

# Two New Australian Silverfish (*Zygentoma*: *Lepismatidae*: *Ctenolepismatinae* and *Nicoletiidae*: *Subnicoletiinae*)

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**ABSTRACT.** *Hemitellessa luismendesi* sp. nov. is described from material collected in leaf litter near Marla in South Australia and *Subtrinemura epigea* sp. nov. is described from a specimen collected at Chester Hill in New South Wales. Molecular data (28S and COI) are presented for both species and the position of *H. luismendesi* within the genus is discussed.

## Introduction

Silverfish represent one of the oldest insect orders, with limited molecular data suggesting an origin some 400 MY (Misof *et al.*, 2014). There are about 650 described extant species placed into 148 genera, arranged in five families and 16 subfamilies, one of which is divided into five tribes. There is however little molecular data that can be used to test the proposed relationships, partly due to the need for gathering fresh material of correctly identified species. Most *Zygentoma* material has been stored either in 70% ethanol or mounted onto slides, making it impractical to obtain quality DNA sequences from museum collections. The authors are currently involved in gathering suitable samples from a wide variety of silverfish taxa in order to further work on the molecular phylogeny of the order. Here we describe two new taxa that are to be included in the broader molecular work.

Australian silverfish fauna is largely endemic with 91% of described species and 52% of genera (Smith, 2018) known only from Australia. A key to the genera can be found in Smith (2017). Four species of the genus *Hemitellessa* Smith, 2016 have been described, all with quite dramatic colour patterns; at least three of which mimic velvet ants [Hymenoptera: Mutillidae] (Smith & Mitchell, 2021). A

further species was collected in deep leaf litter north of Marla in South Australia. It is smaller than the other species and does not show the same striking colour pattern. It is the first record of the genus from South Australia. We also describe an additional species of the subterranean nicoletiid genus *Subtrinemura* Smith, 1998 from the Sydney suburb of Chester Hill, bringing the total number of species in the genus to five, all restricted to south-eastern Australia and Norfolk Island.

## Materials and methods

The holotype and allotype are deposited in the entomological collections of the South Australian Museum in Adelaide and Australian Museum in Sydney as shown in the material examined.

Specimens were initially collected and stored in 100% ethanol until a leg was removed for DNA extraction. The specimens were then transferred to 75–80% ethanol and some later dissected and slide mounted.

Measurement data of whole specimens in alcohol and dissection methods used are as described in Smith (2013). Specimens were dissected and each mounted on two slides using Tendeiro medium (Molero-Baltanás *et al.*, 2000), with

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the head and thorax mounted on one slide and the abdomen on a second slide. Roman numerals are used to indicate abdominal segment number. The following abbreviations are also used: AMS: Australian Museum, Sydney; HW: head width (in millimetres); H+B: head and body length (in millimetres); L/W: length to width (ratio); PI, PII, PIII: legs of pro-, meso- and metathorax respectively; SAMA: South Australian Museum; WA: Western Australia. The term *macrochaetae* refers to the larger stronger pectinate bristles, *setae* refers to smaller thinner bristles (usually simple), *setulae* to the very small, usually straight setae and *cilia* to the trichoid sensilla appearing as thin curly hairs, often associated with the combs, setal collar or notal margins.

### Sampling, DNA extraction, PCR extraction, PCR and DNA sequencing

DNA extractions were performed using the Bioline Isolate II Genomic DNA Kit (Bioline, Eveleigh, NSW) following the manufacturer's protocol with elution volume adjusted to 60 µL. Tissue samples (a single leg from each specimen) were soaked in DNA extraction buffer containing proteinase-K at 50°C for two hours.

Polymerase Chain Reaction (PCR) amplification of the DNA barcode region of the mitochondrial COI gene used the primers and followed the method of Mitchell (2015). For the 28S rDNA D9–D10 region, we used primers 28S\_8fm and 28S\_11rm (Smith *et al.*, 2019). PCR conditions for both genes followed those reported in Mitchell (2015) for COI. PCR products were purified using ExoSAP and sequenced in both directions using ABI Big Dye Terminator v.3.1 chemistry by Macrogen Inc. (Seoul, South Korea).

### DNA sequence assembly and phylogenetic analysis

Forward and reverse direction sequence trace files were assembled using Geneious v.10.2.6 (Kearse *et al.*, 2012). DNA consensus sequences, sequence trace files, and specimen collection data were uploaded to BOLD (<http://www.boldsystems.org/>) where they are accessible as public dataset DS-HEMIMARL (<https://doi.org/10.5883/DS-HEMIMARL>). Sequences newly derived for this study were also deposited in GenBank (accession numbers OL521841–OL521843 and OL665122–OL6655124). Table 1 lists the museum, BOLD and GenBank accession numbers.

A dataset was constructed for concatenated genes for *Hemitelsella* plus outgroups (15 concatenated sequences, four newly sequenced for this study). The 28S and COI

sequences for the *Subtrinemura* taxon were compared with published data on GenBank and BOLD.

Phylogenetic analyses were performed by Bayesian Inference (BI) using MrBayes 3.2.6 (Ronquist *et al.*, 2012) run within Geneious, and by Maximum Likelihood (ML) using W-IQ-TREE web server (<http://iqtree.cibiv.univie.ac.at/>; Trifinopoulos *et al.*, 2016). The BI analysis was set to run for 2 million generations, with a sample frequency of 1,000, using 2 runs, setting the number of chains to 4, and the burnin to 500 samples (i.e., the recommended 25% of samples). The average standard deviation of split frequencies was observed to drop below 0.01, indicating convergence of the chains. ML analysis used the automatic model selection option and all default settings, including 1,000 “ultrafast” bootstrap replicates. All trees were rooted with *Ctenolepisma longicaudatum*.

## Results

### Molecular data

As we have no molecular data for other species of *Subtrinemura* and only two species of *Trinemura* (also placed in the Subnicoletiinae) there is no need to present a tree here for *Subtrinemura epigea* sp. nov.

Figure 1 shows the ML tree produced by W-IQ-TREE for the combined data set for species of *Hemitelsella*, with bootstrap support values above branches, followed by Bayesian posterior probabilities. There is very strong support in the ML analysis (97% bootstrap value) for the monophyly of *Hemitelsella*, but this is not supported by the Bayesian analysis, with *Qantelsella* placed within *Hemitelsella* in the majority of Bayesian trees sampled. *Hemitelsella luismendesi* is sister-group to the remaining *Hemitelsella* species, amongst which relationships are as reported by Smith and Mitchell (2021).

Within *Hemitelsella*, the new species showed 2.5% distance in the COI gene among specimens, and a minimum of 12.6% distance to its nearest neighbour species, *H. transpectinata*. The four 28S sequences were identical in this species, and were 3.7% distant to the nearest neighbour, which was again *H. transpectinata*.

Sequences from the new species of *Subtrinemura* are closest to our previously published sequences of *Trinemura* species (Mitchell *et al.*, 2021). BLAST searches of GenBank with 28S and BOLD searches with COI resulted in closest matches of 98.23% and 83.97%, respectively, in both cases to *Trinemura cundalinae*.

**Table 1.** Museum, BOLD and GenBank accession numbers for all new sequences obtained.

sample ID	museum accession	BOLD Process ID	GenBank COI	GenBank 28S	identification	institution
gbs006184	K.541620	ZYII375-21	OL521841	OL665122	<i>Subtrinemura epigea</i> sp. nov.	AMS
gbs005915	21-000420	ZYII358-21	OL521839	OL665120	<i>Hemitelsella luismendesi</i> sp. nov.	SAMA
gbs005914	K.377943	ZYII357-21	OL521842	OL665123	<i>Hemitelsella luismendesi</i> sp. nov.	AMS
gbs005913	21-000419	ZYII356-21	OL521840	OL665121	<i>Hemitelsella luismendesi</i> sp. nov.	SAMA
gbs005912	K.377942	ZYII355-21	OL521843	OL665124	<i>Hemitelsella luismendesi</i> sp. nov.	AMS

## Systematics

### Family Lepismatidae Latreille, 1802

#### Subfamily Ctenolepismatinae Mendes, 1991: 11

#### *Hemitelsella* Smith, 2016

*Hemitelsella* Smith, 2016: 72. Type species: *Acrotelsella transpectinata* Smith, 2015, by original designation.

#### *Hemitelsella luismendesi* sp. nov.

Smith & Mitchell

urn:lsid:zoobank.org:act:A5C74ADC-80EB-4BDD-9908-86D3AE9C706D

Figs 2–32

**Holotype** ♀ (HW 0.78) SOUTH AUSTRALIA: North of Marla 26.9724°S 133.4000°E 378m asl, 7.vii.2020, Graeme Smith, hand collected in deep dry leaf litter, SAMA 21-000419 & 21-000419A (on two slides). **Paratypes** 1♂ (HW 0.79) same data as holotype, SAMA 21-000420 & 21-000420A (on two slides); 1♀ (HW 0.73) same data as holotype, AMS K.377943 (in alcohol); 1♂ (HW 0.63) same data as holotype, AMS K.377942 (in alcohol).

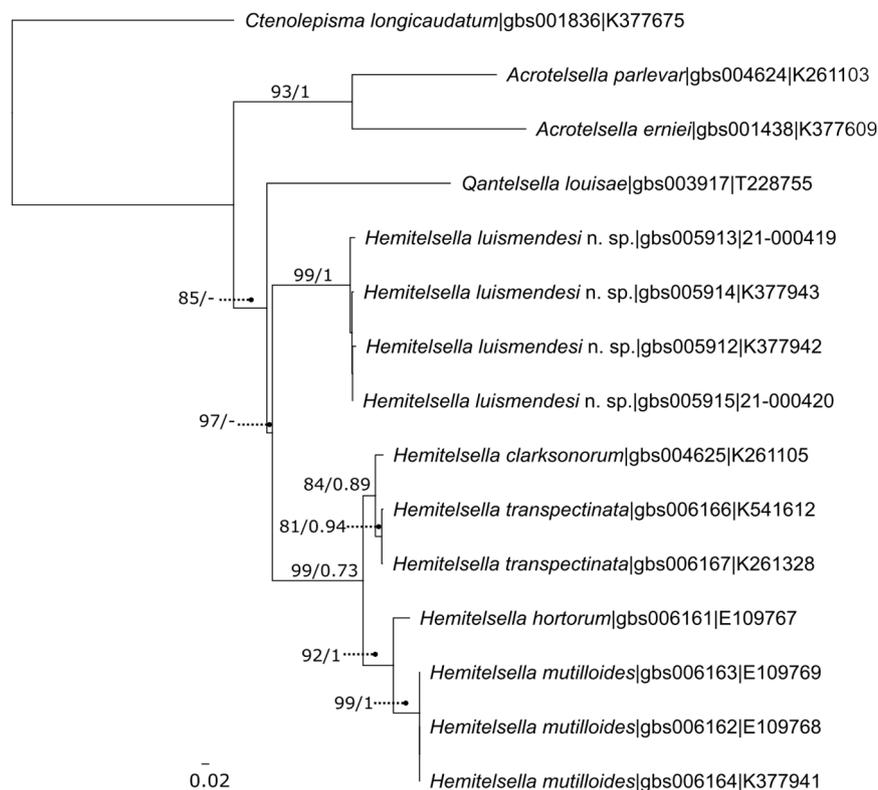
**Diagnosis.** This species is quite distinct from all other described *Hemitelsella* species and can be distinguished by a combination of characters including its much smaller size (less than 5 mm versus 7–8 mm), the apparent lack of a striking scale pattern, the arrangement of the macrochaetae

in the anterior bushes on the frons into distinct rows, the posterior combs of the pro and metanota each consisting of 1–3 macrochaetae (versus one or rarely two in all other described species) and located some distance from the lateral chaetotaxy (almost contiguous in other species), the presence of 1+1 submedial combs on urosternite II, the pointed tips of the larger setae of the tarsal articles (versus rounded tips), the square inner corners of coxites VIII and the presence of three short transverse combs on coxites IX, the most posterior of which may consist of just one or two pectinate macrochaetae.

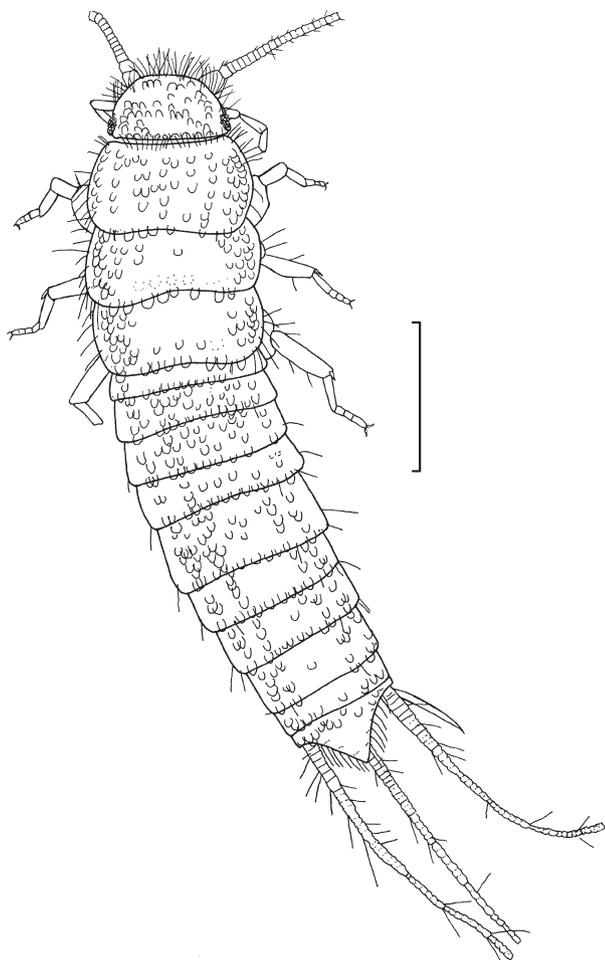
#### Description

**Appearance:** Small silverfish, with narrow body, thorax not much wider than abdomen which only tapers slightly posteriorly from about the fifth abdominal segment (Fig. 1). Appearance when live unrecorded. In alcohol, quite blotchy overall in appearance but with more darker scales on urotergite IX, lateral margins of nota light in appearance, without dark scales possibly hyaline or absent, dark scales on dorsal end of femora and top of tibia, urotergite X with light coloured scales and little pigment, styli IX light coloured with slightly orange apex. Terminal filaments light coloured, slightly more orange distally.

**Body size:** 4.46 mm; head width 0.79 mm; thorax: length 1.28 mm or 0.31 times H+B; width up to 1.09 mm with no great difference between the pro-, meso- and metanota although the pronotum is the narrowest; antenna incomplete >0.93 mm or >0.23 times H+B; terminal filaments all incomplete, maximum length of cercus remaining 1.88 mm or >0.47 H+B; maximum length of median dorsal appendage remaining 1.78 mm or >0.5 H+B.



**Figure 1.** ML tree for concatenated COI and 28S genes with ML bootstrap values and BI posterior probabilities shown above the branches



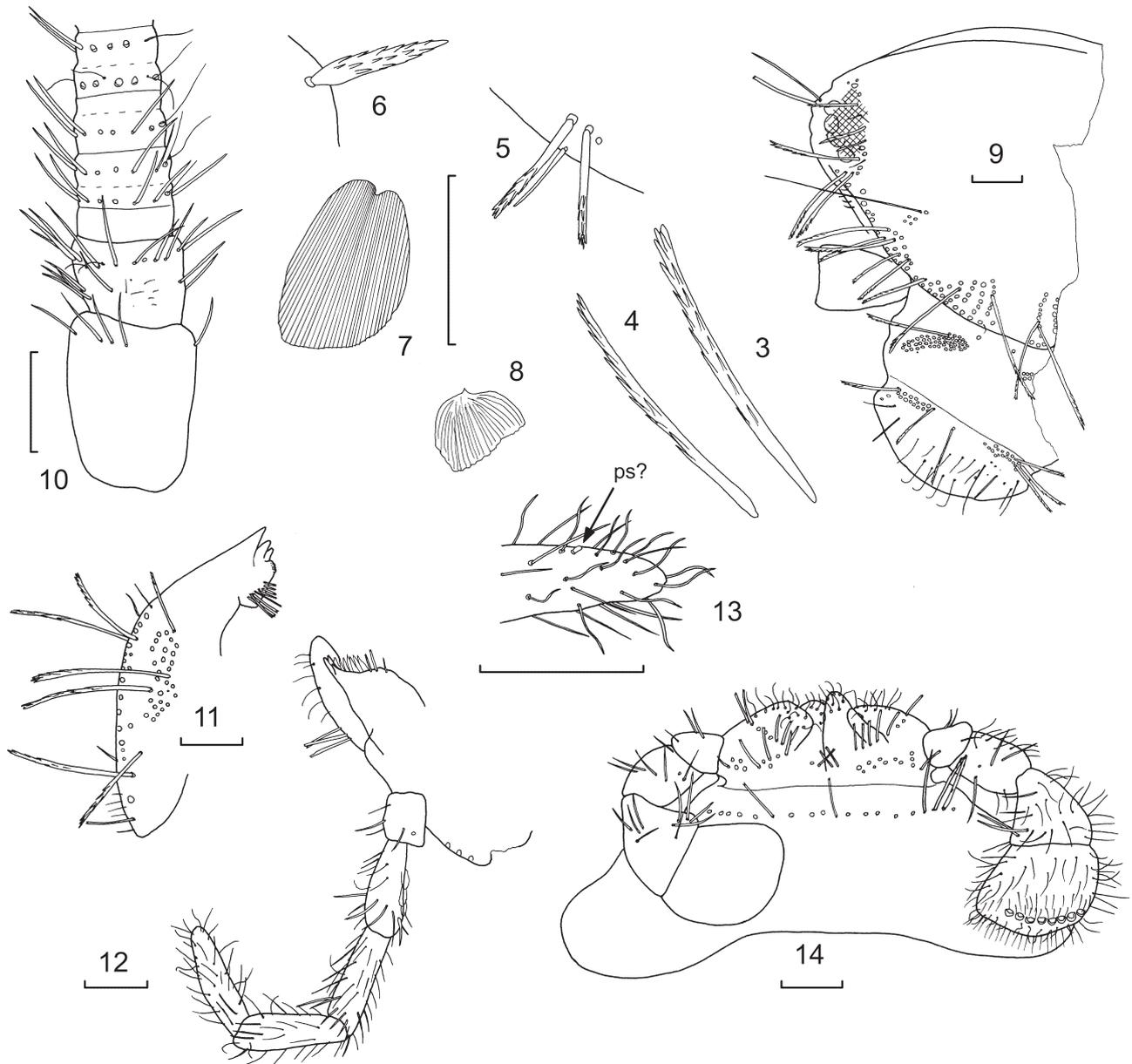
**Figure 2.** *Hemitelsella luismendesi* sp. nov. holotype ♀ habitus

**Pigmentation:** Pigment generally quite orange in colour. Frons with light brown even pigment, clypeus, labrum without pigment, scape and pedicel with moderate orange pigment, the intervals of the flagellum initially with light orange pigment but becoming increasingly darker distally. Maxillae palp with fairly even and moderately dense orange-brown pigment which is darker at the distal end of each article. Labium with orange-brown pigment, the palp also well pigmented overall and darker along the outer margin of all articles. Legs with light to medium orange-brown pigment overall, with darker areas on shoulders of coxa, the distal end of the femora, most of tibia especially dorsally and distally, all tarsal articles with pigment which is darkest at the distal end of each article. Notae and abdominal tergites without obvious pigment but cuticle closer to lateral margins of more granular appearance, thoracic sternae without pigment. Urotergites and urosternites I–VII (VIII in ♂) unpigmented, urotergite X without pigment distally but some around base above cerci. Coxites VIII of female somewhat orange overall, coxites IX of female with quite dark brown around the stylus insertion and along the medial margin. Penis with light pigment overall, styli mostly without pigment slightly more orange at tip, cerci and median filament without obvious pigment basally but becoming more orange-brown distally without annulations. Ovipositor quite dark orange-brown with sutures slightly darker than the surface.

**Macrochaetae:** pectinate and of variable form (Figs 3–6), mostly light to brown, but hyaline or straw coloured in some cases. The macrochaetae along the edges of the notae have minute apical bifurcations and are tapered with very subtle pectinations along the shaft and quite different to the submarginal macrochaetae which are obviously pectinate especially apically. The larger setae of the tarsi are not strikingly sclerotized and lack the rounded tips seen in other species of *Hemitelsella*.

**Scales:** with numerous subparallel ribs that only just surpass the margin of the scale, with ribs mostly close together or even very close together in the darker scales (Fig. 7), these ribs are sometimes diverging from each other distally giving an open fan appearance rather than being almost parallel; shape of scales generally round, although the posterior margin can be quite straight for those scales overhanging the posterior margins of the tergites and others are shaped to fit around setae or combs. Scales found on top of head, on clypeus, scape, the second article of the maxillary palp, all notae, all thoracic sternae, legs but absent from trochanter and tarsi (except the basal article of all tarsi), present on all urotergites and urosternites, styli and on the terminal filaments, even the more distal divisions. Scales of the terminal filaments seem to be of just one type (Fig. 8) which appear somewhat similar to those of the Nicoletiidae with the “ribs” or folds appearing to converge at the attachment point however the detailed structure of the scales is uncertain; lanceolate scales were not seen.

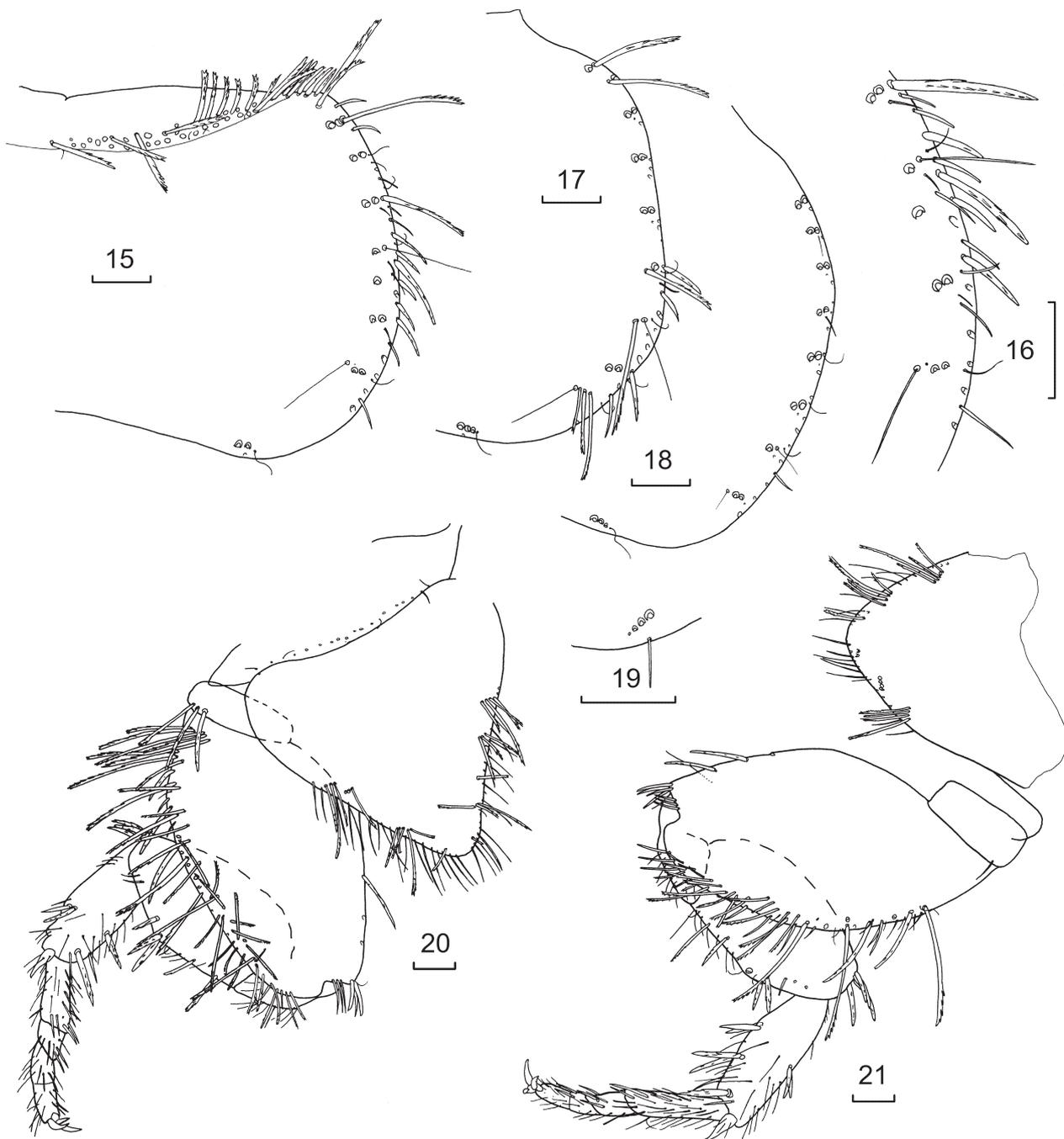
**Head:** wider than long (Fig. 9), with 1+1 moderately strong bushes of pectinate macrochaetae on the antero-lateral corners, the macrochaetae aligned in distinct sublongitudinal rows. A small gap in the chaetotaxy of only about one macrochaeta wide is present along the margin above the antennae and the macrochaetae continue along the margin about three wide for a short distance behind the antennae then another abrupt change occurs with the row only one or two wide until another gap before the supraocular macrochaetae. The 1+1 peri-antennal groups are slightly isolated from marginal rows and consist of only four macrochaetae as well as a cilium or long thin setae. Eyes reddish brown with each ommatidium somewhat isolated from the adjacent ommatidia. Clypeus with 1+1 bushes of about 40 macrochaetae closely packed together, 1+1 setae between the larger bushes close to the dorsal margin. Labrum also with 1+1 bushes of about 20 smaller pectinate macrochaetae as well as a few setae between these groups and two transverse lines of smaller setae, one about midway along the labrum which may be of only four simple setae, the other  $\frac{3}{4}$  behind the anterior end of the labrum. — Scape of antenna (Fig. 10) of medium length, with scales over surface and short robust simple subapical setae, pedicel with a subapical ring of stout setae and another small group of setae ventrally about one third the way along the pedicel, first annulus (interval) of flagellum glabrous, intervals two to four of flagellum each of a single annulus with a single ring of setae, and one or probably two trichobothria; interval five beginning to subdivide into two annuli; sixth interval with two annuli, the basal with setae and cilia, the distal with setae and trichobothria, each interval divided into four annuli by the ninth interval with the trichobothrium only present in the most distal ring. More distal intervals lost in both slide mounted specimens. — Mandibles (Fig. 11) typical for Ctenolepismatinae; a group of about 6–9 strong



**Figures 3–14.** *Hemitelesella luismendesi* sp. nov. holotype ♀ (3) pectinate macrochaeta of peri-ocular group; (4) pectinate macrochaeta of prosternum; (5) pectinate macrochaetae of pronotum; (6) carrot-shaped pectinate macrochaeta from femur of PI; (7) darker scale of pronotum; (8) scale of terminal filaments; (9) head (left side missing, cross-hatched area obscured by eye pigment); (10) antenna, scape, pedicel and basal articles of flagellum; (11) mandible; (12) maxilla; (13) ultimate article of maxillary palp showing possible poculiform sensilla (ps?); (14) labium, prementum and mentum, setae of right palp largely omitted. Scale bars = 0.1 mm.

and short and thinner and longer, apically bifurcated setae distally adjacent to the molar area and two bushes of about 25 and 30 macrochaetae externally. — Maxilla (Fig. 12) with three thick apically bifurcate macrochaetae externally proximal to the palp, the lacinia with three strong teeth, one set further back than the other two, followed by about seven lamellate processes and a row of 2–3 thin simple setae, galea with 3–4 strong, smooth, pointed setae externally in its basal half and a few cilia distally; apical article of maxillary palp (Fig. 13) 3.3–4.0 times longer than wide and 1.2–1.4 times longer than the penultimate article, the ultimate article with a sensillum (probably poculiform) about one quarter back from the apex, rod-like basiconic sensilla were not seen, last three articles of palp with simple setae only although some

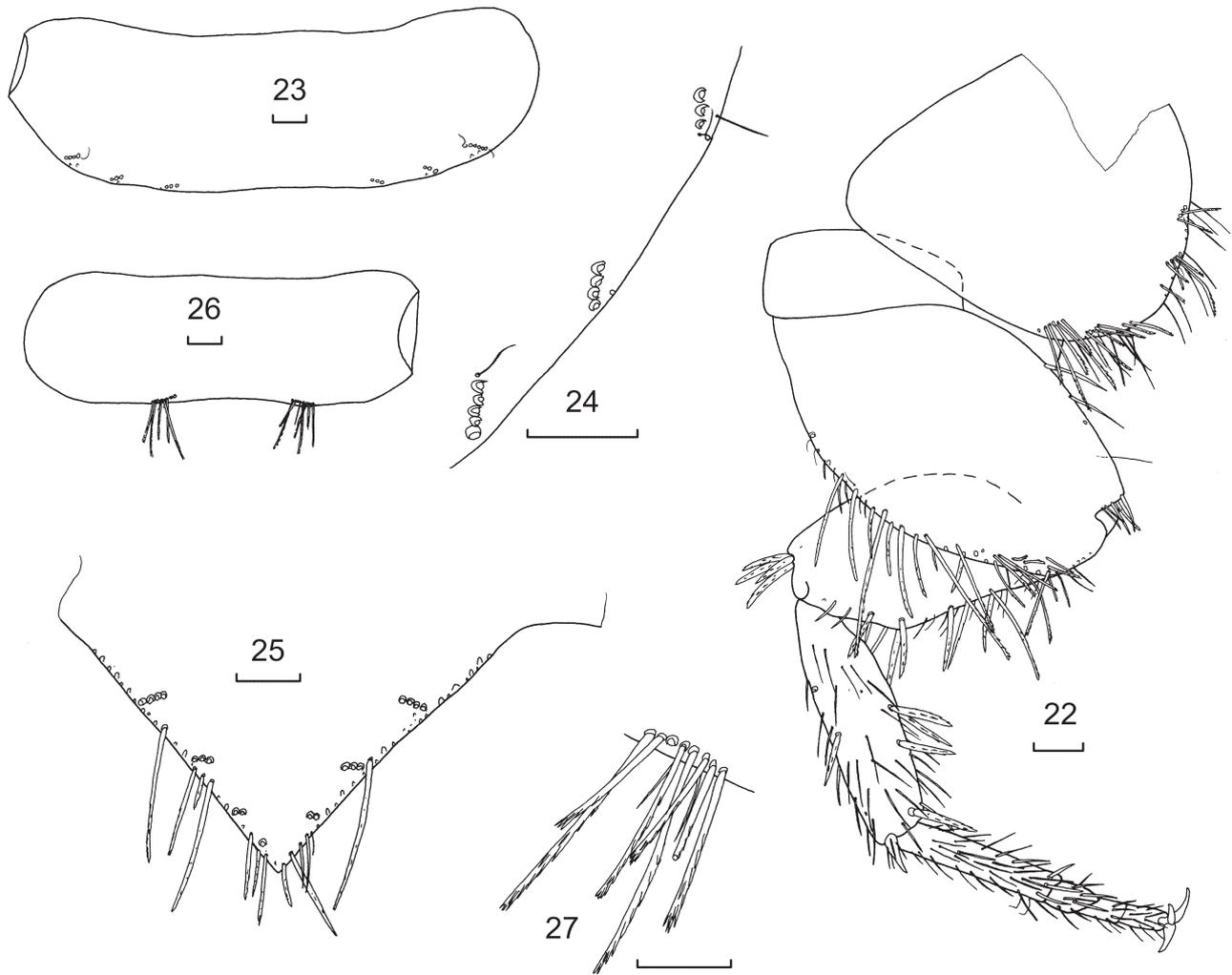
thicker than others, second article with a subapical ring of stronger setae and scales on the outer face, basal article with a few slightly thicker short setae. — Labium (Fig. 14) much wider than long; prementum with a transverse row of strong setae, the most laterad showing pectinations; glossae and paraglossae with oblique and irregular transverse groups of strong apically bifurcated setae and with short curved setulae distally; labial palp with oval/subrectangular apical article, slightly widened medially, 0.8–1.2 times longer than wide with row of 8–10 papillae arranged in a single curved row, other sensilla not observed, covered with numerous fine short, sometimes pigmented, setae as well as longer fine setae on along the distal end; penultimate article as long as the ultimate article.



**Figures 15–21.** *Hemitelsella luismendesi* sp. nov. holotype ♀ (15) pronotum, right half; (16) idem, right trichobothrial areas; (17) mesonotum, right side; (18) metanotum, right side; (19) idem, left posterior comb; (20) presternum, prothoracic sternum and PI; (21) mesosternum and PII. Scale bars = 0.1 mm.

*Thorax*: pronotum (Fig. 15) with setal collar about two macrochaetae wide of both longer and fairly short, strongly pectinate macrochaetae, and a few cilia; lateral margins with many strong smooth or subtly pectinate short macrochaetae as well as some submarginal setulae and cilia, with 7–8 submarginal combs of 1–3 strongly pectinate macrochaetae, the anterior trichobothrial area about 0.42–0.48 along the margin associated with comb N-2 (terminology of Molero-Baltanás, 2010) the trichobothrium located between the comb of one or two macrochaetae and the margin (Fig. 16), the posterior trichobothrium located at the mediad end of

a comb of two macrochaetae located about 0.71 distance along the margin (Fig. 16). Posterior margin with 1+1 combs each of 1–2 pectinate macrochaetae each associated with a marginal seta and a cilium, the posterior combs being positioned somewhat laterally but quite separate from the chaetotaxy of the lateral margin. — Mesonotum (Fig. 17) with lateral chaetotaxy similar to pronotum with eight submarginal combs of 1–3 pectinate macrochaetae, the anterior trichobothrial area located about 0.65–0.66 along the lateral margin, associated with comb N-2 with the trichobothrium located between the single macrochaeta and



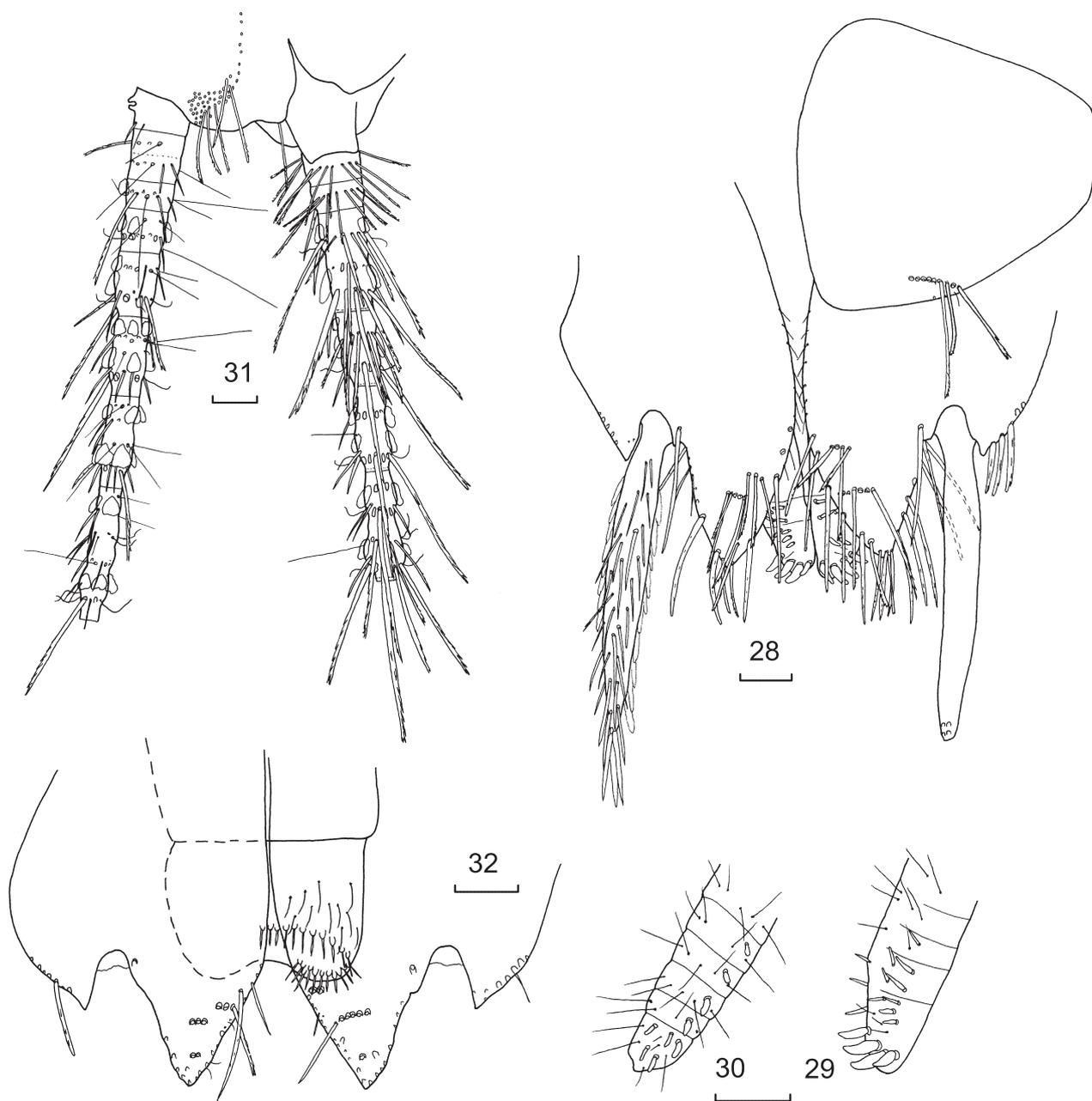
**Figures 22–27.** *Hemitelsella luismendesi* sp. nov. holotype ♀ (22) metasternum and PIII; (23) urotergite IV; (24) detail of left combs of urotergite III; (25) urotergite X; (26) urostermite II; (27) idem, detail of left comb. Scale bars = 0.1 mm.

the margin and with a cilium between the trichobothrium and the seta on the margin. Posterior trichobothrial area 0.84–0.86 along margin, the trichobothrium located mediad to a group of 2–3 macrochaetae (= N) arranged in a line not in a triangle, (which was an unusual arrangement reported in the description of the single known specimen of *H. clarksonorum* Smith, 2016). Posterior margin with quite laterad 1+1 combs each of three macrochaetae with a cilium at the outer end and a marginal seta. — Metanotum (Fig. 18) similar to mesonotum with eight combs of 1–2 macrochaetae, the anterior trichobothrial area associated with the comb (N-1) with the trichobothrium located between the single macrochaeta and the margin about 0.73 along the margin, the posterior trichobothrial area associated with the most posterior comb (N) of a single macrochaeta about 0.84 along the margin and the posterior 1+1 combs each of 1–3 macrochaetae, a laterad cilium and a marginal seta (Fig. 19), also quite distant from the lateral chaetotaxy.

Presternum fairly wide, with transverse row of setae (all lost in holotype) and some small setulae or cilia (Fig. 20). All thoracic sterna with hyaline scales. — Prothoracic sternum (Fig. 20) quite broad, wider at base than long, (L/W 0.88–0.89) subtriangular but broadly rounded on all corners, antero-lateral corners with one or two small setae, posterior

two thirds of lateral margins with long simple setae as well as 5+5 irregular combs of 3–4, 3–5, 1–4, 1–4 and 1–2 strongly pectinate thin macrochaetae and sometimes with additional submarginal macrochaetae between the two most posterior combs. — Mesosternum (Fig. 21) a little longer than wide (L/W 1.09) and 1.2 times as long as the prosternum, with long, thin simple marginal setae around the distal third of the margin, 3+3 combs in its distal third, with 4–5, 4 and 1–2 pectinate macrochaetae per comb (anterior to posterior). — Metasternum (Fig. 22) wider than long (L/W 0.74) apically rounded, quite short only 0.93 times as long as the prothoracic sternum, and with long marginal setae along distal 1/3 of lateral margins and 3+3 combs of longer and shorter pectinate macrochaetae, the more proximal with 4–5, the middle with 4–5 and the most posterior with 1–2 macrochaetae.

Legs (Figs 20–22) becoming progressively longer and more slender, tibia L/W ratio of legs PI 2.6–3.2, PII 2.4–2.7, PIII 3.1–3.8; tarsi L/W ratio PI 4.5–7.2, PII 5.4–7.5, PIII 6.0–7.9. PI (Fig. 20) with comb of three macrochaetae laterally on pre-coxa. Coxa with scales and a comb of about five macrochaetae on the anterolateral corners followed by scattered strong pectinate macrochaetae along the external margin, never grouped into combs of two macrochaetae, the more marginal macrochaetae being much less pectinate,



**Figures 28–32.** *Hemitelesella luismendesi* sp. nov. holotype ♀ unless otherwise indicated by specimen number (28) left coxite VIII, coxites IX and apex of ovipositor, setae of left stylus not shown; (29) apical divisions of anterior gonapophyses; (30) apical divisions of posterior gonapophyses; (31) base of cercus and median dorsal appendage; (32) ♂ (SAMA 21-000420A), coxites IX and penis, styli lost. Scale bars = 0.1 mm.

curved and tapering; inner margin with three strong macrochaetae spaced along the margin and about six setae of varying thickness distally over the articulation. Trochanter with several curved setae and one small pectinate seta. Femur ventrally with two strong, pectinate macrochaetae between the trochanter and the posterior bulge, two strong pectinate carrot-shaped macrochaetae on the bulge and another a small distance distally plus some small curved setae towards the distal end and a cluster of three strong pectinate carrot-shaped macrochaetae over the articulation; anterior margin without macrochaetae. Tibia of PI with two pectinate carrot-shaped macrochaetae about one quarter from the end, and two stronger pectinate carrot-shaped macrochaetae on the ventral margin as well as other setae, setae absent from much

of the ventral surface except for the distal end, usual tibial spur with a few setae. Tarsi of four articles, the basal tarsal article of PI about 40% of the total length of the tarsus, its join with the next article not particularly oblique, the ventral face of all tarsal articles with setae that are only slightly more robust than the other setae and not as strongly rounded as in other species of the genus. Pretarsus with two long curved lateral claws and a much shorter curved medial claw. PII and PIII (Figs 21, 22) similar to PI with only a single seta on the precoxa, lacking the antero-lateral comb on the coxae; the pectinate carrot-shaped macrochaetae on the outer margin of the tibia are progressively more proximal than on PI; legs not dramatically progressively longer anterior to posterior with the tibia of PII being only 1.0–1.1 times longer than that of PI

**Table 2.** Number of macrochaetae per bristle comb *Hemitelsella luismendesi* sp. nov.

segment	urotergite			urosternite
	lateral	sublateral	submedial	
I	2–3	—	—	—
II	3–4	2–3	3	3–8
III	2–4	2–3	2–3	5–9
IV	4–5	3–4	3	8–10
V	5–6	3–4	2–3	8–9
VI	4–5	1–4	0–3	8–9
VII	5–6	3	2–4	7–9
VIII	5–6	—	1–3	8–12
IX	—	—	—	3–4, 5–7, 1–2

and the tibia of PIII being 1.3–1.5 times longer than that of PI, the relative length of the basal tarsal article is progressively longer, being about 55% of the total length on PIII.

**Abdomen:** urotergite I with 1+1 lateral combs of 2–3 macrochaetae each comb associated with one or two marginal setae and 0–2 cilia, urotergites II–VII (Figs 23, 24) with 3+3 combs of macrochaetae as in table 2, the lateral combs also associated with 0–3 small marginal setae and 0–2 cilia, the sublateral combs sometimes associated with a cilium and/or a marginal seta, the submedial combs sometimes associated with a cilium at the laterad end of the comb and 0–2 cilia; urotergite VIII with 2+2 combs, lacking the sublateral comb. Urotergite IX glabrous although a marginal setula insertion is visible on one side in the holotype in the infralateral position. Urotergite X (Fig. 25) triangular with pointed apex (85–88°), wider than long (L/W at base about 0.50–0.53) with strong curved tapered slightly pectinate macrochaetae as well as shorter more obviously pectinate macrochaetae along the lateral margins; with 3+4 combs of 1–4 stout and strongly pectinate macrochaetae.

Urosternite I glabrous, urosternites II–VII with 1+1 lateral combs of 6–9 pectinate macrochaetae (Figs 26, 27) each sometimes associated with 1–2 marginal setae but without a cilium; the combs on the male occasionally interrupted by a space. Styli present on coxites IX only in both sexes. The distance between the combs relative to the average length of each comb is 3.8–8.1.

Genital region of female (Fig. 28) with coxites VIII having quite square inner corners with very little rounding, each coxite bearing a comb of 9–12 pectinate macrochaetae as well as 2–3 small marginal setae. Internal process of coxites IX short, 1.07–1.12 longer than wide at the base and only 2.8–3.0 times longer than the pointed external process, not quite reaching to the end of the ovipositor. Each internal process with a basal smooth macrochaeta mediad of each stylus insertion. Each process with two short transverse combs of pectinate macrochaetae as well as 1–2 additional pectinate macrochaetae near the apex; the more anterior comb of 3–4 macrochaetae, the more posterior of 5–7 macrochaetae; both margins of the inner process with several long rounded, more carrot-shaped and subtly pectinate macrochaetae. — Ovipositor short (1.35 HW) of secondary type, not surpassing

the apex of the short internal processes of coxites IX, both pairs of gonapophyses consisting of a long basal division (about one third to one half the length of the ovipositor), and eight or nine smaller divisions; anterior gonapophyses (Fig. 29) with five modified spines (conules) on the last division, plus one modified spine on each of the next four divisions which also have several long fine setae, posterior gonapophyses with four very robust conules and 2–6 smaller narrower conules as well as a few small setae, following division with two medium and three smaller conules, following division with a single narrow conule and two thin setae, subsequent divisions with small thin setae only (Fig. 30).

Cerci (Fig. 31) basal division almost as long as wide with a partial ring of setae on outer side; following three divisions much wider than long, each with a single ring of setae and macrochaetae as well as some trichobothria; division five about as long as wide, with a sub-basal ring of trichobothria and scales and a antedistal ring of setae, macrochaetae, trichobothria and cilia; sixth division similar except sub-basal ring also with some setae; seventh division with four rings, the sub-basal of scales only, the next of setae and trichobothria, the next with scales and trichobothria and the antedistal as in the previous division; division eight similar except also some trichobothria in the sub-basal ring; division nine with seven rings, the sub-basal of scales and trichobothria, the next with setae and trichobothria, the third with setae and cilia, the next with setae and trichobothria, the fifth ring of scales only, the sixth of setae and cilia and the ultimate as in previous divisions. Median dorsal appendage (Fig. 31) similar, basal division with two incomplete rings of setae; second division with single ring of setae only; the third division with a sub-basal ring of scales and an antedistal ring of setae, macrochaetae and cilia; the next division similar but with some setae in the sub-basal ring; the fifth division of four rings with the sub-basal and third rings of scales only, the second of setae and the most distal as for the cerci; the sixth division similar except a trichobothrium in the second most apical ring of scales; the seventh similar but also with some setae in the second most distal ring.

**Male:** Urosternite VIII with slightly concave posterior margin. Each coxite IX (Fig. 32) with 3+3 transverse combs of 1–5 macrochaetae across medial half of the inner process and a single macrochaeta on the face posterior to the transverse comb adjacent to the stylus insertion; the internal process not acute nor elongated, about twice as long as the external process but only 0.67–0.76 as long as broad at its base; external and internal margins of internal process with several long, often pectinate setae. Outer process small, acute triangular with a few robust setae along the outer margin. Only one pair of styli present (IX) (lost in slide mounted allotype). Penis typical with numerous glandular setae apically, each set on a protuberance. Parameres absent.

**Habitat.** Hand collected using trowel in deep dry leaf litter.

**Etymology.** The species is named *luismendesi* in gratitude for the advice I obtained during a few days spent in 2008 and 2009 with Dr Luis Mendes, a very dedicated and talented entomologist. Twenty years of accumulated questions were answered with practical examples and advice. His willingness to share his knowledge and offer encouragement took my work to a higher level and is much appreciated.

## Discussion

### Molecular data

In contrast to the results obtained for the Heterolepismatinae (Smith *et al.*, 2019) where we failed to identify morphological differences between clades with comparatively large differences in base pairs of 0.9–1.8% for 28S and 7.2% for COI, we find quite pronounced differences in morphology between species that have almost identical 28S sequences and only 5.2% difference in COI. Based on characters usually considered as stable within the Ctenolepismatinae (the shape of the ultimate article of the labial palp, the arrangements of combs on the thoracic sternites) as well as the greatly different scale pattern there seems little doubt that all four species are distinct. *Heterolepisma clarksonorum* and *H. hortorum* have, however, only been described from single specimens, so we have no knowledge of morphological variability in these species. It would appear however, that the molecular differences between morphologically quite distinct species, are considerably smaller than observed in the Heterolepismatinae and more in line with that observed in other more recent insect orders. In our experience the present situation is more common in insects, where the more slowly evolving 28S rDNA gene sequences are useful for phylogeny but often are identical among related species (e.g., Wilson *et al.*, 2014).

### Morphology

The molecular data place *Hemitelsella luismendesi* sp. nov. in a clade distinct from the other described species of the genus and closer to *Qantelsella louisae* Smith. While having several characters that distinguish it from the other species of *Hemitelsella*, none of these are characters that would indicate a closer relationship with *Qantelsella*. It has 3+3 combs on urotergites II–VII not 2+2 combs of *Qantelsella* and it has the transverse combs on coxites IX which are typical of species of *Hemitelsella* but are lacking in *Qantelsella* spp.

The genus *Hemitelsella* appears to be widely distributed in southern Australia with three species described from Western Australia, one from Tasmania and now another from South Australia. Further undescribed species are known from Western Australia. It does not appear to be common. All species so far described have transverse combs on coxites IX and only a single pair of abdominal styli. The ovipositor is short and armed apically with modified spines.

The presence of 1+1 submedial combs on urosternite II was surprising. Mendes (1982) reviewed the various patterns of urosternal chaetotaxy showing that this character is very uncommon within the Lepismatidae being reported only for *Panlepisma* (unplaced) and all genera of the Heterolepismatinae (*Heterolepisma*, *Maritisma* and *Visma*). The presence of 1+1+1 combs on urosternite II is more common, occurring in some species of *Allacrotelsa* (Lepismatinae), *Hyperlepisma* (Ctenolepismatinae) and *Mirolepisma* (Mirolepismatinae). The occurrence of medial combs only on urosternites is also quite common. The occurrence of 1+1 submedial combs in this new species is probably an incidental expression of a primitive condition and of no particular phylogenetic relevance.

## Family Nicoletiidae Lubbock, 1873

Nicoletiidae Lubbock, 1873: 201.

Gymnodermata Joseph, 1882: 25.

Nicoletiinae Lubbock.—Escherich, 1905: 36.

Nicoletiidae Lubbock.—Remington, 1954: 284.

### Subfamily Subnicoletiinae Mendes, 1988

#### *Subtrinemura* Smith, 1998

*Subtrinemura* Smith, 1998: 173. Type species: *Trinemura excelsa* Silvestri, 1920 by original designation.

#### *Subtrinemura epigea* sp. nov. Smith, Mitchell, & Mesaglio

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Figs 33–55

**Holotype** ♂ (HW 0.80) NEW SOUTH WALES: Chester Hill, Wategora Reserve 33.86931°S 151.01257°E, 30.iii.2021, Thomas Mesaglio, AMS K.541620 (on two slides).

**Diagnosis.** Males of this species can be distinguished from the closely related *Subtrinemura anemoneae* by the absence of a process on the scape and by the shape of the apophysis on the pedicel, the parameres that extend beyond the hollow in urosternite IX, by the depth of the hollow, and the reduced number of anemone-like organs on the inner face of the cerci (2–3 versus 6).

### Description

**Appearance:** Small, parallel-sided silverfish with moderately elongate antennae and terminal filaments i.e. a shape typical for genus but at the shorter and wider end of the spectrum. Appearance when live white, pigment lacking (Fig. 33).

**Body size:** H+B in single known specimen about 4.2 mm (HW 0.80), thorax length up to 1.7 mm or about 0.4 H+B and width 0.88 mm; antennae incomplete but >0.5 H+B, at least 80% H+B in photographed specimen; caudal filaments almost complete at 0.75 H+B.

**Scales:** Absent.

**Macrochaetae:** Most simple, parallel-sided with distinct apical bifurcations (Fig. 34) but others are tapered to a pointed apex (Fig. 35); some on legs are stout and carrot-shaped usually with but also without an apical bifurcation (Fig. 36). Some of the longer parallel-sided macrochaetae, when slide mounted, show the same distortion reported in Smith *et al.* (2012) which is now believed to be an artefact caused by the Tendeiro medium.

**Head:** Almost as long as wide, not covered by prothorax at hind margin (Fig. 37), prognathous, vertex with 2+2 apically bifurcate macrochaetae in postero-lateral corners as well as several larger apically tapered macrochaetae across the frons near the posterior margin, lateral margins with several long, mostly apically bifurcate macrochaetae, anterior margin of frons indistinct with four macrochaetae; disc with numerous scattered small fine setae. — Clypeus with 1+1 apically bifurcate macrochaetae sublaterally and 1+1 smaller insertions between and anterior to them. — Labrum with 1+1 lateral thin, apically bifurcate macrochaetae, with six longer and shorter thin simple setae between them plus 1+1 setae

anterior to them. — Antennae elongate; scape of male longer than wide, with several strong macrochaetae (Fig. 38) both above and below, lacking any apophysis; pedicel of male with sub-triangular rounded apophyses on outer face (Fig. 38) about as long as wide, pedicel with a subapical ring of long setae as well as some small setae, the long setae also present on mediad face, ventral face with four areas of glands (Fig. 39); four trichobothria on the basal annulus and one each on the following annuli; intervals beginning to subdivide into two annuli from sixth with trichobothria restricted to the most distal ring of setae, each annulus with curved simple setae and thinner straight setae which become longer than the curved setae; most distal surviving intervals of four annuli, each annulus with a ring of setae as well as several setulae distal to the ring of setae, the cuticle with very many small hair-like denticulations. There may be some basiconic sensilla type C in the penultimate annulus of each interval (see Adel, 1984) but others appear to be much longer and finer, almost indistinguishable from fine setae except that their ends appear to be rounded. — Mandibles (Fig. 40) strong with well-developed molar and incisor regions, with about ten small stout setae behind the molar area and several apically bifurcate macrochaeta on the external face as well as a few longer simple setae. — Maxillae (Fig. 41) of usual form, galea only surpassing length of lacinia by half the length of the two distinct apical papillae, lacinia well sclerotized with one strong apical tooth and a quite strong secondary tooth; pectinate prostheca not much shorter than lacinia with several lamellate processes and about 13 setae along margin in two rows; maxillary palp not greatly elongated, L/W apical article 3.5–3.9 and 1.4–1.7 times the length of the penultimate article; ultimate article bearing usual six branched papillae as well as a single basiconic sensillum type C. — Labium (Fig. 42) longer than wide, ultimate article is about 1.2–1.4 times longer than wide with six papillae of usual type; the penultimate article with a ring of longer setae mid-length.

*Thorax:* Weak, about 0.4 H+B and not wider than the abdomen, all nota of similar size. Pronotum with obvious collar of numerous longer macrochaetae and many smaller setae, pronotum with several strong submarginal macrochaetae along the lateral and posterior margins, some apically bifurcate others tapering to a fine point, as well as shorter setae, disc of nota with many scattered setae or varying sizes (Fig. 43). Meso- and metanota similar except lacking anterior collar (Figs 44, 45).

Legs typical for genus, tibia L/W ratio of legs, PI 3.4, PII 3.6, PIII 4.1 (all measured from slide); tarsi L/W ratio PI 5.8 PII 7.1, PIII 11.3. Legs progressively a bit longer, tibia PII/PI 1.2, PIII/PI 1.5; tarsus PII/PI 1.2 PIII/PI 1.7. Legs not greatly elongate (Figs 46–48). Coxae with about five long macrochaetae spaced along the outer margin as illustrated, inner margin with two macrochaetae, margins and face covered with scattered fine setae; trochanter with one small macrochaeta and several smaller setae; femur mostly with setae along leading margin with a thin macrochaeta  $\frac{1}{3}$ – $\frac{1}{4}$  from the end and a more robust curved macrochaeta and some strong setae over the articulation, posterior margin with a macrochaeta proximally and two macrochaetae on the weak bulge, face covered with scattered small setae; tibia without macrochaetae on the dorsal margin, ventral margin with four macrochaetae as illustrated and a more robust seta distally, the usual distal spur has one or two small barbs (Fig. 49); tarsus with four articles, the basal one about  $\frac{2}{3}$  the length of the other



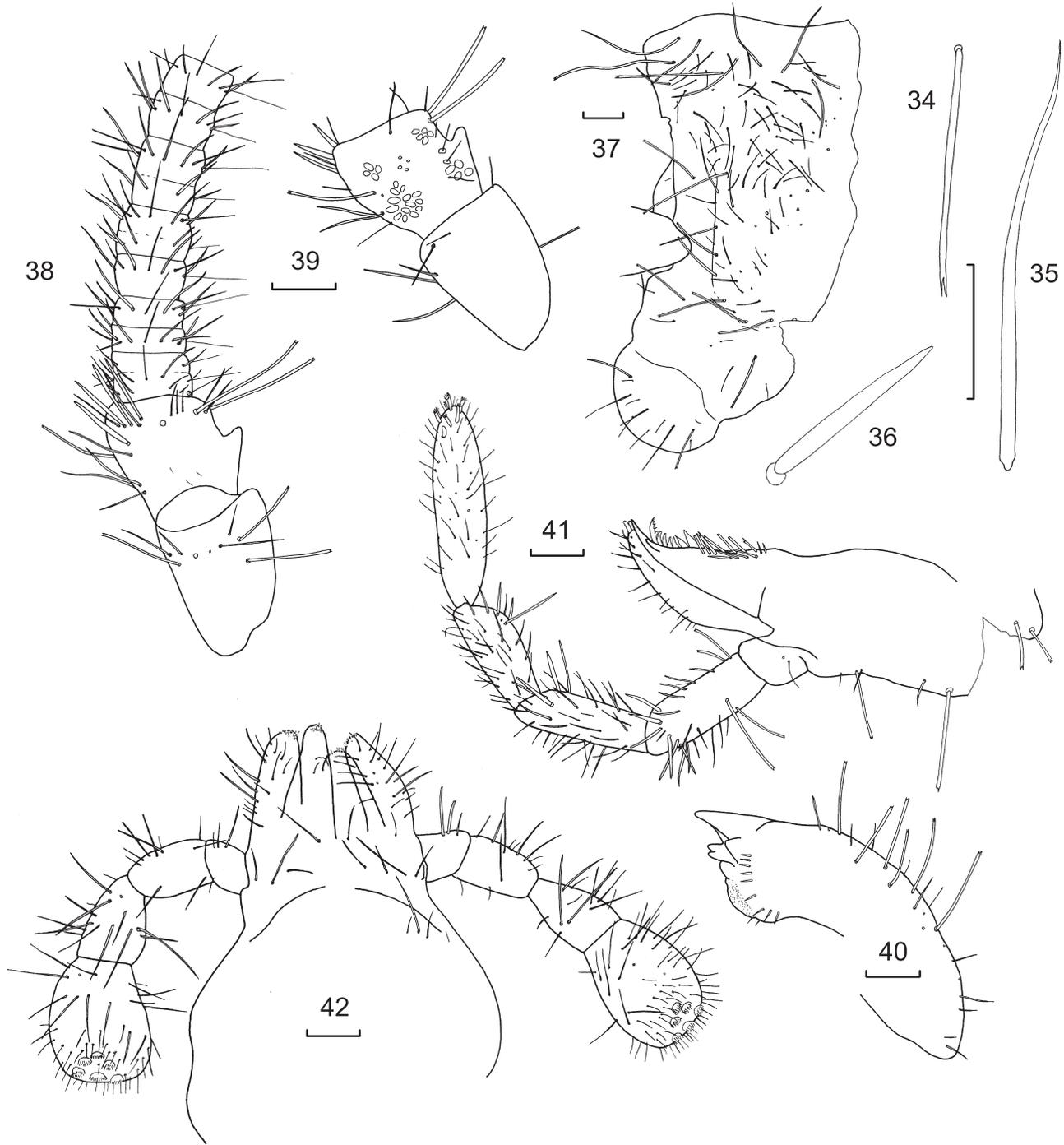
Figure 33. *Subtrinemura epigea* sp. nov.

three together on PI but about the same length as the other three together on both PII and PIII, each article with more robust paired setae distally; pretarsus with two strong claws and a stout medial empodial claw, all claws without barbs.

*Abdomen:* Not much narrower than the thorax at its base. All urotergites wrap around the body without a sharp fold laterally. A suture between the tergite and the paratergites visible on I–VIII. Abdominal tergites I–VIII (Fig. 50) with longer and shorter tapered macrochaetae spaced along posterior margin, two macrochaetae on each side laterad of the suture with six submarginal macrochaetae between the sutures as well as several setae, disc of urotergites with many scattered setae, sometimes quite long.

Urotergite X (Fig. 51) not easy to observe on slide as covered by the genitalia, broadly trapezoidal with 2+2 macrochaetae (not apically bifurcated), the larger being more mediad plus two smaller marginal setae laterad of the macrochaetae and four smaller setae along the concave posterior margin.

Urosternite I not divided into a median sternum and two lateral coxites with only a few setae in the middle of the disc and 1+1 insertions on the convex medial posterior bulge. Urosternite II also entire with slightly concave posterior margin with small 1+1 submedial setae, posterior lateral corners each with two longer setae, disc with more scattered setae. Urosternites III–VI (Figs 52, 53) entire, similar to urosternite II in chaetotaxy but also bearing styli and eversible vesicles, the eversible tip of the vesicle bearing a single small seta towards the stylus end (rarely also a second seta at the opposite end). Urosternite VII similar except bearing pseudovesicles. Urosternite VIII (Fig. 54), small with concave posterior margin, and lacking vesicles



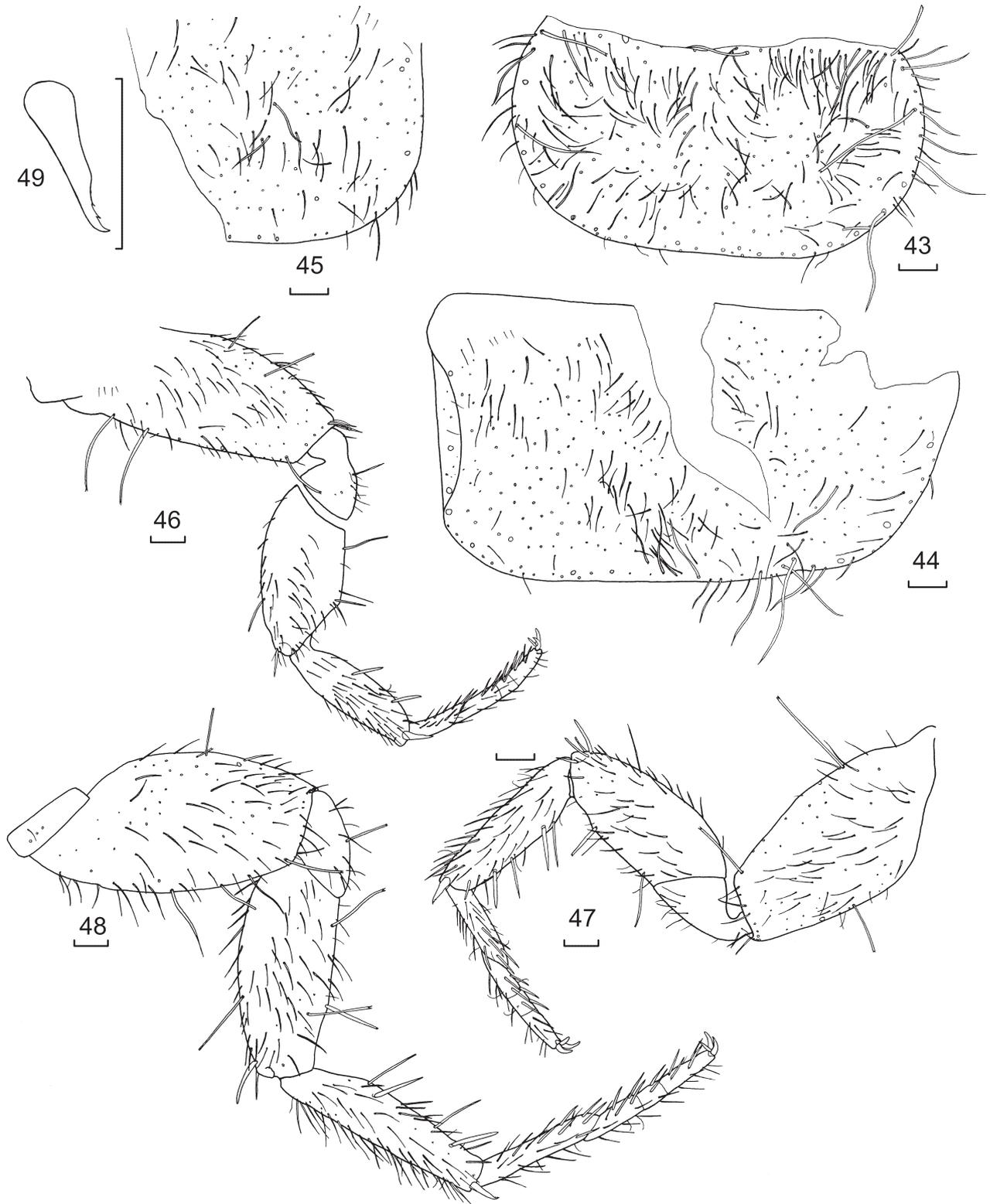
**Figures 34–42.** *Subtrinemura epigea* sp. nov. holotype ♂ (34) apically bifurcate macrochaeta from coxa; (35) pointed macrochaeta from urotergite; (36) carrot-shaped macrochaeta of tibia; (37) head on slide, left side missing; (38) left scape, pedicel and basal flagellomeres from above; (39) scape and pedicel from below; (40) mandible; (41) maxilla, (42) labium. Scale bars = 0.1 mm.

but otherwise with similar chaetotaxy. Styli on segments III–IX, apical spine of the few styli still present all with one or two barbs (Fig. 55).

Urosternite IX (Fig. 56) entire (not divided into separate coxites) bearing styli and short, apically eversible parameres that surpass the bases of the styli by a little more than the depth of the hollow in the posterior margin of the urosternite. — Penis concealed beneath parameres but with short glandular setae apically, similar to those seen on the parameres.

Appendix dorsalis of male (Fig. 56) without modified chaetotaxy, basal division longer than wide with two rings of setae and some short trichobothria; second division longer

with five rings of setae, those in the second and fourth rings without macrochaetae, the most distal ring with more and stronger macrochaetae than the rest; third and subsequent divisions with four rings. Basal division of cerci (Fig. 56) without modified chaetotaxy; following division with three rings of setae, the basal and distal also with trichobothria; third division with two rings of setae and trichobothria, the distal—most with long macrochaetae on the outer side and a broad anemone-like structure on the inner ventral face (Figs 56, 57); fourth division with four rings of setae and trichobothria, the most distal with an anemone-like structure; fifth division similar except the anemone-like structure is



**Figures 43–49.** *Subtrinemura epigea* sp. nov. holotype ♂ (43) pronotum; (44) mesonotum; (45) metanotum, right side; (46) PI; (47) PII; (48) PIII; (49) tibial spur of PII. Scale bars = 0.1 mm.

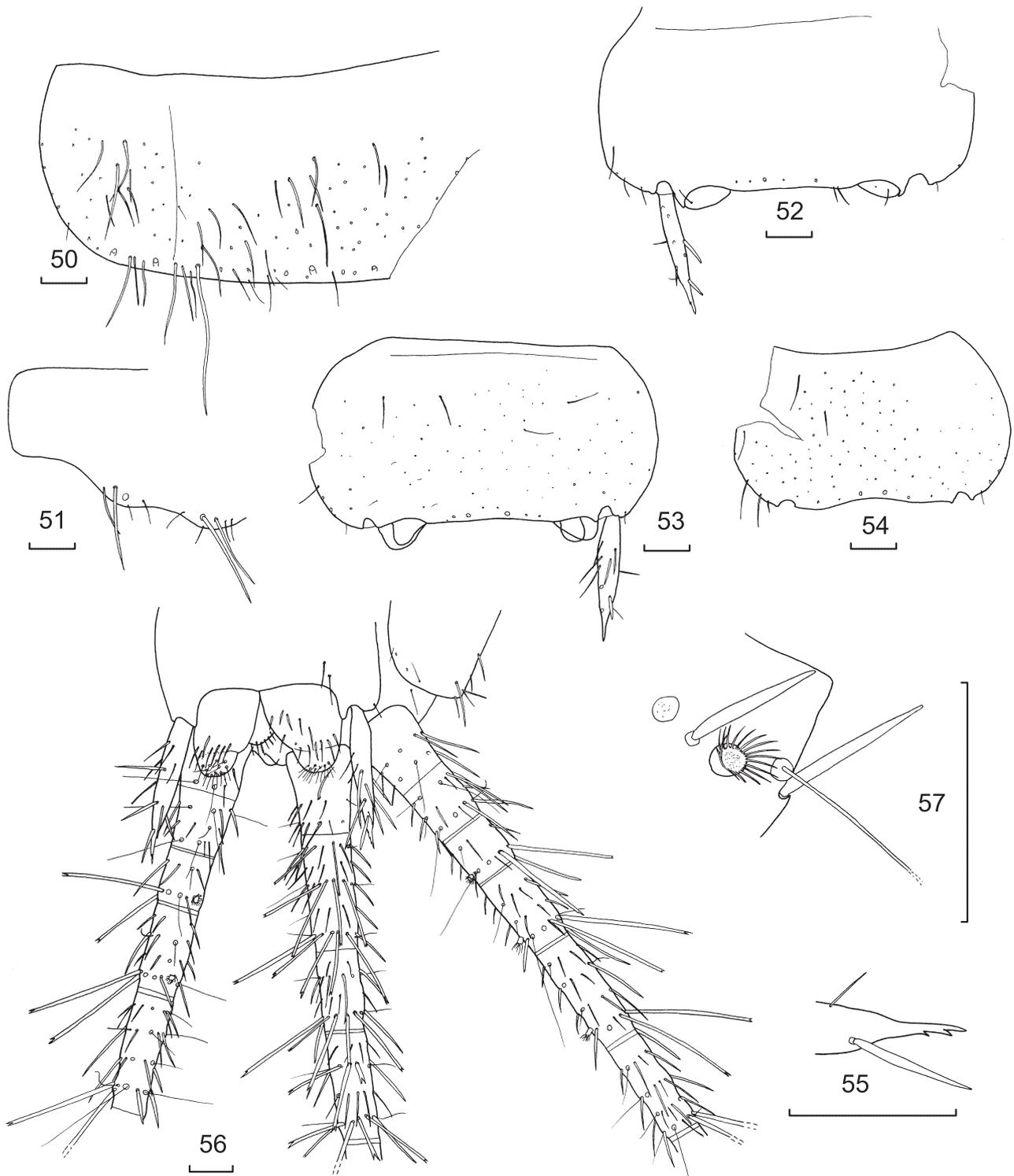
only present on one side; subsequent divisions also with four rings but all lacking anemone-like structures.

*Female:* Unknown.

**Habitat.** The single specimen was collected in *Melaleuca* scrub and grassland in a reserve well within the boundaries

of the city of Sydney. It was found under a fallen *Melaleuca decora* bark sheet, at the surface on clay soil and leaf/bark litter.

**Etymology.** The species is named *epigea* because it lives within the soil layers (epigean).



**Figures 50–57.** *Subtrinemura epigea* sp. nov. holotype ♂ (50) mid-body urotergite, left side; (51) urotergite X; (52) urosternite VI; (53) urosternite VII; (54) urosternite VIII; (55) apical spine of stylus IX; (56) urosternite IX, parameres and bases of terminal filaments; (57) anemone-like structure of cercus. Scale bars = 0.1 mm.

## Discussion

Morphologically the new species appears to be close to *Subtrinemura anemona* (Smith, 1988) bearing similar broad anemone-like structures on the cerci of the males. In other species of *Subtrinemura* these structures are absent or much narrower (*S. norfolkensis* Smith, 1988). It is however quite distinct in being smaller and having completely different secondary sexual processes on the pedicel and lacks a process on the scape.

Nicoletiids are generally subterranean and rarely collected. The specimen was collected on the surface of soil after a period of very heavy extended rainfall in the Sydney basin and this may have caused the silverfish to be on, rather than within the soil.

The species will key to *Subtrinemura anemona* in the key of Smith, 1988 (page 180). It can be separated with a further couplet.

- 16a Scape of male with distinct secondary sexual process ..... *S. anemona* (Smith)  
 —— Scape of male lacking a process ..... *S. epigea* sp. nov.

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