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## Oribatid mites of the genus *Eremulus* Berlese, 1908 (Acari: Oribatida: Eremulidae) from South Africa

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### ABSTRACT

The oribatid mite genus *Eremulus* Berlese, 1908 is reported from South Africa for the first time. Two new species, *Eremulus spindleformis* sp. n. and *E. southafricanensis* sp. n., are described, and an additional description of *Eremulus flagellifer* is given, based on material in the collection of the National Museum (Bloemfontein, South Africa). An identification key to African species of *Eremulus* is presented.

KEY WORDS: Oribatida, *Eremulus*, Afrotropical, mites, identification key, new species.

### INTRODUCTION

The oribatid mite family Eremulidae (Ameroidea) comprises seven genera and 45 species, and has a cosmopolitan distribution (Subías 2004, online version 2011). *Eremulus* is the largest genus, comprising 35 species. This genus was proposed by Berlese (1908) with *Eremulus flagellifer* Berlese, 1908 as the type species. The diagnostic characters of *Eremulus* are (data summarized from descriptions of species): costulae well developed and visible; rostrum rounded; sensilli flagelliform, rarely spindle-shaped (exceptionally with small sensillar head); anterior part of notogaster with transverse foveolate band; 10 to 11 pairs of notogastral setae; anal and adanal setae simple; epimeral setae branched (*Ic* often setiform); genital and aggenital setae branched (exceptionally setiform).

During studies of the oribatid mite collection in the National Museum (Bloemfontein, South Africa) we discovered new species, *Eremulus spindleformis* sp. n. and *E. southafricanensis* sp. n., and also found *E. flagellifer* Berlese, 1908.

Representatives of *Eremulus* have not previously been reported from South Africa, but five species have been recorded on the African continent: *E. adami* Balogh & Mahunka, 1966, *E. africanus* Balogh, 1958, *E. lanceocrinus* Balogh, 1958 (from Congo), *E. csuzdii* Mahunka & Mahunka-Papp, 2009 (from Kenya), and *E. flagellifer* Berlese, 1908 (cosmopolitan). An identification key to the African species is provided.

### MATERIAL AND METHODS

Specimens were studied in lactic acid, mounted on temporary cavity slides for the duration of the study, and then stored in 70% ethanol in vials. All body measurements are in micrometers ( $\mu\text{m}$ ). Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate, to avoid discrepancies caused by different degrees of notogastral distension. Notogastral width refers to the maximum width in dorsal aspect. The length of body setae was measured in lateral aspect.

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Leg setation formulae are given according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulae for leg solenidia are provided (in square brackets) according to the sequence genu–tibia–tarsus.

The holotypes have been deposited at the National Museum, Bloemfontein, South Africa (NMBA). The paratypes are in the Siberian Zoological Museum, Novosibirsk, Russia (SZMN), NMBA and in the personal collection (PC) of the first author.

#### TAXONOMY

Family Eremulidae Grandjean, 1965

Genus *Eremulus* Berlese, 1908

***Eremulus spindleformis* sp. n.**

Figs 1–3

**Etymology:** Named in reference to the spindle-form sensilli.

**Diagnosis:** This species is distinguished from other species of the genus by the following combination of characteristics: body size 397–448×224–265; rostrum weakly protruding anteriorly; transcostula absent; prodorsal setae smooth; interlamellar setae shorter than rostral and lamellar setae; sensilli spindle-form, ciliate; 11 pairs of notogastral setae, medium-sized, setiform and smooth; aggenital setae branched; adanal setae  $ad_1$  longer than  $ad_2$  and  $ad_3$ ; epimeral setae  $1c$  long and setiform.

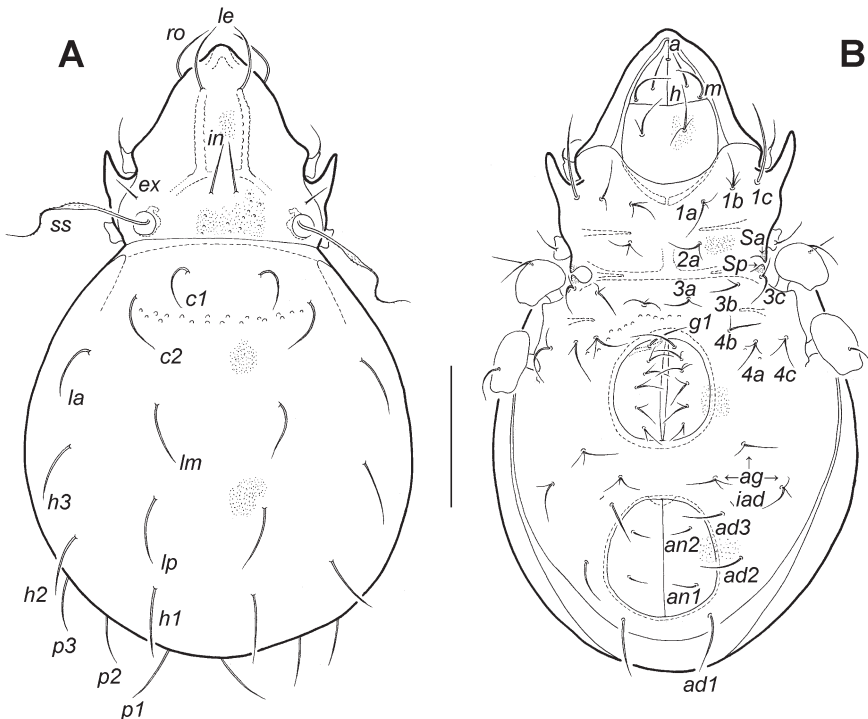


Fig. 1. *Eremulus spindleformis* sp. n.: (A) dorsal view, legs not shown; (B) ventral view, legs not shown (except trochanters). Scale bar = 100  $\mu$ m.

## Description:

*Measurements.* Body length 409 (holotype, female), 397–448 (mean 424, 14 paratypes); body width 243 (holotype, female), 224–265 (mean 240, 14 paratypes).

*Integument* (Fig. 1A, B). Body yellow-grey-brownish. Body and legs covered by secretion granules (diameter up to 1  $\mu\text{m}$ ). Posterior part of prodorsum with foveolae, which are absent between costulae. Foveolate band on notogaster and anterior to genital plates distinct. A small concave region present between rows of notogastral setae *c* and *la*.

*Prodorsum* (Figs 1A; 2A). Rostrum weakly protruding anteriorly. Costulae long, narrow, almost straight. Transcostula absent, but the rudimentary sites present. Rostral (49–57), lamellar (49–57), interlamellar (32–41) and exobothridial (20–24) setae setiform, smooth, inserted on tubercles. Rostral setae inserted in lateral position on prodorsum. Sensilli (110–118) spindle-form, covered by short cilia, with long stalk (45–53), well-developed oblong head (16) and long, flagelliform distal part (49–53). Bothridial margins with teeth (visible under high magnification).

*Notogaster* (Figs 1A; 2B). Anterior border straight. One pair of humeral condyles indistinctly visible and cristae present. Eleven pairs of notogastral setae ( $p_3$  inserted in marginal position) medium in size, approximately similar in length (45–57; only  $p_2$  and  $p_3$  shorter, 28–36), setiform, smooth, covered by thin, colourless cerotegument. Opisthonotal gland opening and lyrifissures located in arrangement typical for genus, but poorly visible.

*Anogenital region* (Fig. 1B). Six pairs of genital ( $g_1$ – $g_6$ ) and three pairs of aggenital (*ag*) setae with two to four branches. Setae  $g_1$  setiform, not branched or with one short cilium. Two pairs of anal ( $an_1$ ,  $an_2$ , 16–20) and three pairs of adanal ( $ad_1$ , 41–45;  $ad_2$  and  $ad_3$ , 28–32) smooth, setiform setae. Adanal setae  $ad_3$  inserted close to anal plates. Lyrifissures *iad* located in arrangement typical for genus.

*Epimeral region* (Figs 1B; 2C, D). Apodemes 1, 2, sejugal apodeme and short apodeme 3 present. Shape of apodemes and epimeral borders typical for the genus. Epimeral setal formula 3–1–3–3. Setae *1c* long (57–65), setiform, smooth or with one short cilium on basal part; all the others shorter, with two to four branches. Two pairs of strongly developed tubercles *Sa* and *Sp* present on epimeral region.

*Gnathosoma* (Fig. 2E–G). Subcapitulum longer than wide: 90–98×61–69. Hypostomal setae of different morphology: *h* branched, longest branch 36–41; *m* (36–41) setiform, curved in basal part, slightly barbed; *a* (20–24) setiform and smooth. Adoral setae absent on lips. Palp (length 49–57) with setation 0–2–1–3–8(+1 $\omega$ ). Palpal setae (except tarsus) slightly barbed; solenidion thickened, pressed to palptarsus. Chelicera (90–94) with small tooth on dorsal side. Cheliceral setae long, setiform and barbed; *cha* (24–26) slightly longer than *chb* (16–20). Tragardh's organ long, narrow, with thin distal part, blunt-ended.

*Legs* (Fig. 3A–D). Legs with one simple claw. Formulae of leg setation and solenidia: I (1–5–3–4–20) [1–2–2], II (1–5–3–4–16) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–3–2–4–12) [0–1–0]; homology of setae and solenidia indicated in Table 1. Setae smooth or slightly barbed unilaterally. Famulus short, setiform, inserted very close to solenidion  $\omega_2$ .

Holotype: ♀ SOUTH AFRICA: *KwaZulu-Natal*: Ladysmith District, 28°28'S 29°51'E, in humid soil and decomposed plant material under indigenous trees, 27.i.1982, C.M. Engelbrecht (NMBA 1888.12.1).

Paratypes: 14, same data as for holotype (5 NMBA, 5 SZMN, 4 PC).

Remarks: The new species is clearly distinguishable from the majority of its congeners by the morphology of sensilli. In having spindle-form sensilli, *E. spindleformis* sp. n. is similar only to *E. jyotsnai* Sarkar, 1991 from India and *E. spinosus* Ermilov & Anich-

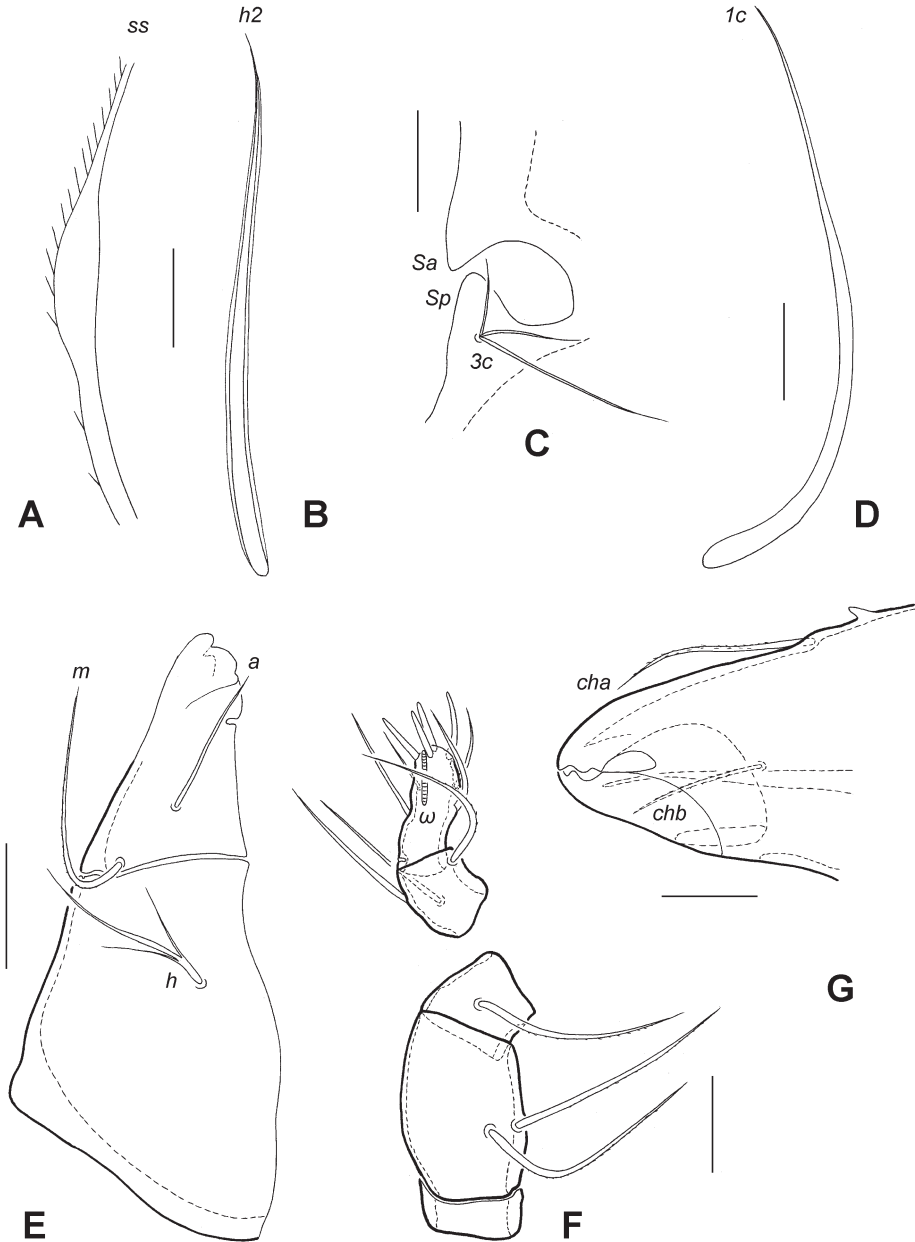


Fig. 2. *Eremulus spindleformis* sp. n.: (A) medial part of sensillus; (B) notogastral setae  $h_2$ ; (C) epimeral tubercles and seta  $3c$ ; (D) epimeral seta  $1c$ ; (E) subcapitulum, right half; (F) palp; (G) chelicera, anterior part. Scale bars A–D, F, G = 10  $\mu$ m; E = 20  $\mu$ m.

kin, 2011 from Vietnam. However, the new species is unlike *E. jyotsnai* in that it has long, setiform, distal parts of sensilli (short in *E. jyotsnai*), setiform notogastral setae (lanceolate in *E. jyotsnai*), interlamellar setae of medium size (very short in *E. jyotsnai*),

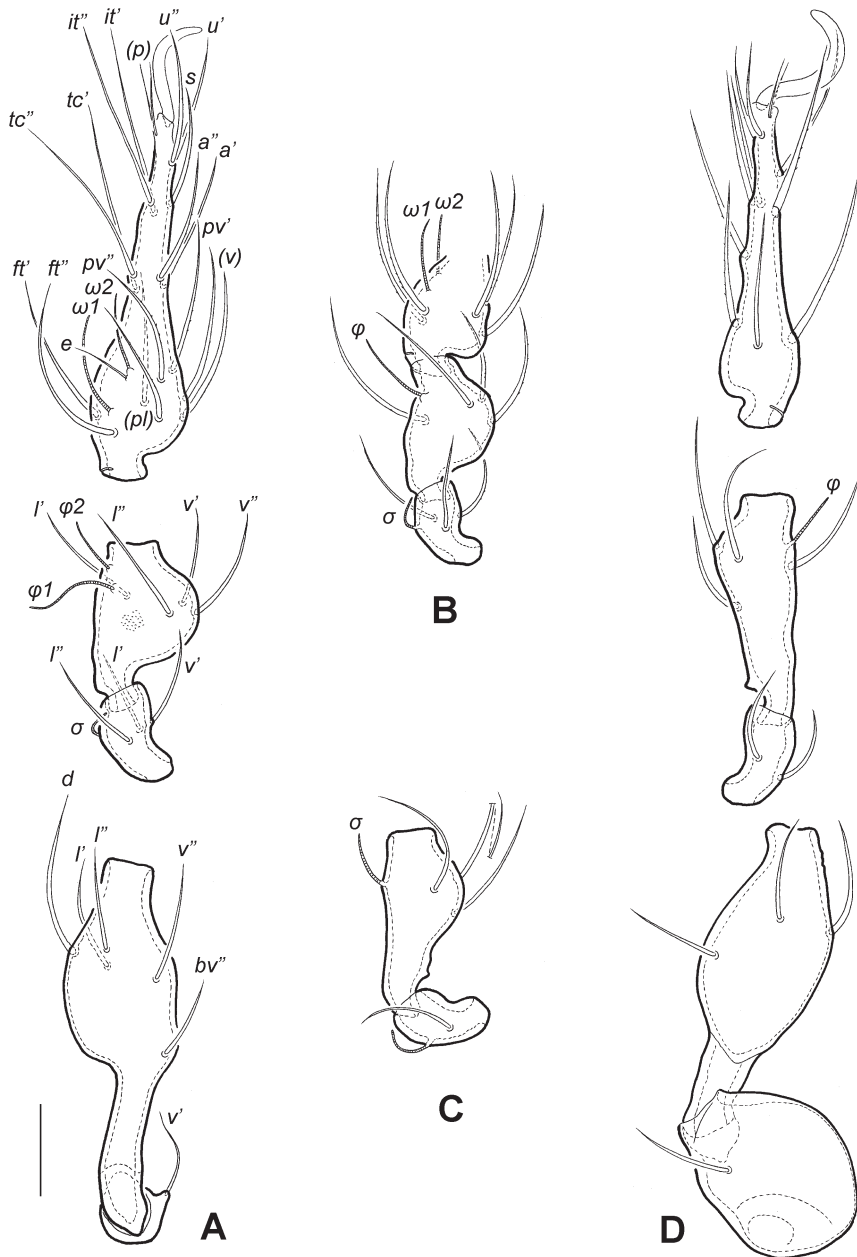


Fig. 3. *Eremulus spindleformis* sp. n.: (A) leg I, right, antiaxial view; (B) tarsus, tibia and genu of leg II, right, antiaxial view; (C) tibia and genu of leg III, left, paraxial view; (D) leg IV, right, antiaxial view. Scale bar = 20  $\mu$ m.

genital and aggenital setae branched (setiform in *E. jyotsnai*), and setiform epimeral setae *lc* (branched in *E. jyotsnai*). *E. spindleformis* sp. n. can be differentiated from *E. spinosus* by the larger body size (282–315×157–166 in *E. spinosus*), sensilli with short cilia (with strong spines in *E. spinosus*), and the medium size of the interlamellar setae (short in *E. spinosus*).

### ***Eremulus southafricanensis* sp. n.**

Fig. 4

Etymology: Named after the country of origin, South Africa.

Diagnosis: This species is distinguished from others by the following combination of characteristics: body size 514–547×282–325; rostrum weakly protruding anteriorly; transcostula present; prodorsal setae smooth; interlamellar setae similar in length to rostral and lamellar setae; sensilli flagelliform, ciliate; 11 pairs of notogastral setae, thin basally and widened medially, smooth; setae *lp* directed laterally, *h*<sub>1</sub> directed postero-medially; setae *lm* inserted below the level of insertions of *h*<sub>3</sub>; aggenital setae branched; adanal setae *ad*<sub>1</sub> and *ad*<sub>2</sub> longer than *ad*<sub>3</sub>; epimeral setae *lc* long and setiform.

Description:

*Measurements.* Body length 530 (holotype, female), 514–547 (mean 528, 12 paratypes); body width 303 (holotype, female), 282–325 (mean 301, 12 paratypes).

*Integument* (Fig. 4A). Body yellow-grey-brownish. Body and legs covered by secretion granules (diameter up to 2 µm). Prodorsum with foveolae. Foveolate band on notogaster with numerous foveolae. Foveolate band anterior to genital plates present. A small concave region is present between rows of notogastral setae *c* and *la*.

*Prodorsum* (Fig. 4A, C). Rostrum weakly protruding anteriorly. Costulae long, narrow, straight. Transcostula present. All prodorsal setae setiform, smooth, inserted on tubercles. Rostral, lamellar and interlamellar setae similar in length (57–65), exobothridial setae shorter (32–41). Rostral setae inserted in lateral position on prodorsum. Sensilli (168–176) flagelliform, covered by short cilia. Bothridial margins with teeth (visible under high magnification).

*Notogaster* (Fig. 4A, D). Anterior border straight. One pair of humeral condyles and cristae present, but they are not very obvious. Eleven pairs of notogastral setae (*p*<sub>3</sub> inserted in margino-ventral position) of medium size, approximately similar in length (57–69; only *p*<sub>1</sub> and *p*<sub>2</sub> a little longer, 69–77; and *p*<sub>3</sub> a little shorter, 53–57), thin basally and widened medially, curved in basal part, smooth. Setae *lp* always directed laterally and *h*<sub>1</sub> always directed postero-medially. Setae *lm* inserted behind the level of insertions of *h*<sub>3</sub>. Opisthonotal gland opening and lyrifissures located in arrangement typical for genus, but poorly visible.

*Anogenital region* (Fig. 4B). Six pairs of genital and three pairs of aggenital setae with two to five branches. Setae *g*<sub>1</sub> setiform, not branched or with one short cilium. Two pairs of anal (24–32) and three pairs of adanal (*ad*<sub>1</sub> and *ad*<sub>2</sub>, 57–69; *ad*<sub>3</sub>, 36–49) smooth, setiform setae. Adanal setae *ad*<sub>3</sub> distant from anal plates. Lyrifissures *iad* located in arrangement typical for genus.

*Epimeral region.* Similar to that of *E. spindleformis* sp. n. Shape and number of apodemes and epimeral borders typical for genus. Epimeral setal formula 3–1–3–3. Setae *lc* long

(57–69), setiform and smooth; all other setae with two to four branches. Two pairs of strongly developed tubercles, *Sa* and *Sp* present on epimeral region.

*Gnathosoma*. Similar to that of *E. spindleformis* sp. n. Subcapitulum longer than wide: 135–143×82–90. Hypostomal setae of different morphology: *h* branched, longest

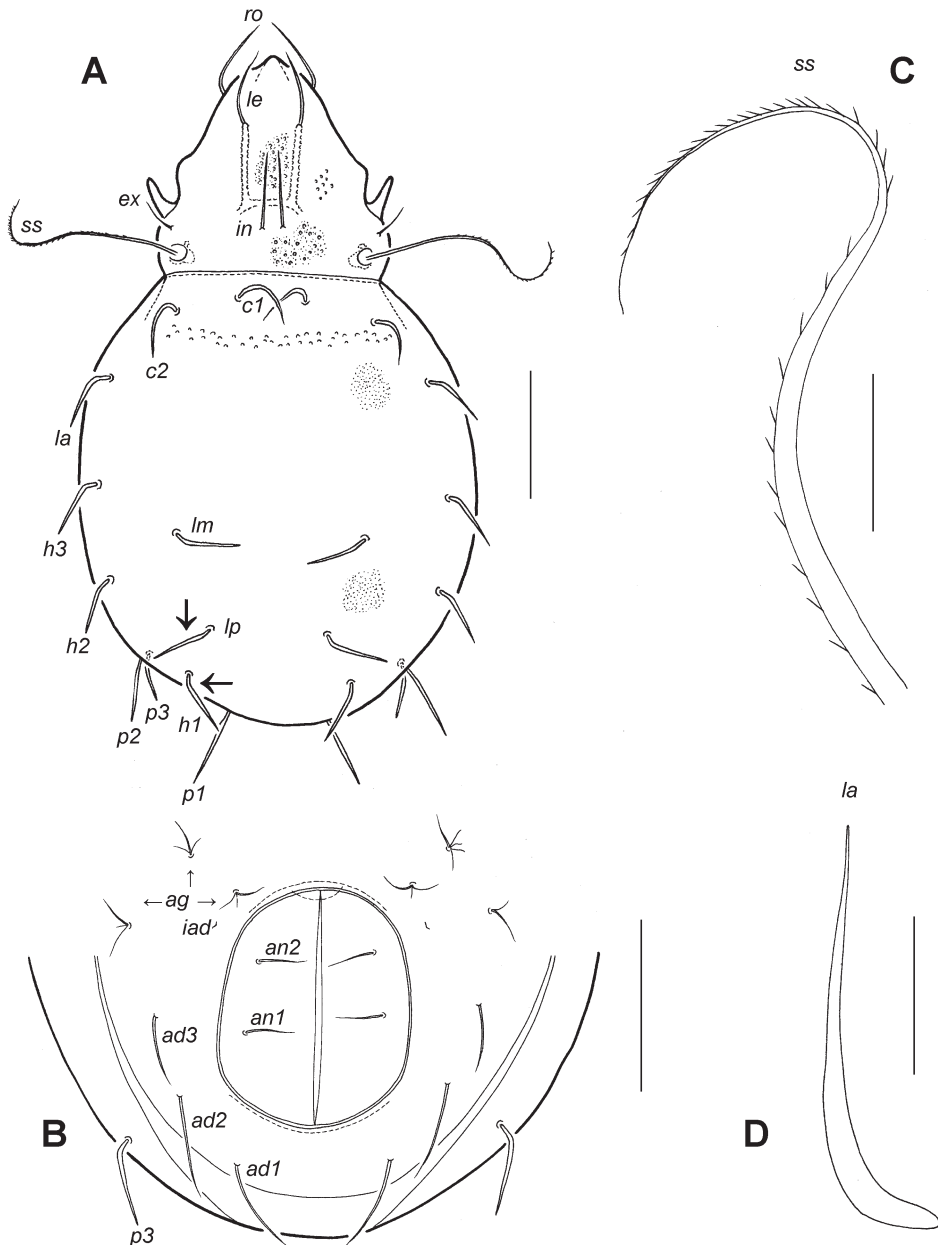


Fig. 4. *Eremulus southafricanensis* sp. n.: (A) dorsal view, legs not shown; (B) ano-aggenital region; (C) medio-distal part of sensillus; (D) notogastral seta *la*. Scale bars A, B = 100 µm; C, D = 20 µm.



TABLE 1

Leg setation and solenidia of *E. spindleformis* sp. n. (same for *E. southafricanensis* sp. n. and *E. flagellifer*). Roman letters refer to normal setae (*e* – famulus), Greek letters refer to solenidia. One apostrophe (') marks setae on anterior and double apostrophe (") setae on posterior side of the given leg segment. Parentheses refer to a pair of setae.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	<i>v</i> '	<i>d</i> , ( <i>l</i> ), <i>bv</i> "', <i>v</i> "	( <i>l</i> ), <i>v</i> ', $\sigma$	( <i>l</i> ), ( <i>v</i> ), $\phi_1$ , $\phi_2$	( <i>ft</i> ), ( <i>tc</i> ), ( <i>it</i> ), ( <i>p</i> ), ( <i>u</i> ), ( <i>a</i> ), <i>s</i> , ( <i>pv</i> ), ( <i>v</i> ), ( <i>pl</i> ), <i>e</i> , $\omega_1$ , $\omega_2$
II	<i>v</i> '	<i>d</i> , ( <i>l</i> ), <i>bv</i> "', <i>v</i> "	( <i>l</i> ), <i>v</i> ', $\sigma$	( <i>l</i> ), ( <i>v</i> ), $\phi$	( <i>ft</i> ), ( <i>tc</i> ), ( <i>it</i> ), ( <i>p</i> ), ( <i>u</i> ), ( <i>a</i> ), <i>s</i> , ( <i>pv</i> ), <i>l</i> "', $\omega_1$ , $\omega_2$
III	<i>l</i> ', <i>v</i> '	<i>d</i> , <i>l</i> ', <i>ev</i> '	<i>l</i> ', $\sigma$	<i>l</i> ', ( <i>v</i> ), $\phi$	( <i>ft</i> ), ( <i>tc</i> ), ( <i>it</i> ), ( <i>p</i> ), ( <i>u</i> ), ( <i>a</i> ), <i>s</i> , ( <i>pv</i> )
IV	<i>v</i> '	<i>d</i> , <i>l</i> ', <i>ev</i> '	<i>d</i> , <i>l</i> '	<i>d</i> , <i>l</i> ', ( <i>v</i> ), $\phi$	<i>ft</i> "', ( <i>tc</i> ), ( <i>p</i> ), ( <i>u</i> ), ( <i>a</i> ), <i>s</i> , ( <i>pv</i> )

branch 41–49; *m* (41–49) setiform, curved in basal part, slightly barbed; *a* (32–36) setiform and smooth. Adoral setae absent on lips. Palp (length 65–69) with setation 0–2–1–3–8(+1 $\omega$ ). Palpal setae (except tarsus) slightly barbed; solenidion thickened, pressed to palptarsus. Chelicera (135–143) with small tooth on dorsal side. Cheliceral setae long, setiform and barbed; *cha* (32–36) longer than *chb* (24). Tragardh's organ long, narrow, with thin distal part, blunt-ended.

*Legs*. Similar to those of *E. spindleformis* sp. n. Legs with one simple claw. Formulae for leg setation and solenidia: I (1–5–3–4–20) [1–2–2], II (1–5–3–4–16) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–3–2–4–12) [0–1–0]; homology of setae and solenidia indicated in Table 1. Setae smooth or slightly barbed unilaterally. Famulus short, setiform, inserted very close to solenidion  $\omega_2$ .

Holotype: ♀ SOUTH AFRICA: *Limpopo*: Lenyenye, 23°03'S 30°22'E, in dry loam soil with decomposed leaf litter under indigenous trees, 31.viii.1982, C.M. Engelbrecht (NMBA 2344.12.1).

Paratypes: 12, same data as for holotype (5 NMBA, 4 SZMN, 3 PC).

Remarks: *E. southafricanensis* sp. n. is clearly distinguishable from the other known species of this genus by the specific orientation of two pairs of notogastral setae (*lp* directed laterally and *h*<sub>1</sub> directed postero-medially).

### ***Eremulus flagellifer* Berlese, 1908**

Fig. 5

Diagnosis: This species is distinguished from others by the following combination of character states: body size 262–282×135–149; rostrum weakly protruding anteriorly; transcostula absent; prodorsal setae smooth; interlamellar setae shorter than rostral and lamellar setae; sensilli flagelliform, ciliate; 11 pairs of notogastral setae, medium size, setiform, with slightly curved tips, smooth; setae *lm* inserted slightly anterior to level of insertions of *h*<sub>3</sub>; aggenital setae branched; adanal setae *ad*<sub>1</sub> little longer than *ad*<sub>2</sub> and *ad*<sub>3</sub>; epimeral setae *lc* long, setiform.

Description:

*Measurements*. Body length 262–282 (mean 272); body width 135–149 (mean 139). *Integument* (Fig. 5A). Body yellow-grey-brownish. Body and legs covered by secretion granules (diameter up to 1  $\mu$ m). Posterior part of prodorsum and band on notogaster with few foveolae. Foveolate band over genital plates present. A small concave region present between rows of notogastral setae *c* and *la*.



Fig. 5. *Eremulus flagellifer*: (A) dorsal view, legs not shown; (B) ano-aggenital region; (C) medio-distal part of sensillus; (D) notogastral seta *la*. Scale bars A, B = 50  $\mu$ m; C, D = 10  $\mu$ m.

*Prodorsum* (Fig. 5A, C). Rostrum weakly protruding anteriorly. Costulae long, narrow, almost straight. Transcostula absent, but rudimentary sites present. Rostral (28–32), lamellar (28–32), interlamellar (18–22) and exobothridial (8) smooth, setiform setae, inserted on tubercles. Rostral setae inserted in dorso-lateral position on prodorsum. Sensilli (65–73) flagelliform, covered by short cilia. Bothridial margins with teeth (visible under high magnification).

*Notogaster* (Fig. 5A, D). Anterior border straight. One pair of inconspicuous humeral condyles and cristae present. Eleven pairs of notogastral setae ( $p_3$  inserted in margino-ventral position) medium size, similar in length (24–32; only  $p_3$  shorter, 16–20), setiform, with slightly curved tips, smooth. Setae *lm* inserted somewhat anterior to level of insertions of  $h_3$ . Opisthotal gland opening and lyrifissures located in arrangement typical for genus, but poorly visible.

*Anogenital region* (Fig. 5B). Six pairs of genital and three pairs of aggenital setae with two to five branches. Two pairs of anal (10–12) and three pairs of adanal ( $ad_1$ , 16–20;  $ad_2$  and  $ad_3$ , 12–16) smooth, setiform setae. Adanal setae  $ad_3$  inserted close to anal plates. Lyrifissures *iad* located in typical arrangement for genus.

*Epimeral region*. Similar to *E. spindleformis* sp. n. Shape and number of the apodemes and epimeral borders typical for the genus. Epimeral setal formula 3–1–3–3. Seta *1c* long (24–28), setiform, smooth or with one short cilium in basal part; all other setae with two to five branches. Two pairs of tubercles *Sa* and *Sp* present on epimeral region.

*Gnathosoma*. Similar to that of *E. spindleformis* sp. n. Subcapitulum longer than wide: 65–69×45–49. Hypostomal setae of different morphology: *h* branched, longest branch 20–22; *m* (20–22) setiform, curved in basal part, slightly barbed; *a* (12–14) setiform and smooth. Adoral setae absent on lips. Palp (length 69–73) with setation 0–2–1–3–8(+1 $\omega$ ). Palpal setae (except tarsus) slightly barbed; solenidion thickened, pressed to palptarsus. Chelicera (36–41) with very small tooth on dorsal side. Cheliceral setae long, setiform and barbed; *cha* (20–24) slightly longer than *chb* (12–16). Tragardh's organ long, narrow, with thin distal part, blunt-ended.

*Legs*. Similar to those of *E. spindleformis* sp. n. Legs with one simple claw. Formulae of leg setation and solenidia: I (1–5–3–4–20) [1–2–2], II (1–5–3–4–16) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–3–2–4–12) [0–1–0]; homology of setae and solenidia indicated in Table 1. Setae smooth or slightly barbed unilaterally. Famulus short, setiform, inserted very close to solenidion  $\omega_2$ .

Material examined: 30 specimens: SOUTH AFRICA: *KwaZulu-Natal*: Royal Natal National Park, 28°36'S 29°05'E, in humid soil and decomposed plant material, 14.xii.1982, C.M. Engelbrecht (NMBA 2905.15).

*Distribution*: This species was known from the Palaearctic, Nearctic, sub-Antarctic regions, north-eastern part of the Oriental region, Australia and the Republic of Congo.

*Remarks*: The characters of the specimens of *E. flagellifer* from South Africa are very close morphologically to the supplementary descriptions of this species (for example by Berlese 1908, 1910; Csiszár & Jeleva 1962; Hammer 1966; Mahunka & Mahunka-Papp 1995). However, *E. flagellifer* differs slightly from the specimens from other countries and geographical regions in respect of its smaller body size (smaller than 300  $\mu\text{m}$  in South African specimens versus larger than 300  $\mu\text{m}$  in the others), and localization of notogastral setae *lm* (inserted a little anterior to the level of setae  $h_3$  in South African specimens versus insertion obviously anterior to the level of setae  $h_3$  in the other specimens).

Key to African species of *Eremulus*

*E. africanus* Balogh, 1958 and *E. lanceocrinus* Balogh, 1958 are not included in this key because both species were described only very briefly. They have been noted as “*sp. inq.*” by Subías (2004, online version 2011).

- 1 Sensilli spindle-form ..... **spindleformis** sp. n.
- Sensilli of other forms ..... 2
- 2 Sensilli strongly widened medially ..... **csuzdii** Mahunka & Mahunka-Papp, 2009
- Sensilli flagelliform ..... 3
- 3 Notogastral setae thin basally and widened medially; setae *lp* and *h*<sub>1</sub> directed distinctively; interlamellar setae not shorter than lamellar and rostral setae ..... **southafricanensis** sp. n.
- Notogastral setae setiform; setae *lp* and *h*<sub>1</sub> not pointing in particular directions; interlamellar setae clearly shorter than lamellar and rostral setae ..... 4
- 4 Notogastral setae with flagellate tip; insertions of interlamellar setae obviously distant from each other ..... **adami** Balogh & Mahunka, 1966
- Notogastral setae without flagellate tip; insertions of interlamellar setae close together ..... **flagellifer** Berlese, 1908

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