Zootaxa 4717 (1): 085–103
https://www.mapress.com/j/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4717.1.8
http://zoobank.org/urn:lsid:zoobank.org:pub:9552345D-8C1E-4E3F-9016-48CF88737A98

Ontogeny of morphological traits in *Oribatella palustris* Hammer, 1962, with remarks on juveniles of Oribatellidae (Acari: Oribatida)

BADAMDORJ BAYARTOGTOKH[1,*] & SERGEY G. ERMILOV[2]
[1]*Department of Biology, School of Arts and Sciences, National University of Mongolia, Ulaanbaatar, Mongolia (e-mail: bayartogtokh@num.edu.mn)*
[2]*Tyumen State University, Tyumen, Russia (e-mail: ermilovacari@yandex.ru);*
[*]*corresponding author (e-mail: bayartogtokh@num.edu.mn, tel. (976)-11-325-435)*

Abstract

In this work, the larva and tritonymph of *Oribatella palustris*, an Antarctic and Subantarctic species of the Neotropical region are investigated along with supplementary re-description of adults. Comparative characteristics of juveniles of Oribatellidae, especially larvae and tritonymphs, are given based on this study and available literature sources; keys for identification of larvae and tritonymphs of *Oribatella* are also presented. Previous record of *Oribatella palustris* from a tropical island of Mexico is questioned.

Key words: Oribatellidae, comparative analysis, morphology, ontogeny, juvenile instars

Introduction

The genus *Oribatella* Banks, 1895 (family Oribatellidae) is one of the species-richest genera of oribatid mites with a worldwide distribution, and presently comprises 135 species, including two subspecies (Subías 2019). According to Subías (2004, 2019), *Oribatella* encompasses seven subgenera, however, Ermilov and Behan-Pelletier (2014) considered two taxa, *Fberninia* Özdikmen, 2008 and *Fenestoribates* Balogh & Mahunka, 1969 as independent genera, which have been treated previously as subgenera of *Oribatella*. Furthermore, these authors suggested moving two other genera, which have been assigned to Oribatellidae, *Cuspidozetes* Hammer, 1962 and *Novoribatella* Engelbrecht, 1986 to Ceratozetidae and Tegoribatidae, respectively.

Oribatella has been intensively studied in Europe (e.g. Bernini 1974, 1975, 1977, 1978; Bernini & Avanzati 1983; Pérez-Iñigo 1988, 1989; Weigmann 2001; Shtanchaeva & Subías 2009) and North America (e.g. Behan-Pelletier & Eamer 2010; Behan-Pelletier 2011; Behan-Pelletier & Walter 2012; Seniczak & Seniczak 2013), and therefore, the temperate regions of the Palaearctic (71 spp.) and Nearctic (34 spp.) regions show much higher diversity of *Oribatella* than other biogeographical realms. This genus has also a relatively high diversity in the Neotropical and Oriental regions, where 20 and 15 species have been found, respectively (Ermilov & Anichkin 2012; Subías 2019). The other biogeographical realms have very low diversity of *Oribatella*, where only four species have been recorded in the Afrotropical region, two species in the Antarctica and Subantarctica, and only a single species in the Australian region (Subías 2019).

Collectively, members of *Oribatella* occur throughout the world, from tropics to arctic, and inhabit ranging from forests and grasslands to tundra. Representatives of this genus found in various microhabitats, such as soil and litter to fungal sporocarps to tree bark and canopies (e.g. Behan-Pelletier 2011; Behan-Pelletier & Walter 2012). Species belonging to this genus are primary decomposers and may feed on fungal hyphae or algae (Behan-Pelletier & Hill 1983; Wunderle 1992; Schneider *et al*. 2004).

The adults of *Oribatella* are easily recognizable by their large lamellae covering most of prodorsum, with deep incision between cusps; strong lamellar setae in the middle incised cusps, and long, strong interlamellar setae protruding beyond the rostrum. However, it is remarkable that little-published information exists relating to the morphological ontogeny of *Oribatella*. Currently, the ontogenetic morphologies of 14 species of *Oribatella* are known

Accepted by M. Fuangarworn: 5 Nov. 2019; published: 31 Dec. 2019

at different levels, and the descriptions of the majority species have been exclusively based on adults (see Norton & Ermilov 2014; Seniczak *et al*. 2015).

In his early treatises on British oribatid mites, Michael (1880*a*, *b*, 1884) firstly studied the unspecified nymph (instar not identified) of his newly described species, *Oribatella quadricornuta* (Michael, 1880). Later, Tuxen (1943) roughly characterized a nymph of *Oribatella berlesei* (Michael, 1898), with a general illustration. Grandjean (1953*a*) studied the gastronotum of the tritonymph of *Oribatella calcarata* (C.L. Koch, 1835). Hammer (1958) illustrated a nymph of *Oribatella punctata* Hammer, 1958, but no description is given. Chistyakov (1983, 1984, 1987) investigated the postembryonic development and juvenile morphology of *Oribatella sexdentata* Berlese, 1916 and *O. berlesei*. During the last decade, the juveniles of various species were extensively investigated, either at the time of new species decriptions (*Oribatella canadensis* Behan-Pelletier & Eamer, 2010, *Oribatella metzi* Behan-Pelletier, 2011, *Oribatella nortoni* Behan-Pelletier, 2011, *Oribatella heatherae* Behan-Pelletier & Walter, 2012, *Oribatella pawnee* Behan-Pelletier & Walter, 2012, *Oribatella yukonensis* Behan-Pelletier & Walter, 2012) or re-study of the known species (*Oribatella arctica* (Thor, 1930), *Oribatella superbula* (Berlese, 1904), *O. calcarata*, *O. quadricornuta*) (Seniczak & Seniczak 2013; Seniczak *et al*. 2015).

As for the juveniles of species from other genera of Oribatellidae, the deutonymph of *Joelia fiorii* (Coggi, 1898) and tritonymph of *Ophidiotrichus tectus* (Michael, 1884) are partly known (Grandjean 1953*a*, 1956). Moreover, Grandjean (1953*b*) characterized the ontogenetic instars of Oribatellidae.

According to these studies, the juveniles of *Oribatella* are apopheredermous, with scalps of preceding instars; body colourless, cuticle without plicae. Bothridium and bothridial seta fully formed in all instars; the latter seta mostly fusiform, but rarely clavate. Gastronotic setae long; setation usually unideficient; larvae with 11 or 12 pairs, nymphs with 13–15 pairs of gastronotic setae; adult loses setae c_1 and c_3. Pygidial shield absent; humeral organ present laterally in sejugal region. Genital setal formula (larva to adult): 0-1-3-5-6; aggenital setal formula 0-0-1-1-1. Opisthonotal gland present in all instars; cupule development normal. Setation of protonymphal leg IV normal (0-0-0-0-7). Nymphs carry exuvial scalps using setae c_1, c_2 and of *l*-series or forming special muff around apical part of seta *da* (see also Norton & Behan-Pelletier 2009).

During taxonomic identification of previously unstudied oribatid mites from southern Chile (Patagonia), which were stored in the collections of the Tyumen State University Museum of Zoology (Tyumen, Russia), we found some juveniles of *Oribatella palustris* Hammer, 1962, allowing us to investigate its partial ontogeny.

The main goal of the present work is to suplimentarily redescribe and illustrate this species based on adults and available juveniles, and to present a comparative analysis of morphological characters of juvenile instars in Oribatellidae based on our own data and on available literature sources. This work is part of our continuing study on ontogeny oribatid mite fauna (e.g. Bayartogtokh & Ermilov 2017, 2018; Bayartogtokh *et al*. 2018).

Material and methods

Material. Two larvae, 16 tritonymphs and 10 adults of *Oribatella palustris* Hammer, 1962 were collected from: Chile, Región de Magallanes y de la Antártica Chilena, Provincia de Magallanes, 30 km south-east of Punta Arenas, before Laguna Parrillar National Park, 53°23’00”S, 071°13’34”W, swamp, moss *Sphagnum magellanicum*, Berlese funnel extraction, 10.XI.2014 (V.A. Stolbov & S.A. Ivanov).

The juveniles were identified as *O. palustris* based on the following reason: adults were of the appropriate size to have juvenile instars with such dimensions; only this oribatellid species was registered when studying concrete moss sample.

Methods. 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 notogaster/gastronotum. Notogastral/gastronotic 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 (μm). 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.

Drawings were made with a camera lucida using a Leica transmission light microscope “Leica DM 2500”. SEM photos were made with the aid of a JEOL-JSM-6510LV SEM microscope.

Morphological terminology used in this paper follows that of F. Grandjean: see Travé & Vachon (1975) for references, Norton (1977) for leg setal nomenclature, and Norton & Behan-Pelletier (2009), for overview.

The following abbreviations are used in the text and on the figures: *lam*—lamella; *ro*, *le*, *in*, *bs*, *ex*—rostral, lamellar, interlamellar, bothridial and exobothridial setae, respectively; LA, TN—larva and tritonymph, respectively; *rr*—rostral ridge; *dlr*—dorsolateral ridge; *ho*—humeral organ; *D*—dorsophragmata; *P*—pleurophragmata; *gt*—genal tooth; *Ad*—sejugal porose areas; *Am*, *Ah*—humeral porose areas; *c*, *da*, *dm*, *dp*, *la*, *lm*, *lp*, *h*, *p*—notogastral/gastronotic setae; *ld*—line of dehiscence; *Aa*, *A1*, *A2*, *A3*—notogastral porose areas; *ia*, *im*, *ip*, *ih*, *ips*, *iad*—lyrifissures/cupules; *gla*—opisthonotal gland opening; *a*, *m*, *h*—subcapitular setae; *or*—adoral setae; *sup*, *inf*, *l*, *d*, *cm*, *acm*, *ul*, *sul*, *lt*, *vt*—palp setae; ω—palp and leg tarsal solenidion; *sac*—axillary saccule; *cha*, *chb*—cheliceral setae; *Tg*—Trägårdh's organ, *Cl*—Claparède's organ; *Pd I*, *Pd II*—pedotecta I, II, respectively; *1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *3c*, *4a*, *4b*, *4c*—epimeral setae; *g*, *ag*, *an*, *ad*—genital, aggenital, anal and adanal setae, respectively; *cus*—custodium; *dis*—discidium; *cp*—circumpedal carina; *Ap*—postanal porose area; *po*—preanal organ; *Tr*, *Fe*, *Ge*, *Ti*, *Ta*—leg trochanter, femur, genu, tibia, tarsus, respectively; *pa*—leg porose area; σ, φ—leg genial and tibial solenidia; ε—famulus; *v*, *ev*, *bv*, *l*, *d*, *ft*, *tc*, *it*, *p*, *u*, *a*, *s*, *pv, pl*—leg setae.

Results

Family Oribatellidae
Genus *Oribatella* Banks, 1895
Type species *Oribatella quadridentata* Banks, 1895

Oribatella palustris Hammer, 1962

(Figures 1–11)

Diagnosis

Adult. Body size: 514–548 × 332–348. Body surface microfoveolate, lamellae and anterolateral parts of pteromorphs partially striate, pedotecta I and lateral parts of pteromorphs with striae forming reticulate pattern. Rostrum pointed. Distal parts of lamellae with long, straight, smooth teeth similar in length and deep U-shaped indentation between them; inner margins fused basally by short translamella. Rostral setae long, setiform, heavily ciliated, lamellar and interlamellar setae long, bacilliform, heavily barbed, bothridial setae short, clavate, barbed (stalks and basal part of heads sunken in bothridia). Tutorial cusps with strong triangular tooth and some small teeth. Pteromorphs with one strong tooth and several small teeth laterally. Notogastral setae short, setiform, barbed. Epimeral setae *3b*, *3c*, *4b* and *4c* long, thickened, heavily barbed, other setae of medium size or short, setiform, barbed. Anogenital setae short, setiform, barbed. Adanal setae ad_1 and ad_2 located posterior, ad_3 lateral to anal aperture. Leg tarsi with three claws.

Juveniles (based on larva and tritonymph). Nymphs carry exuvial scalps using setae c_1, c_2 and of *d*-series. Rostrum rounded, tritonymphs with triangular rostral ridge. Rostral, lamellar, interlamellar and exobothridial setae long, bacilliform, heavily barbed, *ro* shortest. Bothridial setae of medium size, clavate, barbed. Larvae with 12 pairs of long, bacilliform heavily barbed setae (except short and setiform h_2, h_3). Tritonymphs with 15 pairs of long bacilliform heavily barbed setae (except short and setiform c_1, p_2, p_3).

Adult (Figures 1–5)

Measurements. Body length: 514–548 (10 specimens: five females and five males); notogaster width: 332–348 (10 specimens). No clear differences between females and males in body size.

Integument (Figures 1(a, b), 2(a, c), 4(b), 5(a, c)). Body colour brown. Surface microfoveolate (diameter of foveoles less than 1). Lamellae, trochanters IV and anterolateral parts of pteromorphs partially striate. Pedotecta I and lateral parts of pteromorphs with striae forming reticulate pattern.

Prodorsum (Figures 1(a, b), 2(a), 5(a, b, c)). Rostrum pointed. Anterior part of prodorsum slightly hump-like. Distal parts of lamellae with well-developed teeth (outer and inner teeth similar in length, straight, smooth) and deep U-shaped indentation between them. Inner margins located very close to each other, fused basally by short translamella. Rostral setae (123–131) setiform, heavily ciliated unilaterally. Lamellar (110–114) and interlamellar

(190–205) setae bacilliform, heavily barbed; *le* slightly thicker than *in*. Bothridial setae (their length out of bothridia 28–32) clavate, barbed; bothridial stalks and basal part of heads sunken in bothridia, therefore only medioanterior part of heads visible in dorsal view. Exobothridial setae and their alveoli not visible. Tutorial cusps with strong triangular tooth and two to four small additional teeth distally. Genal teeth large, rectangular. Dorsophragmata and pleurophragmata distinct. Sejugal porose areas diffuse.

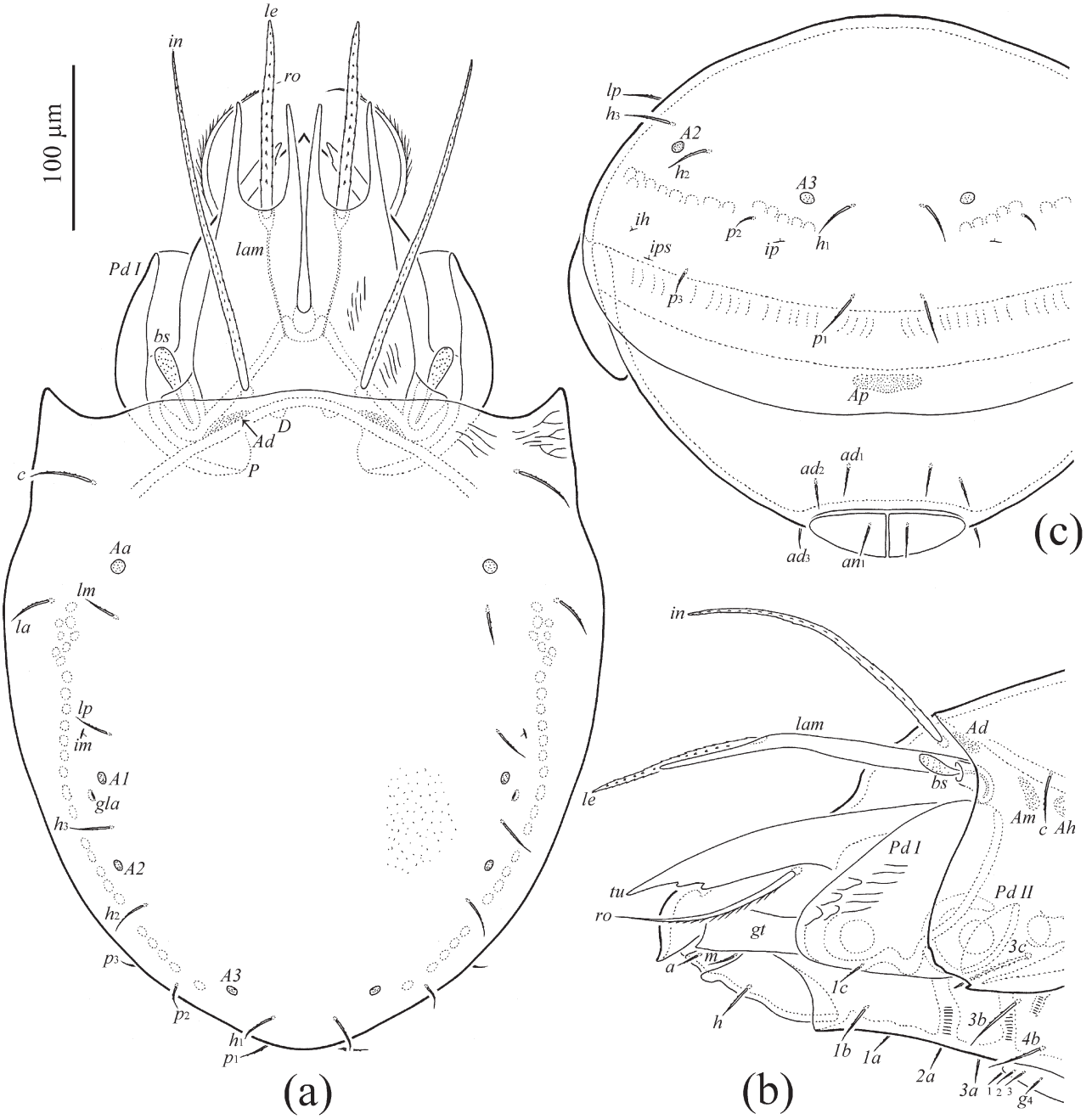

FIGURE 1. *Oribatella palustris* Hammer, 1962, adult: (a) dorsal view (legs not illustrated), (b) anterior part of body, lateral view (legs not illustrated), (c) posterior view.

Notogaster (Figures 1(a, b, c), 2(a, b), 5(a, b, c)). Anterior margin straight. Posterior margin broadly rounded. Pteromorphs with one strong tooth and several small additional teeth laterally. Notogastral setae (*c*, 36–41; p_2, p_3, 14–15; others 24–28) setiform, barbed; setae in dorsocentral part of notogaster absent. With four pairs (10–12) of rounded porose areas. Lyrifissures (*ia* not observed), opisthonotal gland openings and circumgastric sigillar band distinct.

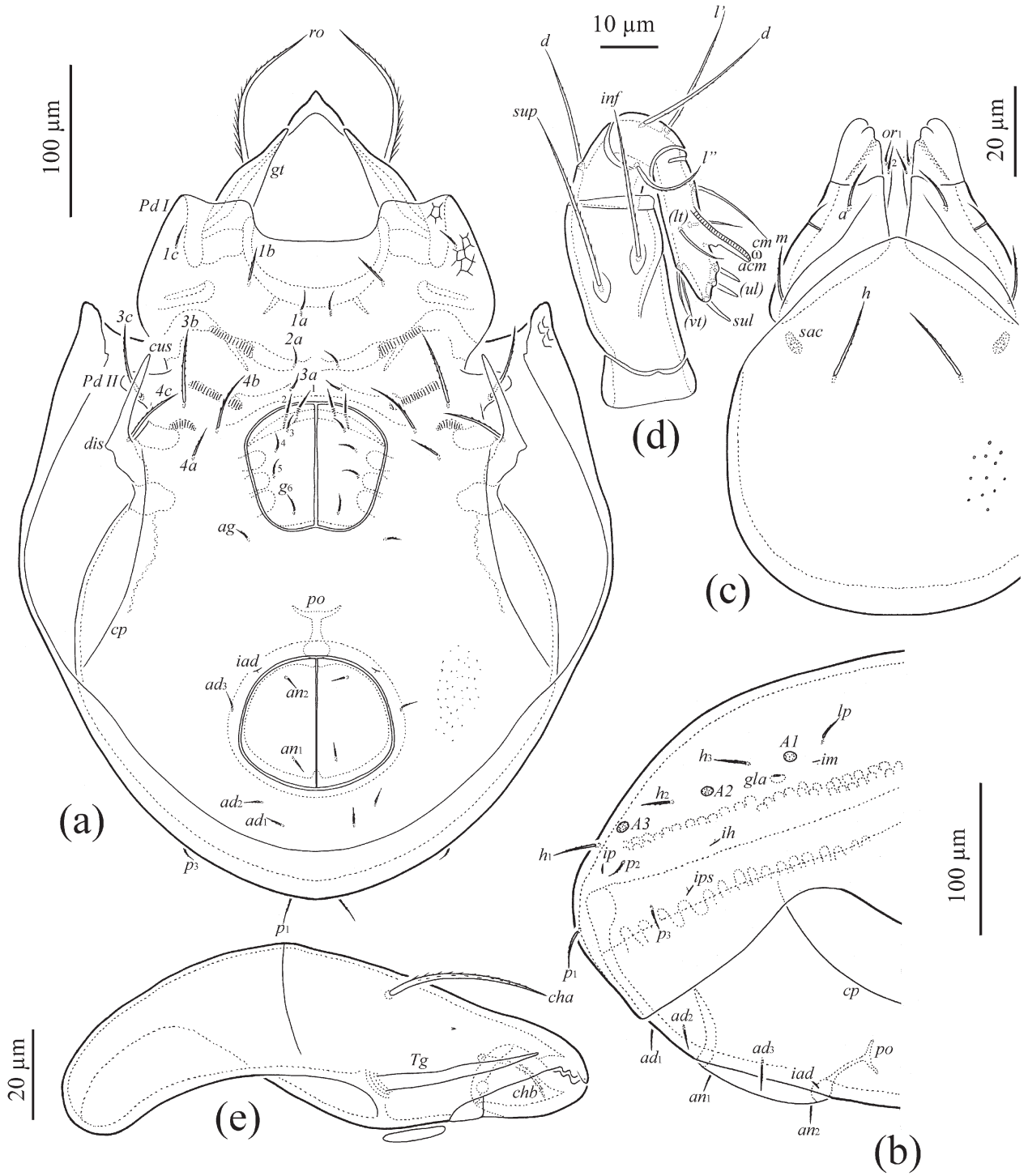

FIGURE 2. *Oribatella palustris* Hammer, 1962, adult: (a) ventral view (gnathosoma and legs not illustrated), (b) posterior part of body, lateral view, (c) subcapitulum, ventral view, (d) palp, right, antiaxial view, (e) chelicera, left, paraxial view.

Gnathosoma (Figures 1(b), 2(c, d, e), 5(b)). Subcapitulum longer than wide (110–114 × 82–90). Subcapitular setae (*a*, *m*, 16–18; *h*, 24–28) setiform, slightly barbed. Two pairs of adoral setae (8–10) setiform, thin, smooth. Palps (length 82–86) with setation 0-2-1-3-9(+ω). Solenidion of palptarsi attached mediodistally to seta *acm*. Post-palpal setae (8) spiniform, smooth. Axillary saccules distinct, slightly elongated. Chelicerae (length 118–123) with two setiform, barbed setae (*cha*, 36–41; *chb*, 20–24). Trägårdh's organ of chelicerae tapered.

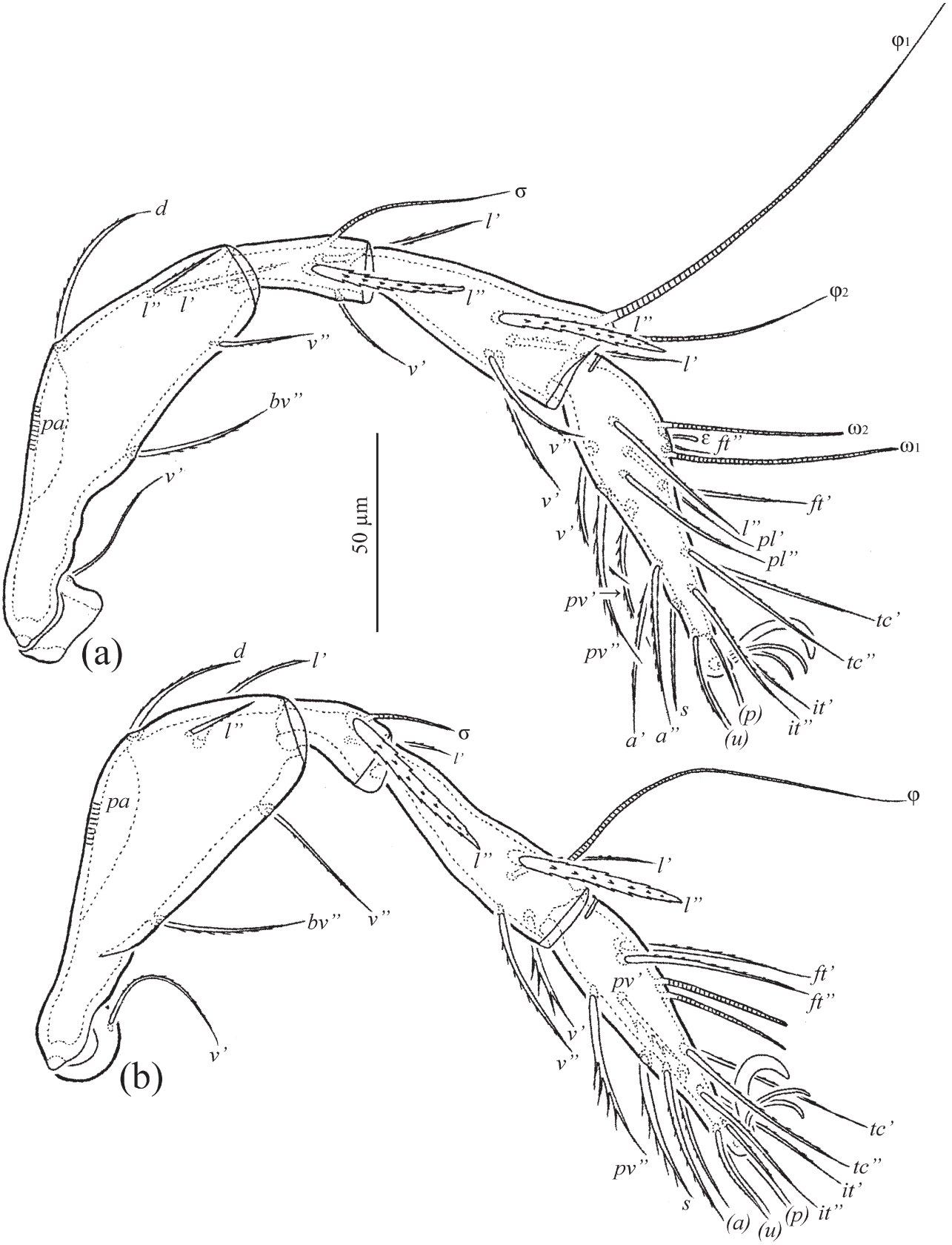

FIGURE 3. *Oribatella palustris* Hammer, 1962, adult: (a) leg I, right, antiaxial view, (b) leg II, right, antiaxial view.

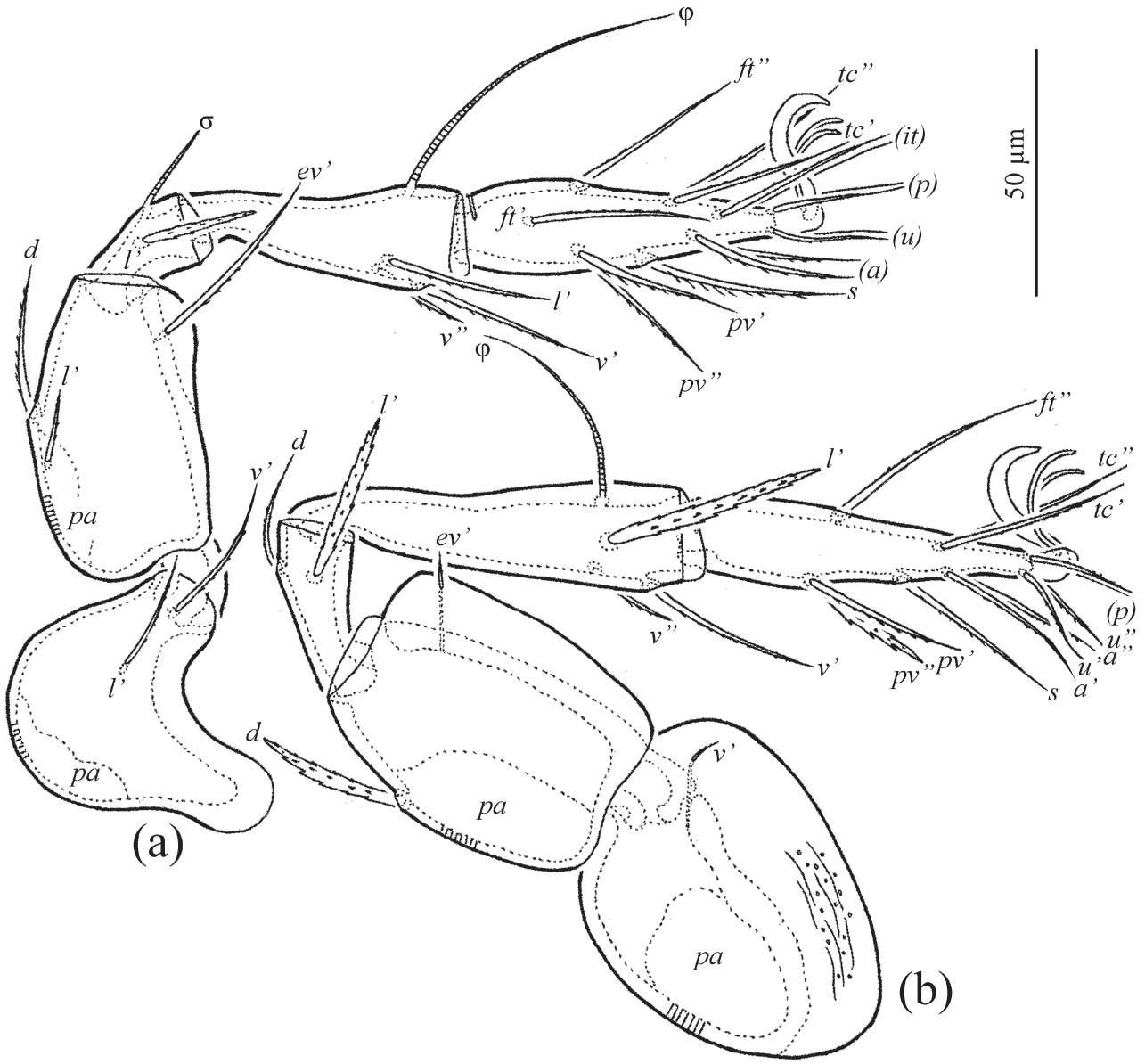

FIGURE 4. *Oribatella palustris* Hammer, 1962, adult: (a) leg III, left, antiaxial view, (b) leg IV, left, antiaxial view.

Epimeral and lateral podosomal regions (Figures 1(b), 2(a), 5(b)). Epimeral setal formula 3-1-3-3. Setae *3b*, *3c*, *4b* and *4c* (45–49) thickened, heavily barbed, others (*1a*, *2a*, *3a*, *1c*, 16*; 1b*, *4a*, 20–24; *4b*, 32–36) setiform, barbed. Custodia, discidia and circumpedal carinae well developed. Pedotecta I represented by large laminae, pedotecta II by small laminae. Humeral porose areas *Am* diffuse, *Ah* well bordered, oval.

Anogenital region (Figures 1(b, c), 2(a, b), 5(b, c)). Six pairs of genital (12), one pair of aggenital (12), two pairs of anal (12) and three pairs of adanal (16) setae setiform, barbed. Adanal setae ad_1 and ad_2 located posterior, ad_3 lateral to anal aperture. Adanal lyrifissures slightly diagonal, located close and anterolateral to anal plates. Postanal porose area oval (28–36 × 10–12)

Legs (Figures 3(a, b), 4(a, b), 5(a, b, c)). Tridactylous, median claw distinctly thicker than laterals, all smooth on dorsal side. Porose area on all femora and on trochanters III, IV well visible. Formulas of leg setation and solenidia: I (1(*v'*)–5(*d*, (*l*), *bv"*, *v"*)–3((*l*), *v'*)–4((*l*), (*v*))–20((*ft*), (*it*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), (*pl*), *v'*, *l"*, ε) [1(σ)–2($φ_1$, $φ_2$)–2($ω_1$, $ω_2$)]; II (1(*v'*)–5(*d*, (*l*), *bv"*, *v"*)–2(*l*)–4((*l*), (*v*))–15((*ft*), (*it*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [1(σ)–1(φ)–2($ω_1$, $ω_2$)]; III (2(*l'*, *v'*)–3(*d*, *l'*, *ev'*)–1(*l'*)–3(*l'*, (*v*))–15((*ft*), (*it*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [1(σ)–1(φ)–0]; IV (1(*v'*)–2(*d*, *ev'*)–2(*d*, *l'*)–3(*l'*, (*v*))–12(*ft"*, (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [0–1(φ)–0]. Setae *l"* on genua I, II, and *l'* on genua III and IV and on tibiae IV thick. Famulus of tarsi I erect, slightly swollen distally, inserted between seta *ft"* and solenidion $ω_2$.

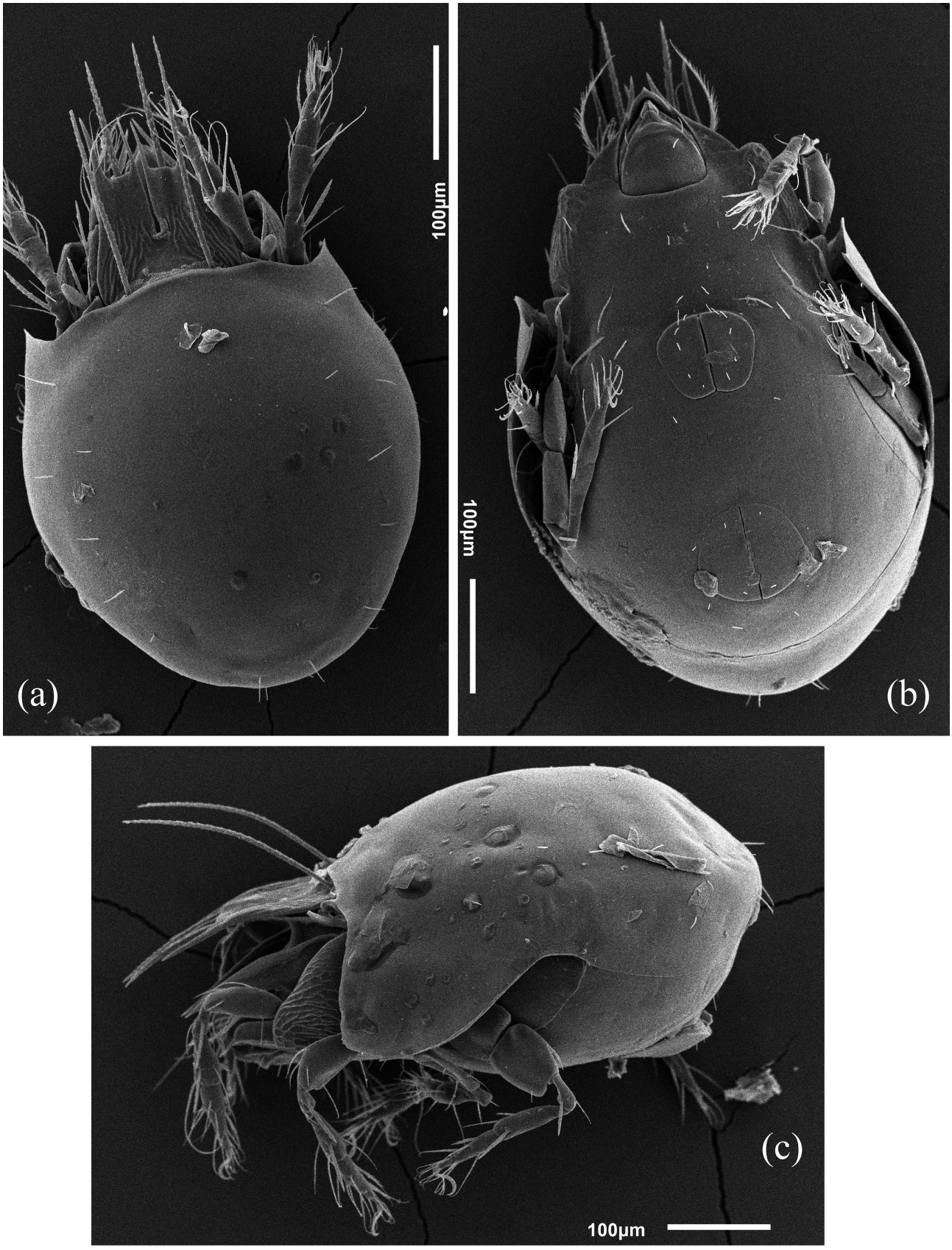

FIGURE 5. *Oribatella palustris* Hammer, 1962, adult, SEM photos: (a) dorsal view, (b) ventral view, (c) lateral view.

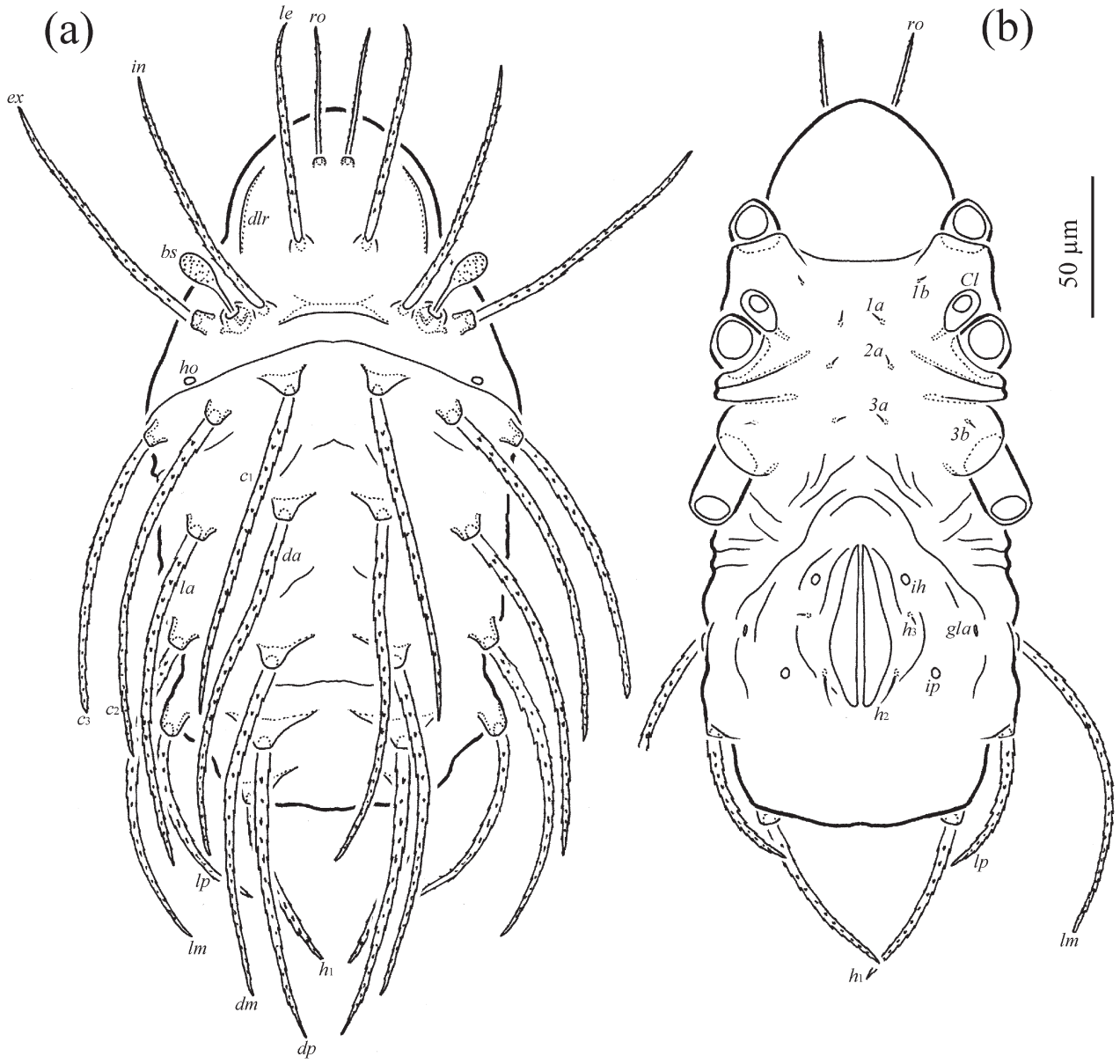

FIGURE 6. *Oribatella palustris* Hammer, 1962, larva: (a) dorsal view, (b) ventral view (gnathosoma and legs except basal parts not illustrated).

Juveniles *(Larva and tritonymph; Figures 6–11)*

Measurements. Total length of larvae: 232–240 (n=2), tritonymphs: 464–514 (n=16). Total width of larvae: 123–127 (n=2), tritonymphs: 298–315 (n=16).

Integument (Figures 6(a, b), 7(a, b), 9(a, b), 10(a)). Body cuticle colorless in larvae, to light brownish in tritonymphs, generally smooth. Gastronotic and anogenital regions weakly and sparsely folded.

Prodorsum (Figures 6(a), 7(a), 8(a), 10(a), 11(a, b)). Relatively short, about 1/3-2/5 length of gastronotic region, with one pair of dorsolateral ridges and transverse ridge between interlamellar setae. Rostrum rounded, but tritonymphs with triangular rostral ridge, creating illusion of a pointed rostrum in dorsal view. Rostral (La: 45–49; Tn: 61–69), lamellar (La: 82–90; Tn: 143–151), interlamellar (La: 90–94; Tn: 151–159) and exobothridial (La: 90–94; Tn: 127–139) setae bacilliform, heavily barbed, inserted on tubercles. Bothridial setae (La: 26–28; Tn: 36–41) clavate, barbed, stalk and head similar in length. Humeral organs slightly developed, located posterolateral to exobothridial setae.

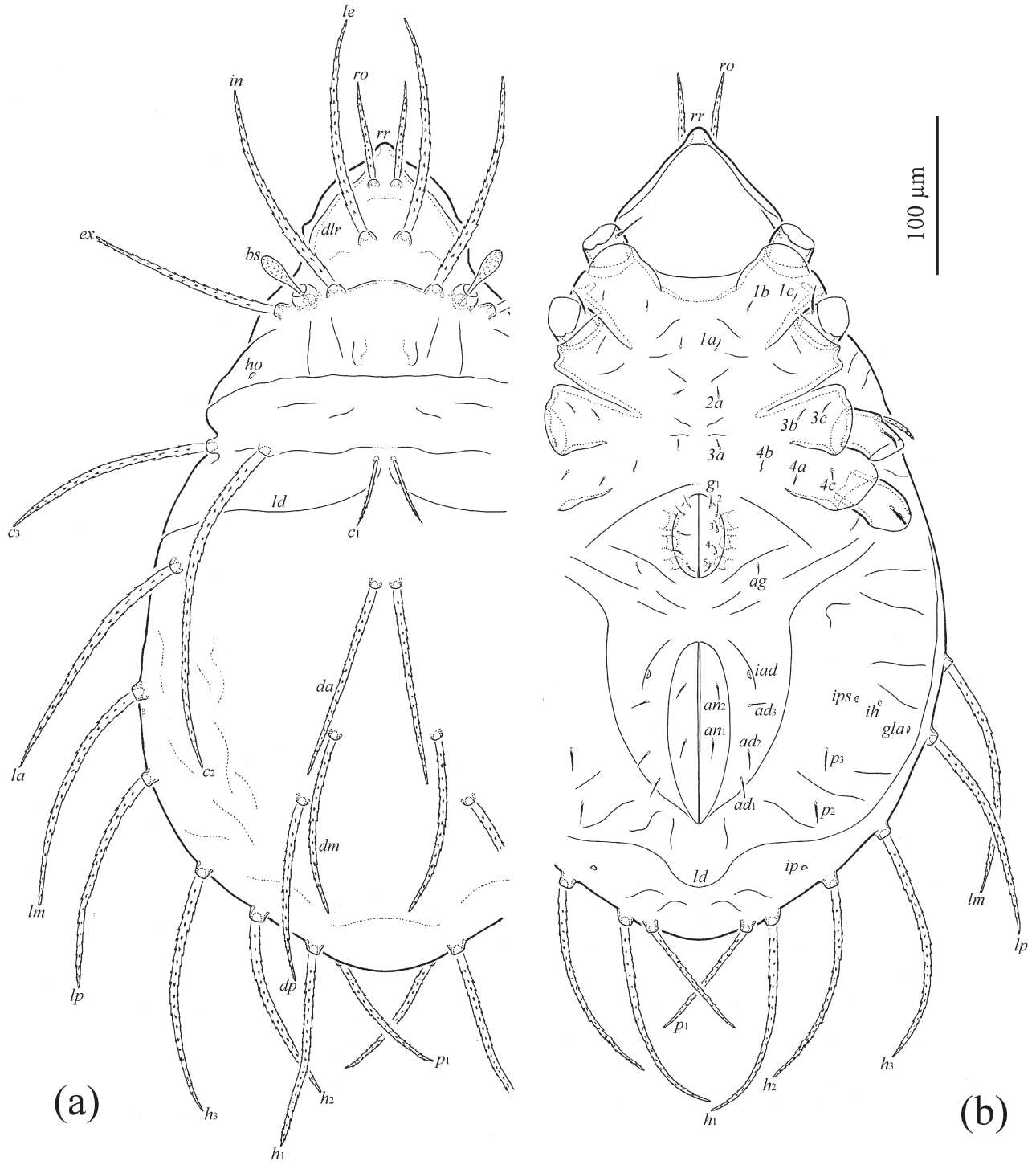

FIGURE 7. *Oribatella palustris* Hammer, 1962, tritonymph: (a) dorsal view, (b) ventral view (gnathosoma and legs except basal parts not illustrated).

Gastronotic region (Figures 6(a, b), 7(a, b), 8(a), 10(a, b), 11(a, b)). In larvae, anterior margin of gastronotum straight, its posterior margin slightly truncate; circular line of dehiscence not observed; with 12 pairs of setae (c_1, *da*, *dm*, 123–143; *lp*, h_1, 69–82; h_2, 12–16; h_3, 4; others 102–123); h_2 setiform, slightly barbed, h_3 setiform, smooth, others bacilliform heavily barbed, inserted on large apophyses. In tritonymphs, anterior margin of gastronotum straight, its posterior margin broadly rounded; centrodorsal part usually covered by three exuvial scalps, which loosely attached on gastronotum using setae c_1, c_2 and of *d*-series, therefore easily lost; circular line of dehiscence well developed; with 15 pairs of setae (c_1, 53–61; c_2, 225–237; *da*, *dm*, *dp*, p_1, 110–123; p_2, p_3, 16–20; others 139–151); c_1,

p_2, p_3 setiform, slightly barbed, others bacilliform, heavily barbed, inserted on large apophyses. Opisthonotal gland openings and all standard cupules distinct.

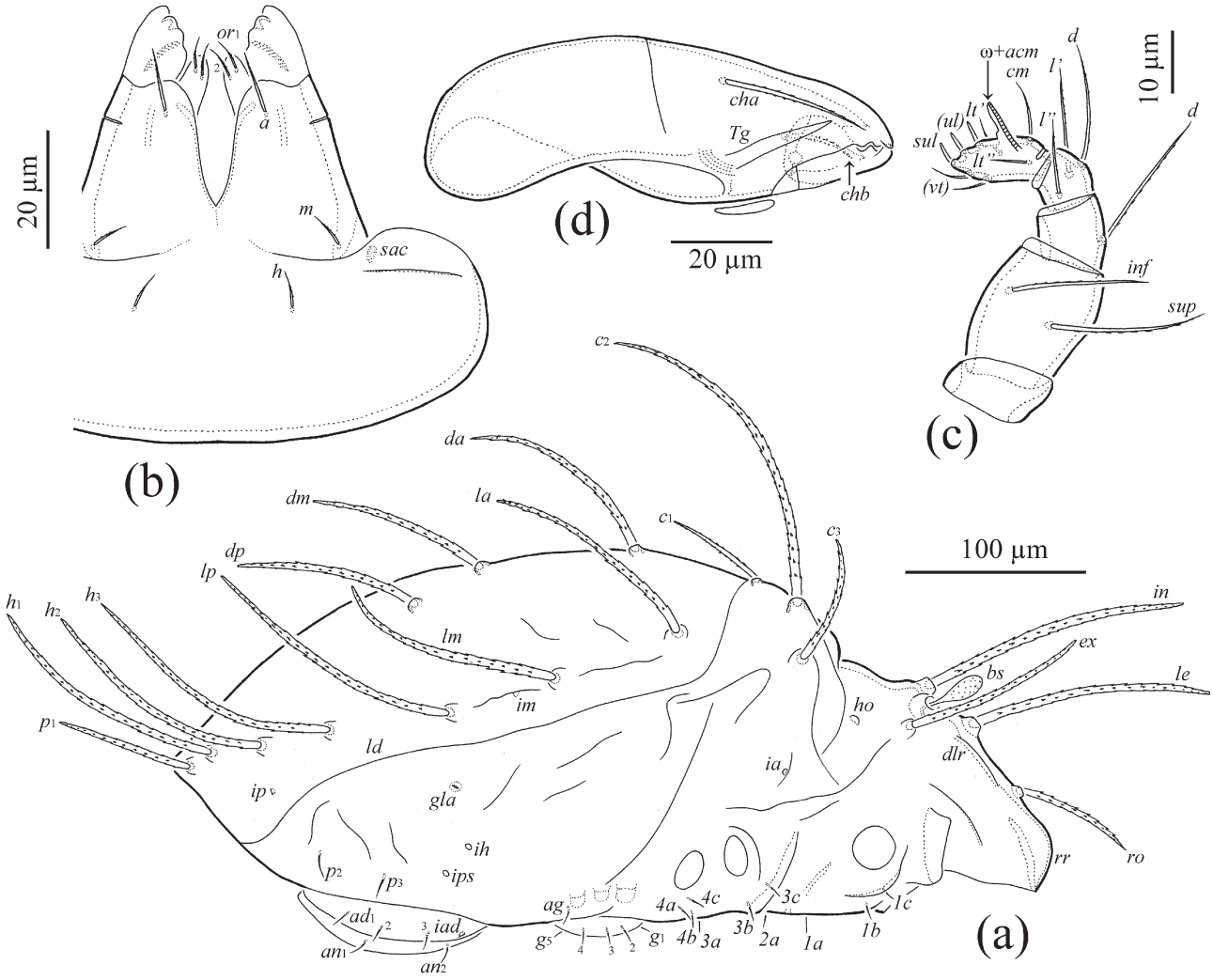

FIGURE 8. *Oribatella palustris* Hammer, 1962, tritonymph: (a) lateral view (gnathosoma and legs not illustrated), (b) subcapitulum, ventral view, (c) palp, left, antiaxial view, (d) chelicera, left, paraxial view.

Gnathosoma (Figures 8(b, c, d), 10(b)). Subcapitulum wider than long (La: 45 × 53; Tn: 77–90 × 98–110). Subcapitular setae (La: *a*, 10; *m*, *h*, 6; Tn: *a*, 16; *m*, *h*, 12) setiform, roughened. Two pairs of adoral setae (La: 4; Tn: 8) setiform, thin, smooth. Palps (La: length 41; Tn: length 61–69) with setation 0-2-1-3-9(+ω). Solenidion of palptarsi attached mediodistally to seta *acm*. Postpalpal setae (La: 2; Tn: 6) spiniform, smooth. Axillary saccules distinct, slightly elongated. Chelicerae (La: length 69; Tn: length 98–102) with two setiform, barbed setae (La: *cha*, 20; *chb*, 12; Tn: *cha*, 32–34; *chb*, 16–18). Trägårdh's organ of chelicerae tapered.

Epimeral region (Figures 6(b), 7(b), 8(a), 10(b)). Setal formulas for epimeres: larvae 3-1-2 (third setae of first epimere forms protective scale over respective Claparède's organs); tritonymphs 3-1-3-3. Epimeral setae (La: 6; Tn: 12) setiform, thin, smooth.

Anogenital region (Figures 6(b), 7(b), 8(a), 10(b)). Number of genital, aggenital, anal and adanal setae: larvae 0–0–0–0; tritonymphs: 5–1–2–3, respectively. Anogenital setae (12) of tritonymphs setiform, thin, smooth. Cupules *ih* (in La, Tn), *ips* (in Tn), *iad* (in Tn) and opisthonotal gland openings (in La, Tn) well visible.

Legs (Figures 9(a, b, c, d), 10(b), 11(a)). Claw of each leg smooth. All femora with ventroparaxial porose area. Formulas of leg setation and solenidia in larvae: I (0–2(*d*, *bv''*)–2(*l*)–3((*l*), *v'*)–14((*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), ε) [1(σ)–1(φ_1)–1(ω_1)], II (0–2(*d*, *bv''*)–2(*l*)–3((*l*), *v'*)–13((*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [1(σ)–1(φ)–1(ω)], III (0–2(*d*, *ev'*)–1(*l'*)–1(*v'*)–13((*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [1(σ)–1(φ)–0]; in tritonymphs: I (1(*v'*)–4(*d*, (*l*), *bv''*)–2(*l*)–4((*l*), (*v*))–18((*ft*), (*it*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), (*pl*), ε)) [1(σ)–2(φ_1, φ_2)–2(ω_1, ω_2)], II (1(*v'*)–4(*d*, (*l*), *bv''*)–2(*l*)–4((*l*),

(*v*)–15((*ft*), (*it*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [1(σ)–1(φ)–2(ω_1, ω_2)], III (2(*l'*, *v'*)–3(*d*, *l'*, *ev'*)–1(*l'*)–3(*l'*, (*v*))–15((*ft*), (*it*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [1(σ)–1(φ)–0], IV (1(*v'*)–2(*d*, *ev'*)–2(*d*, *l'*)–3(*l'*, (*v*))–12(*ft"*, (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)) [0–1(φ)–0].

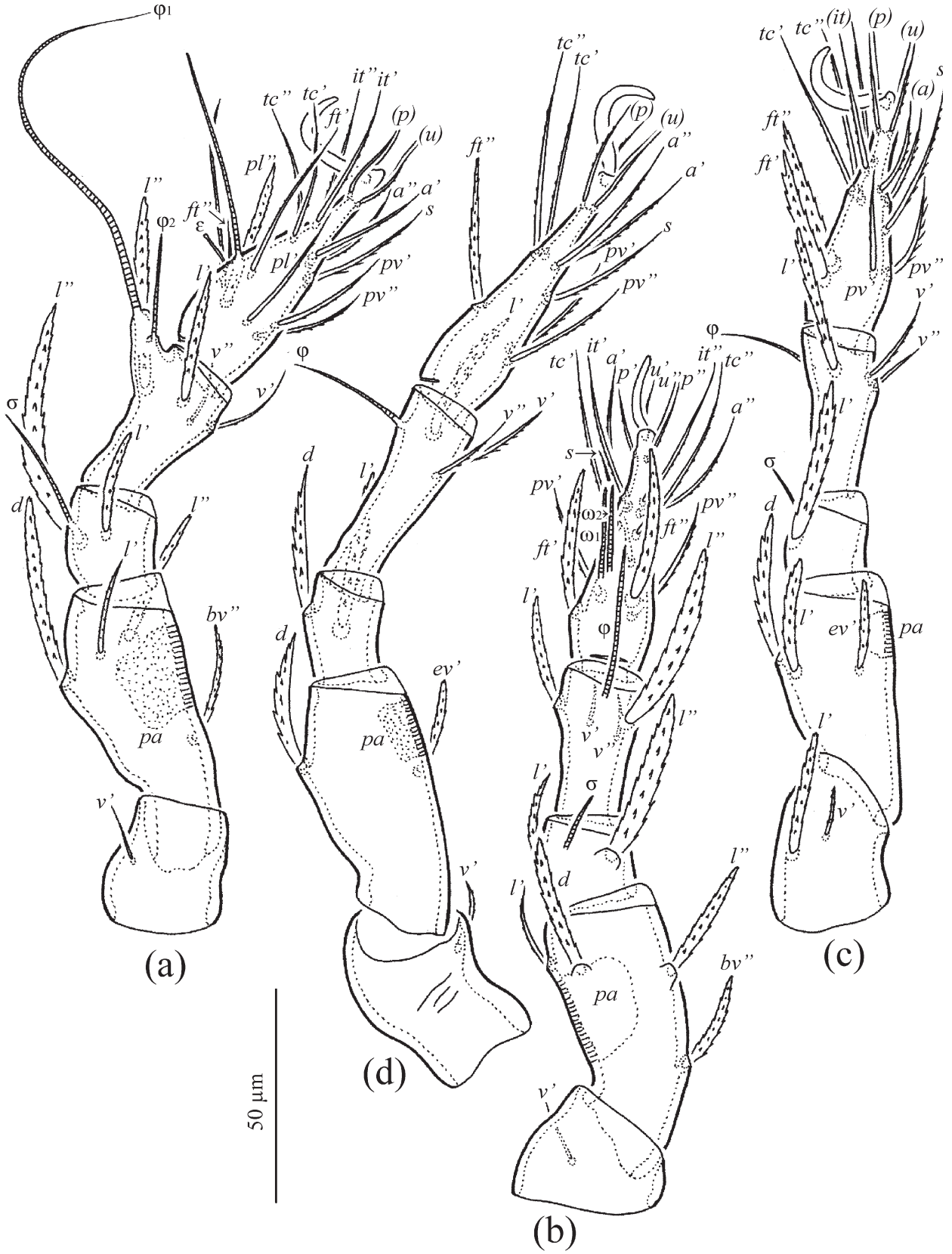

FIGURE 9. *Oribatella palustris* Hammer, 1962, tritonymph: (a) leg I, left, paraxial view, (b) leg II, right, dorsoantiaxial view, (c) leg III, left, antiaxial view, (d) leg IV, right, paraxial view.

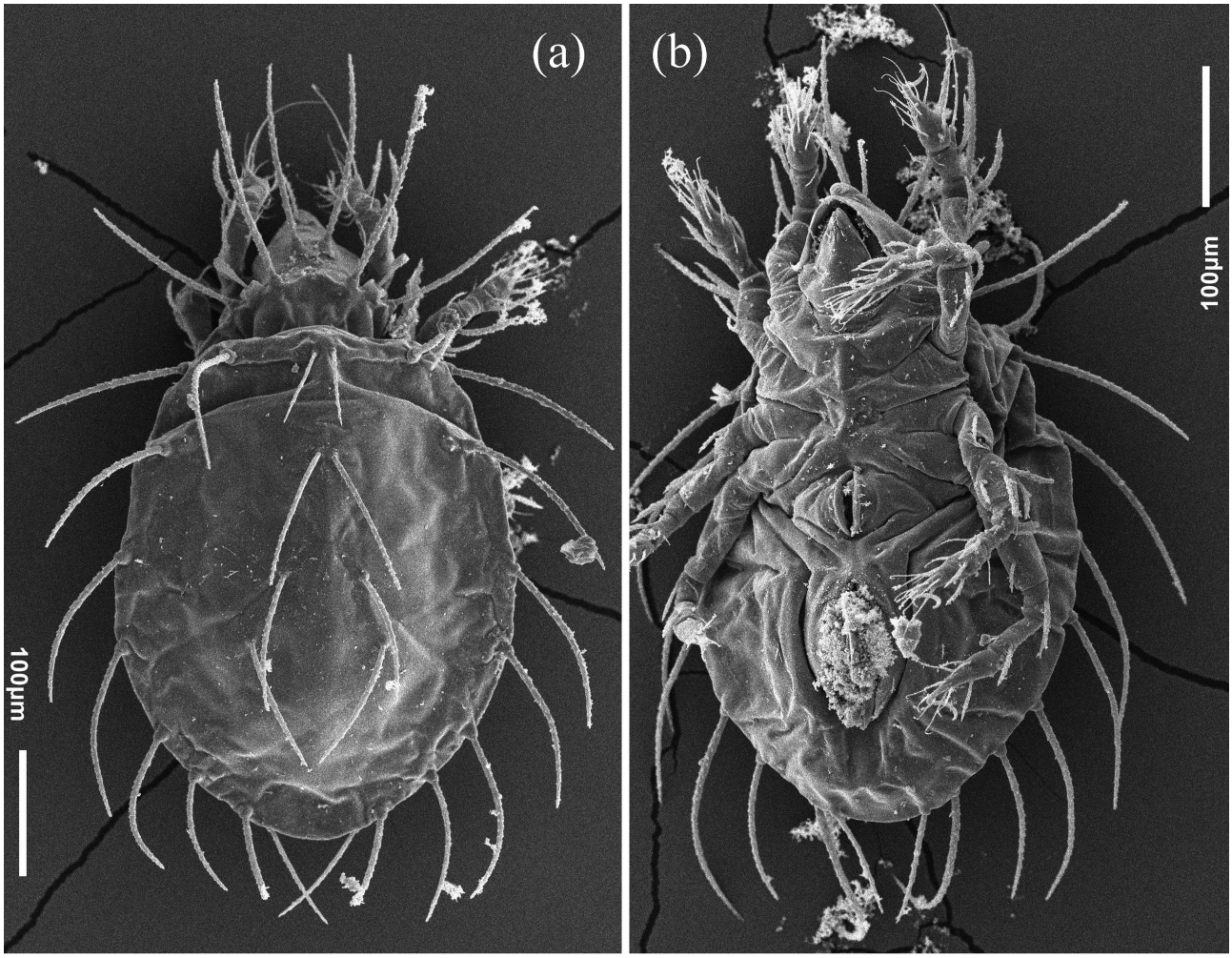

FIGURE 10. *Oribatella palustris* Hammer, 1962, tritonymph, SEM photos: (a) dorsal view without exuvial scalp, (b) ventral view.

Remarks on ontogenic changes

The juveniles are unpigmented, flesh-coloured with smooth cuticle; gastronotic and anogenital regions weakly folded in both larva and nymphs. The prodorsum is stockier in larva than in tritonymph, in contrast, the gastronotum is slimmer in larvae, but much stockier in tritonymph. Five pairs of prodorsal setae (including bothridial seta) are constant during ontogeny, except seta *ex*, which is lost in adult; in larva and tritonymph, the rostral seta is much shorter and thinner than other setae, while the other setae subequal in size. In both larva and tritonymph, the bothridium is small, rounded, whereas in adult, it is with scales and large opening. The bothridial seta has short stalk and clavate head in both juveniles and adult. In juveniles, pygidial shield is not developed; line of dehiscence is well developed posterior to setae of *c*-series in tritonymph. The larva bears 12 pairs, the tritonymph bears 15 pairs of gastronotic setae, while the adult has 10 pairs of notogastral setae. The larva has only six pairs, whereas the tritonymph takes 10 pairs of epimeral setae, which is unchanged in adult. The tritonymph bears five pairs of genital setae, along with one pair of aggenital, two pairs of anal and three pairs of adanal setae. Except for genital setae (six pairs in adult), the anogenital setation of tritonymph remains the same in adult stage.

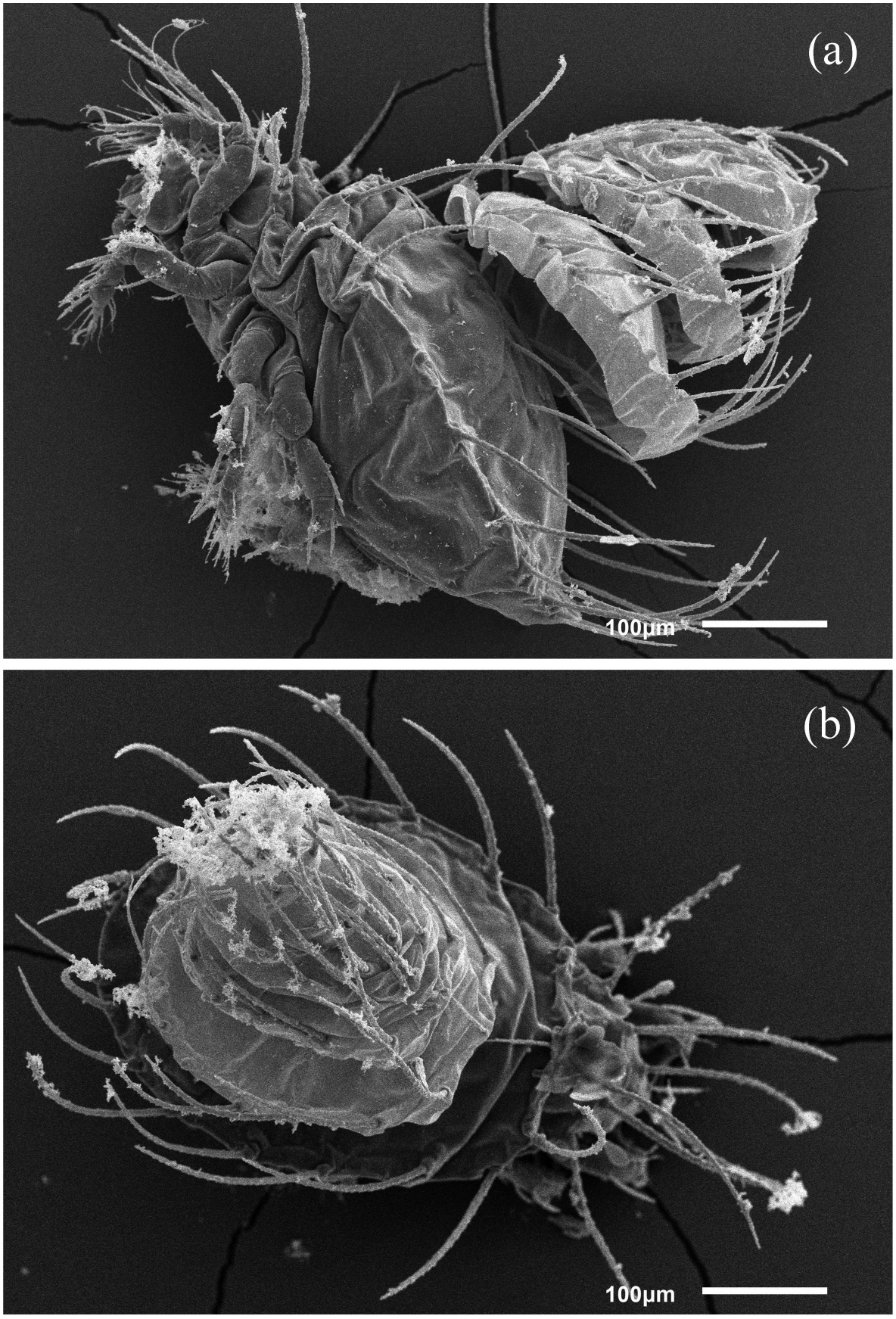

FIGURE 11. *Oribatella palustris* Hammer, 1962, tritonymph, SEM photos: (a) lateral view with exuvial scalps, (b) dorsal view with exuvial scalps.

Distribution and ecology

Oribatella palustris is an Antarctic and Subantarctic species with a limited distribution in the southern part of the Neotropical Region. This species has been discovered from southern Chile, around Punta Arenas, where it inhabits the meadow black peat-soil with low ferns, *Taraxacum*, *Medicago*, and grasses under barberry shrubs (Hammer 1962). Later, this species was found in the West Falkland Island, and collected from the soil and vegetation materials with closely cropped turf with improved grasses and good drainage (Starý & Block 1996, 1998). We found this species from the samples, which have been collected from the Chilean Antarctic swamp with mosses.

Vázquez (1999) recorded *O. palustris* from the Cozumel Island, which is the largest Caribbean island of Mexico, located along the eastern side of the Yucatan Peninsula. In our opinion, this tropical finding is questionable, and the species identification should be verified.

Discussion

As mentioned above, the juveniles of most species of *Oribatella* are still unknown, which causes difficulties in further systematic, phylogenetic, ecological, biogeographical and other experimental studies. Therefore, diagnosis and detailed morphological characterization of juvenile instars and comparative data on different species and related genera are needed. For this reason, some comparative information on species of Oribatellidae, with known juveniles is given below.

From the previous and present studies, it can be generalized that the juvenile morphologies of Oribatellidae are similar and quite uniform, but there are some different traits, which distinguish the juvenile instars of various species. The description and illustration of all juvenile instars are known only for a few species of *Oribatella*, but in most species, only larvae and tritonymphs have been investigated. On the other hand, the protonymph and deutonymph of *Oribatella* are quite similar to the tritonymph except for the number of epimeral and anogenital setae, and body size. Therefore, our comparison given below is restricted to the larva and tritonymph.

The body size among the compared juveniles of Oribatellidae is highly variable as the body length of larvae and tritonymph of compared species are vary between 168–241 μm and 282–598 μm, respectively. The larvae of *O. superbula*, *O. metzi* and *O. pawnee* have smallest body size (168–207 μm), whereas those of *O. calcarata*, *O. quadricornuta* and *O. palustris* are the largest (236–241 μm) in their body length. Among the tritonymphs, *O. metzi*, *O. nortoni* and *O. superbula* show the smallest body size (282–310 μm), whereas *O. calcarata*, *O. heatherae* and *O. palustris* are the largest (489–598 μm). Generally, the body sizes of adults are proportional to those of juveniles, where the adults of *O. metzi*, *O. superbula* and *O. nortoni* have smallest body size, while those of *O. calcarata*, *O. heatherae* and *O. palustris* are largest among the other species with known juveniles. The juveniles and adults of the other species show intermediate body size.

The relative size and shape of the setiform organs, such as bothridial and gastronotic setae are varied from species to species, and can be used as specific characters. For instance, based on the morphology of bothridial setae, the larvae of *Oribatella*-species can be divided into two main groups: the first group consists of such species as *O. arctica*, *O. berlesei*, *O. calcarata* and *O. palustris*, which has the short, clavate bothridial setae,opposed to the long, mostly fusiform setae in other species. Further, the larvae of *Oribatella*-species differ from one another not only in the morphology of gastronotic setae, but also in their numbers. Thus, the larvae of most *Oribatella*-species have seta h_1, but *O. nortoni* lacks it. Further, setae c_1, *da*, *dm*, *dp* or all gastronotic setae in the larvae of *O. yukonensis* and *O. nortoni* are very broad and leaf-shaped, while those in the other species are not broadened, but setiform or bacilliform. As for the length of gastronotic setae, the larvae of most *Oribatella*-species have very long setae extending beyond the insertions of the next two rows of setae, while the larva of *O. arctica* has relatively short gastronotic setae extending only beyond setal insertions of the next row.

The tritonymphs of *O. arctica* and *O. palustris* have short, clavate bothridial setae, but are very long and mostly fusiform in the respective instar of the other species. In the tritonymphs of *Oribatella*, the number and morphology of gastronotic setae are also being species-specific characters. The tritonymphs of most species have 15 pairs of gastronotic setae, however, two species, *O. metzi* and *O. calcarata* have 13 pairs of gastronotic setae. In the former species, setae *dm* and *dp* are lost, whereas, in the second species c_1 and *dm* are usually absent (rarely occurs, unilaterally). Only 14 pairs of gastronotic setae are developed in the tritonymph of *O. arctica* (*dp* lost, rarely occurs its al-

veolus). For shape of gastronotic setae, the tritonymphs of *O. nortoni* and *O. punctata* have very broad, leaf-shaped or feather-like setae, while the other species bear setiform setae. In the tritonymphs of only few species, such as *O. berlesei*, *O. calcarata*, *O. heatherae* and *O. yukonensis*, all gastronotic setae are long, and subequal, whereas in other species, the marginal setae are long, but all or some of the central setae are short. For instance, in the tritonymphs of *O. metzi*, *O. nortoni*, *O. palustris* and *O. sexdentata*, seta c_1 is distinctly shorter than other gastronotic setae, while in *O. arctica*, *O. quadricornuta* and *O. superbula*, not only c_1, but also some setae of *d*-series are shorter than other gastronotic setae.

As for the other genera of Oribatellidae, only the tritonymph of *Ophidiotrichus tectus* was described with partial illustration, which is clearly differs from the known tritonymphs of *Oribatella* in the specifically wided gastronotic seta *da*, which is modified as an attachment device for exuvial scalps (see below).

As there is no diagnostic characterization of juveniles of Oribatellidae, the following key can be used for identification of their known larvae and tritonymphs.

Key to known larvae of *Oribatella*

1 Gastronotum with 12 pairs of setae, h_1 well developed; all or most gastronotic setae thin, setiform 2
- Gastronotum with 11 pairs of setae, h_1 absent; all gastronotic setae very broad, leaf shaped . . . . . *Oribatella nortoni* Behan-Pelletier, 2011
2 All gastronotic setae thin, setiform. 3
- Gastronotic setae c_1, *da*, *dm* and *dp* very broad, leaf shaped, other setae setiform . . . . . *Oribatella yukonensis* Behan-Pelletier & Walter, 2012
3 Bothridial seta short, shorter than interlamellar seta, clavate. 4
- Bothridial seta long, nearly as long as interlamellar seta, mostly fusiform, rarely clavate 6
4 Gastronotic setae very long, extending insertions of next two rows of setae; exobothridial seta very long, longer than interlamellar seta. 5
- Gastronotic setae medium long, extending only setal insertions of next one row; exobothridial seta very short, about ¼ length of interlamellar seta . . . . . *Oribatella arctica* Thor, 1930
5 Gastronotic seta h_3 medium long, thick, barbed; interlamellar setae short, not reaching rostrum . . . . . *Oribatella berlesei* (Michael, 1898)
- Gastronotic seta h_3 short, thin, smooth; interlamellar setae very long, extending beyond rostrum . . . . . *Oribatella calcarata* (Koch, 1835)
6 Bothridial seta fusiform, pointed distally 7
- Bothridial seta clavate, rounded distally 9
7 Bothridial seta very long, longer than exobothridial seta. 8
- Bothridial seta much shorter than exobothridial seta . . . . . *Oribatella quadricornuta* (Michael, 1880)
8 Prodorsal and gastronotic setae inserted on large tubercle; distance between pair of setae *da*-*da* same as that between c_1–c_1. . . . . *Oribatella metzi* Behan-Pelletier, 2011
- Prodorsal and gastronotic setae inserted not on large tubercles, but on dorsal shield; distance between pair of setae *da*-*da* greater than that between c_1–c_1 . . . . . *Oribatella sexdentata* Berlese, 1916
9 Gastronotic setae very thick, same thickness throughout its length, strongly barbed . . . . . *Oribatella pawnee* Behan-Pelletier & Walter, 2012
- Gastronotic setae thin, tapered distally, normally barbed. . . . . *Oribatella superbula* (Berlese, 1904)

Key to known tritonymphs of Oribatellidae

1 All gastronotic setae straight or normally arched; seta *da* with normal structure 2
- Gastronotic seta *da* with specific structure, winding and twisted distally; other gastronotic setae normal . . . . . *Ophidiotrichus tectus* (Michael, 1884)
2 All gastronotic setae long, approximately same in length 3
- Marginal setae on gastronotum long, but some of central setae short or minute 7
3 With 15 pairs of gastronotic setae 4
- With 13 pairs of setae (c_1, *dm* or *dp* absent) 6
4 Body length not more than 440 μm; bothridial seta strongly barbed. 5
- Body length 522 μm; bothridial seta weakly barbed marginally . . . . . *Oribatella heatherae* Behan-Pelletier & Walter, 2012
5 Gastronotic setae very long, strongly barbed; bothridial seta barbed throughout its length . . . . . *Oribatella yukonensis* Behan-Pelletier & Walter, 2012
- Gastronotic setae medium long, sparsely barbed; bothridial seta barbed only in distal half . . . . . *Oribatella berlesei* (Michael, 1898)

6 Setae c_1 and *dm* absent; bothridial seta very thin; nymphs do not carry exuvial scalps. . . . . *Oribatella calcarata* (Koch, 1835)
- Setae *dm* and *dp* absent; bothridial seta bacilliform, heavily barbed; nymphs carry exuvial scalps . . . . . *Oribatella metzi* Behan-Pelletier, 2011
7 Either c_1 or some setae of *d*-series minute, smooth 8
- Gastronotic setae c_1 and some of *d*-series not minute, but distinctly shorter than other setae 9
8 Setae *dm* and *dp* minute, c_1 long, barbed; bothridial seta long, extending beyond rostrum. . . . . *Oribatella canadensis* Behan-Pelletier & Eamer, 2010
- Setae c_1 minute, *dm* and *dp* short, smooth; bothridial seta short, not reaching rostrum. . . . . *Oribatella arctica* Thor, 1930
9 Only seta c_1 distinctly shorter than other setae. 10
- Not only c_1, but also some setae of *d*-series distinctly shorter than other setae 11
10 Bothridial seta short, clavate; gastronotic seta c_1 minutely barbed . . . . . *Oribatella palustris* Hammer, 1962
- Bothridial seta very long, setiform; gastronotic seta c_1 smooth . . . . . *Oribatella sexdentata* Berlese, 1916
11 All gastronotic setae setiform, tapered distally; anterior margin of gastronotum medially distinctly convex. 12
- All gastronotic setae broadened, not tapered distally; anterior margin of gastronotum medially not convex, but widely rounded . . . . . *Oribatella nortoni* Behan-Pelletier, 2011
12 Bothridial seta very long, longer than *le* and *in*; setae c_1, *da* and *dp* distinctly shorter than other setae . . . . . *Oribatella superbula* (Berlese, 1904)
- Bothridial seta medium long, shorter than *le* and *in*; only setae c_1 and *da* distinctly shorter than other setae. . . . . *Oribatella quadricornuta* (Michael, 1880)

Acknowledgements

We thank A.A. Gubin (Tyumen state University, Tyumen, Russia) for SEM photos, and Drs. V.A. Stolbov and S.A. Ivanov (Tyumen State University, Tyumen, Russia) for collecting mites in Chile. Thanks are also due to anonymous reviewers for their critical reading of the manuscript with valuable comments, which considerably improved this article. This research was partly supported by the Science and Technology Foundation of Mongolia, and the National University of Mongolia.

References

Balogh, J. & Mahunka, S. (1969) The zoological results of the Hungarian soil zoological expeditions to South America. 11. Acari: Oribatids from the material of the second expedition, II. *Opuscula Zoologica Budapest*, 9 (1), 31–69.

Banks, N. (1895) On the Oribatoidea of the United States. *Transactions of the American Entomological Society*, 22, 1–16.

Bayartogtokh, B. & Ermilov, S.G. (2017) Nymphal instars of two *Pergalumna* species, with remarks on morphological ontogeny of Galumnidae (Acari, Oribatida). *Systematic & Applied Acarology*, 22 (4), 518–540. https://doi.org/10.11158/saa.22.4.8

Bayartogtokh, B. & Ermilov, S.G. (2018) Ontogeny of morphological traits in *Teleioliodes ghanensis* Wallwork, 1963, with remarks on juveniles of Neoliodidae (Acari: Oribatida). *Zootaxa*, 4540 (1), 40–53. https://doi.org/10.11646/zootaxa.4540.1.6

Bayartogtokh, B., Ermilov, S.G., Shtanchaeva, U. Ya. & Subías, L.S. (2018) Ontogeny of morphological traits in *Eupelops variatus* (Mihelčič, 1957), with remarks on juveniles of Phenopelopidae (Acari: Oribatida). *Systematic & Applied Acarology*, 23 (1), 161–177. https://doi.org/10.11158/saa.23.1.13

Behan-Pelletier, V.M. (2011) *Oribatella* (Acari, Oribatida, Oribatellidae) of eastern North America. *Zootaxa*, 2973 (1), 1–56. https://doi.org/10.11646/zootaxa.2973.1.1

Behan-Pelletier, V.M. & Eamer, B. (2010) The first sexually dimorphic species of *Oribatella* (Acari, Oribatida, Oribatellidae) and a review of sexual dimorphism in the Brachypylina. *Zootaxa*, 2332 (1), 1–20. https://doi.org/10.11646/zootaxa.2332.1.1

Behan-Pelletier, V.M. & Hill, S.B. (1983) Feeding habits of sixteen species of Oribatei (Acari) from an acid peat bog, Glenamoy, Ireland. *Revue d'Écologie et de Biologie du Sol*, 20 (2), 221–267.

Behan-Pelletier, V.M. & Walter, D.E. (2012) *Oribatella* (Acari, Oribatida, Oribatellidae) of Western North America. *Zootaxa*, 3432 (1), 1–62. https://doi.org/10.11646/zootaxa.3432.1.1

Berlese, A. (1904) Acari nuovi. Manipulus III. *Redia*, 2, 10–32.

Berlese, A. (1916) Centuria terza di Acari nuovi. *Redia*, 12, 283–338.

Bernini, F. (1974) Notulae Oribatologicae XIII. La famiglia Oribatellidae (Acarida, Oribatei) nell'Arcipelago Toscano. (Studi sulla Riserva Naturale dell'Isolla di Montecristo, X). *Lavori della Societa Italiana di Biogeografia*, New Series, 5, 429–504.

https://doi.org/10.21426/B65110013
Bernini, F. (1975) Notulae Oribatologicae XIII. La famiglia Oribatellidae (Acarida, Oribatei) nell'Arcipelago Toscano. (Studi sulla Riserva Naturale dell' Isola di Montecristo, X). *Lavori della Societa Italiana di Biogeografia*, New Series, 5, 429–504.
https://doi.org/10.21426/B65110013
Bernini, F. (1977) Notulae Oribatologicae XVII. Nuovi dati sul genere Oribatella in Italia (Acarida, Oribatei). *Redia*, 60, 457–505.
Bernini, F. (1978) Notulae Oribatologicae XX. Il Genere *Oribatella* in Italia (Acarida, Oribatida). *Redia*, 6, 503–538.
Bernini, F. & Avanzati, A.M. (1983) Notulae Oribatologicae XXIX. Le Oribatellidae (Acarida, Oribatida) viventi sul massiccio sardo-corso. *Lavori della Societa Italiana di Biogeografia*, New Series, 8, 347–400.
https://doi.org/10.21426/B68110173
Chistyakov, M.P. (1983) *Postembryonic development of Oribatella sexdentata Berlese, 1916 (Oribatei)*. Gorky State Pedagogical Institute, Gorky, 28 pp. [in Russian]
Chistyakov, M.P. (1984) *Postembryonic development of Oribatella berlesei Michael, 1898 (Oribatei)*. Gorky State Pedagogical Institute, Gorky, 20 pp. [in Russian]
Chistyakov, M.P. (1987) Postembryonic development of oribatid mites of the superfamily Oribatelloidea Woolley, 1956. *In*: Striganova, B.R. (Ed.), *Soil fauna and soil fertility*. Nauka Publishing, Moscow, pp. 538–539. [in Russian]
Coggi, A. (1898) Descrizione di specie nuove di Oribatidi italiani e annotazioni intorno a specie conosciute. *Bollettino della Società Entomologica Italiana*, 30, 68–83.
Engelbrecht, C.M. (1986) New oribatid taxa and distribution records predominantly from southern Africa (Acari: Oribatei: Oribatelloidea). *Navorsinge van die Nasionale Museum, Bloemfontein*, 5 (9), 169–250.
Ermilov, S.G. & Anichkin, A.E. (2012) A new species of *Oribatella* (Acari: Oribatida: Oribatellidae) from Vietnam, including a key to species of the genus from the Oriental region. *International Journal of Acarology*, 38 (4), 301–307.
https://doi.org/10.1080/01647954.2011.647771
Ermilov, S.G. & Behan-Pelletier, V.M. (2014) Revision of *Fenestrobates* (Acari, Oribatellidae) with description of *F. marauni* sp. nov. from South America, and new diagnosis for Oribatellidae. *Zootaxa*, 3827 (2), 258–272.
https://doi.org/10.11646/zootaxa.3827.2.7
Grandjean, F. (1953*a*) Observations sur les Oribates (27e série). *Bulletin du Museùm National d'Histoire Naturelle*, Series 2, 25, 469–476.
Grandjean, F. (1953*b*) Essai de classification des Oribates (Acariens). *Bulletin de la Société Zoologique de France*, 78 (5–6), 421–446.
Grandjean, F. (1956) Observations sur les Oribates (36e série). *Bulletin du Museùm National d'Histoire Naturelle*, Series 2, 28, 450–457.
Hammer, M. (1958) Investigations on the oribatid fauna of the Andes Mountains. I. The Argentine and Bolivia. *Det Kongelige Danske Videnskabernes Selskab Biologiske Skrifter*, 10, 1–129.
Hammer, M. (1962) Investigations on the oribatid fauna of the Andes Mountains. III. Chile. *Det Kongelige Danske Videnskabernes Selskab Biologiske Skrifter*, 13 (2), 1–96.
Koch, C.L. (1835) *Deutschlands Crustaceen, Myriapoden und Arachniden. Heft 1–3*. F. Pustet, Regensburg. Available from: https://doi.org/10.5962/bhl.title.49866 (accessed 13 November 2019)
Michael, A.D. (1880*a*) A further contribution to the knowledge of British Oribatidae (Part I). *Journal of the Roy Microscopical Society, London*, 3, 32–43.
https://doi.org/10.1111/j.1365-2818.1880.tb05649.x
Michael, A.D. (1880*b*) A further contribution to the knowledge of British Oribatidae (Part II). *Journal of the Roy Microscopical Society, London*, 3, 177–201.
https://doi.org/10.1111/j.1365-2818.1880.tb05657.x
Michael, A.D. (1884) *British Oribatidae. Vol. I*. Ray Society, London, 336 pp.
Michael, A.D. (1898) Oribatidae. *In*: Schulze, F.E. (Ed.), *Das Tierreich. Vol. 8. Lief. 3. Acarina*. Friedländer und Sohn, Berlin, pp. 1–93.
https://doi.org/10.5962/bhl.title.69306
Norton, R.A. (1977) A review of F. Grandjean's system of leg chaetotaxy in the Oribatei (Acari) and its application to the family Damaeidae. *In*: Dindal, D.L. (Ed.), *Biology of oribatid mites*. SUNY College of Environmental Science and Forestry, Syracuse, pp. 33–61.
Norton, R.A. & Behan-Pelletier, V.M. (2009) Chapter 15. *Oribatida*. *In*: Krantz, G.W. & Walter, D.E. (Eds.), *A manual of acarology*. Texas Tech University Press, Lubbock, pp. 430–564.
Norton, R.A. & Ermilov, S.G. (2014) Catalogue and historical overview of juvenile instars of oribatid mites (Acari: Oribatida). *Zootaxa*, 3833 (1), 1–132.
https://doi.org/10.11646/zootaxa.3833.1.1
Özdikmen H. (2008) Some nomenclatural changes for Acari (Ixodida and Oribatida). *Munis Entomology & Zoology*, 3 (2), 691–698.
Pérez-Iñigo, C. (1988) Revisión de las especies españolas del genero *Oribatella* Banks, 1895 (Acari, Oribatei). I. *Oribatella inflexa* Mihelcic, 1957. *Boletín de la Asociación Española de Entomología*, 12, 81–91.

Pérez-Iñigo, C. (1989) Revisión de las especies españolas del género *Oribatell*a Banks, 1895 (Acari, Oribatei). II. *Oribatella berlesei* (Michael, 1898) y *O. berninii*, n. sp. *Boletín de la Asociación Española de Entomología*, 13, 133–142.
Schneider, K., Renker, K., Scheu, S. & Maraun, M. (2004) Feeding biology of oribatid mites: a minireview. *Phytophaga, Palermo*, 14, 247–256.
Seniczak, S. & Seniczak, A. (2013) Differentiation of external morphology of *Oribatella* Banks, 1895 (Acari: Oribatida: Oribatellidae), in light of the ontogeny of three species. *Journal of Natural History*, 47 (23–24), 1569–1611. https://doi.org/10.1080/00222933.2012.763056
Seniczak, S., Seniczak, A. & Coulson, S.J. (2015) Morphology, distribution and certain population parameters of the Arctic mite *Oribatella arctica* (Acari: Oribatida, Oribatellidae). *International Journal of Acarology*, 41 (5), 395–414. https://doi.org/10.1080/01647954.2015.1048727
Shtanchaeva, U.Ya. & Subías, L.S. (2009) A review of oribatid mites of the family Oribatellidae (Acariformes, Oribatida) from the Caucasus. *Zoologicheskii Zhurnal*, 88 (2), 143–163. [in Russian] https://doi.org/10.1134/S0013873808020103
Starý, J. & Block, W. (1996) Oribatid mites (Acari, Oribatida) of the Falkland Islands, South Atlantic and their zoogeographical relationships. *Journal of Natural History*, 30 (4), 523–535. https://doi.org/10.1080/00222939600770281
Starý, J. & Block, W. (1998) Distribution and biogeography of oribatid mites (Acari, Oribatida) in Antarctica, the Sub-Antarctic Islands and nearby areas. *Journal of Natural History*, 32 (6), 861–894. https://doi.org/10.1080/00222939800770451
Subías, L.S. (2004) Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes: Oribatida) del mundo (excepto fósiles). *Graellsia*, 60 (Número Extraordinario), 3–305. https://doi.org/10.3989/graellsia.2004.v60.iExtra.218
Subías, L.S. (2019) *Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes: Oribatida) del mundo (excepto fósiles)*. 536 pp. Available from: http://bba.bioucm.es/cont/docs/RO_1.pdf (accessed 8 November 2019)
Thor, S. (1930) Beiträge zur Kenntnis der Invertebratenfauna von Svalbard. *Skrifter om Svalbard og Ishavet, Oslo*, 27, 1–156.
Travé, J. & Vachon, M. (1975) François Grandjean. 1882–1975 (Notice biographique et bibliographique). *Acarologia*, 17 (1), 1–19.
Tuxen, S.L. (1943) Die zeitliche und räumliche Verteilung der Oribatiden-Fauna (Acar.) bei Maelifell, Nord-Island. *Entomologiske Meddelelser*, 23, 321–336.
Vázquez, M.M. (1999) *Catálogo de los ácaros oribátidos edáphicos de Sian Ka'an, Quintana Roo, México*. Universidad de Quintana Roo, Chetumal, 126 pp.
Weigmann, G. (2001) Contribution to the taxonomy of European Poronota I. *Oribatella* and *Anachipteria*. *Spixiana*, 24 (3), 235–240.
Wunderle, I. (1992) Die Oribatiden-Gemeinschaften (Acari) der verschiedenen Habitate eines Buchenwaldes. *Carolinea, Karlsruhe*, 50, 79–144.