The genus *Scapheremaeus* (Acari, Oribatida, Cymbaeremaeidae) in the oribatid mite fauna of New Zealand, with description of two new species

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Abstract

Two new species of oribatid mites of the genus *Scapheremaeus* (Oribatida, Cymbaeremaeidae), *S. gibbus* sp. n. and *S. luxtoni* sp. n., are described from New Zealand. *Scapheremaeus gibbus* sp. n. is morphologically most similar to *S. humeratus* Balogh & Mahunka, 1967, but differs from the latter by the number of notogastral, genital and adanal setae, morphology of bothridial setae, position of adanal lyrifissures and absence of humeral processes. *Scapheremaeus luxtoni* sp. n. is morphologically most similar to *S. yamashitai* Aoki, 1970, but differs from the latter by the morphology of notogastral and rostral setae, morphology of leg solenidia *φ₂*, and development of humeral processes. The species *Scapheremaeus zephyrus* Colloff, 2010 is recorded for the first time in New Zealand. An identification key to the known New Zealand species of *Scapheremaeus* is provided.

Keywords

Oribatid mites, *Scapheremaeus*, new species, new record, key, New Zealand
**Introduction**

*Scapheremaeus* is a large genus of oribatid mites (Acari, Oribatida, Cymbaeremaeidae), which was proposed by Berlese (1910) with *Eremaeus patella* Berlese, 1886 as type species. At present, the genus comprises more than 110 species and has a cosmopolitan distribution (except the Antarctic region) (Subías 2004, updated 2015; Ermilov and Anichkin 2015). The generic characters of *Scapheremaeus* are summarized by Colloff (2009). The identification keys to species from some regions and countries have been presented by Sitnikova (1975), Rios and Palacios-Vargas (1998), Balogh and Balogh (2002), Colloff (2010), Norton et al. (2010), and Ermilov and Anichkin (2015). The information about juvenile instars is summarized by Norton and Ermilov (2014), with some new data added by Ermilov et al. (2015).

During studies of oribatid mites from New Zealand, we discovered two new species of *Scapheremaeus*, *S. gibbus* sp. n. and *S. luxtoni* sp. n., and also found a known species, *S. zephyrus* Colloff, 2010, which was previously recorded only in Australia. The primary aim of our paper is to describe these species.

Three other species of *Scapheremaeus* are known from New Zealand (Hammer 1966): *S. emarginatus* Hammer, 1966, *S. insularis* Hammer, 1966 and *S. patella* (Berlese, 1886). The second aim of our paper is to provide an identification key for all known species of this genus in New Zealand.

**Materials and methods**

The collection locality and habitat for each new species are given in the “*Material examined*” sections. Additionally, two specimens (female and male) of *S. zephyrus* were collected from: New Zealand, South Island, Central Otago, Old Man’s Range, 45°18’58”S, 169°11’45”E, 1646 m a.s.l., in soil and debris under *Dracophyllum muscoides* cushion, 17 February 2014 (M. Minor).

Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. The body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Notogastral width refers to the maximum width in dorsal aspect. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus.

General terminology used in this paper follows that of Grandjean (summarized by Norton and Behan-Pelletier 2009; Colloff 2009).

Drawings were made with a camera lucida using a Carl Zeiss transmission light microscope “Axioskop-2 Plus”. Images were obtained with an AxioCam Icc3 camera using a Carl Zeiss transmission light microscope “Axio Lab.A1”.
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Descriptions

Scapheremaeus gibbus sp. n.

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Figs 1–22

**Diagnosis.** Body size: 270–307 × 131–147. Body surface areolate-retticulate. Costulae reduced, terminated by tubercles. Transcostula not developed. Rostral setae thin, directed medially. Lamellar setae minute. Bothridial setae globular. Humeral processes and circumdorsal scissure absent. Thirteen pairs of short, simple notogastral setae. Anterior tectum of ventral plate strongly developed. Palp femora with one seta. Five pairs of genital setae. Lyrifissures *iad* in transverse position. Monodactylous. Femora I and II with extremely large ventral expansions.

**Description.**

**Measurements.** Body length: 299 (holotype: female), 270–307 (seven paratypes: four females and three males); notogaster width: 147 (holotype), 143–151 (seven paratypes).

**Integument.** Body color light yellow-brownish. Body surface with areolate-retticulate sculpturing.

**Prodorsum.** Rostrum broadly rounded. Costulae reduced, terminated by tubercles, bearing lamellar setae. Transcostula absent. Rostral setae (*ro*, 10) thin, smooth, directed medially, inserted on transverse fold. Lamellar setae minute (*le*, 4), thin, straight, inserted nearer to bothridia than rostral setae. Interlamellar and exobothridial setae and their alveoli absent. Bothridial setae (*ss*, 22–24) globular, pigmented, with short stalk (6–8) and longer (16) head, having longitudinal ridges.

**Notogaster.** Normal in form, not flattened. Anterior margin slightly convex medially. Lenticulus (*len*) distinct. Humeral regions without processes. Centrodorsal zone forming longitudinal hump-like structure. Circumdorsal scissure absent. Thirteen pairs of simple notogastral setae, located on small tubercles. Centro-dorsal part with four pairs of setae (*da*, *dm*, *ln*, *dp*). All lyrifissures (*im*, *ip*, *ib*, *ips*; except *ia*) well visible. Opisthonthal gland openings (*gla*) located posteriorly to *im*.

**Gnathosoma.** Subcapitulum longer than wide (53–57 × 32–36). Subcapitular setae thin, smooth; *a* and *m* (both 10) longer than *b* (6) and adoral setae (*or*₁, *or*_₂, 4–6). Setae *a* slightly thicker than other. Palps (41–45) with setation 0–1–1–3–9(+)ω). Solenidion free, not attached to eupathidium (*acm*). Chelicerae (53–57) with two simple, barbed setae; *cha* (16–18) longer than *chb* (12). Trägårdh’s organ long, tapered.

**Epimeral and lateral podosomal regions.** Anterior tectum strongly developed. Pedotecta I large, concave in dorsal view and scale-like in lateral view. Pedotecta II elongated, bifurcate distally in ventral view and broadly triangular in lateral view. Apodemes 1, 2, sejugal and 3 distinctly developed. Epimeral setal formula 3–1–2–2. Epimeral setae short (4), thin, smooth. Discidia (*dis*) roundly triangular.

**Anogenital region.** Five pairs of genital (*g₁–g₅*), one pair of aggenital (*ag*), two pairs of anal (*an₁, an₂*) and two pairs of adanal (*ad₁, ad₂*) setae similar in length (4), thin, smooth, inserted on small tubercles. Lyrifissures *iad* in transverse position. Ovipositor
Figures 1–3. *Scapheremaeus gibbus* sp. n., adult: 1 dorsal view 2 ventral view (legs not shown) 3 lateral view (gnathosoma and legs except basal parts not shown). Scale bar 50 µm.
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Figures 4–12. Scapheremaeus gibbus sp. n., adult: 4 frontal view of prodorsum (legs I except basal parts not shown) 5 posterior view 6 subcapitulum and palp 7 chelicera, antiaxial view 8 ovipositor 9 leg I, without trochanter, right, antiaxial view 10 femur of leg II, left, paraxial view 11 leg III, without tarsus, left, antiaxial view 12 leg IV, left, antiaxial view. Scale bars 50 µm (4, 5), 20 µm (6–12).
elongated (68–77 × 32–36), lobes (36–41) longer than length of distal section (beyond middle fold; 32–36). Each of three lobes with four straight, smooth setae, $\psi_1 \approx \tau_1$ (20) longer than $\psi_2 \approx \tau_2 \approx \tau_b \approx \tau_c$ (8–10). Coronal setae and their alveoli absent.

Legs. Monodactylous. Femora I and II with extremely large ventral expansions. Porose areas ($p.a$) slightly visible, oval. Formulas of leg setation and solenidia: I (0–4–2–4–16) [1–2–2], II (0–4–2–3–15) [1–1–1], III (1–2–1–3–14) [1–1–0], IV (0–2–1–3–12) [1–1–0]; homology of setae and solenidia as indicated in Table 1. Famuli ($\varepsilon$) short, slightly dilated distally. Solenidia simple, $\sigma$ on genua IV minute. Setae $l$ on tibiae I setiform, not modified.

Material examined. Holotype (female) and seven paratypes (four females and three males): New Zealand, South Island, Central Otago, Old Man’s Range, 45°18’58”S, 169°11’45”E, 1646 m a.s.l., in soil and debris under *Dracophyllum muscoides* cushion, 17 February 2014, collected by M. Minor.

Figures 13–17. *Scapheremaeus gibbus* sp. n., dissected adult, microscope images: 13 lamellar setae and ornamentation in centro-dorsal part of prodorsum 14 bothridial seta 15 lenticulus and sculpture on anterior part of notogaster 16 sculpture on centro-dorsal part of notogaster 17 sculpturing in dorso-lateral part of notogaster. Scale bar 20 µm.
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Figures 18–22. Scapheremaeus gibbus sp. n., dissected adult, microscope images: 18 sculpturing in anterior part of epimeral region 19 genital plates 20 left anal plate and sculpturing in adanal part of ventral plate 21 pedotecta II 22 femur I, left, paraxial view. Scale bar 20 μm.

Type deposition. The holotype and two paratypes are deposited in the New Zealand National Arthropod Collection, Auckland, New Zealand; two paratypes are deposited in the collection of the Senckenberg Institution, Frankfurt, Germany; three
paratypes are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

**Etymology.** The specific name *gibbus* refers to the clearly convex centrodorsal notogastral region, forming longitudinal elongate hump-like structure.

**Remarks.** The new species is most similar to *S. humeratus* Balogh & Mahunka, 1967 from Congo (see Balogh and Mahunka 1967) in having small body size, monodactylous legs, simple notogastral setae, areolate body surface, and absence of circumdorsal furrow. However, it differs from the latter by the presence of 13 pairs of notogastral setae (versus 11), globular bothridial setae (versus fusiform), five pairs of genital setae (versus six), two pairs of adanal setae (versus three), transverse position of adanal lyrifissures (versus longitudinal) and absence of humeral processes (versus well developed).

### *Scapheremaeus luxtoni* sp. n.
http://zoobank.org/8F13864C-3F7C-44A9-B831-2C4892BB7F89
Figs 23–47

**Diagnosis.** Body size: 381–415 × 199–232. Centro-dorsal part of notogaster areolate. Dorso-lateral parts of notogaster and ventral plate tuberculate. Costulae and transcostula strong. Rostral setae thin, straight. Lamellar setae minute. Bothridial setae globular. Humeral processes small, rounded. Circumdorsal scissure present. Ten pairs of short, simple notogastral setae. Palp femora with two setae. Six pairs of genital setae. Lyrifissures *iad* longitudinally oriented. Tridactylous.

**Description.** **Measurements.** Body length: 381 (holotype: male), 381–415 (three paratypes: all females); notogaster width: 199 (holotype), 232 (same for three paratypes).

**Integument.** Body color light yellow-brownish. Anterior part of prodorsum and centro-dorsal part of notogaster with areolate sculpturing. Dorso-lateral parts of notogaster and ventral plate with elongated ridge-like tubercles.

**Prodorsum.** Rostrum broadly rounded. Costulae (*cos*) distinct, forming slightly visible *X*-structure, terminated by large tubercles, which connected by thick transcostula (*tcos*). Rostral setae (6) thin, straight, inserted on transverse fold. Lamellar setae (4)
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...minute, inserted nearer to rostral setae than to bothridia. Interlamellar and exobothridial setae and their alveoli absent. Bothridial setae (22–24) globular, pigmented, with short stalk (6) and longer (16–18) head, having longitudinal ridges.

*Notogaster* flattened. Anterior margin straight. Lenticulus distinct. Humeral processes (*Hp*) slightly developed, tubercle-like in dorsal view and rounded in lateral view.

**Figures 23–25.** *Scapheremaeus luxtoni* sp. n., adult: 23 dorsal view 24 ventral view (legs not shown) 25 lateral view (gnathosoma and legs except basal parts not shown). Scale bar 50 µm.
Centrodorsal zone with longitudinal elongate hump–like structure. Circumdorsal scissure (f) present. Ten pairs of simple notogastral setae, located on small tubercles. Centro-dorsal part with two pairs of setae (lm, lm), both inserted near to scissure. All lyrifissures (except ia) well visible. Opisthontal gland openings located medially to ih.

_Gnathosoma._ Subcapitulum longer than wide (82–90 × 61–69). Subcapitular setae thin, smooth; a and adoral setae (all 10) longer than m and b (both 6–8). Setae a slightly thicker than other. Palps (53–61) with setation 0–2–1–3–9(+ω). Solenidion free, not attached to eupathidium. Chelicerae (82–90) with two simple, barbed setae (both 16–20). Trägårdh’s organ long, tapered.

_Epimeral and lateral podosomal regions._ Anterior tectum slightly developed. Pedotecta I of medium size, concave in dorsal view and scale–like in lateral view. Pedotecta II elongated, bifurcate distally in ventral view and broadly triangular in lateral view. Apodemes 1, 2, sejugal and 3 distinctly developed. Epimeral setal formula 3–1–2–2. Epimeral setae short (4), thin, smooth. Discidia roundly triangular.

_Anogenital region._ Six pairs of genital, one pair of aggenital, two pairs of anal and three pairs of adanal setae similar in length (4), thin, smooth, inserted on small tubercles. Lyrifissures iad longitudinally oriented. Ovipositor elongated (52–56 × 41–45), lobes (32–36) longer than length of distal section (beyond middle fold; 20). Each of three lobes with four straight, smooth setae, ψ₁ ≈ τ₁ (24–28) longer than ψ₂ ≈ τ₂ ≈ τ₃ ≈ τ₄ (16). Coronal setae and their alveoli absent.

_Legs._ Tridactylous. Porose areas slightly visible, oval. Formulas of leg setation and solenidia as in _S. gibbus_ sp. n.; homology of setae and solenidia as indicated in Table 1. Famuli short, slightly dilated distally. Solenidia (except simple ω on tarsi and ϕ₂, and thin σ on genua I) dilated distally. Setae l on tibiae I setiform, not modified.

_Material examined._ Holotype (male) and three paratypes (all females): New Zealand, South Island, Central Otago, Pisa Range, 44°52’19”S, 169°10’30”E, 1880 m a.s.l., in soil and debris under _Dracophyllum muscoides_ cushion and in the soil outside of _D. muscoides_ cushion, 18 February 2014, collected by M. Minor.

_Type deposition._ The holotype and one paratype are deposited in the New Zealand National Arthropod Collection, Auckland, New Zealand; one paratype is deposited in the collection of the Senckenberg Institution, Frankfurt, Germany; one paratype is deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

_Etymology._ The specific name is dedicated to the well–known acarologist Malcolm Luxton, for his extensive contributions to our knowledge of New Zealand oribatid mite fauna.

_Remarks._ The new species is similar to _S. yamashitai_ Aoki, 1970 from Japan (see Aoki 1970; Fujikawa 2002) in having circumdorsal furrow, tridactylous legs, costulae and transcostula, ten pairs of minute notogastral setae and areolate centrodorsal region of notogaster. However, it differs from the latter by the presence of thin notogastral setae (versus thickened), straight rostral setae (versus curved medially), short and dilated distally leg solenidia ϕ₂ (versus long and simple) and slightly developed humeral processes (versus well developed).
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Figures 26–35. *Scapheremaeus luxtoni* sp. n., adult: 26 frontal view of prodorsum 27 posterior view 28 subcapitulum 29 palp 30 chelicera, antiaxial view 31 ovipositor 32 leg I, right, antiaxial view 33 femur of leg II, left, paraxial view 34 trochanter, femur and genu of leg III, left, antiaxial view 35 leg IV, left, antiaxial view. Scale bars 50 µm (26, 27), 20 µm (28–35).
Figures 36–42. Scapheremaeus luxtoni sp. n., dissected adult, microscope images: 36 bothridial seta and sculpture of latero-basal part of prodorsum 37 costulae and transcostula 38 lenticulus and sculpture on latero-anterior part of notogaster 39 humeral process, right, dorsal view 40 sculpture on centro-dorsal part of notogaster 41 notogastral seta $p_3$, 42 pedotecta I and II. Scale bar 20 µm.

Also, in having circumdorsal furrow, tridactylous legs, costulae, minute notogastral setae, straight rostral setae and areolate centrodorsal region of notogaster, S. luxtoni sp. n. is similar to S. zephyrus Colloff, 2010 from Australia (see Colloff 2010) and
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New Zealand (our data). However, it differs from the latter by the presence of large tubercle-like distal parts of costulae (versus small), strong transcostula (versus absent), ten pairs of thin notogastral setae (versus nine pairs and thickened) and three pairs of adanal setae (versus two pairs).

**Key to species *Scapheremaeus* from New Zealand**

1. Notogastral circumdorsal scissure absent; costulae reduced, represented by tubercle-like cusps; legs monodactylous .................................................. 2

2. Notogastral circumdorsal scissure present; costulae well developed; legs tridactylous ................................................................. 3

3. 

**Figures 43–47. *Scapheremaeus luxtoni* sp. n., dissected adult, microscope images:** 43 sculpture on anterior part of epimeral region 44 anterior part of right anal plate 45 sculpture between genital and anal apertures 46 femur I, left, paraxial view 47 tarsus IV, left, antiaxial view. Scale bar 20 µm.
2 Notogaster with 13 pairs of setae; notogastral setae simple; leg femora I, II with extremely large ventral expansions; body size: 270–307 × 131–147 ........

-- Notogaster with 10 pairs of setae; notogastral setae dilated distally; leg femora I, II without extremely large expansions; body length: 330 .......................................................... S. gibbus sp. n.

3 Costular cusps elongate conical; notogastral setae dilated distally; body length: 420 .......................................................... S. insularis Hammer, 1966

-- Costular cusps tubercle-like, not elongated; notogastral setae simple or slightly thickened .......................................................... 4

4 Notogaster with 14 pairs of setae; centro-dorsal notogastral setae (da, dm, dp) developed; body size: 360–495 × 284 ...................... S. patella (Berlese, 1886)¹

-- Notogaster with 9–10 pairs of setae; centro-dorsal notogastral setae (da, dm, dp) not developed ........................................................................ 5

5 Notogaster with 9 pairs of setae (p₂ not developed); two pairs of anal setae; transcostula absent; body size: 384–391 × 202–211.................................

.......................................................... S. zephyrus Colloff, 2010

-- Notogaster with 10 pairs of setae (p₂ developed); two pairs of anal setae; transcostula present; body size: 381–415 × 199–232 ........ S. luxtoni sp. n.

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¹ See also redescriptions in Hammer (1966), Mahunka (1977), Mahunka and Mahunka-Papp (1995).
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