Invertebrate Taxonomy, 2000, **14**, 591–606

Lamingtonacarus, a new genus of Algophagidae (Acari : Astigmata) from water-filled treeholes in Queensland, Australia

Norman J. Fashing[AD], *Barry M. OConnor*[B] *and Roger L. Kitching*[C]

[A]Department of Biology, College of William and Mary, Williamsburg, VA 23187-8795, USA.
[B]Museum of Zoology, University of Michigan, Ann Arbor, MI 48109-1079, USA.
[C]Australian School of Environmental Studies, Griffith University, Nathan, QLD 4111, Australia.
[D]To whom correspondence should be addressed. Email: njfash@facstaff.wm.edu

Abstract. A new genus, *Lamingtonacarus*, gen. nov., and two new species, *L. oreillyorum*, sp. nov. and *L. posidonis*, sp. nov., are described from adults and deutonymphs collected from water-filled treeholes in an Australian subtropical rainforest. This constitutes the first described species of Algophagidae from Australia. The discovery of a deutonymphal instar in the ontogeny of *L. oreillyorum,* sp. nov. is the first for a member of the subfamily Algophaginae.

Introduction

Mites of the family Algophagidae inhabit semiaquatic and aquatic habitats and are presently known from the Palearctic, Nearctic and Oriental regions as well as from subantarctic islands. While members of the subfamily Hericiinae are found in sap fluxes or wet subcortical habitats [*Fusohericia* (Vitzhum 1931; Baker and Crossley 1964) and *Hericia* (Robin 1868; Michael 1903; Vitzhum 1931; Samsinak 1972)], members of the subfamily Algophaginae are often completely aquatic and have been recorded from brackish or intertidal waters [*Algophagus* (Hughes 1955) and *Neohyadesia* (Hughes and Goodman 1969)], algal mats in rivers [(*Algophagopsis* (Fain and Johnston 1975)], and water-filled treeholes [*Algophagus* (Fashing and Wiseman 1980)]. Subantarctic species of *Algophagus* have also been collected from grasses, mosses and moist humus (Fain 1974). Since the genus *Prohericia*, currently placed in the subfamily Hericiinae, is known only from a single deutonymph collected from a bark beetle, a phoretic relationship that is considered unusual (OConnor and Moser 1985), its habitat remains a mystery.

During studies on the structure and dynamics of aquatic arthropod communities associated with water-filled treeholes in Lamington National Park in southeastern Queensland (Kitching and Callaghan 1982; Kitching 1987; Jenkins and Kitching 1990), one of us (Kitching) first recovered specimens representing two undescribed species of Algophagidae. These mites were initially referred to the family Hyadesiidae, the family in which the Algophagidae was included at that time (Kitching and Callaghan 1982). They were subsequently studied in the laboratory by Fashing, who obtained the deutonymph, the first to be discovered in the subfamily Algophaginae. Fashing (1998) also reported on the functional morphology and probable feeding ecology of these mites. Since these species could not be assigned to any of the nominal genera in the family, a new genus is proposed.

Materials and methods

Detritus (leaves, twigs, etc.) along with water was collected from treeholes in the buttress roots of brush box (*Lophostemon confertus* (R. Br.) Wilson and Waterh., Myrtaceae) at Lamington National Park, Queensland, Australia. Collections were brought back to the laboratory, placed in finger bowls, and examined for mites under a dissecting microscope. Specimens were cleared in Nesbitt's solution and mounted in Hoyer's medium on microscope slides (Krantz 1978; Evans 1992). Since most dorsal setae of adult *L. oreillyorum,* sp. nov. are readily lost, all adult specimens collected directly from treeholes were missing many dorsal setae. Quiescent tritonymphs of this species were therefore collected from the treehole detritus and individually placed, along with a small piece of detritus, in a small, water-filled rearing cell; upon eclosion to adult, specimens were cleared and mounted as above. Such specimens are not completely sclerotised since allowing time for sclerotisation led to loss of setae.

10.1071/IT99021 0818-0164/00/040591

Characters to be measured were traced onto paper using a drawing tube, and measurements made with a calibrated Zeiss Zidas digitiser. All measurements are given in micrometres (μm) in the following order: holotype female, mean and range (in parentheses). Sample sizes for measured *L. oreillyorum*, sp. nov. are females 9, males 6, and deutonymphs 5, and for *L. posidonis,* sp. nov. females 10 and males 8. Relative position of setae and other structures are as in figures. Nomenclature for idiosomal setae follows Griffiths *et al.* (1990) and for leg setae, Grandjean (1939).

For observation of characters under the scanning electron microscope (SEM), live specimens were put through several baths of distilled water in an attempt to cleanse them of debris. They were then briefly submerged in distilled water near boiling point in order to force protraction of appendages. Specimens were then dehydrated in ethyl alcohol, dried using the critical point procedure, individually affixed to stubs using double-sided sticky tape, and coated with gold-palladium in a sputter coater. Microscopy was performed with an AMR 1200.

Abbreviations

ANIC	Australian National Insect Collection, CSIRO Entomology, Canberra
BM	The Natural History Museum, London
NJF	Personal collection, Norman Fashing, Williamsburg, VA
QM	Queensland Museum, Brisbane, Queensland
UMMZ	University of Michigan, Museum of Zoology, Ann Arbor, MI

Keys to adult and deutonymphal Algophagidae

Adults

1. Axillary organs extending posteroventrally over coxal fields II; empodial claws equal to or shorter than pretarsal ambulacra; males with some setae of tarsus IV suckerlike; in sap fluxes on trees.....2
   Axillary organs restricted to dorsal and ventral regions between legs, not extending posteroventrally over coxal fields II; empodial claws I–II often longer than membranous pretarsal ambulacra; males with setae of tarsus IV flattened, filiform, or spinelike, never suckerlike; in semi-terrestrial or submerged aquatic habitats.....3
2. Body entirely sclerotised, cuticle smooth, without ornamentation; tarsi III–IV of female and III of male extremely attenuate.....*Fusohericia*
   Body with sclerotisation restricted to prodorsal region and numerous small sclerites on hysterosomal dorsum; cuticle often with long microtrichae in unsclerotised regions; tarsi not attenuate as above.....*Hericia*
3. Anterior idiosoma with strongly sclerotised cuticle extending laterally from prodorsal sclerite and ventrally over coxal fields I–II; internal vertical setae trifurcate or multibranched; tarsus III bearing 8 setae (seta *r* present).....*Lamingtonacarus*
   Anterior idiosoma without such sclerotisation; prodorsal sclerite discrete, not connected to other sclerotised areas; coxal fields I–II not totally sclerotised; internal vertical setae simple; tarsus III bearing 7 setae (seta *r* absent).....4
4. Axillary organs small, restricted to dorsal surface above base of legs I; female with ovipore between coxal fields I–II; epigynial apodeme abutting anterior coxal apodemes I.....*Neohyadesia*
   Axillary organs larger, extending onto ventral surface between legs I–II; female with ovipore between coxal fields II–IV; epigynial apodeme clearly separated from coxal apodemes I.....5
5. Hysterosoma completely sclerotised dorsally; ocelli present on a raised protuberance anterior to scapular setae; tarsus I with solenidion ω2 absent.....*Algophagopsis*
   Hysterosoma unsclerotised or with small paired sclerites in anterior region; ocelli absent; tarsus I with solenidion ω2 present.....*Algophagus*

Deutonymphs

1. Propodosomal ocelli present; legs I longer than half the body length; gnathosoma reduced to a sclerotised plate without setae or solenidia.....*Prohericia*
   Propodosomal ocelli absent; legs I less than half the body length; gnathosoma present, bearing solenidia or setae, or both.....2
2. Attachment organ with anterior lateral cuticular suckers well developed; tarsus III bearing 8 setae (seta *r* present).....*Lamingtonacarus*, gen. nov.
   Anterior lateral cuticular suckers of attachment organ absent; tarsus III bearing 7 setae (seta *r* absent).....3
3. Ambulacaral stalks of pretarsi III–IV more than twice as long as their respective tarsi.....*Fusohericia*
   Ambulacaral stalks of pretarsi III–IV at most only slightly longer than their respective tarsi.....*Hericia*

Genus ***Lamingtonacarus***, gen. nov.

Type species: *Lamingtonacarus oreillyorum*, sp. nov., by present designation.

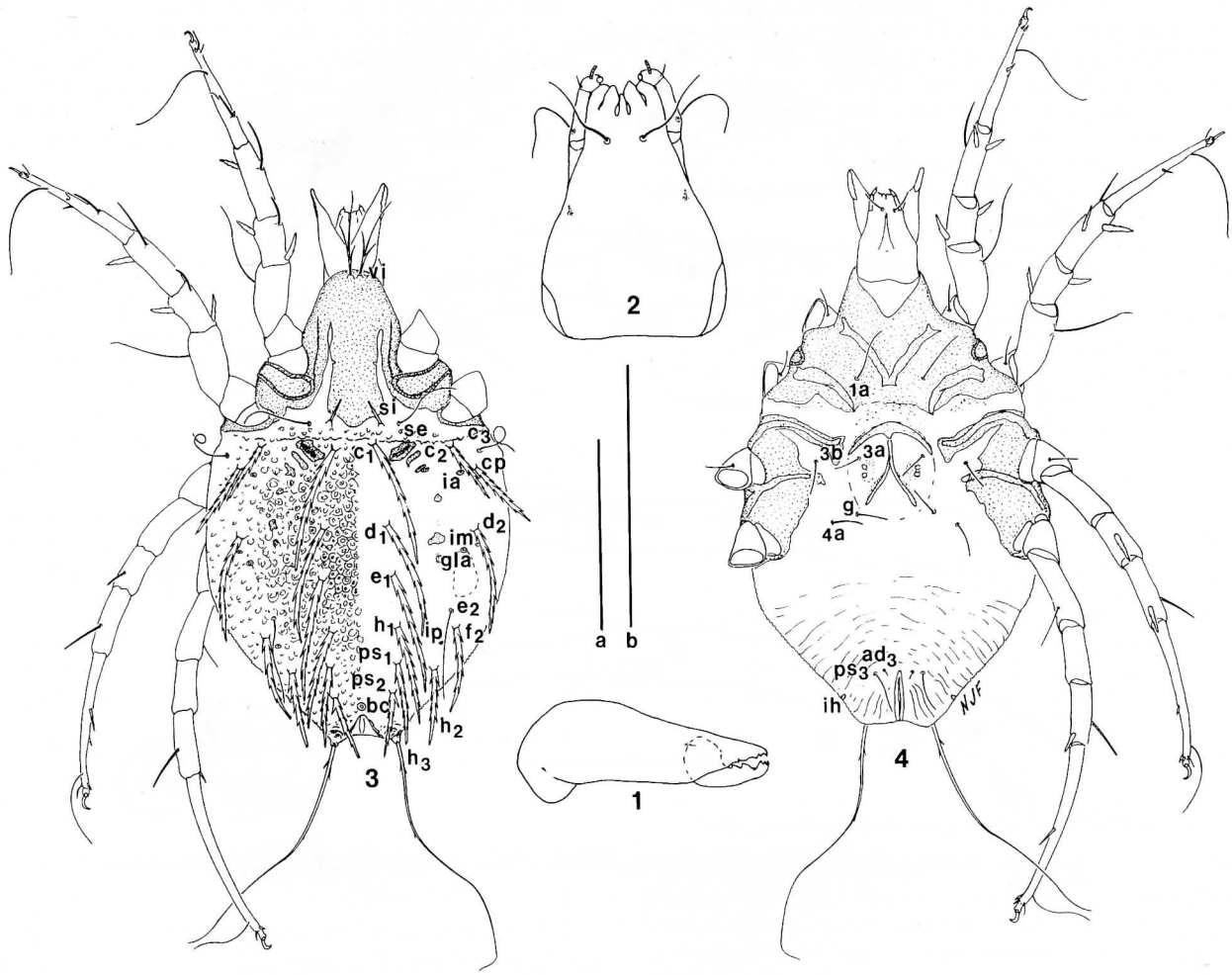
Diagnosis

Description of adult

Propodosoma with sclerotised camerostome (Fig. 37), consisting of heavily sclerotised cuticle contiguous with anterior margin of prodorsal sclerite, extending laterally around bases of legs, and ventrally over the coxae; remainder of dorsum sclerotised, but less so, and usually mammilated with rounded protuberances (Figs 9, 38); axillary organs largely restricted to dorsal and lateral space between bases of legs I–II; idiosoma distinctly bilobed posteriorly; internal vertical setae (*vi*) trifurcate (Fig. 42); other dorsal setae variable, but at least f_2, h_1, h_2, ps_1, and ps_2 with distinct barbs; coxal field II without seta; leg setation as in other Algophagidae except seta *r* present on tarsus III, and solenidion ω2 absent from tarsus I.

Description of deutonymph

Gnathosomal remnant (Figs 12, 21–22) with subcapitulum about as long as wide, palpal supracoxal setae very short, positioned dorsally on subcapitulum, ventral subcapitular setae usually present; dorsal cuticle with raised protuberances (Fig. 13); attachment organ with anterior lateral and posterior median cuticular suckers (among others) well developed; leg setation as in other Algophagidae except seta *nG* present on genu III, and solenidion ω2 absent from tarsus I; tarsi I–II with setae *la*, *ra*, and *e* foliate.



Figs 1–4. *Lamingtonacarus oreillyorum*, sp. nov., female: *1*, chelicera, lateral view; *2*, subcapitulum, ventral view; *3*, idiosoma, dorsal view; *4*, idiosoma, ventral view. Scale bars: a, Figs *3*, *4*, 200 μm; b, Figs *1*, *2*, 100 μm.

Lamingtonacarus oreillyorum, sp. nov.

(Figs 1–28)

Hyadesiid mite. Kitching and Callaghan 1982; Kitching 1983.
Algophagid. Kitching and Pimm 1985; Kitching and Beaver 1990.
Algophagid mit\e. Kitching 1987; Pimm and Kitching 1987; Jenkins and Kitching1990; Jenkins *et al.* 1992.
Algophagidae sp. 2. Fashing 1998.

Material examined

Holotype. Queensland: ♀, water-filled treeholes in Box Forest, Lamington National Park, via Canungra, 1.5 km ESE of O'Reillys' Guesthouse (bearing 106°E from guesthouse). Reared in laboratory from cultures established by Fashing from collections made 29.i.1994 (QM).

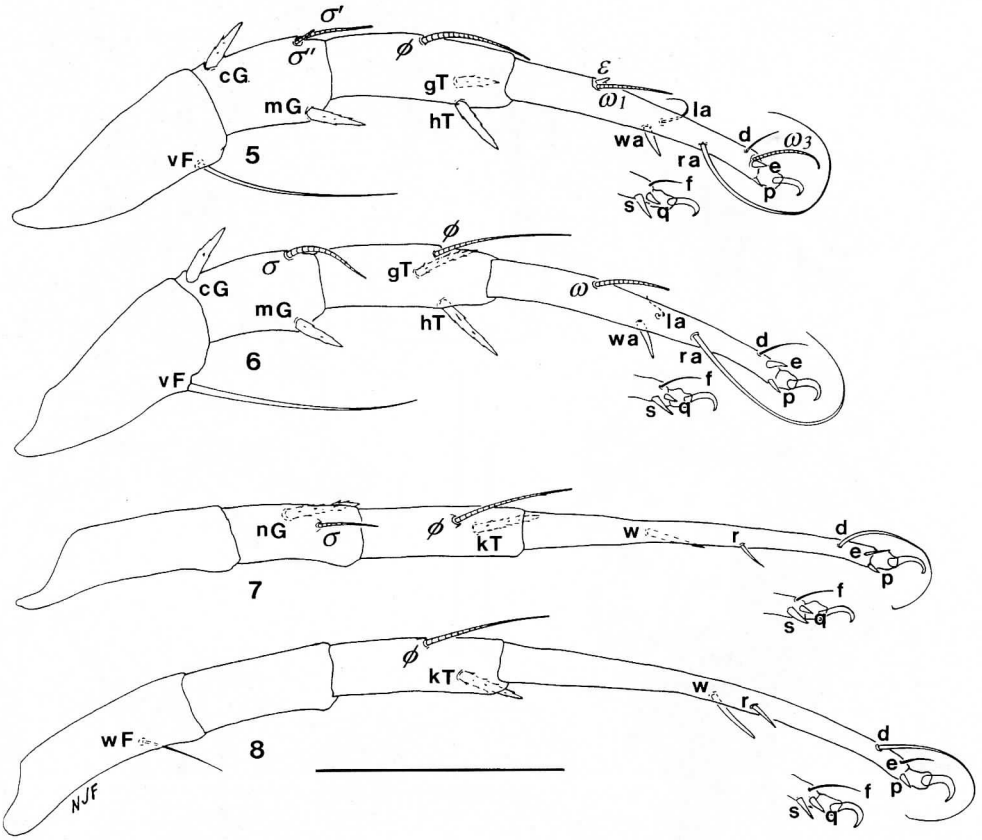
Paratypes. **Queensland:** 8♀, 6♂, same data as holotype (ANIC, BM, NJF, QM, UMMZ); 13♀, 10♂, collected by Fashing at same locality, 9.ii.1994 (ANIC, BM, NJF, QM, UMMZ); 22♀, 20♂, 11 tritonymphs, 4 protonymphs, and 2 larvae collected by Kitching at same locality, v.1980, xii.1982, i.1983, iv.1983, 1983 (ANIC, BM, QM, UMMZ); 4 deutonymphs, 1 pharate deutonymph reared in laboratory from cultures established by Fashing from collections made at same locality, 9.ii.1994 (ANIC, BM, QM, UMMZ); 1 deutonymph collected by Fashing at same locality, 29.i.1994 (ANIC).

Description

Female (Figs 1–11)

Body ovoid, length 496, 514 (477–553); width at level of coxae III 336, 334 (317–368). Gnathosoma with chelate chelicerae (Fig. 1) with digits thin and with few well-developed teeth, cheliceral seta very short and spine-like; subcapitulum (Fig. 2) bearing a pair of short, spine-like, palpal supracoxal setae dorsolaterally and a pair of filiform subcapitular setae ventrally. Each palpal tibia bears a filiform dorsal seta, a°°°°°nd each palpal tarsus a filiform dorsal seta, a subapical solenidion, and a basal rounded eupathidium; ventral palpal seta absent.

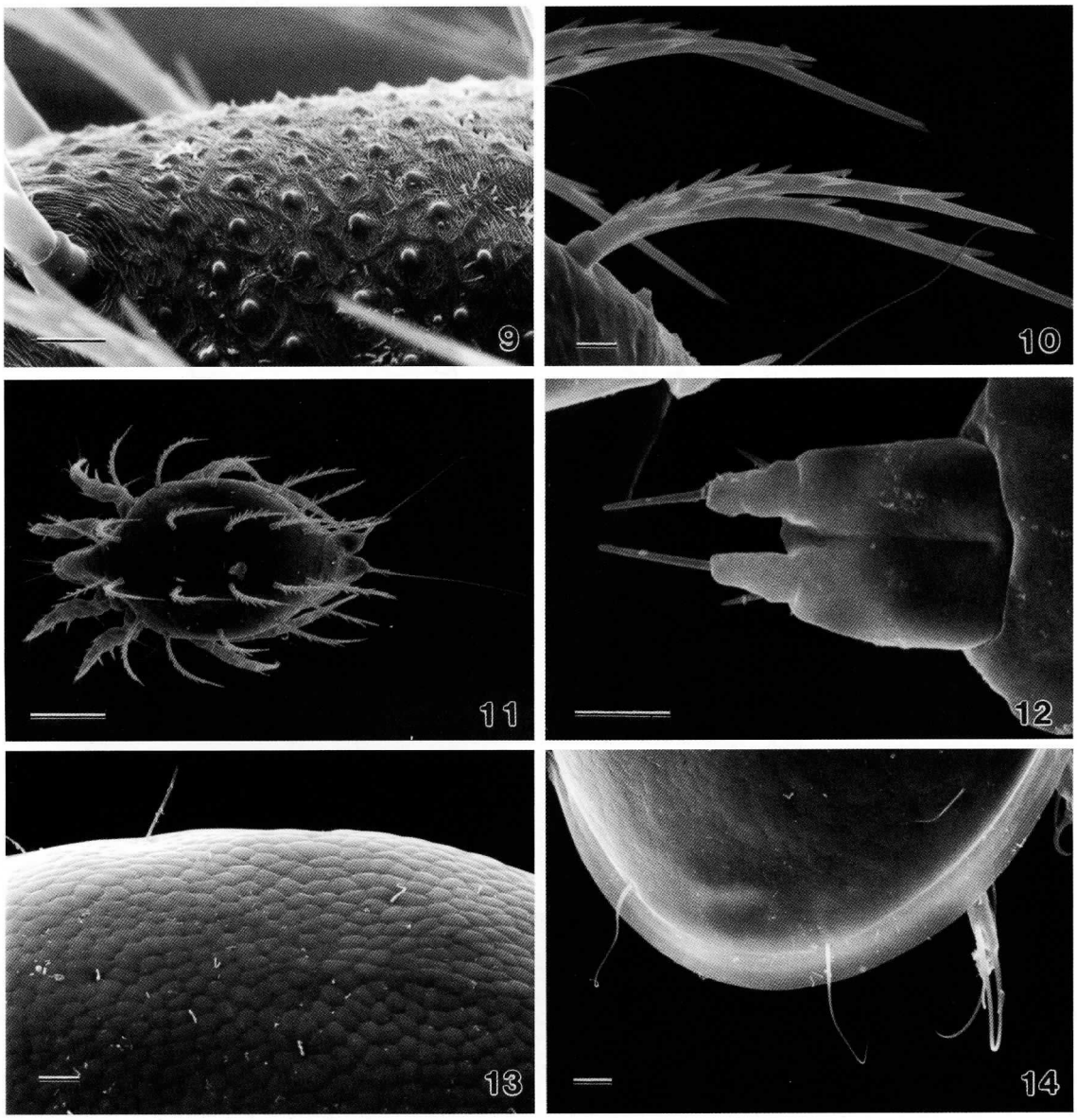
Dorsum (Fig. 3). Cuticle lightly sclerotised, mammilated with small rounded protuberances that are sometimes enclosed in a reticulate pattern (Fig. 9). From three to eight



Figs 5–8. *Lamingtonacarus oreillyorum*, sp. nov., female: *5*, leg I; *6*, leg II; *7*, leg III; *8*, leg IV. Scale bar: 100 μm.

small islands of heavily sclerotised cuticle in a chain running lengthwise between central row and lateral row of setae from c_1 to e_1, the first of these have shallow central depressions and demarcate the dorsal sejugal apodemes. Prodorsal sclerite over twice as long as wide, extending to level of trochanters II. A pair of small unsclerotised areas representing vestigial alveoli of setae *ve* midway on lateral margins of prodorsal sclerite. Heavily sclerotised cuticle contiguous with prodorsal sclerite anteriorly, extending posteriolaterally, surrounding bases of trochanters I and II. Sejugal furrow absent. Grandjean's organs and supracoxal setae absent. Opisthonotal gland openings (*gla*) posterior to setae d_2. Cupules located as follows: *ia* slightly mesiad of seta *cp*, *im* slightly posterior to seta d_2, and *ip* between setae f_2 and h_2. Bursa copulatrix at end of short tube located just above anus; extremely long internal inseminatory canal leads to weakly sclerotised spermatheca. Dorsum bearing 17 pairs of setae arising from elevated tubercles (Fig. 10). Seta *vi* trifurcate with few small barbs on medial branch 85, 85 (76–92); seta *si* lanceolate, sometimes with short barbs, 20, 25 (18–33); setae c_1 96, 114 (76–140), c_2 58, 66 (50–89), *cp* 73, 85 (73–96), d_1 96, 122 (96–148), d_2 90, 105 (90–119), e_1 103, 123 (103–137), f_2 64, 83 (64–98), h_1 83, 104 (83–116), h_2 63, 73 (63–81), ps_1 63, 85 (63–110), and ps_2 63, 66 (58–75) all biserrate (Fig. 10) and arching posteriorly over idiosoma (Fig. 11). Setae *se* 106, 104 (82–116), c_3 66, 78 (65–90) and e_2 101, 99 (84–110) all filiform. Seta h_3 219, 260 (219–282) filiform with few barbs, arising from cone-shaped idiosomal projections (Fig. 11). In most adult specimens collected from treeholes, the long, enlarged, biserrate setae are broken off at the base, a phenomenon not observed in larvae and homeomorphic nymphs.

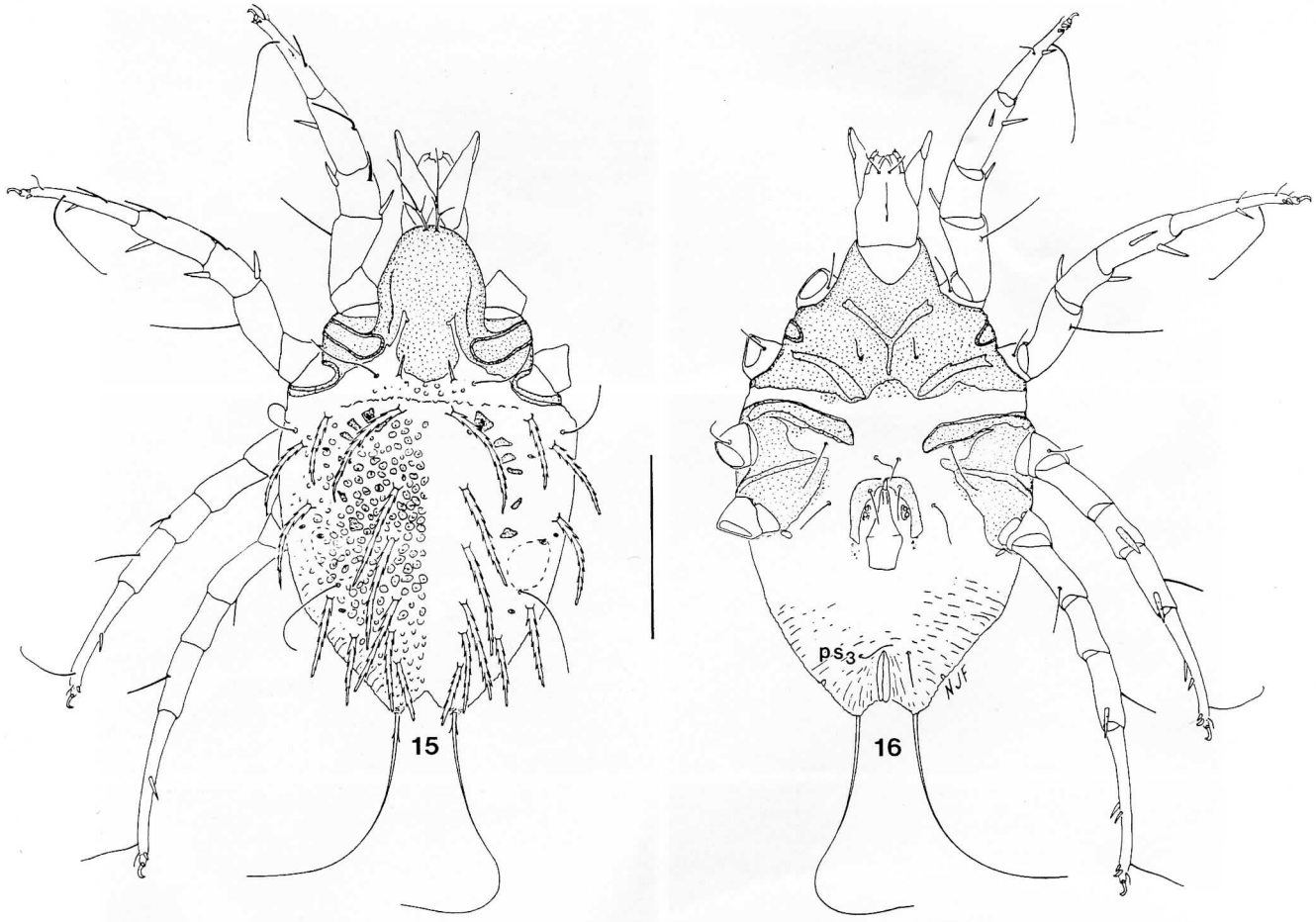
Venter (Fig. 4). Heavily sclerotised cuticle extending from dorsum of propodosoma and covering its venter. Heavy sclerotisation also surrounding bases of trochanters III and IV and extending over coxae; coxae III deeply incised with narrow band of lightly sclerotised cuticle; remaining cuticle lightly sclerotised. Anterior coxal apodemes I directed posteromedially, joining at midline in a V-shape. Anterior coxal apodemes II and III directed posteromedially; anterior coxal apodemes IV directed medially. Epigynial apodeme arched anteriorly, extending laterally to bases of setae *3a*; oviporus located centrally between coxae III and IV, sclerotised on margins. Genital papillae vestigial, arising from small island of sclerotised cuticle. Cupules *ih* on lateral margin of idiosoma directly anterior to setae h_3. Anus ventroterminal. Venter bearing seven pairs



Figs 9–14. *Lamingtonacarus oreillyorum*, sp. nov.: *9*, cuticular sculpturing on dorsum, female; *10*, enlarged dorsal setae, female; *11*, curvature of setae, dorsal view, female; *12*, subcapitulum, ventral view, deutonymph; *13*, cuticular sculpturing on dorsum, deutonymph; *14*, flange surrounding dorsum of idiosoma, deutonymph. Scale bars: Figs 9, 10, 12, 13, 14, 10 μm; Fig. 11, 100 μm.

of thin, filiform setae: *1a* 43, 76 (43–79), *3a* 25, 31 (25–38), *3b* 41, 41 (30–49), *4a* 33, 34 (32–38), *g* 35, 38 (35–45), ad_3 14, 14 (11–16) and ps_3 40, 41 (36–44).

Legs (Figs 5–8). Legs well sclerotised, I–II originate dorsolaterally, III–IV ventrolaterally. Lengths, measured from base of trochanter to tip of tarsus: I 344, 340 (324–365), II 370, 362 (348–374), III 382, 367 (343–392), IV 424, 418 (404–437). Tarsal lengths: I 124, 122 (114–130), II 143, 137 (128–144), III 166, 152 (143–166), IV 193, 185 (177–193). Setation (I to IV): tarsus 9–9–8–8; tibia 2–2–1–1, genua 2–2–1–0, femora 1–1–0–1, and trochanters 1–1–1–0. Setation trochanter to tibia as follows: trochanters I–III each with a filiform seta (*pR, sR*); femora I, II and IV each with a filiform seta (*vF, wF*), *vF* long, *wF* short; genua I, II with setae *cG* and *mG* and genu III with seta *nG* a stout spine with short barbs; tibiae I, II with setae *gT* and *hT* and tibiae III, IV with setae *kT* spines with short barbs. Tarsal setation as follows: I, II with setae *wa* and III, IV with setae *w* slender spines; I, II with long, filiform seta *ra* and III, IV with seta *r* short spines; I, II with seta *d* short, filiform, and III, IV with seta *d* long, filiform; I–II with seta *la* short, filiform; I–IV with seta *f* short, filiform; seta *e* a spine on I, II, more filiform



Figs 15, 16. *Lamingtonacarus oreillyorum*, sp. nov., male: *15*, idiosoma, dorsal view; *16*, idiosoma, ventral view. Scale bar: 200 μm.

on III, IV; proral setae (*p* and *q*) I–IV short spines of equal length, seta *s* I–IV a spine. Solenidia (I to IV): tarsi 2–1–0–0, tibiae 1–1–1–1, genua 2–1–1–0; genua I–III with solenidia σ originating one-fourth of way from apical end, solenidion σ′′ one-fourth length of σ′; tibiae I–IV with solenidion φ slightly more than one-half length of segment and originating approximately midway on segment; tarsus I with solenidion ω1 originating one-fourth of length from base, solenidion ω3 apical, and ω2 absent. Tarsus I with spinelike famulus ε adjacent to solenidion ω1. Pretarsi with membranous ambulacra and slender, curved claws; condylophores very weakly developed.

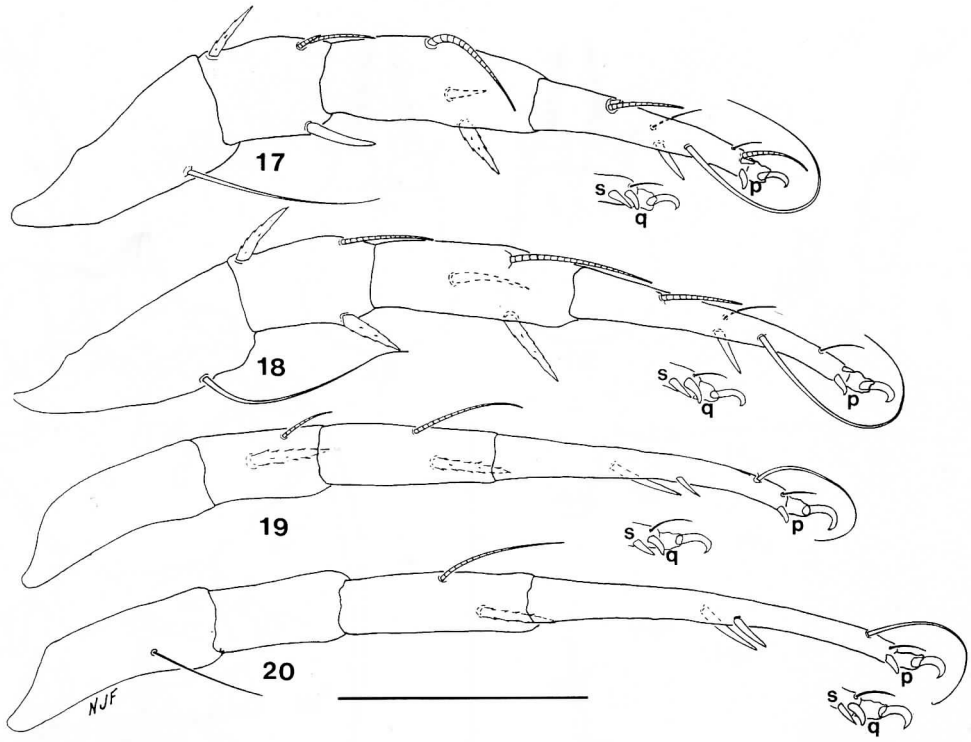
Male (Figs 15–20)

Body ovoid, length 504 (480–524), width at level of coxae III 314 (298–334). Gnathosoma and general features of idiosoma similar to female.

Dorsum (Fig. 15). Similar to female in degree of cuticular sclerotisation and ornamentation pattern. Dorsum bearing 17 pairs of setae with shapes similar to female. Setae *vi* 86 (79–97); *si* 27 (20–34), *se* 101 (89–112), c_1 132 (104–155), c_2 81 (51–110), c_3 77 (68–85), *cp* 96 (85–107), d_1 122 (109–133), d_2 108 (99–113), e_1 124 (111–134), e_2 104 (100–108), f_2 86 (73–104), h_1 110 (97–122), h_2 78 (68–86), h_3 273 (234–319), ps_1 84 (69–99), ps_2 69 (63–77).

Venter (Fig. 16). Similar to female in degree of cuticular sclerotisation, genital papillae, and apodeme structure, except for narrow U-shaped band of sclerotised cuticle surrounding aedeagus and apodemes I uniting to form a Y-shaped sternum. Aedeagus strongly sclerotised, hinged posteriorly, located between coxal fields IV. A narrow, inverted U-shaped band of heavily sclerotised cuticle surrounds aedeagus. Anus ventroterminal. Venter bearing six pairs of thin, filiform setae: *1a* 71 (57–83), *3a* 26 (23–29), *3b* 56 (48–62), *4a* 48 (46–50), *g* 37 (32–40) and ps_3 40 (35–43); setae ad_3 lacking.

Legs (Figs 17–20). Lengths, from base of trochanter to tip of tarsus: I 337 (327–359), II 364 (351–385), III 354 (344–370), IV 397 (389–408). Tarsal lengths: I 103 (97–111), II 126 (120–135), III 130 (125–139), IV 163 (159–169). Leg lengths, relative to idiosomal lengths, not significantly different from those of female; however, tarsal lengths, relative to total leg lengths, significantly shorter in males. Male similar in leg chaetotaxy and solenidotaxy to



Figs 17–20. *Lamingtonacarus oreillyorum*, sp. nov., male: *17*, leg I; *18*, leg II; *19*, leg III; *20*, leg IV. Scale bar: 100 μm.

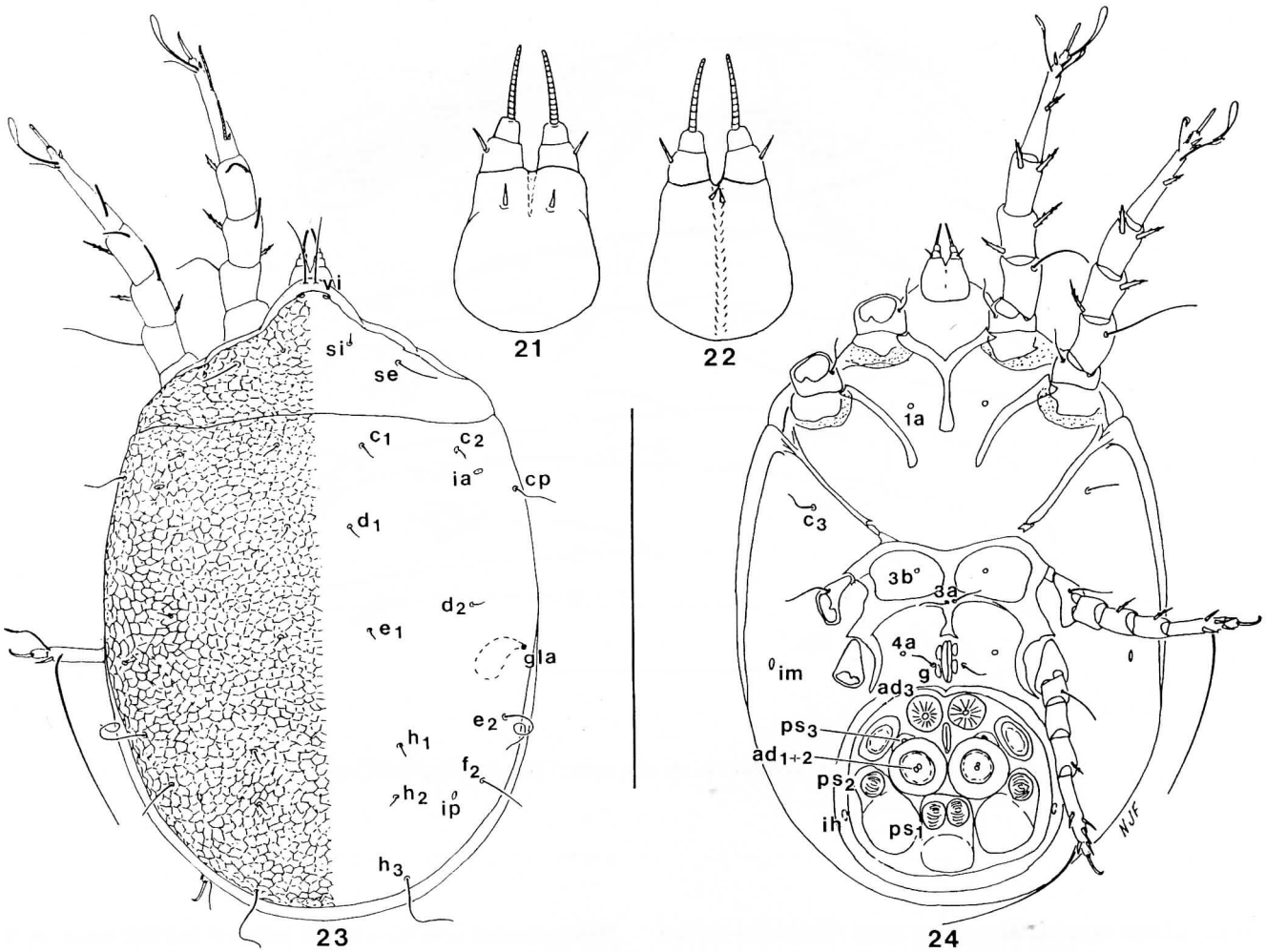
female, except tarsal setae *p* and *q* more robust and curved ventrally, seta *s* slightly displaced paraxially, closer to seta *q*, and genual setae *gT* I–II not barbed.

Deutonymph (Figs 12–14, 21–28)

Body broadly ovoid; length 345 (325–366); width 234 (217–275). Gnathosoma with subcapitulum and palps well developed (Figs 12, 21–22); subcapitulum with medial trough-like furrow ventrally, bearing a pair of very short supracoxal setae (*elc p*) dorsally. Some specimens bear a pair of ventral subcapitular setae between and ventral to base of palps. Palps bearing palpal solenidia apically and filiform palpal setae (*dm*) laterally.

Dorsum (Fig. 23). Dorsum largely covered by reticulate-sculptured (Fig. 13) propodosomal and hysterosomal sclerites; sclerites separated by well-developed sejugal furrow. Lateral margin of hysterosomal sclerite extends outward as a narrow, thin flange (Fig. 14). Apex of propodosomal sclerite with a pair of unsclerotised areas representing vestigial alveoli of setae *ve*. Internal vertical setae (*vi*) filiform, positioned slightly anterior to apex of propodosomal sclerite, length 33 (31–35). Propodosomal sclerite with two pairs of filiform setae: *si* 8 (7–9) and *se* 25 (20–29). Hysterosomal sclerite with 11 pairs of hairlike setae: c_1 9 (6–11), c_2 11 (10–14), *cp* 20 (18–23), d_1 7 (6–8), d_2 9 (8–12), e_1 7 (6–8), e_2 77 (72–87), f_2 24 (22–26), h_1 6 (5–9), h_2 6 (5–8) and h_3 37 (35–41). Opisthosomal gland openings located laterally between setae d_2 and e_2. Cupules *ia* approximately midway between setae c_2 and *cp*; cupules *ip* slightly posterior and mesiad of setae f_2.

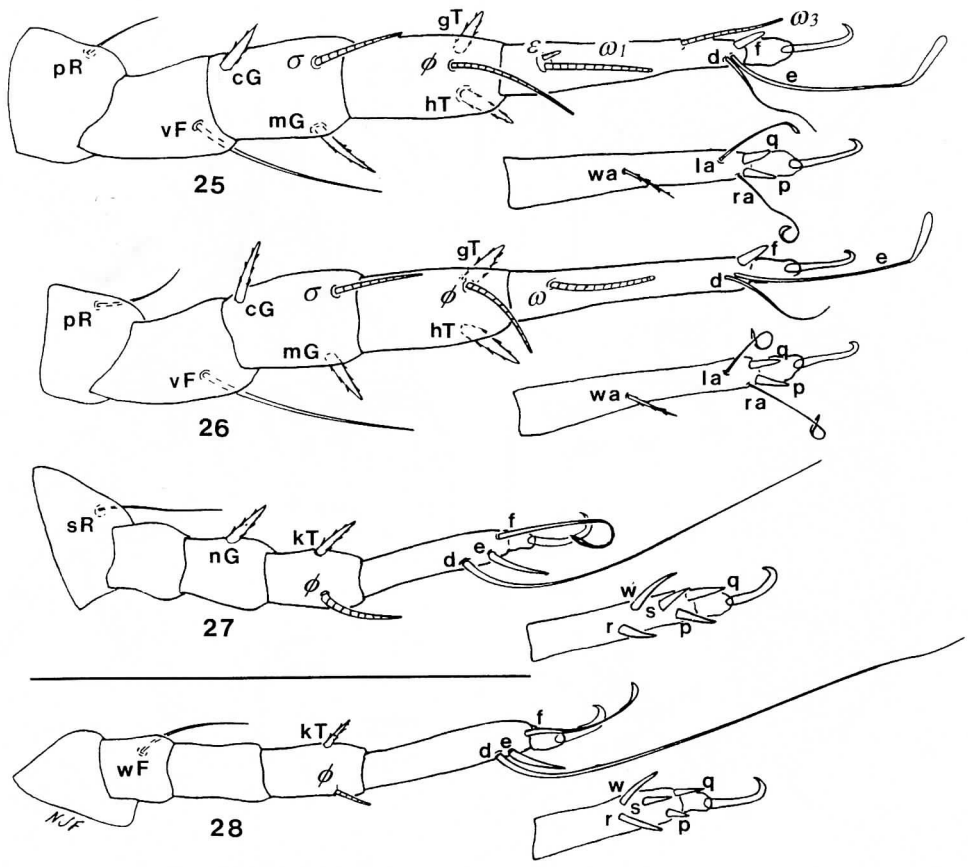
Venter (Fig. 24). Narrow bands of sclerotisation on coxae around bases of trochanters I and II. Anterior apodemes of coxal fields I fused to form Y-shaped sternum; anterior apodemes of coxal fields II curved medially. Posterior apodemes of coxal fields II curved medially, ending contiguous to anterior apodemes III. Anterior apodemes of coxal fields III fused with each other and with anterior apodemes of coxal fields IV; posterior apodemes III fused with anterior apodemes IV and also with base of anterior apodemes III, coxal fields III completely enclosed. Posterior medial apodeme well developed, extending from anterior apodemes IV to genital opening. Setae c_3 filiform, length 18 (13–22), positioned between legs II and III. Setae of coxal fields I (*1a*), III (*3b*) and IV (*4a*) absent, their positions represented by vestigial alveoli. Setae *3a* 16 (11–19) filiform, located at junction of apodemes IV and median apodeme. Genital opening between coxae IV; setae *g* 16 (11–23) filiform, flanking



Figs 21–24. *Lamingtonacarus oreillyorum*, sp. nov., deutonymph: *21*, subcapitulum, dorsal view; *22*, subcapitulum, ventral view; *23*, idiosoma, dorsal view; *24*, idiosoma, ventral view. Scale bar: Figs *21*, *22*, 100 μm; Figs *23*, *24*, 200 μm.

genital opening. Genital papillae short, two-segmented, rounded apically. Cupules *im* located laterally, between legs III and IV; cupules *ih* lateral to posterior portion of attachment organ and under its fringe. Attachment organ well developed with membrane-like outer fringe. Anterior suckers (ad_3) with spokes radiating from center. Median suckers larger, consisting of a marginal ring surrounding an inner core containing paired vestigial alveoli (ad_{1+2}). Pair of small refractile spots (vestigial alveoli of ps_3) anteriolateral to median suckers. Setae ps_2 conoidal and situated posteriolateral to median suckers; Setae ps_1 conoidal and situated contiguously, posterior to median suckers. Anterior and posterior lateral and posterior medial cuticular suckers well developed. Anus located between anterior and median suckers.

Legs (Figs 25–28). Legs elongate, all segments free. Legs I 150 (140–160) and II 149 (140–156) longer than legs III 103 (97–110) and IV 115 (106–129). Tarsal lengths: I 51 (48–54), II 50 (48–52), III 33 (32–34), IV 37 (34–39). Setation (I–IV): tarsus 8–8–8–8, tibiae 2–2–1–1; genua 2–2–1–1, femora 1–1–0–1, trochanters 1–1–1–0. Setation, trochanters to tarsi: trochanters I–III each with filiform seta (*pR, sR*); femora I, II, IV each with filiform seta (*vF, wF*), *vF* longer than *wF*; genua I, II with setae *cG* and *mG* and genua III with seta *nG* stout spines with short serrations; tibiae I, II with setae *gT* and *hT* and tibiae III, IV with setae *kT* stout spines with short serrations. Tarsal setation as follows: I, II with setae *wa* slender spines with short serrations, III, IV with spinous setae *w* and *r*; seta *d* filiform, short on I, II and quite long on III, IV; I, II with setae *ra* and *la* foliate; setae *f* stout spines on I, II, foliate on III, IV; seta *e* long, spatulate on I, II, spinous on III, IV; prorals (*p* and *q*) short spines on all tarsi; III, IV with spinous seta *s*. Solenidia (I–IV): tarsus 2–1–0–0, tibiae 1–1–1–1 and genua 1–1–0–0. Spinelike famulus ε on tarsus I. All pretarsi consisting of short membranous ambulacra with hooked empodial claws, claws longer than ambulacra; condylophores not observed.



Figs 25–28. *Lamingtonacarus oreillyorum*, sp. nov., deutonymph: *25*, leg 1; *26*, leg II; *27*, leg III; *28*, leg IV. Scale bar: 100 μm.

Etymology

The species is named in honor of the O'Reilly family, Lamington National Park, Queensland, for their dedication to preserving the rainforest.

Lamingtonacarus posidonis, sp. nov.

(Figs 29–48)

Hyadesiid mite. Kitching and Callaghan 1982; Kitching 1983.
Algophagid. Kitching and Pimm 1985; Kitching and Beaver 1990.
Algophagid mite. Kitching 1987; Pimm and Kitching 1987; Jenkins and Kitching1990; Jenkins *et al.* 1992.
Algophagidae sp. 1. Fashing 1998.

Material examined

Holotype. Queensland: ♀, collected from water-filled treehole in Box Forest, Lamington National Park, via Canungra, 1.5 km ESE of O'Reillys' Guesthouse (bearing 106°E from guesthouse), 29.i.1994 (QM).

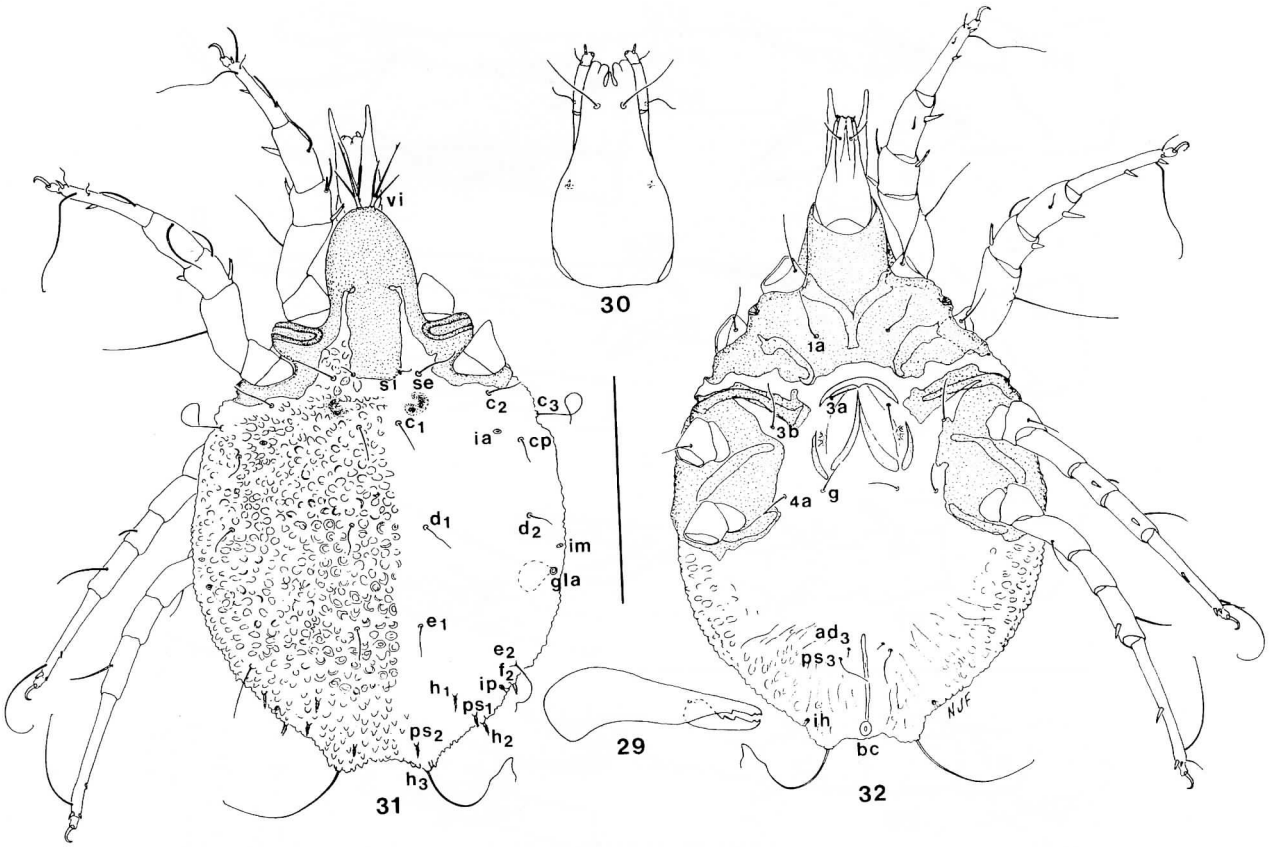
Paratypes. **Queensland:** 9♀, 9♂ collected by Fashing at same locality as holotype, 29.i.1994 (ANIC, BM, NJF, QM, UMMZ); 24 ♀, 4 ♂, 7 tritonymphs collected by Kitching at same locality, v.1980, xii.1982, i.1983, iv.1983, 1983 (ANIC, BM, QM, UMMZ).

Description

Female (Figs 29–42)

Body ovoid, length 484, 489 (476–520); width at level of coxae III 315, 314 (307–319). Gnathosoma with slender, chelate chelicerae (Fig. 29) with more weakly developed teeth, both digits centrally with elongate, blade-like tooth; subcapitulum (Fig. 30) slender, bearing a pair of filiform subcapitular setae ventrally and a pair of short, spine-like supracoxal setae dorsolaterally. Each palpal tibia bears a filiform dorsal seta, and each palpal tarsus a filiform dorsal seta, a subapical solenidion, and a basal rounded eupathidium.

Dorsum (Fig. 31). Cuticle sclerotised, bearing mound-like mammilations (Fig. 38). One pair of rounded sclerites with deep central pits between scapular setae and setae c_1 demarcating the dorsal sejugal apodemes (Fig. 39). Prodorsal sclerite over twice as long as wide, extending to level of legs II. A pair of small unsclerotised areas representing the vestigial alveoli of setae *ve* occur midway on lateral margins of prodorsal sclerite. Heavily sclerotised cuticle continuous with anterior of prodorsal sclerite extends posteriolaterally surrounding bases of trochanters I and II. Grandjean's organs and supracoxal setae absent. Axillary organs located dorsally

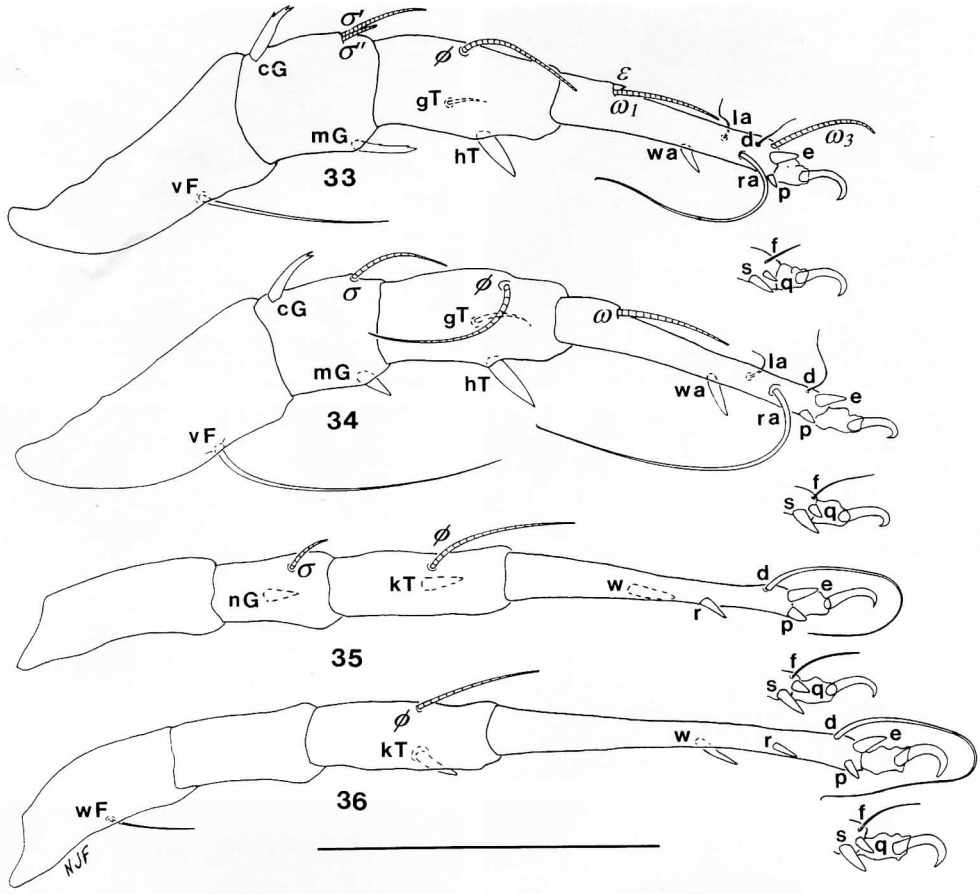


Figs 29–32. *Lamingtonacarus posidonis*, sp. nov., female: *29*, chelicera, lateral view; *30*, subcapitulum, ventral view; *31*, idiosoma, dorsal view; *32*, idiosoma, ventral view. Scale bar: Figs *29*, *30*, 100 μm; Figs *31*, *32*, 200 μm.

behind insertions of legs I, extending laterally between legs I and II, but not extending ventrally onto coxae. Opisthonotal gland openings (*gla*) on lateral margin between setae d_2 and e_2. Cupules located as follows: *ia* slightly anterior and mesiad of seta *cp*, *im* on lateral margin and slightly posterior seta d_2, and *ip* on lateral margin and slightly mesiad setae f_2. Bursa copulatrix a short sclerotised tube just above anus (Fig. 40); internal inseminatory canal very long. Dorsum bearing 17 pairs of setae, which arise from short, cuticular projections (Fig. 41). Seta *vi* trifurcate (Fig. 42) 67, 57 (50–67); setae *si* 19, 20 (14–29), *se* 69, 67 (59–71), c_1 28, 26 (23–33), c_2 38, 31 (25–42), c_3 101, 86 (70–101), *cp* 20, 22 (17–36), d_1 33, 32 (28–38), d_2 18, 23 (15–32), e_1 30, 30 (26–34), e_2 72, 78 (61–96) hairlike (e_1 occasionally barbed at base). Setae h_3 144, 141 (102–166) filiform, arising from small idiosomal mounds. Setae f_2 11, 12 (9–17), h_1 17, 17 (9–23), h_2 17, 18 (15–26), ps_1 11, 10 (9–13) and ps_2 11, 18 (11–26) pilose (Fig. 41) (h_1 occasionally filiform).

Venter (Fig. 32). Heavily sclerotised cuticle extending from dorsum and covering the propodosoma. Heavy sclerotisation also surrounding the bases of trochanters III and IV and extending over coxae III and IV; coxae III deeply incised with narrow band of less sclerotised cuticle. Remaining cuticle lightly sclerotised. Anterior coxal apodemes I directed posteromedially, joining at midline to form a Y-shaped sternum. Anterior coxal apodemes II and III directed posteromedially; anterior coxal apodemes IV directed anteriomedially. Epigynial apodeme arched anteriorly, extending laterally to bases of setae *3a*; oviporus located centrally between coxae III and IV, sclerotised on margins. An elongate arc of sclerotised cuticle flanks oviporous laterally on each side. Genital papillae vestigial, arising from a small island of sclerotised cuticle. Cupule *ih* on idiosomal margin directly anterior seta h_3. Anus ventroterminal. Venter bearing seven pairs of hairlike setae: *1a* 42, 46 (41–55), *3a* 25, 22 (18–26), *3b* 38, 36 (32–40), *4a* 37, 35 (27–40), *g* 28, 28 (22–36), ad_3 8, 10 (6–17) and ps_3 40, 37 (34–40). One or both setae *1a* absent on some specimens.

Legs (Figs 33–36). Legs heavily sclerotised; lengths, measured from base of trochanter to tip of tarsus: I 243, 250 (238–258), II 262, 255 (247–264), III 255, 256 (246–266), IV 291, 296 (282–323). Tarsal lengths: I 72, 76 (72–80), II 88, 86 (82–89), III 93, 92 (88–94), IV 117, 119 (117–123). Setation (I to IV): tarsus 9–9–8–8; tibia 2–2–1–1, genua 2–2–1–0,



Figs 33–36. *Lamingtonacarus posidonis*, sp. nov., female: *33*, leg I; *34*, leg II; *35*, leg III; *36*, leg IV. Scale bar: 100 μm.

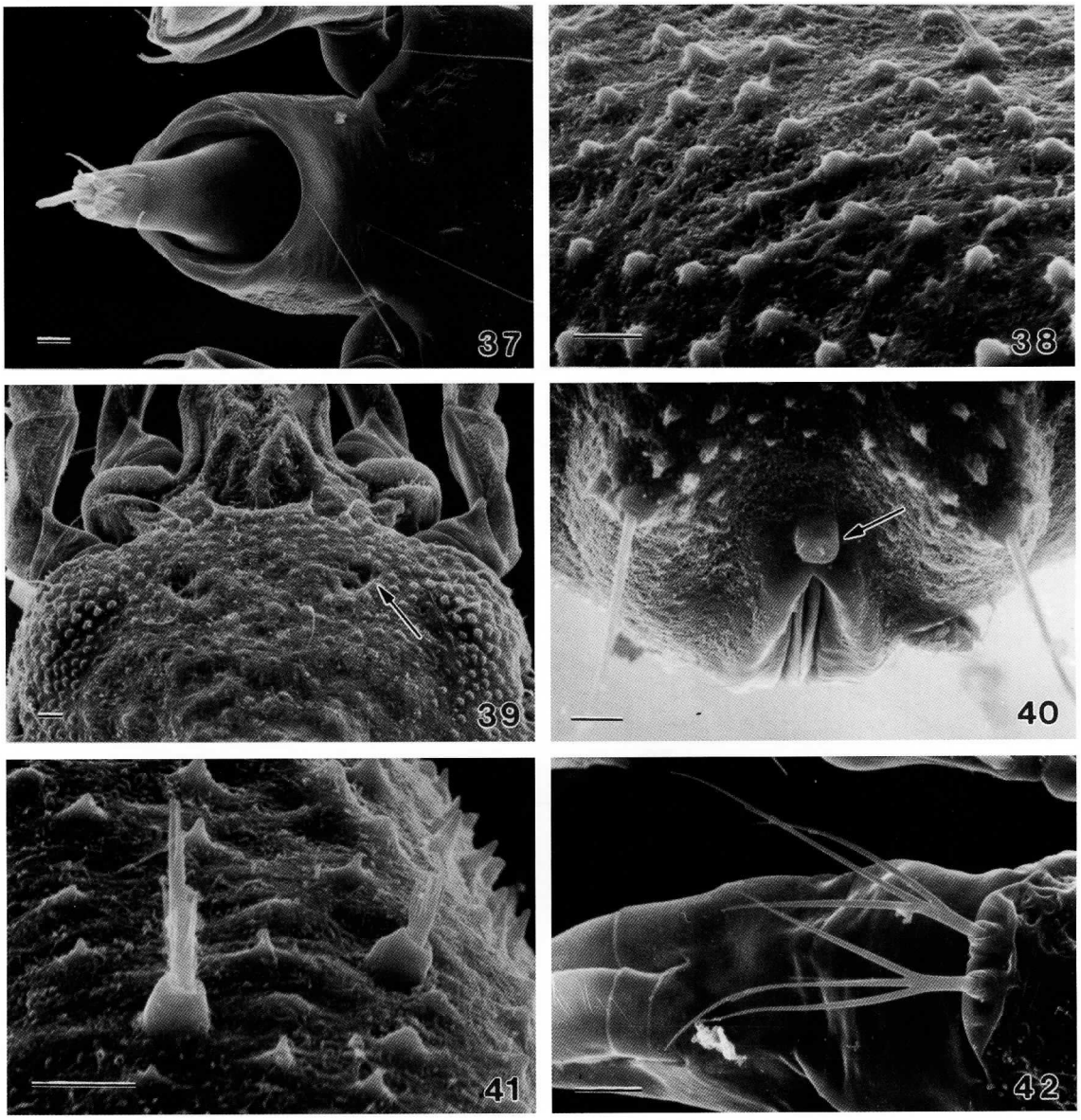
femora 1–1–0–1, and trochanters 1–1–1–0. Setation, trochanter to tibia, as follows: trochanters I–III each with a filiform seta (*pR, sR*); femora I, II and IV each with a filiform seta (*vF, wF*), *vF* long, *wF* short; genu I with setae *cG* and *mG* stout spines, notched at apex; genu II with setae *cG* and *mG* stout spines, *cG* notched at apex; genu III with seta *nG* a stout spine; tibiae I, II with setae *hT* stout spines and *gT* slender spines, and tibiae III, IV with setae *kT* stout spines. Tarsal setation as follows: I, II with setae *wa* and III, IV with seta *w* stout spines; I, II with long, filiform seta *ra* and III, IV with seta *r* stout spines; I, II with seta *d* short, filiform, and III, IV with seta *d* long, filiform; I–II with seta *la* and I–IV with seta *f* short, filiform; I–IV with setae *e* stout spines; proral setae (*p* and *q*) I–IV short spines of approximately equal length, setae *s* I–IV stout spines. Solenidia (I to IV): tarsi 2–1–0–0, tibiae 1–1–1–1, genua 2–1–1–0; genua I–III with solenidia σ originating one-fourth of way from apical end, solenidion σ′′ one-third length of σ′, tibiae I–IV with solenidion ϕ slightly less than the length of segment and originating approximately midway; tarsus I with solenidion ω1 originating one-fifth of segment length from base, solenidion ω3 apical, ω2 absent. Tarsus II with ω originating one-sixth of segment length from base. Tarsus I with short, spinelike famulus ε adjacent to solenidion ω1. Pretarsi with membranous ambulacra and slender, curved claws; condylophores absent.

Male (Figs 43–48)

Body ovoid, length 455 (428–469), width at level of coxae III 276 (253–292). Gnathosoma and general features of idiosoma similar to female.

Dorsum (Fig. 43). Dorsum similar in sclerotisation pattern to female, bearing 17 pairs of setae with shapes similar to female: *vi* 51 (38–59); *si* 14 (5–24), *se* 51 (44–73) c_1 18 (7–25), c_2 16 (11–21), c_3 60 (50–78), *cp* 17 (6–24), d_1 20 (12–29), d_2 21 (12–30), e_1 20 (13–29), e_2 71 (55–86), f_2 16 (4–25), h_1 12 (7–16), h_2 27 (15–38), h_3 174 (153–186), ps_1 14 (13–18), ps_2 19 (15–23).

Venter (Fig. 44). Except for genital area, venter similar to female in degree of cuticular sclerotisation, apodeme structure, and genital papillae. Aedeagus strongly sclerotised, hinged posteriorly, and located between coxal fields IV. A narrow, inverted U-shaped band of sclerotised cuticle



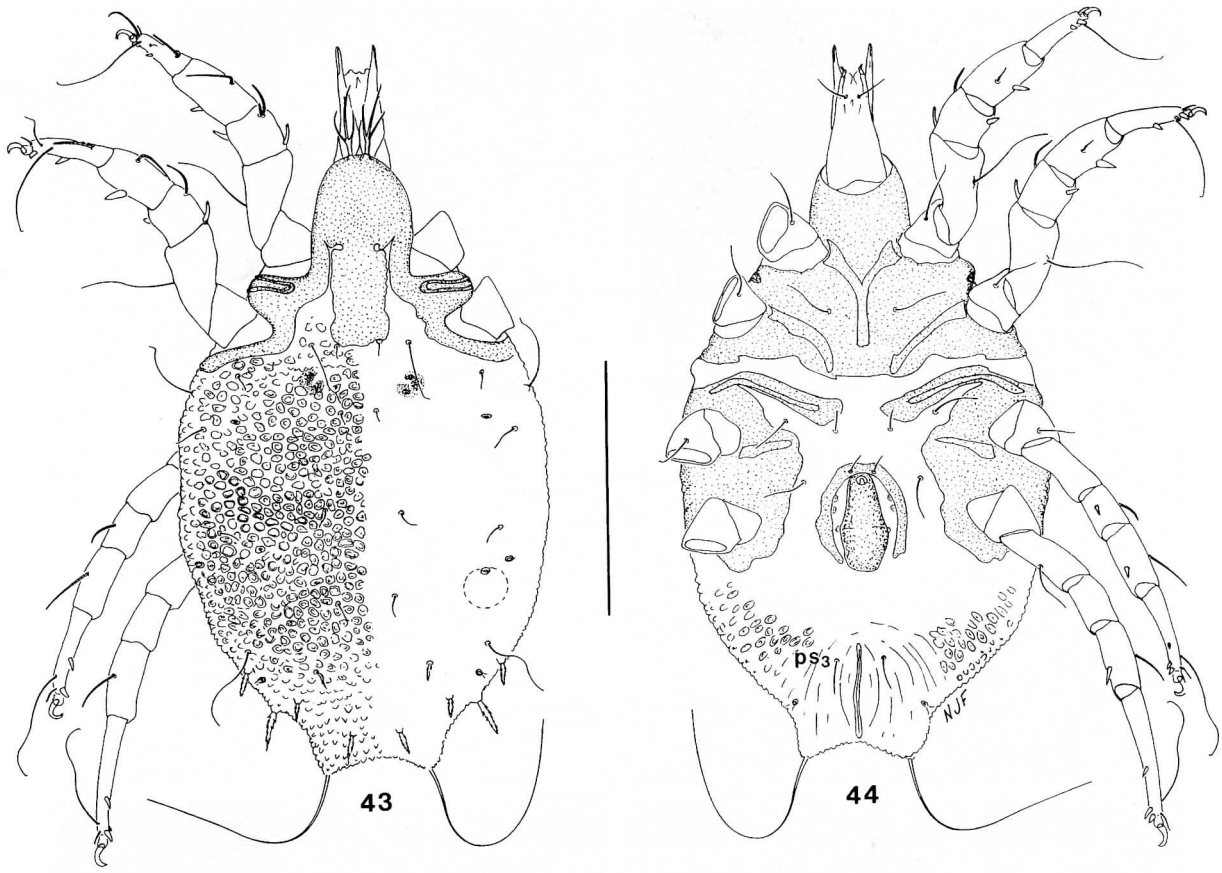
Figs 37–42. *Lamingtonacarus posidonis*, sp. nov., female: *37*, camerostome, ventral view; *38*, cuticular sculpturing on dorsum; *39*, propodosoma, dorsal view, illustrating dorsal sejugal apodemes (arrow); *40*, bursa copulatrix (arrow), dorsal view; *41*, serrated dorsal setae; *42*, setae vi. Scale bar: 10 μm.

surrounding aedeagus, anus ventroterminal. Venter bearing six pairs of filiform setae: *1a* 42 (34–50), *3a* 17 (14–30), *4a* 31 (23–36), *3b* 32 (22–40), *g* 17 (12–21) and ps_3 34 (25–39).

Legs (Figs 45–48). Leg lengths, base of trochanter to tip of tarsus: I 221 (199–236), II 241 (226–268), III 231 (202–256), IV 272 (252–292). Tarsal lengths: I 46 (42–49), II 65 (57–74), III 67 (59–75), IV 96 (89–101). Legs of male, especially I and II, more robust than in female. Relative to idiosomal length, leg I of male significantly shorter than leg I of female; however relative lengths of legs II–IV similar between the sexes. Relative to leg length, all tarsi of male are significantly shorter than their counterparts on the female. With the following exceptions, legs of male similar to female in regard to setae and solenidia: genual setae *mG* I not notched at apex; tarsal setae *p* and *q* much more robust in male and curved ventrally; and tarsal setae *e* a slender spine.

Etymology

The specific name is latinised from Poseidon, the mythological Greek ruler of the sea. The trifurcate internal vertical seta resembles a trident, Poseidon's signature weapon.



Figs 43–44. *Lamingtonacarus posidonis*, sp. nov., male: *43*, idiosoma, dorsal view; *44*, idiosoma, ventral view. Scale bar: 200 μm.

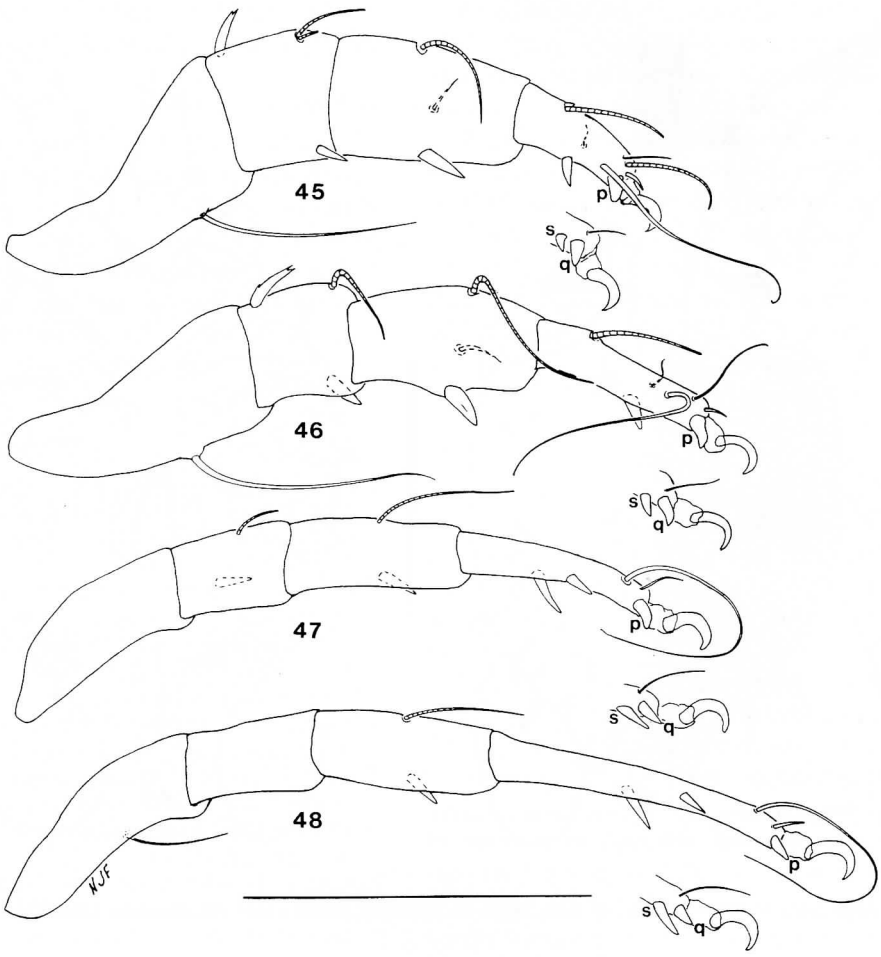
Remarks

Lamingtonacarus posidonis can be readily distinguished from *L. oreillyorum* by its smaller size, more heavily sclerotised cuticle, and short, mostly filiform, dorsal setae. The subcapitulum and chelicerae of *L. posidonis* are also more slender than those of *L. oreillyorum*.

Systematic position

Lamingtonacarus belongs to the subfamily Algophaginae as diagnosed by OConnor and Moser (1985), although that diagnosis must be modified somewhat to include the new genus. Those authors diagnosed the subfamily by three derived character states: anterior apodeme of coxal field III curving around the end of apodeme IV, anterior tarsi sexually dimorphic, and loss of the deutonymph. *Lamingtonacarus* does have anterior apodeme III enlarged and distinctly curved, but the tip of the apodeme does not curve beyond the tip of apodeme IV. This condition is clearly more similar to the condition in other Algophaginae than to the shorter, more or less straight apodemes of the Hericiinae. The sexual dimorphism of the anterior tarsi of *Lamingtonacarus* is similar to that of other Algophaginae. Discovery of a deutonymph in *L. oreillyorum* falsifies the last of the three synapomorphies used to diagnose the Algophaginae.

Within the Algophaginae, adults of *Lamingtonacarus* share several unique synapomorphies with the genus *Neohyadesia*, particularly in the male, suggesting a sister-group relationship between these genera. In the male of these genera, ventral setae *3a* are positioned distinctly anterior of the genital region; in other Algophagidae and the sister family Carpoglyphidae, these setae are positioned on the anterior edge of the male genital region. In the outgroup Carpoglyphidae, the Hericiinae, and other algophagine genera, setae *s* of tarsi I–II of the male are shifted paraxially and are 'coupled' with setae *q*. In *Neohyadesia* and *Lamingtonacarus*, the positional shift is less distinct, and there is a space between the alveoli of setae *s* and *q*. The distribution of these states suggests that this latter condition in *Neohyadesia* and *Lamingtonacarus* is the result of a reversal. In the Hericiinae and other Algophaginae, setae *p* and *q* of tarsi III–IV are more blunt apically than the sharply pointed form in the female. In *Neohyadesia* and *Lamingtonacarus*, these setae in the male are more similar to their form in the female. Finally, in both sexes, seta *d* of tarsi I–II is longer than the ω3 soleni-



Figs 45–48. *Lamingtonacarus posidonis*, sp. nov., male: *45*, leg I; *46*, leg II; *47*, leg III; *48*, leg IV. Scale bar: 100 μm.

dion of tarsus I in the Hericiinae and other algophagine genera. In *Neohyadesia* and *Lamingtonacarus*, these setae are shorter than the solenidion.

Deutonymphs of *Lamingtonacarus* differ from other described genera in the shape of the subcapitulum (only slightly rounded laterally as opposed to much more rounded in the other taxa which retain the subcapitulum), very short palpal supracoxal setae positioned almost mid dorsally on the subcapitulum (as opposed to longer and more laterally positioned in other taxa which retain the setae), the presence (in most specimens) of ventral subcapitular setae, the presence of well-developed anterior lateral cuticular suckers on the attachment organ (absent in other taxa), and the presence of seta *r* on tarsus III (absent in other taxa). Using deutonymphs of the sister-family Carpoglyphidae as outgroup, the subcapitular shape and retention of anterior lateral cuticular suckers may be considered as plesiomorphic in *Lamingtonacarus*. Form and position of the palpal supracoxal seta and loss of seta *r* are shared between Carpoglyphidae and other Algophagidae, suggesting that the states of these characters in *Lamingtonacarus* are derived, although the latter may be the result of a reversal as the seta is present in other hemisarcoptoid families. *Lamingtonacarus* deutonymphs are highly unusual in bearing a pair of setae on the subcapitular venter. The only other astigmatid mite retaining these setae in the deutonymph is *Troxocoptes minutus*, a highly unusual species of uncertain family placement. We regard the presence of these setae in the deutonymph as an evolutionary reversal.

Biological observations

Species of the genus *Lamingtonacarus* have thus far been collected only from the water-filled treeholes in the buttress roots of brush box (*L. conferta*) and strangler figs (*Ficus* spp.) in the brush box forest of Lamington National Park. Collections from water-filled treeholes in other parts of Queensland have not yielded specimens of this genus. The treehole fauna of other sites in Australasia (including New Guinea) has been studied intensively (Kitching, in press) along a latitudinal gradient from Tasmania to northern New

Guinea. Although occasional mites have been found in these samples, they have never occurred in the numbers or with the frequency of algophagid mites encountered at Lamington. The more precise identity of the occasional mites encountered elsewhere in these surveys has not been confirmed.

In a study of eleven water-filled treeholes from the box forest at Lamington National Park in which each treehole was sampled monthly, algophagid mites occurred on at least one occasion in all treeholes. In most of the treeholes we detected algophagid mites only occasionally and in relatively low numbers. In three of the eleven treeholes, however, mites were almost always present and densities reached as high as 1000+ per litre of sample on some occasions.

Although *L. posidonis* and *L. oreillyorum* are generally found cohabiting treeholes, *L. oreillyorum* is usually the dominant species with much larger populations. The two species probably differ in their feeding behaviours. SEM studies on the functional morphology of the mouth parts suggest that *L. oreillyorum* is a shredder, ingesting leaf material and associated microbes by biting chunks out of leaves, while *L. posidonis,* with its more slender chelicerae, is a grazer, scraping fungal hyphae from the surface of decomposing leaves (Fashing 1998).

The discovery of a deutonymphal instar with typical modifications for phoresy indicates that at least some species of the subfamily Algophaginae use this specialised facultative instar as a means for dispersal, although in the case of *L. oreillyorum* the host on which it is phoretic remains unknown.

The apparent abscission of the large, pectinate dorsal setae in adult *L. oreillyorum* is unique in the Astigmata. In fact, having enlarged, pectinate setae of this form is unique among aquatic mites in general. Most fully aquatic mites, regardless of taxonomic group, tend to have their dorsal idiosomal setae thin, filiform and relatively short, an adaptation that facilitates mobility in the dense aquatic medium. The unique form of the setae as described above in adults of *L. oreillyorum* also occurs in the larvae and homeomorphic nymphs; however, in the immature instars, the setae never undergo abscission but are retained throughout the stadium. The form of these setae in *L. oreillyorum* suggests that they may function as a deterrent to predators. The algophagid mites share the treeholes with predatory arrhenurid and ascid mites (Kitching and Pimm 1985), although the latter are uncommon and may be merely facultative, occasional inhabitants. In addition, predatory tanypodine midge larvae, as well as the predatory tadpoles of a frog, can be found in the treeholes. Although such enlarged setae could potentially protect adult as well as immature mites from predators, they would also have a negative effect during copulation. Males of *L. oreillyorum* are approximately the same size as females and mount dorsally during copulation, facing in the same direction as the female and overlapping her to a great extent. If the enlarged, posteriorly arched setae were present, they would undoubtedly hold the male away from the female and thereby interfere with copulation.

Acknowledgments

We thank the Queensland National Parks and Wildlife Service for permits to collect. NJF would also like to express his gratitude to Ms H. Mitchell for her assistance and support while at Griffith University, and to Dr D. Walter, University of Queensland, for providing equipment and help whenever needed. This research was supported in part by a Faculty Semester Research Assignment awarded to NJF by the College of William and Mary.

References

Baker, E. W., and Crossley, Jr., D. A. (1964). A new species of mite, *Fusohericia lawrencei*, from an artificial tree-hole (Acarina: Glycyphagidae). *Annals of the Natal Museum* **16**, 3–8.

Evans, G. O. (1992). 'Principles of Acarology.' (CAB International: Wallingford.)

Fain, A. (1974). Acariens recoltés par le Dr. J. Trave aux îles subantarctiques I. Familles Saproglyphidae et Hyadesidae (Astigmates). *Acarologia* **16**, 684–708.

Fain, A., and Johnston, D. (1975). A new algophagine mite, *Algophagopsis pneumatica* gen. n., sp. n. living in a river (Astigmata : Hyadesidae). *Bulletin et Annales de la Societe Royale d'Entomologie de Belgique* **111**, 66–70.

Fashing, N. J. (1998). Functional morphology as an aid in determining trophic behaviour: The placement of astigmatic mites in food webs of water-filled treehole communities. *Experimental and Applied Acarology* **22**, 435–453.

Fashing, N. J., and Wiseman, L. L. (1980). *Algophagus pennsylvanicus*—A new species of Hyadesidae from water-filled treeholes. *International Journal of Acarology* **6**, 79–84.

Grandjean, F. (1939). La chaetotaxie des pattes chez les Acaridiae. *Bulletin de la Société Zoologique de France* **64**, 50–60.

Griffiths, D. A., Atyeo, W. T., Norton, R. A., and Lynch, C. A. (1990). The idiosomal chaetotaxy of astigmatid mites. *Journal of Zoology (London)* **220**, 1–32.

Hughes, A. M. (1955). A new genus and species of hyadesid mite—*Algophagus antarcticus*—from Heard Island. *Australian National Antarctic Research Expedition Reports, Series B, Zoology* **1**, 1–19.

Hughes, A. M., and Goodman B. J. A. (1969). *Neohyadesia signyi* (Hyadesidae : Acarina): A new genus and species from Signy Island, South Orkney Islands. *British Antarctic Survey Bulletin* **22**, 39–48.

Jenkins, B., and Kitching, R. L. (1990). The ecology of water-filled treeholes in Australian rainforests: food web reassembly as a measure of community recovery after disturbance. *Australian Journal of Ecology* **15**, 199–205.

Jenkins, B., Kitching, R. L., and Pimm, S. L. (1992). Productivity, disturbance and food web structure at a local spatial scale in experimental container habitats. *Oikos* **65**, 249–255.

Kitching, R. L. (1983). Community structure in water-filled treeholes in Europe and Australia – comparisons and speculations. In 'Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities'. (Eds J. H. Frank and L. P. Lounibos.) pp. 205–222. (Plexus Publishing, Inc.: Medford, NJ.)

Kitching, R. L. (1987). Spatial and temporal variation in food webs in water-filled treeholes. *Oikos* **48**, 280–288.

Kitching, R. L. (in press). 'Container Habitats and Foodwebs: The Natural History and Ecology of Phytotelmata.' (Cambridge University Press: Cambridge.)

Kitching, R. L., and Beaver, R. A. (1990). Patchiness and community structure. In 'Living in a Patchy Environment'. (Eds B. Shorrocks and I. R. Swingland.) pp. 147–176. (Oxford University Press: New York.)

Kitching, R. L., and Callaghan, C. (1982). The fauna of water-filled tree holes in box forest in southeast Queensland. *Australian Entomological Magazine* **8**, 61–70.

Kitching, R. L., and Pimm, S. L. (1985). The length of food chains: phytotelmata in Australia and elsewhere. *Proceedings of the Ecological Society of Australia* **14**, 123–140.

Krantz, G. W. (1978). 'A Manual of Acarology, Second Edition.' (Oregon State University Book Stores: Corvallis, OR.)

Michael, A. D. (1903). 'British Tyroglyphidae II.' (The Ray Society: London.)

OConnor, B. M., and Moser, J. C. (1985). Phylogenetic relationships of the Algophagidae (Acari : Astigmata), with descriptions of a new subfamily, genus and species. *Annals of the Entomological Society of America* **78**, 783–789.

Pimm, S. L., and Kitching, R. L. (1987). The determinants of food chain lengths. *Oikos* **50**, 302–307.

Robin, M. C. (1868). Recherches sur une espece nouvelle de sarcoptides du genre glyciphage. *Journal of Anatomy and Physiology (Paris)* **5**, 603–628.

Samsinak, K. (1972). Redescription of *Hericia georgei* Michael, 1903 (Acarina, Tyroglyphidae) phoretic on Lepidoptera. *Annales Zoologici Fennici* **9**, 65–68.

Vitzthum H. G. (1931). Terrestrische Acarinen (unter Ausschluss der Oribatiden und Ixodiden) der Deutschen Limnologischen Sunda-Expedition. *Archiv für Hydrobiologie Supplementband* **9**, 59–134.

Manuscript received 8 October 1999; revised and accepted 4 February 2000.