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A new genus and species of Digamasellidae (Acari: Mesostigmata) displaying some extraordinary gnathosomal structures

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Original research

ABSTRACT

A new genus and species of digamasellid mites is described based on adult females and males. *Bulbolaelaps bossei* **n. gen., n. sp.** was collected from the fruiting bodies of gilled fungi on a tree trunk in Zanjan province, Iran. The new genus can be distinguished from the other genera of Digamasellidae by having a bulbous swollen protuberance on the venter of the palptrochanter; corniculi weakly formed and epistome weakly sclerotised; hypostomal setae *h1* and *h2* positioned more or less transversely; deutosternal groove narrow with limited number of denticles; ventral base of female cheliceral digit with a spine-like projection; and setae *ad1* and *pd1* tarsi II–IV narrowly lanceolate apically.

Keywords Gamasida; gilled fungi; Iran; Rhodacaroidea
Zoobank http://zoobank.org/44AF1A1E-DE98-40C7-9C18-E497FA14F849

Introduction

The family Digamasellidae was first erected by Evans (1957) and then fully defined by Lindquist (1975) based on a limited number of genera. For this family, Shcherbak (1980) recognised eight genera – *Dendrolaelaps* Halbert, 1915, *Dendrolaelaspis* Lindquist, 1975, *Dendroseius* Karg, 1965, *Insectolaelaps* Shcherbak, 1980, *Longoseius* Chant, 1961, *Multidendrolaelaps* Hirschmann, 1974, *Oligodentatus* Shcherbak, 1980, and *Orientolaelaps* Bregetova & Shcherbak, 1977. The classification of Digamasellidae attributed to Shcherbak (1980) does not include the type genus *Digamasellus*. In his unpublished thesis, Castilho (2012) presented a key for the 11 genera of Digamasellidae and added *Digamasellus* Berlese, 1905, *Panteniphis* Willmann, 1949, *Pontiolaelaps* Luxton, 1984 to those of Shcherbak (1980). Castilho *et al.* (2012) listed 13 genera considering *Dendrolobatus* Shcherbak, 1983 and *Lindquistoseius* Genis, Loots & Ryke, 1968 as valid genera. They briefly defined the family Digamasellidae as:

With two-tined palp tarsal claw; *most genera with podonotal and opisthonotal shields separated*; *generally with scleronoduli*; *without desclerotised punctae bands on dorsal and ventral shields*; *with seta St4 on sternal shield*; *tibia I with 5 dorsal setae*; *and genu and tibia IV with 6 to 8 setae each*.

Members of the family Digamasellidae are mainly found in decaying organic material, on the soil surface, in galleries of bark beetles, under bark of trees, manure, and in bracket fungi

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where they feed on small arthropods, nematodes and even fungi. Deutonymphs of some species are phoretic on insects (Karg, 1993; Lindquist *et al.*, 2009). The purpose of this study is to described a new genus and species of digamasellid mite found in association with gilled fungi from Iran.

Material and methods

Mites were collected by direct removal from gilled fungi and then preserved in 70% ethanol. Specimens were cleared in a mixture of Nesbitt and lactophenol solutions 1:1, and mounted in modified Hoyer's medium as described by Faraji & Bakker (2008). Specimens were examined using a Leica DM 2500 light microscope equipped with differential interference contrast (DIC) and drawings were made with the aid of a camera lucida (drawing tube) attached to an Olympus phase contrast microscope. All measurements are in micrometres (µm). Fixed cheliceral digit measured from the anterior part of dorsal lyrifissure to apical hook. The mean of the measurements is given followed by the range in parentheses. The setal notations for the idiosoma follow Lindquist & Evans (1965), and leg chaetotaxy follows Evans (1963). Notations of idiosomal solenostomes (pore-like structures) as well as lyrifissures (poroids) follow Athias-Henriot (1975).

The type specimens are deposited in ANIC = Australian National Insect Collection, CSIRO, Canberra, Australia; BMNH = Natural History Museum, London; JAZM = Jalal Afshar Zoological Museum, Iran; SMNG = Senckenberg Museum of Natural History, Görlitz and OSAL = Ohio State Acarology Collection.

Results

Digamasellidae Evans, 1957

Bulbolaelaps n. gen.

Zoobank: E66CAB95-8D7E-41C3-8AE1-2F083488D393

Type species: *Bulbolaelaps bossei*

Diagnosis Podonotal and opisthonotal shields separated in both sexes; in males, opisthonotal shield fused with opisthogastric shield; scleronoduli present; almost all dorsal shield setae barbed (except *S5*, long, simple and mainly coiled), most of them apically bulbous; sternal seta *St3* migrated inwards; palps with bulbous swollen protuberance on the venter of the palptrochanter; corniculi weakly formed and epistome weakly sclerotised and fimbriated dorsally; hypostomal setae *h1* and *h2* aligned more or less transversely; deutosternal groove narrow; ventral base of female cheliceral digit with a spine-like projection; setae *ad1* and *pd1* on legs II–IV narrowly lanceolate apically.

Etymology The generic name *Bulbolaelaps* refers to the extraordinary bulbous shape of the protuberance on the venter of the palptrochanter.

Bulbolaelaps bossei n. sp.

Zoobank: D30B10CD-1081-4556-B9E3-94A09756195F

(Figs 1–5)

Description

Adult Female — seven specimens measured.

(Figs 1, 3A–D, 4A–C, E–G and 5)

Dorsal idiosoma (Fig. 1A). Relatively large mite, idiosoma 737 (723–756) long and 512 (505–524) wide; podosomal and opisthosomal shields separated and entirely reticulated; podonotal shield 297 (288–303) long and 421 (418–225) wide (at widest point: level of setae

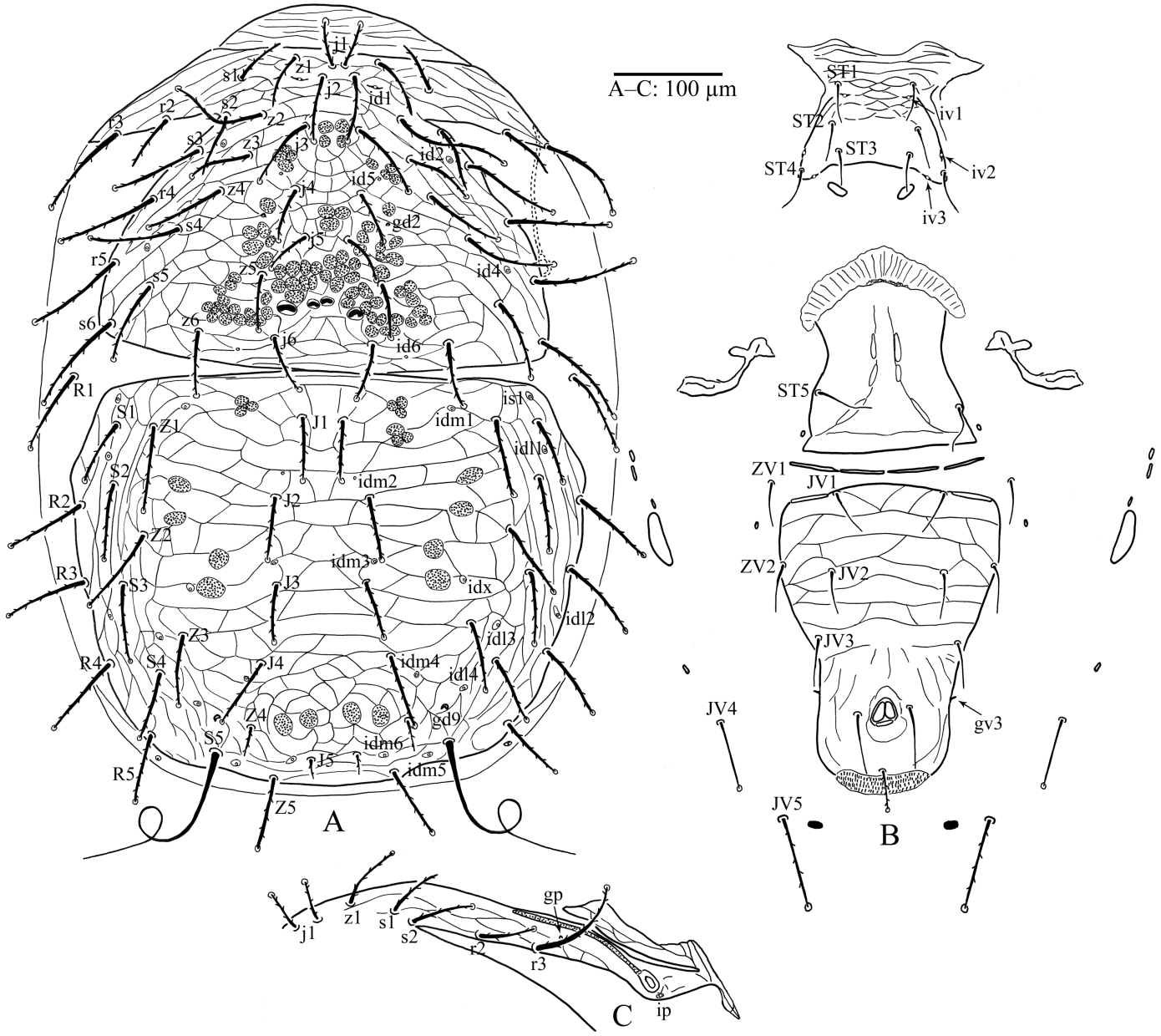


Figure 1 ***Bulbolaelaps bossei*** **n. gen., n. sp.** (Female): A – Idiosoma, dorsal view; B – Idiosoma, ventral view; C – Peritreme, peritrematal plate, exopodal plate and anterior part of opisthonotal shield.

s6) with 22 pairs of setae, all setae barbed and mostly knobbed apically (except for *z1*, *s1*, *s2* and *r2* with either pointed or knobbed tip); lengths of podonotal setae: *j1* 37 (35–39), *j2* 57 (54–60), *j3* 71 (65–76), *j4* 48 (46–52), *j5* 45 (43–47), *j6* 57 (55–58), *z1* 50–51, *z2* 90 (88–92), *z3* 57 (54–60), *z4* 71 (66–77), *z5* 53–54, *z6* 60 (59–62), *s1* 50 (47–52), *s2* 57 (55–60), *s3* 85 (81–87), *s4* 83 (81–85), *s5* 90 (85–95), *s6* 107 (104–112), *r2* 56 (54–58), *r3* 103 (101–106), *r4* 91 (88–94), *r5* 102 (100–104), prepodonotal area (anterior to *j1* setae) weakly sclerotised 37–38 long; podonotal shield with one pair of solenostomes (*gd2*) and 5 pairs of poroids (*id1*, *id2*, *id4*, *id5*, *id6*) as well as two pairs of relatively large scleronoduli between setae *z5* and *j6*; opisthonotal shield 383 (380–385) long and 478 (473–485) wide (at widest point) with 19

pairs of barbed setae (except for *S5* long, simple and coiled, mostly with one loop, occasionally with two loops or none but with irregular shape), mostly apically knobbed (except for *Z4* and *J5*); lengths of opisthonotal setae: *J1* 60–61, *J2* 61 (57–64), *J3* 59 (57–61), *J4* 72 (68–74), *J5* 22–23, *Z1* 88 (87–90), *Z2* 87 (85–88), *Z3* 77 (73–81), *Z4* 32, *Z5* 71 (67–79), *S1* 63 (62–65), *S2* 89 (85–93), *S3* 86 (81–88), *S4* 67 (63–73), *S5* 254 (239–284), *R2* 82 (76–90), *R3* 84 (79–93), *R4* 83 (79–90), *R5* 68 (66–69); *R1* 94 (88–103) on lateral integument; opisthonotal shield with 1 pair of solenostomes (*gd9*) and 12 pairs of poroids (*idm1*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idx*, *idl1*, *idl2*, *idl3*, *idl4*).

Peritreme and peritrematal shield (Fig. 1C). Peritrematal shield reticulated fused anteriorly with podonotal shield and extending posteriorly behind coxa IV carrying setae *r2*, *r3*, poroid *ip* and gland *gp*; peritreme relatively short 151 (144–158) long, extending forward to level of mid coxa II.

Ventral idiosoma (Figs 1B, 4G). Tritosternum (Fig. 4G) 145 (140–147) long with laciniae serrated subapically free for *ca*. one third of the length; presternal area without any plate, ornamentation or patches of striae; sternal shield weakly sclerotised with striae and reticulations on its anterior half, posterior margin slightly concave, 91 (88–98) long and 131 (128–136) wide at level of setae *St3*, with four pairs of setae and three pairs of lyrifissures (*iv1*, *iv2* and *iv3*); *St1* 36–38, *St2* 35–39, *St3* 36–39, *St4* 41–46; *St2* and *St3* slightly thicker than *St1* and *St4*; *St3* migrated inwards; two small platelets positioned on soft cuticle posterior to sternal shield; a pair of endopodal plates situated between coxae III–IV and genital shield; genital shield relatively short, width at widest point (posterior margin) 157 (153–161), *St5* 44–46 and *iv5* off the shield; one pair of metapodal shields 53–63 x 12–13 associated with three small platelets posterior to coxa IV; ventrianal shield pear-shaped with transverse striae and reticulations on anterior half, length 291 (289–295), width at level of setae *Zv2* (widest point) 203 (199–207); with four pairs of pre-anal setae (*Jv1* 42–44, *Jv2* 39–43, *Jv3* 43–44, *Zv2* 44–46), para-anal setae 60 (57–65) and post-anal seta 42 (41–44), all ventrianal setae simple except post-anal seta knobbed apically and barbed; solenostomes *gv3*, rod-like flanking ventrianal shield level with anterior margin of anal opening; three pairs of setae surrounding ventrianal shield on integument *Zv1* simple *Jv4* knobbed apically and *Jv5* knobbed apically and barbed (*Jv4* 65–72, *Jv5* 94 (92–98), *Zv1* 41–43), three pairs of poroids (*ivo*) surrounding ventrianal shield.

Spermathecal apparatus. Not distinct; location of solenostome not discernible.

Gnathosoma. Corniculi (Plate 5D) weakly formed/sclerotised and difficult to detect; internal malae (Plate 5E) lanceolate and ventrally with spiculi; salivary stylets (Plate 5C) narrow, not sclerotised, and apically flatten; cheliceral digits relatively short, fixed digit 27–28 long, subapical ridge with two small teeth and apical hook and a pilus dentilis; movable digit 35–36 long with four teeth (two distal teeth are smaller), ventral base of female cheliceral digit with a paraxial spine-like projection (Figs 4A and B); deutosternum weakly developed and narrow with five transverse rows, most distal one smooth, three middle ones each unidentate, proximal row much wider and multidenticulate (Fig. 4F); hypostomatic setae *h3* 43–44 longer than *h1* 21–22, *h2* 24–25 and palpcoxal seta *pc* 35–36, *h1* and *h2* more or less transversely aligned; epistome triangular fimbriated dorsally, weakly sclerotised and difficult to detect (Fig. 4C, plate 5B); palpus 125 (124–127) long; number of setae on trochanter, femur, tibia and tarsus: 2, 5, 6, 7 and 14, respectively; venter of palptrochanter with a bulbous swollen protuberance (Fig. 4E, Plate 5A). Ventrolateral surface of papltrochanter split longitudinally, the split flanked with sclerotised lips, and a bulbous swollen protuberance emerging from the split.

Legs. Legs I–IV with paired claws and rounded pulvilli, lengths of legs: leg I 464 (460–466), leg II 401 (398–403), leg III 416 (403–425), leg IV 495 (487–509), all legs shorter than idiosoma; setation of legs I–II–III–IV: coxae 2–2–2–1, trochanters 6–5–5–5, femora 13–11–6–6, genua 12 (2 3/2 2/1 2) – 11(2 3/1 2/1 2) – 9 (2 2/1 2/1 1) – 7 (1 2/1 2/0 1), tibiae 12 (2 3/2 2/1 2) – 10 (2 2/1 2/1 2) – 8 (2 1/1 2/1 1) – 7 (1 1/1 2/1 1), tarsi II–IV with 18 setae; all setae aciculate except *ad1* and *pd1* on tarsi II–IV narrowly lanceolate apically (Plate 5F) and ventral setae of femora, genua and tarsi on legs II–IV slightly thickened (Figs 3A–D).

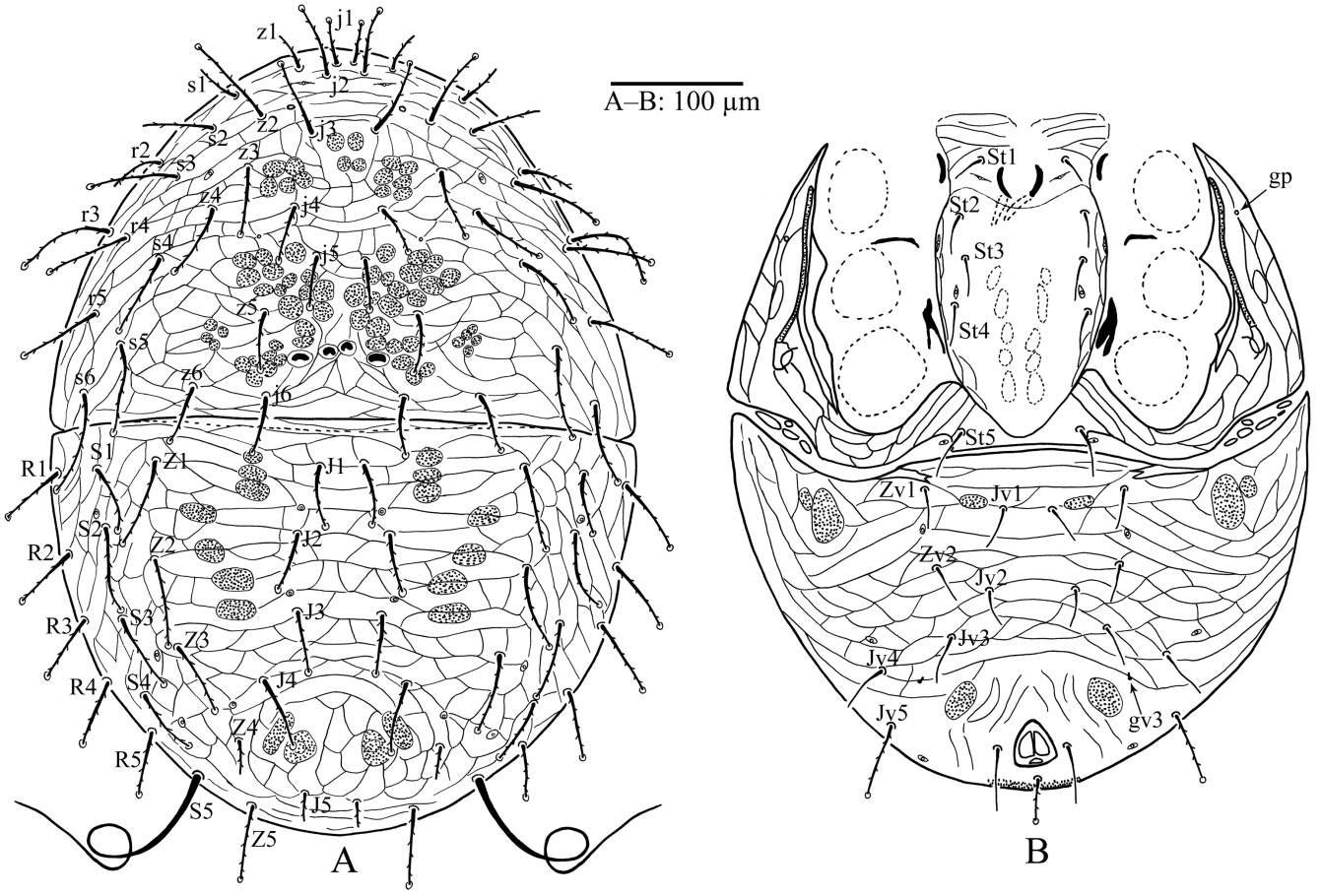


Figure 2 ***Bulbolaelaps bossei*** **n. gen., n. sp.** (male): A – Idiosoma, dorsal view; B – Idiosoma, ventral view.

Adult male — Seven specimens measured.

(Figs 2, 3E, 4D and 4H)

Dorsal idiosoma (Fig. 2A). Idiosoma 629 (616–635) long and 457 (456–460) wide; podonotal and opisthosomal shields more or less similar to those of females, but slightly wider so to bear *r2*, *r3* and *R1*; podonotal shield 306 (293–313) long and 452 (445–455) wide (at widest point: level of setae *s6*); lengths of podonotal setae: *j1* 36 (35–38), *j2* 52 (51–53), *j3* 58 (56–60), *j4* 45 (44–46), *j5* 42 (41–43), *j6* 48–49, *z1* 42 (41–43), *z2* 72 (70–74), *z3* 50 (48–51), *z4* 64 (61–67), *z5* 49–50, *z6* 51 (51–53), *s1* 38 (36–40), *s2* 47 (46–47), *s3* 69 (66–71), *s4* 66 (60–70), *s5* 72 (68–77), *s6* 75–76, *r2* 44 (40–49), *r3* 87–88, *r4* 69 (67–71), *r5* 67 (66–68); opisthonotal shield 335 (320–343) long and 452 (448–455) wide (at widest point: level of setae *S1*) with 20 pairs of setae (*R1* on the shield); lengths of opisthonotal setae: *J1* 51–52, *J2* 51–52, *J3* 49–50, *J4* 58 (57–59), *J5* 22 (21–23), *Z1* 64 (63–66), *Z2* 69 (67–71), *Z3* 60–61, *Z4* 26 (25–28), *Z5* 62–63, *S1* 46–47, *S2* 67–68, *S3* 65–66, *S4* 52–53, *S5* 250 (228–269), *R1* 58–59, *R2* 53–54, *R3* 52–53, *R4* 55 (51–58), *R5* 45 (42–46).

Peritreme and peritrematal shield. Peritreme as in female 166 (150–175) long, peritrematal shield fused anteriorly and laterally with podonotal shield, and extending posteriorly behind coxa IV merging with triangular parapodal shields at level of setae *St5*.

Ventral idiosoma (Fig. 2B). Tritosternum 108 (106–111) long; sternogenital shield with some striae anteriorly and laterally, 243 (241–246) long and 136 (131–144) wide at level of setae *St3*, with four pairs of setae and three pairs of lyrifissures, *St1* 36–38, *St2* 34–36, *St3* 38, *St4* 42–43; *St5* 44–49 on a separate triangular parapodal shields fused with peritrematal

shield; soft lateral cuticle between peritrematal shield and ventrianal shield with 4–6 pairs of small platelets; ventrianal shield reticulated, length 282 (261–296), width at widest point 445 (440–450); with seven pairs of pre-anal opisthogastric setae, all simple except *Jv5* barbed and apically knobbed (*Jv1* 36–39, *Jv2* 36–43, *Jv3* 36–43, *Jv4* 46–51, *Jv5* 55–61, *Zv1* 38–39, *Zv2* 40–43); para-anal setae simple 55 (52–57) and post-anal seta barbed and apically knobbed 37 (32–39).

Gnathosoma. Corniculi, epistome (Fig. 4D), deutosternum and internal malae as in female; fixed cheliceral digit 31–32 long with one tooth and apical hook and pilus dentilis; movable digit 40–43 long with a single tooth (Fig. 4H); spermatodactyl stout, curved dorsally and apically pointed 46–49 long; palpus similar to that of females showing venter of palptrochanter with a bulbous swelling protuberance.

Legs. Lengths of legs: leg I 497 (486–510), leg II 418 (402–433), leg III 429 (420–442), leg IV 513 (505–518), setation of legs I–IV and form of setae on legs I, III and IV as in female; leg II showing sexual dimorphism, femur with seta *av1* markedly enlarged spinelike and blunt with partial circular ribbing pattern, *av1* genu, tibia and *mv* tarsus also thickened and blunt but shorter than on femur (Fig. 3E).

Etymology The specific name *bossei* is after Mr. Theo Bosse, the facility manager of Eurofins MITOX BV, who has kindly supported and provided the senior author with research tools, equipment and chemicals during many studies.

Type material and depository Holotype female, 22 July 2011, from fruiting bodies of wet gilled fungi (possibly a species of *Pleurotus* sp., fam. Pleurotaceae) on a tree trunk, Chiyar, Zanjan Province, Iran (36°43′47.1″N 48°18′28.6″E), deposited in JAZM, collector: Mohsen Zare; six females and eighteen males, same data as holotype: one paratype female and four paratype males deposited in JAZM; two paratype females and four paratype males deposited in ANIC; one paratype female and three paratype males deposited in SMNG; one paratype female and three paratype males deposited in BMNH; one paratype female and three paratype males deposited in OSAL.

Remarks The new genus mainly differs from the other genera of Digamasellidae by the following apmorphic attributes: (1) a bulbous (membranous) swollen protuberance at the venter of the palptrochanter. This feature is unique in the family Digamasellidae. A similar feature "membranous flap" was reported by Costa (1968), Moraza (2019) and Nemati *et al.* (2019) for the genus *Reticulolaelaps* Costa (Laelapidae). By dissecting the palps, Nemati *et al.* (2019) showed that membranous flap was connected to the inner part of the palptrochanter, more or less the same location as for the new genus here. The swollen protuberance in *Bulbolaelaps* is three-dimensional and kept its shape even after re-mounting and for a dissecting the specimen. For *Reticulolaelaps* the membranous flap might have been three-dimensional in living individuals but after mounting and dissecting it became flattened. (2) Corniculi weakly formed and epistome weakly sclerotised. Even with a DIC microscope and with dissected specimens, these two features are not easy to observe. Corniculi of the other genera of digamasellids are well sclerotised and mainly horn-like (bifid in the male of *Longoseius* Chant, 1961 and with a curved groove in the male of *Panteniphis* Willmann, 1949). The epistome of ***Bulbolaelaps* n. gen.** is triangular and fimbriated dorsally while the other genera have epistome mainly triramous or occasionally biramous (in *Longoseius*). *Orientolaelaps* Bregetova & Shcherbak, 1977 shows a triangular shape but in fact it can be considered triramous with reduced median and lateral tines; (3) Hypostomal setae *h1* and *h2* more or less transversely aligned. In all other genera of digamasellids, seta *h1* is positioned far anterior to seta *h2*; (4) Deutosternal groove narrow and weakly developed with four transverse rows of denticles, the most distal one smooth, the three middle ones each unidentate, the proximal row much wider and multidenticulate. In all other genera of digamasellids the deutosternum has a relatively wider groove with five (rarely six) rows of denticles with the proximal row much widened; (5) Ventral base of female cheliceral digit with a spine-like projection. In the other genera of Digamasellidae this projection does not exist; (6) Setae *ad1* and *pd1* on tarsi II–IV narrowly lanceolate apically. This feature is not present in any other digamasellid genera or other closely related families; and (7) All

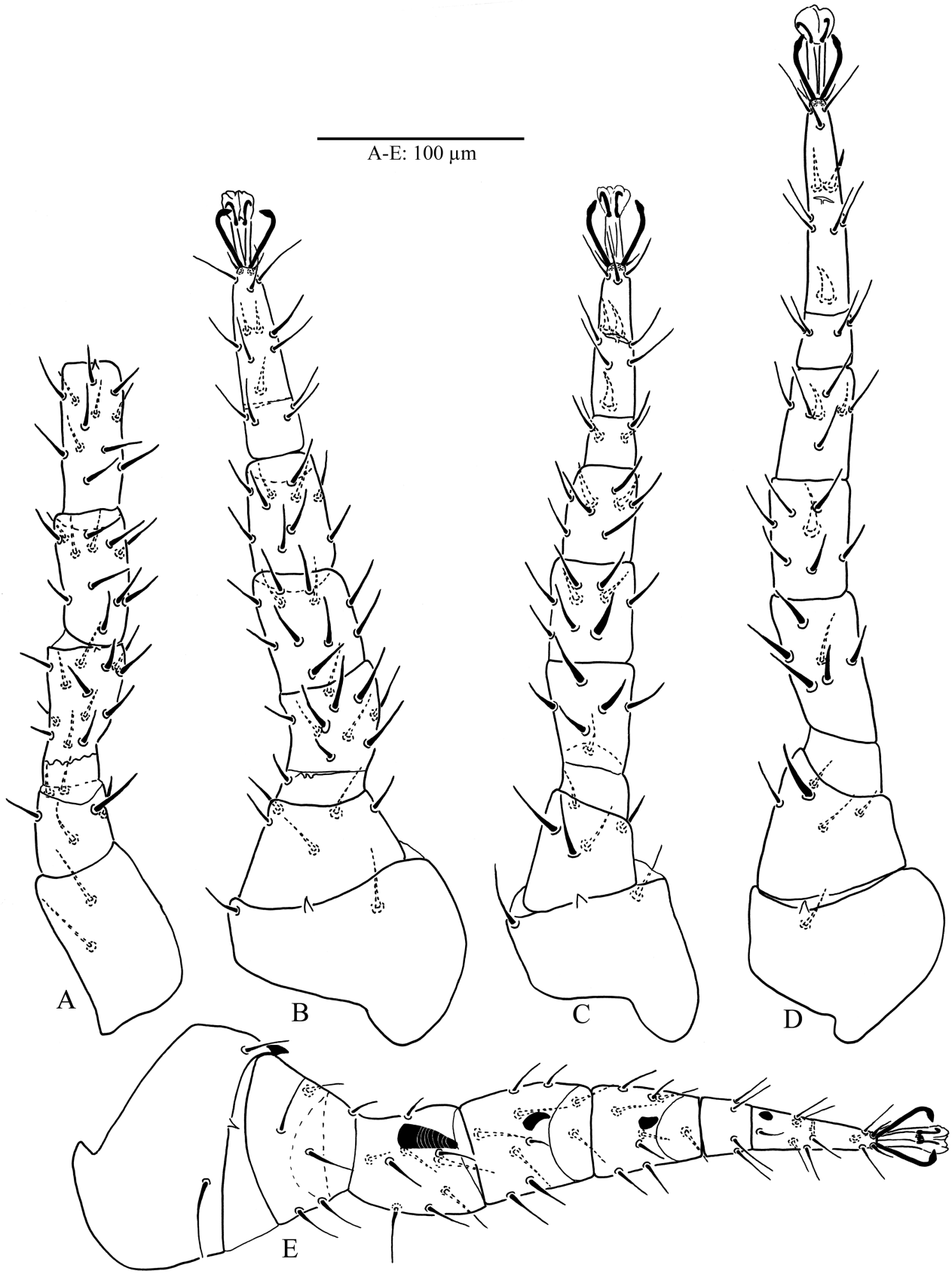


Figure 3 ***Bulbolaelaps bossei*** **n. gen., n. sp.** (Female): A – Leg I (tarsus not depicted); B – Leg II; C – Leg III; D – Leg IV; (male): E – Leg II.

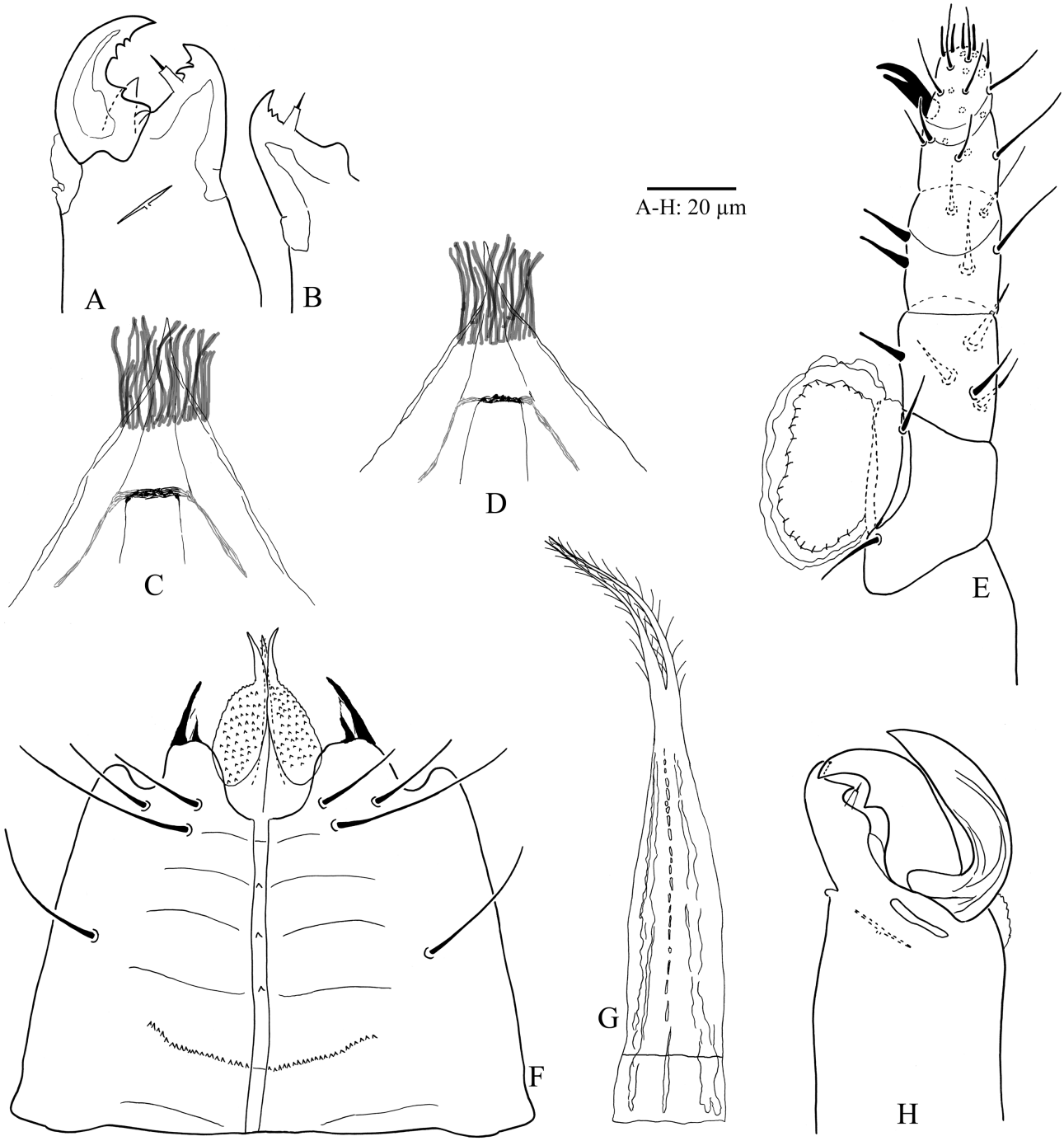


Figure 4 ***Bulbolaelaps bossei*** **n. gen., n. sp.** (female): A and B – Chelicerae; C – Epistome; E – Palp, ventral view; F – Hypostome; G – Tritosternum; (male): D – Epistome; H – Chelicera.

dorsal shield setae barbed, and most knobbed apically. This feature does not exist in any other digamasellid genera except *Dendrolaelaspis* Lindquist, 1975, which shows some posterior opisthonotal setae stout, spatulate and a few setae serrate and *Dendrolaelaps quadritorus* (Robillard) shown to have two pairs of opisthonotal setae stout, spatulate (Lindquist 1975; Robillard 1971).

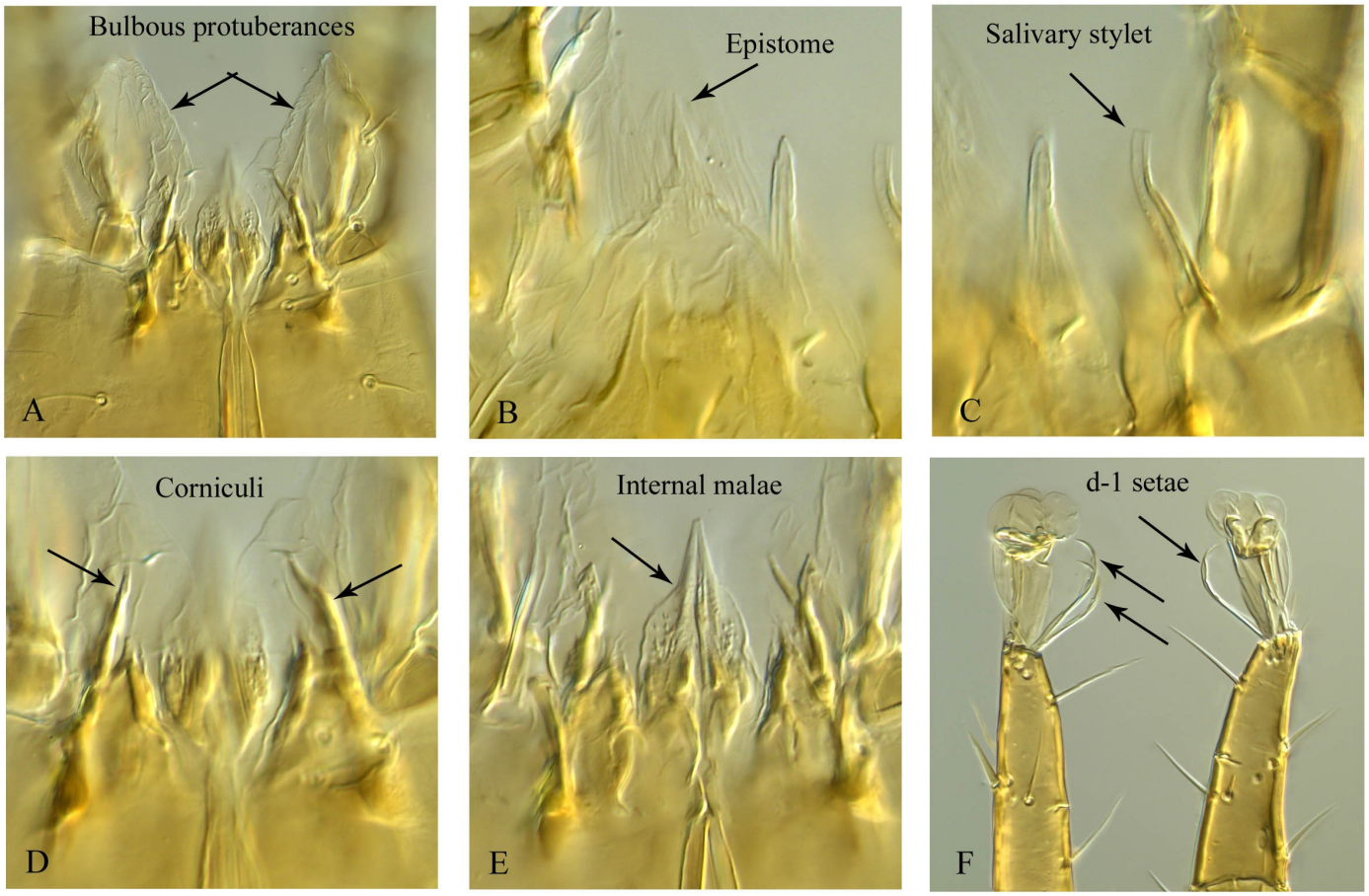


Figure 5 ***Bulbolaelaps bossei*** **n. gen., n. sp.** (female): Gnathosoma: A – Bulbous protuberances; B – Epistome; C – Salivary stylets; D – Corniculi; E – Internal malae; Legs: F – tarsi II (right-hand side) and Tarsus III (left-hand side), photomicrographs without scale bar.

Discussion and conclusion

According to the key to families of order Mesostigmata (Lindquist *et al.*, 2009) as well as definitions provided by Lindquist (1975), Shcherbak (1980) and Castilho *et al.* (2012), we have placed ***Bulbolaelaps bossei*** **n. sp.** in the family Digamasellidae based on the following key morphological characters: Dorsal shield divided; two pairs of scleronoduli present; *S5* long and coiled; females with four pairs of setae and three pairs of poroids on the sternal shield; palptarsal apotele 2-tined; basal row of deutosternal denticles greatly widened and more multidenticulate; 13 setae on femur I; 12 setae on each of genu and tibia I, and seven setae on each genu and tibia IV; males with setae *St5* on separate triangular parapodal shields; ventrianal shield of males merged laterally and posteriorly with opisthonotal shield; and femur, genu, tibia and tarsus of leg II in males each with ventral setae thickened and robust.

There are some key morphological characters in Digamasellidae to separate genera and to propose sister groups. These are: the basal row of deutosternal denticles being greatly widened and more multidenticulate, the male setae *St5* on separate triangular parapodal shields, dorsal shields separated, presence of scleronoduli, location of spermathecal opening (coxa III or IV) and anterior migration of the opisthonotal shield without median notch. The first two characters seem to be strong apomorphic traits at the family level. Unfortunately, males of a few genera have not been described yet. Also, the location of spermathecal solenostome in ***Bulbolaelaps*** **n. gen.** is not known. Considering these characters, ***Bulbolaelaps*** **n. gen.** can be grouped with *Insectolaelaps* Shcherbak, 1980, *Multidendrolaelaps* Hirschmann, 1974 and *Oligodentatus*

Shcherbak, 1980.

Because only the adults were collected from the fruiting bodies of gilled fungi, we are not confident about the true habitat of this species. The apparent absence of the juveniles from the fungi might suggest another habitat for development of juveniles. If immatures also inhabit fungi, their absence may be explained by two reasons: the collector picked up the large individuals (adults) which with naked eyes were easily detectable or almost all immatures had already reached to adulthood before the moment of sampling. The presence of a bulbous (membranous) swollen protuberance on the venter of the palptrochanter may be an adaptation for optimal feeding. This protuberance is located exactly in front of hypostomatic setae *h1* and *h2*. Migration of seta *h1* backwards might be an adjustment for the presence of this protuberance. It will be interesting to find whether juveniles show this feature as well. The reduced form of corniculi, which are to the contrary stronger among some gamasines associated with fungi, may indicate this species as a liquid feeder. As a matter of fact, some gilled fungi exude beads of moisture, called guttation (Parmasto and Voitk, 2010). Interestingly, this species was collected from gilled fungi completely covered by moisture and individuals were walking easily on the wet surface. It is possible that the gnathosoma has evolved in a way to consume guttated drops. On the other hand, the chelicerae of this species look very robust suitable for crushing fungal hyphae rather than sucking fluids. Catching live individuals and rearing them in the laboratory would solve feeding habits of this species.

Having most of dorsal shield setae relatively long, barbed and knobbed apically as well as modified form of apical setal pair d-1 of tarsi II-IV may give the mite an advantage to move freely among fungal gills as well as acting as tactile sensory giving information about the location of gills.

Dispersal of this species is another interesting topic that needs a further investigation, with the deutonymph being the phoretic instar in digamasellids. Thunes *et al.* (2000) found 36 species of beetles associated with a fungus (*Fomitopsis pinicola*) in a Norwegian spruce forest, and Yamashita *et al.* (2015) reported 82 coleopteran species associated with bracket fungi in a Bornean tropical rain forest. It is possible that deutonymphs of this new species uses adult coleopteran species for dispersal to new habitats.

A revision of the genera of Digamasellidae is still required especially for the status of the two enigmatic genera of *Panteniphis* and *Pontiolaelaps*. The definition for the family Digamasellidae should also be widened based on the new discoveries in this study. A comprehensive study including molecular research is needed to determine the phylogenetic relationship among digamasellid genera.

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