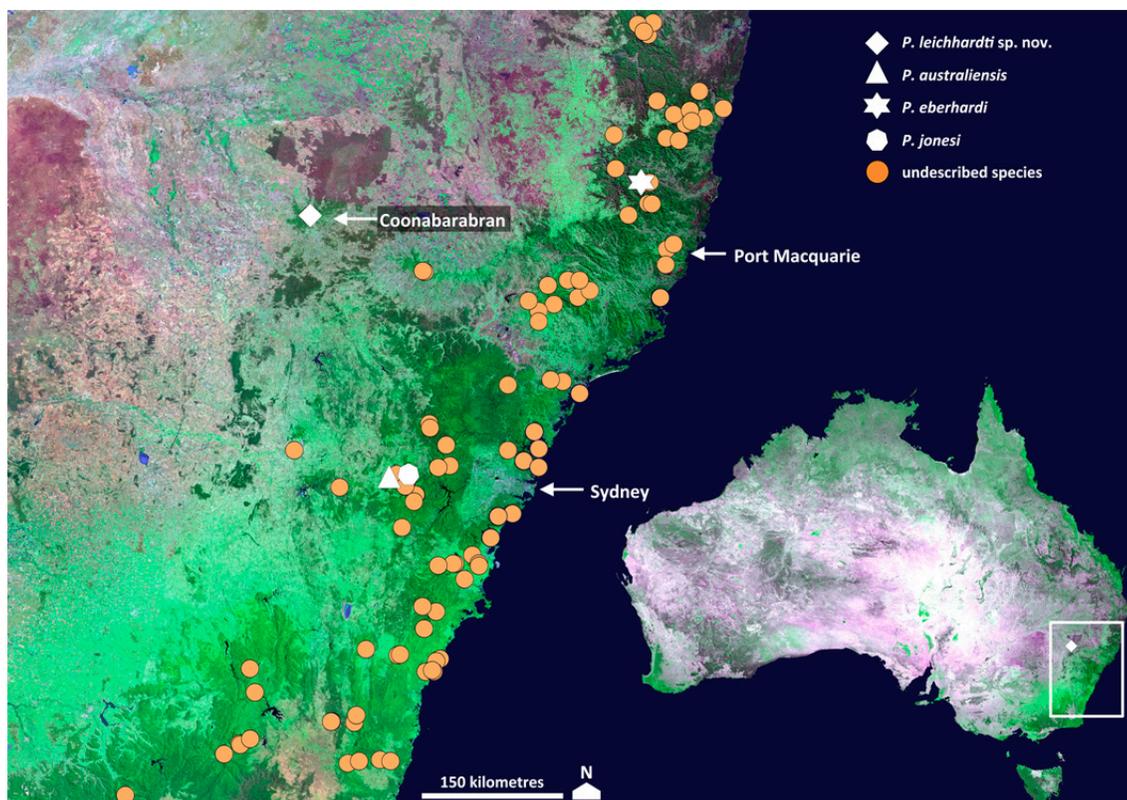


FIG. 1. Map showing locality of *Pseudotyranochthonius leichhardti* sp. nov. plus records of described and putatively undescribed species occurring in New South Wales, Australia. The epigeal records are based on a complete examination of specimens lodged with Australian museums.

in Australia are known from a single locality (Chamberlin 1962; Hoff 1951; Beier 1966, 1968; Dartnall 1970) or very few collecting sites (Mallick & Driessen 2005) only, and can be considered as short- or narrow-range endemics *sensu* Harvey (2002) and Ponder & Colgan (2002). Given this pattern, *P. leichhardti* sp. nov. is likely endemic to the Warrumbungle National Park.

**Habitat and Climate.** Tall sclerophyll forest in elevated terrain (G. Milledge, pers. com.). The Warrumbungle National Park has an annual average rainfall of 720 mm, with higher precipitation levels expected for the peaks of the Range. Rainfall decreases rapidly further inland (less than 600 mm for Cheddington weather station, c. 6 km west of the Range) and the occurrence of *Pseudotyranochthonius*

there is unlikely. The specimens were collected in November when temperatures and rainfall increase following winter (June to August; driest month is September).

**Conservation status.** Unknown.

**Remarks.** *Pseudotyranochthonius leichhardti* sp. nov. is one of many putative new species in New South Wales awaiting taxonomic description. Although the genus as a whole has not been revised, *P. leichhardti* sp. nov. can be easily diagnosed by means of its unique pedipalp morphology. I note, however, that most other putative species in New South Wales are morphologically less distinct and cryptic, so that a taxonomic approach based solely on morphology will fail. A combination of morphology and molecular tools, including multi-gene barcoding, linked

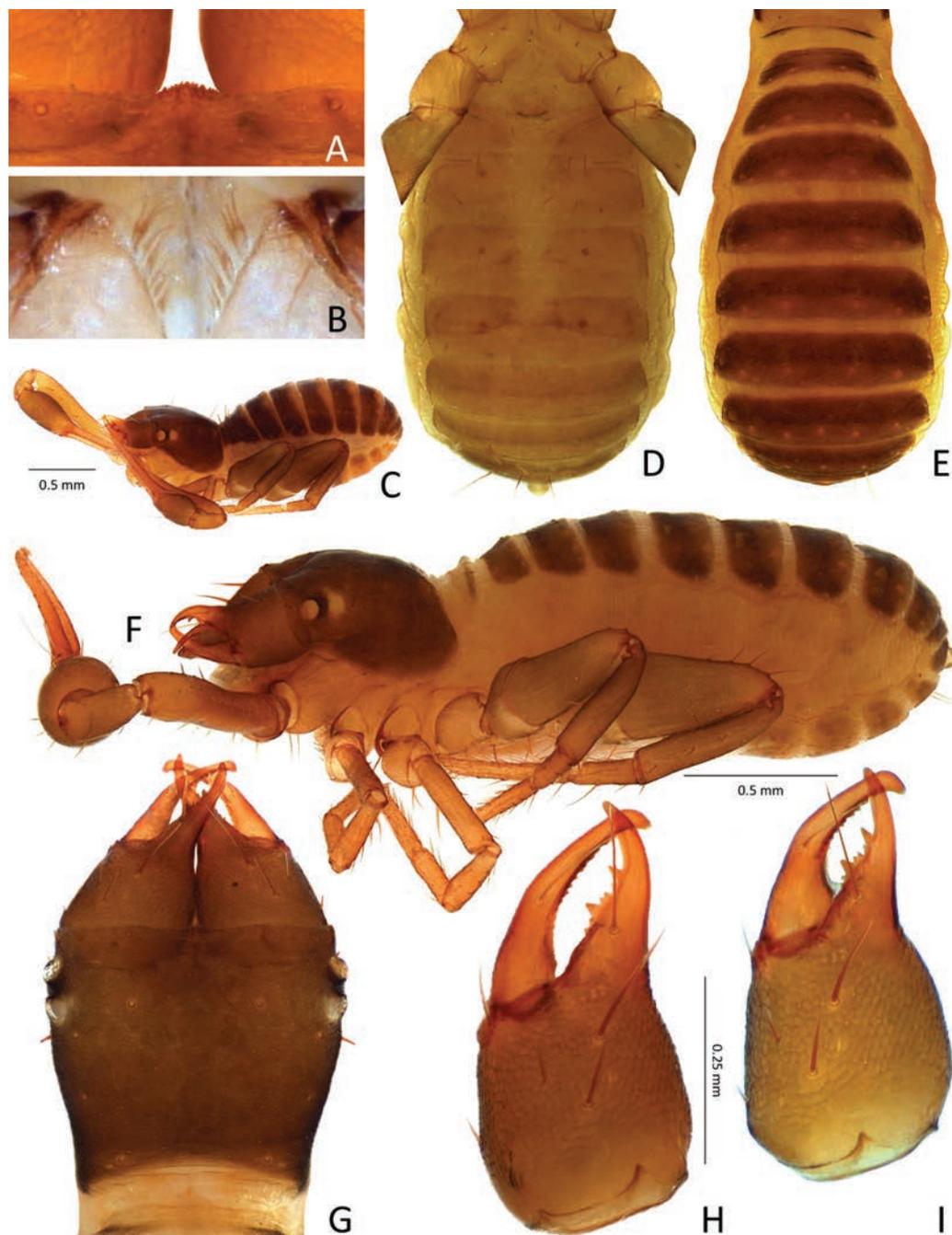


FIG. 2. *Pseudotyranochthonius leichhardti* sp. nov., holotype female (AMS KS 75442, figs. A, B, D, E, F, G, H, I) and paratype male (AMS KS 119840, fig. C): A, epistome, dorsal; B, coxal blades, ventral; C, habitus, lateral; D, abdomen, ventral; E, same, dorsal; F, habitus, lateral; G, cephalothorax and chelicerae, dorsal; H, left chelicera, lateral; and I, same, ventrolateral.

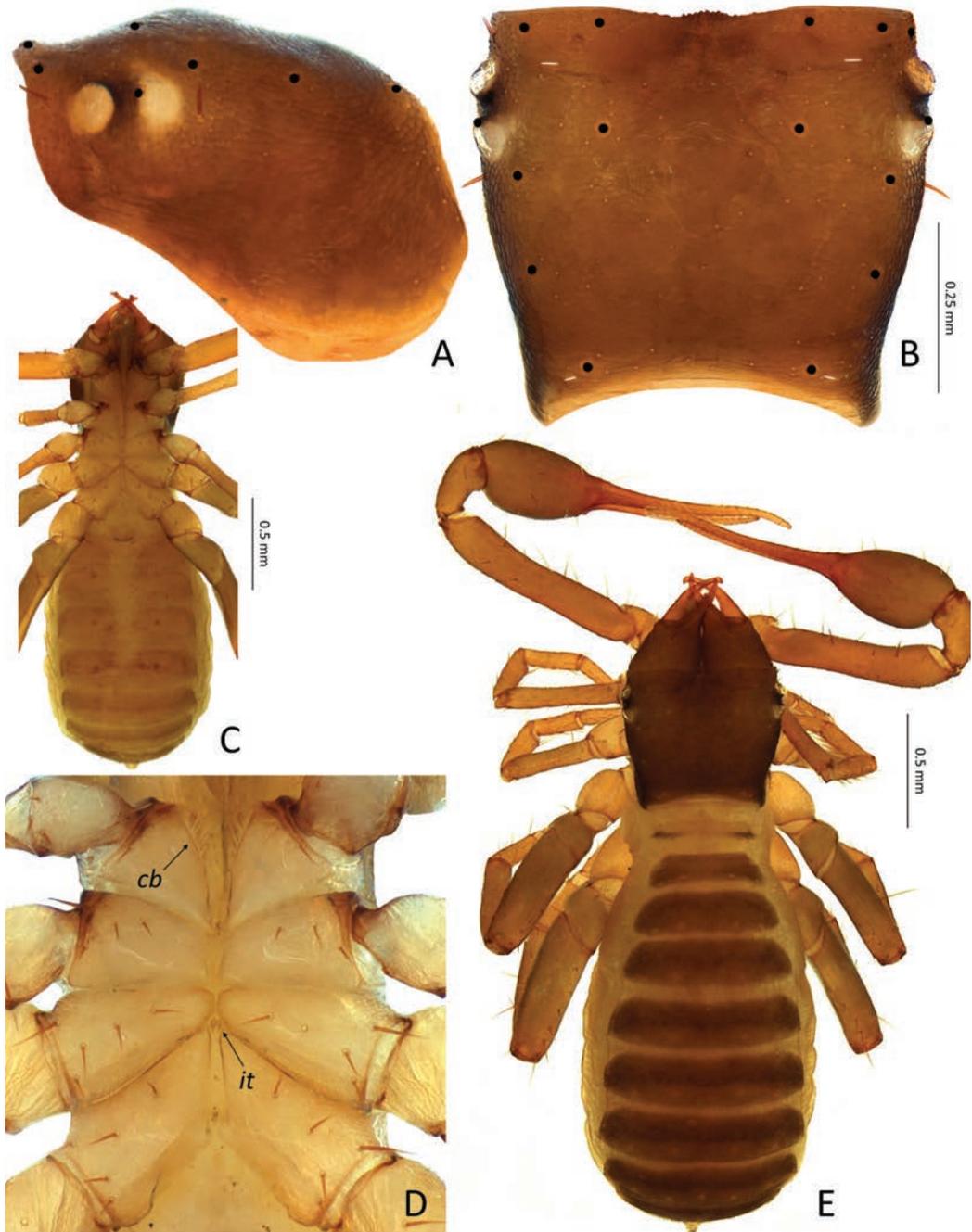


FIG. 3. *Pseudotyranochthonius leichhardti* sp. nov., holotype female (AMS KS 75442): **A**, cephalothorax, lateral; **B**, same, dorsal (black circles refer to the position of setae, white dashes to position and orientation of lyrifissures); **C**, habitus, ventral; **D**, coxae, ventral; and **E**, habitus, dorsal. Abbreviations: *cb*, coxal blades; *it*, intercoxal tubercle.

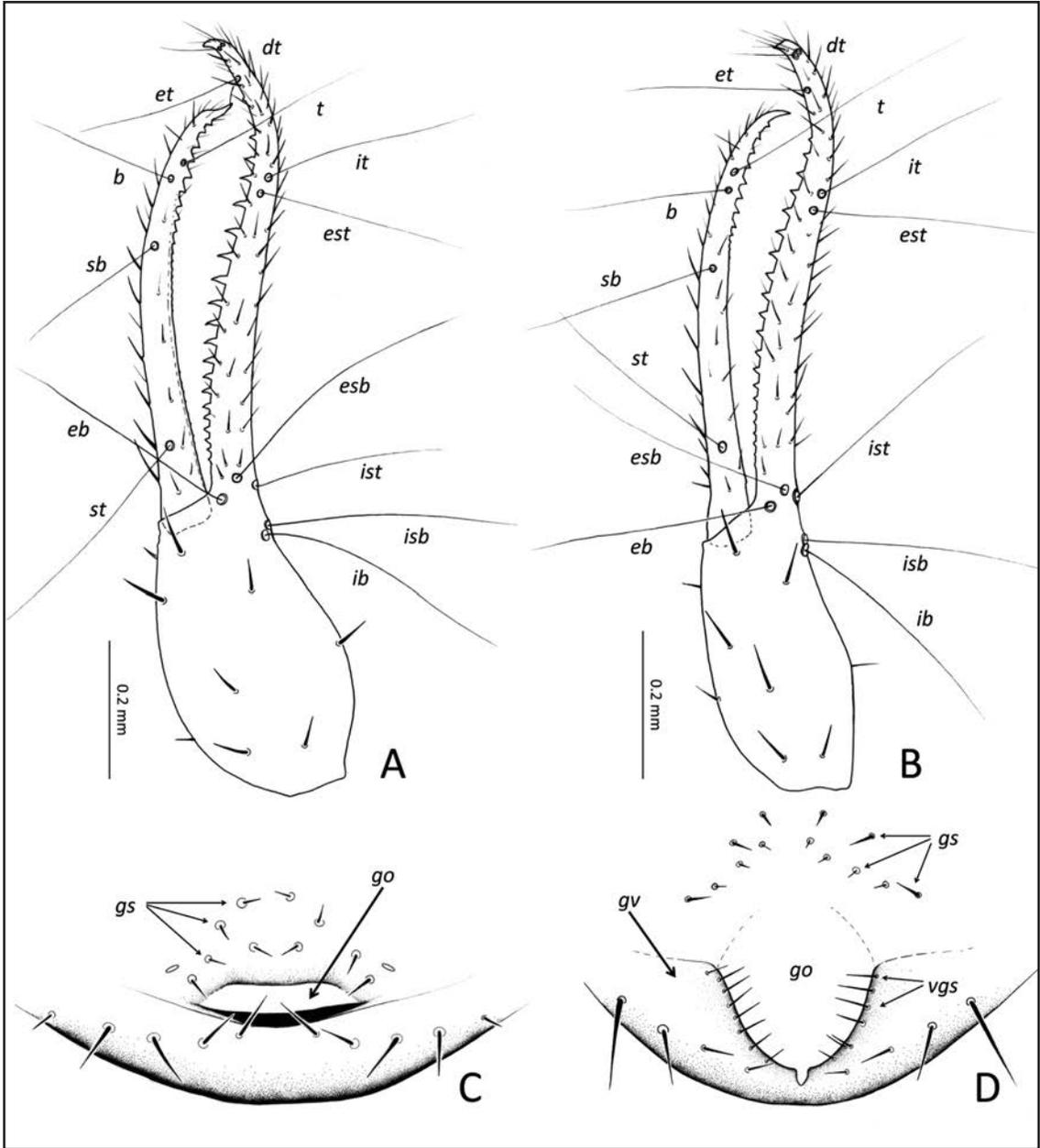


FIG. 4. *Pseudotyranochthonius leichhardti* sp. nov., paratype female (AMS KS 119839): **A**, left chela and **C**, genital region; paratype male (AMS KS 119840): **B**, left chela and **D**, genital valves. Abbreviations: gs, genital seta; go, genital opening; gv, genital valve; vgs, valvular genital seta.

with increased spatial sampling will be necessary to establish a stable taxonomy. The following key is preliminary and allows the identification of described species only.

KEY TO DESCRIBED SPECIES OF  
*PSEUDOTYRANNOCHTHONIUS*  
FROM NEW SOUTH WALES

1. Without eyes. . . . . 2  
– With eyes . . . . . 3
2. Body length c. 3.6 mm; cephalothorax almost as broad as long, retrolateral side of chelicerae with 11 setae, with 12–14 coxal blades on coxa I and 5 setae on coxa II; from Stockyard Creek Karst (The Castles Nature Reserve). . . . . *P. eberhardi* Harms & Harvey, 2013  
– Body length c. 3.0 mm; cephalothorax significantly longer than broad, retrolateral side of chelicerae with 9 setae, with 9–11 coxal blades on coxa I and 4 setae on coxa II; from Jenolan Karst (Blue Mountains National Park) . . . . . *P. jonesi* (Chamberlin, 1962)
3. Body length c. 1.7 mm; movable chelal finger almost as long as fixed finger; fixed finger with c. 23 acute teeth, movable finger with 5 acute teeth distally, both fingers slightly curved; from SE Edith (Blue Mountains National Park area) . . . . . *P. australiensis* Beier, 1966  
– Body length 1.8–2.4 mm; movable chelal finger much shorter than fixed finger; fixed finger with c. 20 slightly reclinate teeth, movable finger with 9 reclinate teeth distally, both fingers strongly curved distally; from Warrumbungle National Park . . . . . *P. leichhardti* sp. nov.

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