Revision of *Rhizoglyphus* Claparède (Acari: Acaridae) of Australasia and Oceania

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Abstract

Mites of the genus *Rhizoglyphus* (Acari: Acaridae) are commonly associated with the underground storage organs such as bulbs and corms of many plants. Some species can cause damage to crops and ornamental plants, both in greenhouses and in the field. They are also important in biosecurity and trade because they are frequently found in exported/imported horticultural products such as carrots, corms of taro and flower bulbs. In this revision, we examined more than 1840 *Rhizoglyphus* mite specimens of different stages mainly from Australasia and Oceania. Fifty nine stages of 11 species are described: *R. caladii* Manson (adult female, adult homeomorphic male, tritonymph, larva), *R. columbianus* Oudemans (adult female, adult homeomorphic male, tritonymph, protonymph, larva), *R. echinopus* (Fumouze & Robin) (adult female, adult homeomorphic male, tritonymph, protonymph, larva), *R. howensis* Manson (adult female, adult homeomorphic male, protonymph), *R. minutus* Manson (adult female, adult homeomorphic male, tritonymph, deutonymph, protonymph, larva), *R. ogdeni* **sp. n.** (adult female, adult homeomorphic male, tritonymph), *R. ranunculi* Manson (adult female, adult homeomorphic male, tritonymph), *R. robini* Claparède (adult female, adult homeomorphic male, adult heteromorphic male, tritonymph, deutonymph, protonymph, larva), *R. setosus* Manson (adult female, adult homeomorphic male, adult heteromorphic male, tritonymph, deutonymph, protonymph, larva), *R. singularis* Manson (adult female, adult homeomorphic male, adult heteromorphic male, tritonymph, protonymph) and *R. tokelau* **sp. n.** (adult female, adult homeomorphic male). *Rhizoglyphus longispinosus* Ho & Chen, 2001 is

considered as a junior synonym of *R. caladii* Manson, 1972; *R. tacitri* Manson, 1972 a junior synonym of *R. columbianus* Oudemans, 1924; and *R. tsutienensis* Ho & Chen, 2000 a junior synonym of *R. singularis* Manson, 1972. Keys to adult females and males of *Rhizoglyphus* of Australasia and Oceania are provided. Lists of hosts and distributions of these species are also provided.

Key words: Acari, Acaridae, *Rhizoglyphus*, bulb mites, review, new species, new synonyms, host plants, distribution

Introduction

Mites of the genus *Rhizoglyphus* (Acari: Acaridae) are commonly associated with the underground storage organs such as bulbs and corms of many plants. Some species are cosmopolitan and can cause damage to crops and ornamental plants, both in greenhouses and in the field (Diaz *et al*. 2000). Because of the pest status of some species, mites of this genus are generally considered undesirable and are classified as quarantine species by many countries such as New Zealand and Australia.

This taxonomic revision of Australasian and Oceania *Rhizoglyphus* was initiated due to the quarantine importance of these mites in the region. *Rhizoglyphus* mites are frequently intercepted by New Zealand and Australian biosecurity officers in horticultural products such as carrots, corms of taro and flower bulbs. Due to the unresolved state of the taxonomy of this genus, rapid and accurate identification of intercepted species is difficult. As a result, intercepted specimens were determined to the genus level and the shipments were fumigated, which added costs to exports and reduced the quality of produce, as well as causing environmental and human health concerns. The importance of taxonomy to biosecurity and trade was recognized by the New Zealand Biosecurity Authority of Ministry of Agriculture and Forestry, and Plant Protection Service of the Secretariat of the Pacific Community, who funded this project. The primary objective of this paper is to revise all *Rhizoglyphus* species in the region and provide keys, descriptions and illustrations to facilitate the rapid and accurate identification of all species. In addition, other data of biosecurity importance (e.g. host plants and distribution) are also provided.

Materials and methods

More than 1840 mites including 872 adult females, 417 adult homeomorphic males, 54 adult heteromorphic males, 240 tritonymphs, 48 deutonymphs, 96 protonymphs and 113 larvae mounted in 603 slides were studied using an interference-phase contrast microscope. They are from the following collections: New Zealand Arthropod Collection in Landcare Research, Auckland, New Zealand (NZAC); the National Plant Pest Reference Laboratory, Ministry of Agriculture and Forestry in Lincoln and Auckland, New Zealand (NPPRL); Agricultural Scientific Collections Unit, Orange Agricultural Institute, NSW Agriculture, Orange NSW, Australia (ASCU); Australian Quarantine and Inspection Service (AQIS); South Australian Museum, Adelaide, Australia (SAM); Australian National Insect Collection, Canberra, Australia (ANIC); The Natural History Museum, London, UK (BMNH); The Oudemans Collection, The National Museum of Natural History, Leiden, The Netherlands (RMNH); Taiwan Agricultural Research Institute (TAL). Holotype specimens of two new species, *R. ogdeni* and *R. tokelau,* are deposited in NPPRL.

All measurements were made from slide-mounted specimens using stage-calibrated ocular micrometers. Chelicerae were measured from the basal articulations to the tips of movable digits. Idiosomal lengths were measured from the anterior margins to the posterior margins. Idiosomal widths were measured as the maximum width of the idiosoma between leg II and III. Dorsal body setae were measured from the alveoli to tips. Legs were measured from the bases of trochanters to the tips of claws. Femora of legs were measured from the ventral junction between the trochanter and femur to junction between the femur and genu. Genua were measured from junction between the femur and genu to junction between the genu and tibia.

Tibiae were measured from the junction between the genu and tibia to the junction between the tibia and tarsus. Tarsi were measured from the posterior margins to the tips of claws. Setae, spines and solenidia on legs were measured from the alveoli to tips. The number A × number B of anal sucker or anal disc means the length × width. The L/W of setae or spines is the ratio of their length and basal width. Backslashes in material examined indicate different slides. All measurements are given in micrometers.

The terminology of idiosomal chaetotaxy follows Griffiths *et al*. (1990) and the terminology of palp and leg chaetotaxy follows that of Grandjean (1939) and Griffiths (1970). The terminology of the copulatory organ follows that of Klimov and OConnor (2003).

List of abbreviations

Ganthosoma

cha	cheliceral setae
elcp	supracoxal setae of palp
m	infracapitular setae

Idiosoma

vi	internal pair of vertical setae
ve	external pair of vertical setae
sci	internal pair of scapular setae
sce	external pair of scapular setae
scx	supracoxal setae of leg I
c_1	innermost (first) pair of setae in first series or row on hysterosoma
c_2	second pair of setae in first series or row on hysterosoma
c_p	third pair of setae in first series or row on hysterosoma
c_3	fourth pair of setae in first series or row on hysterosoma
d_1	innermost (first) pair of setae in second series or row on hysterosoma
d_2	second pair of setae in second series or row on hysterosoma
e_1	innermost (first) pair of setae in third series or row on hysterosoma

e_2 second pair of setae in third series or row on hysterosoma
f_2 setae in fourth series or row on hysterosoma
h_1 innermost (first) pair of setae in fifth series or row on hysterosoma
h_2 second pair of setae in fifth series or row on hysterosoma
h_3 third pair of setae in fifth series or row on hysterosoma
ia anterior pair of cupules (lyrifissures) on dorsal hysterosoma
im middle pair of cupules (lyrifissures) on dorsal hysterosoma
ip poterior pair of cupules (lyrifissures) on dorsal hysterosoma
ih caudal pair of cupules (lyrifissures) on hysterosoma
gla opisthonotal glands
1a coxal-sternal setae associated with bases of legs I
3a innermost (first) pair of coxal-sternal setae associated with bases of legs III
3b second pair of coxal-sternal setae associated with bases of legs III
4a coxal-sternal setae associated with bases of legs IV
g genital setae
ps_1 first pair of pseudanal setae
ps_2 second pair of pseudanal setae
ps_3 third pair of pseudanal setae
ad_1 first pair of adanal setae
ad_2 second pair of adanal setae
ad_3 third pair of adanal setae

Legs

ω_1 proximal solenidion near bases of conical spine (ba) on tarsi I and II
ω_2 proximal solenidion on tarsus I
ω_3 apical solenidion on tarsus I
ε famulus at base of solenidion (ω_1) on tarsus I
φ solenidion on tibia
σ' anteriorly-located solenidion on genu I
σ'' posterior-located solenidion on genu I
σ solenidion on genua II and III
ba proximal conical spine on tarsi I and II

e	subterminal dorsal conical spine or seta
wa	mid-ventral conical spine or seta
gT	anteriorly-located conical spine or seta on tibia
hT	posterior-located conical spine or seta on tibia
cG	anteriorly-located conical spine or seta on genu
mG	posterior-located conical spine or seta on genu
vF	ventral seta on femur
L/W	ratio of length / basal width of spine or seta

Genus *Rhizoglyphus* Claparède, 1869

Rhizoglyphus Claparède, 1869, 18: 445.
Rhyzoglyphus Berlese, 1921, 14: 143–147.
Rhisoglyphus Hughes, 1948, 39; Sevastianov & Marroch, 1993, 72(7): 147. (mis-spelt)

Diagnosis

Adult. Idiosoma saccate, 500–900 long, whitish to semi-transparent. Dorsum with 4 pairs of prodorsal setae and 12 pairs of hysterosomal setae. External vertical setae small or vestigial, situated about halfway along lateral margins of prodorsal shield. Internal scapular setae obviously shorter than external scapular setae, and very small, vestigial or absent in a few species. Supracoxal setae *scx* smooth, large or small. Grandjean's organ bifurcate or simply bladed. Legs reddish brown. Tarsi I and II each with a proximal conical spine (*ba*) near bases of solenidion (ω_1) and famulus (ε). Tarsus I with 4 long terminal setae and 1 apical solenidion (ω_3), tarsus II with 4 long terminal setae, tarsus III with 3 long terminal setae, tarsus IV with 2 long terminal setae in female and 1 long terminal seta in male. Some tarsal setae slightly flattened apically.

Description

Adult female (Figs. 1–5)

Gnathosoma (Fig. 3). Chelicerae chelate, having a small ventral seta (*cha*) at base of terminal digits. Basal part of palp fused to infracapitulum, bearing a lateral spine-like palpal supracoxal seta (*elcp*). Terminal part of palp having 2 segments, basal segment bearing 2 simple setae; the other segment bearing 1 simple seta, 1 solenidion and 1 button-like ventral eupathidium. Infracapitulum with a pair of whip-like ventral setae (*m*).

Idiosoma (Figs. 1–2). Prodorsum with a longitudinal rectangular shield, 4 pairs of prodorsal setae (*vi*, *ve*, *sci* and *sce*), and 1 pair of

lateral sclerites. Prodorsal shield punctate, and its posterior margin straight or concave. Internal vertical setae (*vi*) situated at anterior margin of prodorsal shield, straight or slightly barbed and close to each other. External vertical setae (*ve*) small or vestigial, situated about halfway along lateral margins of prodorsal shield. Internal scapular setae (*sci*) situated behind prodorsal shield, small or vestigial, obviously shorter than external scapular setae (*sce*). Basal part of lateral sclerite with a narrow supracoxal gland opening and terminal part with a bifurcate or bladed Grandjean's organ. Supracoxal setae (*scx*) smooth, thick or thin, lateral to base of sclerite. Hysterosoma with 12 pairs of setae (c_1, c_2, c_p, c_3, d_1, d_2, e_1, e_2, f_2, h_1, h_2 and h_3), 4 pairs of lyrifissures (*ia*, *im*, *ip*, and *ih*) and 1 pair of opisthonotal glands. Setae c_p, e_2 and f_2 situated dorsolaterally or ventrolaterally; c_3 small or vestigial, situated ventrolaterally; h_2 situated posteriorly and h_3 situated ventroposteriorly. Lyrifissures *ia* situated posteriorad of c_2; *im* close to d_2, often in ventral side; *ip* close to f_2; *ih* in ventral side, lateral to anal opening. Gland opening (*gla*) posteriorad of d_2. Leg coxae fused with idiosoma, each bounded by a sclerotised apodeme. Left and right apodemes of coxae I fused together along midline. A pair of thin sclerotised sejugal apodemes present between coxae II and coxae III. Coxa I with 1 seta (*1a*), coxa III with 2 setae (*3a* and *3b*), and coxa IV with 1 seta (*4a*). Genital opening present between coxae III and IV, with 2 pair of genital papillae covered by genital valves and 1 pair of genital setae (*g*). Genital folds present. Anal opening posteriorad of genital opening, with 1–6 pairs of setae (ad_3, ps_3, ps_2, ad_2, ps_1 and ad_1), ps_3 always present but others may be vestigial or not visible. Copulatory opening posteriorad of anal opening, connecting a small sheild which varies in shape, and leads a thin or progressively broadened spermathecal duct into the sac-like inner part of spermatheca. Base of inner part of spermatheca often sclerotised, at its tips with a pair of “Y”, “V” or “U”-shaped sclerites of oviducts.

Legs (Fig. 5). Reddish brown. Tarsi I and II each with a proximal

conical spine (*ba*) near bases of solenidion (ω_1). Tarsus I with 4 long terminal setae and 1 long solenidion (ω_3), tarsus II with 4 long terminal setae, tarsus III with 3 long terminal setae, tarsus IV with 2 long terminal setae. Chaetotaxy of legs (I–IV): coxae 1, 0, 2, 1; trochanters 1, 1, 1, 0; femora 1, 1, 0, 1; genua 2 + 2 σ, 2 + 1 σ, 1 + 1 σ, 0; tibiae 2 + 1 φ, 2 + 1 φ, 1 + 1 φ, 1 + 1 φ; tarsi 8 c + 4 t + 3 ω + 1ε, 8 c + 4 t + 1 ω, 7 c + 3 t, 8 c + 2 t (c: conical spine, t: long tactile seta).

Adult homeomorphic male (Figs. 6–10)

Similar to adult female except: genital opening situated between coxae IV; aedeagus present; with 1 pair of anal suckers and 3 pairs of setae (*ps*$_3$, *ps*$_2$ and *ps*$_1$), without setae *ad*$_1$, *ad*$_2$ and *ad*$_3$; solenidion φ on tibia IV conical, spine-like; tarsus IV having 2 suckers. Complement of setae on legs as in adult female except tarsi IV with 7 c + 1 t.

Adult heteromorphic male (Figs. 131–134)

Similar to adult homeomorphic male but both sides or one side of leg III about doubled in size. Body setae slightly longer. Complement of setae on legs as in adult homeomorphic male except tarsi III with 1 enlarged terminal claw, 5 tactile setae and 3 conical spines.

Tritonymph (Figs. 135–138)

Similar to adult female except: genital folds absent; setae around anal opening much shorter (*ps*$_1$ and *ps*$_2$ may be vestigial or not visible), *ad*$_1$, *ad*$_2$ and *ad*$_3$ often vestigial or not visible. Complement of setae on legs as in adult female.

Deutonymph (Figs. 139–142)

Also known as hypopus. Body highly sclerotised, dorsoventrally flat. Gnathosoma reduced. Chelicerae absent. Idiosomal setae small (except *vi* and *h*$_2$). Setae *scx* situated ventrally. With 2 pairs of genital papillae and 1 pair of genital setae. Ventral hysterosomal area forming an anal attachment organ, which bears 6 pairs of attachment structures (modifies setae). Solenidion σ" on genu I absent. Solenidion ω_3 on tarsi I proximal. Seta *ba* absent. Some of the appical setae on tarsi foliate. Chaetotaxy of legs (I–IV): coxae 1, 0, 2, 1; trochanters 1, 1, 1,

0; femora 1, 1, 0, 1; genua 2 + 1 σ, 2 + 1 σ, 1 + 1 σ, 0; tibiae 2 + 1 φ, 2 + 1 φ, 1 + 1 φ, 1 + 1 φ; tarsi 1 c + 7 t + 3 ω + 1ε, 1 c + 8 t + 1 ω, 8 t, 1 c + 7 t.

Protonymph (Figs. 143–146)

Similar to adult female except: ventral setae *3a* and *4a* absent; genital folds absent; with 1 pair of genital papillae; with 1–3 pairs of pseudanal setae (ps_1 and ps_2 may be vestigial or not visible), ad_1, ad_2 and ad_3 absent; solenidion ω_3 on tarsi I absent; trochanter IV to tibia IV nude. Chaetotaxy of legs (I–IV): coxae 1, 0, 1, 0; trochanters 0, 0, 0, 0; femora 1, 1, 0, 0; genua 2 + 2 σ, 2 + 1 σ, 1 + 1 σ, 0; tibiae 2 + 1 φ, 2 + 1 φ, 1 + 1 φ, 0; tarsi 8 c + 4 t + 2 ω + 1ε, 8 c + 4 t + 1 ω, 7 c + 3 t, 7 c + 1 t.

Larva (Figs. 147–150)

Similar to adult female except: hysterosoma with 10 pairs of setae (f_2 and h_3 absent); ventral setae *3a* and *4a* absent; without genital opening, genital setae and genital papillae; setae around anal opening absent; with 3 pairs of legs (leg IV absent); with 1 pair of Claparède organs between coxae I–II; solenidia ω_2 and ω_3 on tarsi I absent. Chaetotaxy of legs (I–III): coxae 0, 0, 0; trochanters 0, 0, 0; femora 1, 1, 0; genua 2 + 2 σ, 2 + 1 σ, 1 + 1 σ; tibiae 2 + 1 φ, 2 + 1 φ, 1 + 1 φ; tarsi 8 c + 4 t + 1 ω + 1ε, 8 c + 4 t + 1 ω, 7 c + 3 t.

Remarks

Since the description of the first species, *Rhizoglyphus echinopus* (Fumouze & Robin, 1868), more than 70 species and subspecies have been named (Diaz *et al.* 2000). The main contributors have been Berlese (1921), Michael (1901, 1903), Oudemans (1924a, 1924b), Zachvatkin (1941), Hughes (1948, 1961, 1976), Nesbitt (1949, 1988, 1993), Eyndhoven (1961, 1963, 1968), Manson (1972) and Fain (1988). The opposing concepts of the two important species (i.e. *R. echinopus* and *R. robini* Claparède) among two schools (Zachvatkin, Hughes and followers *versus* Eyndhoven, Manson and followers) have

caused a great deal of confusion. Diaz *et al*. (2000) provide a comprehensive review of the biology and control of mites of this genus, with a checklist of species and their taxonomic status.

Manson (1972) provided an excellent revision of eight species of *Rhizoglyphus* from New Zealand and a few other countries in the South Pacific. This revision of Australasian and Oceanian *Rhizolgyphus* builds on the work of Manson (1972). We were able to examine many more specimens from a wider range of localities, including specimens of Oudemans and Hughes. This paper provides a full taxonomic revision of *Rhizolgyphus* from Australasia and Oceania. Two new species are described and three new synonyms are proposed.

Key to stages of *Rhizoglyphus* Claparède

1. With 4 pairs of legs; hysterosoma with 12 pairs of setae (f_2 and h_3 present) (Fig. 122); Claparède organs absent; genital papillae present (1 or 2 pairs) (Fig. 123).....2
- With 3 pairs of legs; hysterosoma with 10 pairs of setae (f_2 and h_3 absent) (Fig. 147); Claparède organs present, located between coxae I–II (Fig. 148); genital papillae absent.....larva
2. Body saccate (Fig. 122); gnathosoma developed, chelicerae chelate (Fig. 122); ventral hysterosoma without an anal attachment organ; genu I with 2 solenidia (Fig. 126) 3
- Body highly sclerotised, dorsoventrally flat (Fig. 139); gnathosoma reduced, chelicerae absent (Fig. 140); ventral hysterosoma with an anal attachment organ (Fig. 140); genu I with only 1 solenidion (Fig. 142).....deutonymph
3. With 2 pairs of genital papillae (Fig. 123); ventral setae *3a* and *4a* present; solenidion ω_3 on tarsus I present; femur IV and tibia IV not nude (Fig. 126) 4
- With 1 pair of genital papillae (Fig. 144); ventral setae *3a* and *4a* absent; solenidion ω_3 on tarsus I absent; femur IV and tibia IV nude (Fig. 146) ..... protonymph

4. Genital folds present (Fig. 123); with either spermatheca or aedeagus (Figs. 123, 128)..... (adult) 5
- Genital folds absent (Fig. 136); without spermatheca or aedeagus.. ..... tritonymph
5. With aedeagus; without spermatheca; hysterosoma with a pair of anal suckers (Fig. 128); tarsus IV with 2 suckers (Fig. 130)..... ..... (adult male) 6
- Without aedeagus but with spermatheca (Fig. 123); without anal suckers; tarsus IV without suckers (Fig. 126) ..... adult female
6. Leg III similar to other legs, tarsal claw normal (Fig. 130) .... adult homeomorphic male
- Leg III enlarged and with a strong terminal claw (Fig. 134)..... ..... adult heteromorphic male

Key to adult females of Australasian *Rhizoglyphus* Claparède

1. Setae *sci* not close to *sce*; ratio *sci-sci* : *sci-sce* < 2 (Fig. 122) 2
- Setae *sci* very close to *sce*; ratio *sci-sci* : *sci-sce* > 7 (Fig. 109); NEW ZEALAND..... *R. ranunculi* Manson, 1972 (p. 197)
2. Sclerites of oviducts close or moderately separate, distance between them less than 45 μm (Fig. 125); *scx* slender or minute (Fig. 124) 4
- Sclerites of oviducts widely apart, distance between them greater than 75 μm (Fig. 39); *scx* stout (Fig. 38).....3
3. Grandjean's organ deeply bifurcate (Fig. 38); *scx* bifurcate terminally; palpal *elcp* long, 37–40 μm; setae e_1 long, nearly as long as distance between e_1-e_1; ratio length : basal width of *gT* on tibia II = 17–23; WORLDWIDE..... ..... *R. echinopus* (Fumouze & Robin, 1868) (p. 74)
- Grandjean's organ moderately bifurcate (Fig. 98); *scx* simple, not bifurcate terminally; *elcp* short, 19–25 μm; setae e_1 short, no more than half distance between e_1-e_1; ratio length : basal width of *gT* on

tibia II = 9–11; NEW ZEALAND .... *R. ogdeni* Fan & Zhang, **sp. n.** (p. 176)

4. With six, four or one pair of setae around anal opening, ps_2 small or vestigial (Fig. 123); spine *ba* on tarsus I at least two thirds as long as solenidion ω_1 5

- With three pairs of strong setae (> 30 μm) around anal opening, ps_2 the longest (Fig. 2); spine *ba* on tarsus I small, about half length of solenidion ω_1; NEW GUINEA, INDIA / NEPAL, TAIWAN .... *R. caladii* Manson, 1972 (p. 21)

5. Setae ad_1 strong, more than three times as long as ps_3 and more than five times as long as ad_2 (Fig. 203) 6

- setae ad_1 often small or vestigial (Fig. 123), if long then whip-like, no more than three times as long as ad_2 (Fig. 152) 7

6. Setae *scx* minute or small, < 20 μm (Fig. 17); shield connected with copulatory opening prominent (Fig. 18); AUSTRALIA, COLOMBIA, TAHITI ISLANDS .... *R. columbianus* Oudemans, 1924 (p. 43)

- Setae *scx* long and pointed, > 50 μm (Fig. 204); shield connected with copulatory opening undeveloped; TOKELAU ISLAND .... *R. tokelau* Fan & Zhang, **sp. n.** (p. 347)

7. Setae d_2 far from *gla*, d_2-*gla* > 30 μm (Fig. 122); sclerites of oviducts small, shorter than 12 μm (Fig. 125) 8

- Setae d_2 close to *gla*, d_2-*gla* < 15 μm (Fig. 181); sclerites of oviducts prominent, longer than 15 μm (Fig. 184); FIJI, INDIA, INDONESIA, TAIWAN ..... *R. singularis* Manson, 1972 (p. 316)

8. Setae ad_1 and ad_2 small or vestigial, shorter than ps_3; ps_1 small or vestigial, not longer than ps_3 (Fig. 123) 9

- Setae ad_1 and ad_2 longer than three times of length of ps_3 and ad_3; ps_1 about 1.5 times as long as ps_3 (Fig. 152); AUSTRALIA, COOK ISLANDS, CUBA, FIJI, HONG KONG, JAPAN, NEW GUINEA, PACIFIC ISLANDS, SAMOA, SINGAPORE,

TAIWAN, THAILAND, TONGA, U.S.A. .... *R. setosus* Manson, 1972 (p. 270)

9. Setae *sci* more than 10 µm (Fig. 122); bases of h_{1-3} slightly expanded, not bulb-like (Fig. 122); with one or six pairs of small setae around anal opening (Fig. 125); copulatory opening simple, tube-like; *vi* long, about three times as long as tibia I 10
- Setae *sci* vestigial, less than 5 µm (Fig. 70); bases of h_{1-3} often expanded, bulb-like (Fig. 70); with four pairs of minute setae around anal opening (Fig. 73); copulatory opening sclerotised and conical (Fig. 73); *vi* short, about two times as long as tibia I; FIJI, NEW ZEALAND, NIUE ISLAND, SAMOA, TONGA .... *R. minutus* Manson, 1972 (p. 129)

10. With six pairs of setae around anal opening (Fig. 125); distance between sclerites of oviducts less than 10 µm (Fig. 125); WORLDWIDE ..... *R. robini* Claparède, 1869 (p. 216)
- With one pair of setae around anal opening (Fig. 59); distance between sclerites of oviducts about 20–22 µm (Fig. 59); AUSTRALIA ..... *R. howensis* Manson, 1972 (p. 110)

Key to adult males of Australasian *Rhizoglyphus* Claparède

1. Setae *sci* not close to *sce*; ratio *sci-sci* : *sci-sce* < 2 2
- Setae *sci* very close to *sce*; ratio *sci-sci* : *sci-sce* > 5 (Fig. 114); NEW ZEALAND ..... *R. ranunculi* Manson, 1972 (p. 197)
2. Anal discs small, without radiating lines (Fig. 129)..... 3
- Anal discs large, with radiating lines (Fig. 24) 6
3. Pseudanal setae ps_1 very long, at least three times as long as ps_2 (Fig. 102); cheliceral setae simply pointed (Fig. 103)..... 4
- Pseudanal setae ps_1 shorter than or as long as ps_2 (Fig. 157); cheliceral setae bifurcate (Fig. 158); AUSTRALIA, COOK ISLAND, CUBA, FIJI, HONG KONG, JAPAN, NEW GUINEA,

PACIFIC ISLANDS, SAMOA, SINGAPORE, TAIWAN, THAILAND, TONGA, U.S.A ... *R. setosus* Manson, 1972 (p. 270)

4. Aedeagus broadly truncated (Fig. 43); *scx* stout (Fig. 43) 5
- Aedeagus tapered (Fig. 129); *scx* slender (Fig. 127); WORLDWIDE .....*R. robini* Claparède, 1869 (p. 216)
5. Grandjean's organ deeply bifurcate (Fig. 43); *scx* bifurcate terminally; palpal *elcp* long, 37–31 μm; ratio *sci-sci* : *sci-sce* = 1.2–1.5; WORLDWIDE..... .....*R. echinopus* (Fumouze & Robin, 1868) (p. 74)
- Grandjean's organ moderately bifurcate (Fig. 103); *scx* not bifurcate terminally; palpal *elcp* short, 17–20 μm; ratio *sci-sci* : *sci-sce* = 0.9–1.0; NEW ZEALAND..... .....*R. ogdeni* Fan & Zhang, **sp. n.** (p. 176)
6. Pseudanal setae ps_1 very long, at least three times as long as ps_2 (Fig. 187).....7
- Pseudanal setae ps_1 as long as or shorter than ps_2 (Fig. 22) 9
7. Setae d_2 far from *gla*, d_2-*gla* > 24 (Fig. 61) 8
- Setae d_2 close to *gla*, d_2-*gla* <15 (Fig. 186); FIJI, INDIA, INDONESIA, TAIWAN.....*R. singularis* Manson, 1972 (p. 316)
8. Setae d_1 less than 1.5 times as long as d_2; ratio *sci-sci* : *sci-sce* = 0.9–1.0 (Fig. 61); ω_1 on tarsus I short, 12–18 μm; AUSTRALIA... ..... *R. howensis* Manson, 1972 (p. 110)
- Setae d_1 about twice as long as d_2; ratio *sci-sci* : *sci-sce* = 0.5 (Fig. 206); ω_1 on tarsus I long, 23–25 μm; TOKELAU ISLAND ....*R. tokelau* Fan & Zhang, **sp. n.** (p. 347)
9. Setae d_2 far from *gla*, d_2-*gla* > 25 (Fig. 75) 10
- Setae d_2 close to *gla*, d_2-*gla* < 15 (Fig. 21); AUSTRALIA, COLOMBIA, TAHITI ISLANDS..... ..... *R. columbianus* Oudemans, 1924 (p. 43)
10. Setae *sci* long, subequal to distance between *sci-sci*; e_1 ultra long, about twice distance between e_1-e_1 (Fig. 6); σ' on genu I shorter

than σ", ratio σ' : σ" = 0.7–0.8 (Fig. 10); NEW GUINEA, INDIA / NEPAL, TAIWAN ..... *R. caladii* Manson, 1972 (p. 21)

- Setae *sci* vestigial, less than one tenth of distance between *sci-sci*; e_1 about as long as distance between e_1-e_1 (Fig. 75); σ' on genu I longer than σ", ratio σ' : σ" = 1.3 (Fig. 79); FIJI, NEW ZEALAND, NIUE ISLAND, SAMOA, TONGA .... *R. minutus* Manson, 1972 (p. 129)

***Rhizoglyphus caladii* Manson, 1972 (Figs. 1–14)**

Rhizoglyphus caladii Manson, 1972, 13: 638.
Rhizoglyphus longispinosus Ho & Chen, 2001, 43: 47; **syn. n.**

Diagnosis

Adult female. Cheliceral setae *cha* branched terminally. Prodorsal shield evenly punctate. Setae *vi* thick and pointed, *sci* about as long as genu I, ratio *sci-sci* : *sci-sce* = 1.4 (1.4–1.7). Grandjean's organ long and bifurcate terminally. Supracoxal setae *scx* slender and pointed. Setae c_1 0.9 (0.7–0.9) times of length of d_2, c_3 about as long as c_1, d_1 1.2 (1.1–1.2) times of length of d_2, d_2 far from *gla*, e_1 6.7 (4.6–6.7) times of length of d_2, e_2 1.1 (1.0–1.1) times of length of f_2. Anal opening with 3 pairs of long and strong setae, ps_1 and ps_3 about as long as genu IV, ps_2 more than 1.5 times of length of genu IV; ad_1, ad_2 and ad_3 absent. Copulatory opening ring-shaped, spermathecal duct long and thin, slightly expanded near base of inner part of spermatheca. Base of inner part of spermatheca with a small triangular scleritised structure. Sclerites of oviducts Y-shaped, distance between them 17 (12–17), basal part slightly shorter than branches. Genu I, *mG* slender, L/W = 12 (9–12), ratio $\sigma' : \sigma'' = 0.7$ (0.7–0.9). Solenidion ω_1 on tarsus I thin and long, slightly broadened at its middle part, 22 (21–22) long. Conical spine *ba* on tarsi I about 0.5 (0.5–0.6) times of length of ω_1. Genu II, *cG* L/W = 7 (4–7), *mG* slender, L/W = 10 (10–12).

Adult homeomorphic male. Setae *vi* 2.6 (2.4–2.6) times as long as genu I. Setae c_1 0.7 (0.7–0.9) times of length of d_2, c_3 as long as or slightly longer than c_1, d_1 1.1 (1.1–1.2) times of length of d_2, d_2 far from *gla*, e_1 5.5 (5.4–5.5) times of length of d_2, e_2 1.1 times of length of f_2. Ratio *sci-sci* : *sci-sce* = 1.5 (1.5–1.6). Aedeagus tapered, lumpy internally (Fig. 9). Anal discs with 7–9 radiating lines, its diameter about as long as ps_2. Setae ps_1 0.5 (0.5–0.6) times as long as genu IV,

about as long as $ps_{2;}$ ps_3 thin and pointed. Ratio σ' : σ" = 0.8. Solenidion φ on tibia IV one half to two thirds of length of seta *kT*.

Tritonymph. Setae *vi* 2.2 times as long as genu I. Setae c_1 1.1 times of length of d_2, c_3 as long as c_1, d_1 1.1 times of length of d_2, d_2 not close to *gla*, e_1 4.5 times of length of d_2, e_2 1.1 times of length of f_2. Anal opening with 3 pairs of long setae.

Larva. Setae *vi* 1.2 times as long as genu I. Setae c_1 1.1 times of length of d_2, d_1 1.1 times of length of d_2, e_1 5.6 times of length of d_2. Claparède organ long, its basal part 4.0 times as long as terminal part.

Description

ADULT FEMALE (Figs. 1–5, n = 4)

Gnathosoma. Chelicerae 115 (115–134); *cha* branched, 6 (6–8); palpal *elcp* 11 (11–14); infracapitular setae *m* 32 (32–52).

Dorsum. Idiosoma 611 (611–776) long, 361 (361–555) wide. Prodorsal shield 112 (112–125) long, evenly punctulate, posterior margin slightly concave, distance between *ve-ve* 89 (88–92). Setae *vi* thick and pointed, 92 (92–101) long, 2.9 (2.1–2.9) times of length of genu I, distance between *vi-vi* 14 (10–15); *ve* 5 (5–6). Setae *sci* obviously long, 39 (39–50), distance between *sci-sci* 53 (53–66); *sce* prominently long, 247 (241–271), distance between *sci-sce* 38 (38–42), ratio *sci-sci* : *sci-sce* = 1.4 (1.4–1.7). Grandjean's organ long and bifurcate terminally, 35 (35–39). Supracoxal setae *scx* slender and pointed, 32 (32–62). Setae c_1 32 (32–42) long, 0.9 (0.7–0.9) times of length of d_2, distance between c_1-c_1 128 (128–167); c_2 37 (37–45); c_p 215 (215–238); c_3 32 (32–47); d_1 43 (43–47) long, 1.2 (1.1–1.2) times of length of d_2, distance between d_1-d_1 98 (97–102); d_2 37 (37–44), d_2 far from *gla*, d_2-*gla* 46 (46–57); e_1 248 (197–248) long, 6.7 (4.6–6.7) times of length of d_2, distance between e_1-e_1 121 (121–155); e_2 247 (217–247) long, 1.1 (1.0–1.1) times of length of f_2; f_2 235 (203–235); h_1 267 (233–267); h_2 285 (231–285); h_3 207 (205–222).

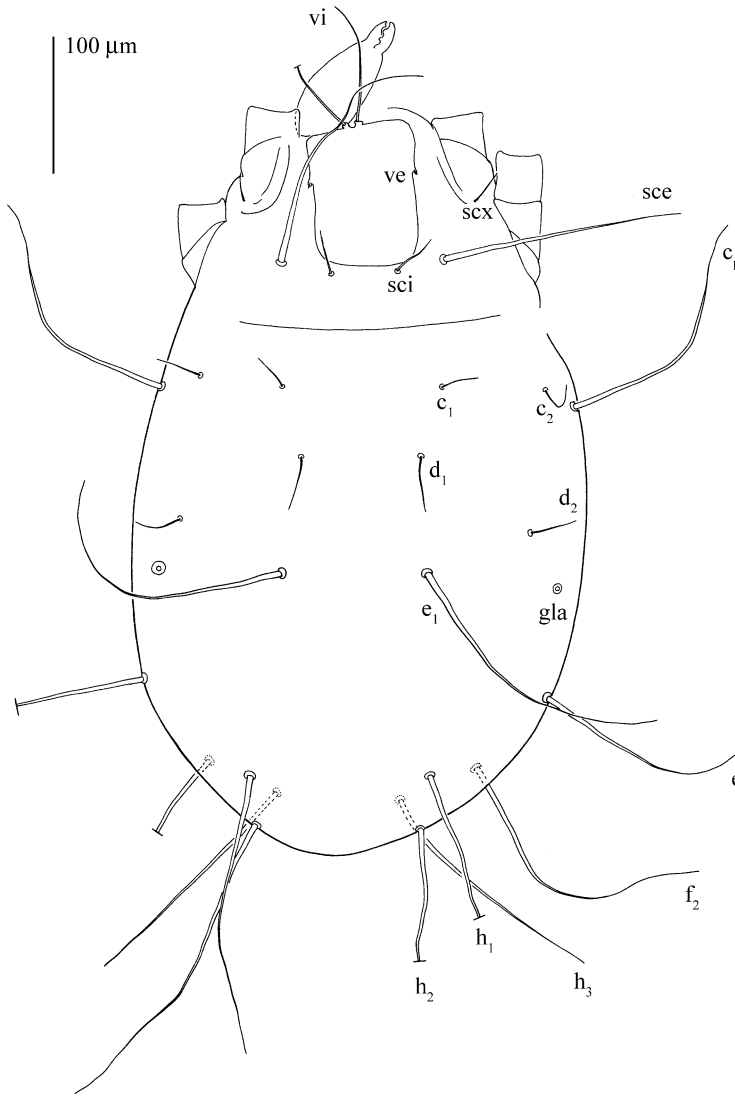

FIGURE 1. *Rhizoglyphus caladii* Manson (adult female). Dorsal view of idiosoma.

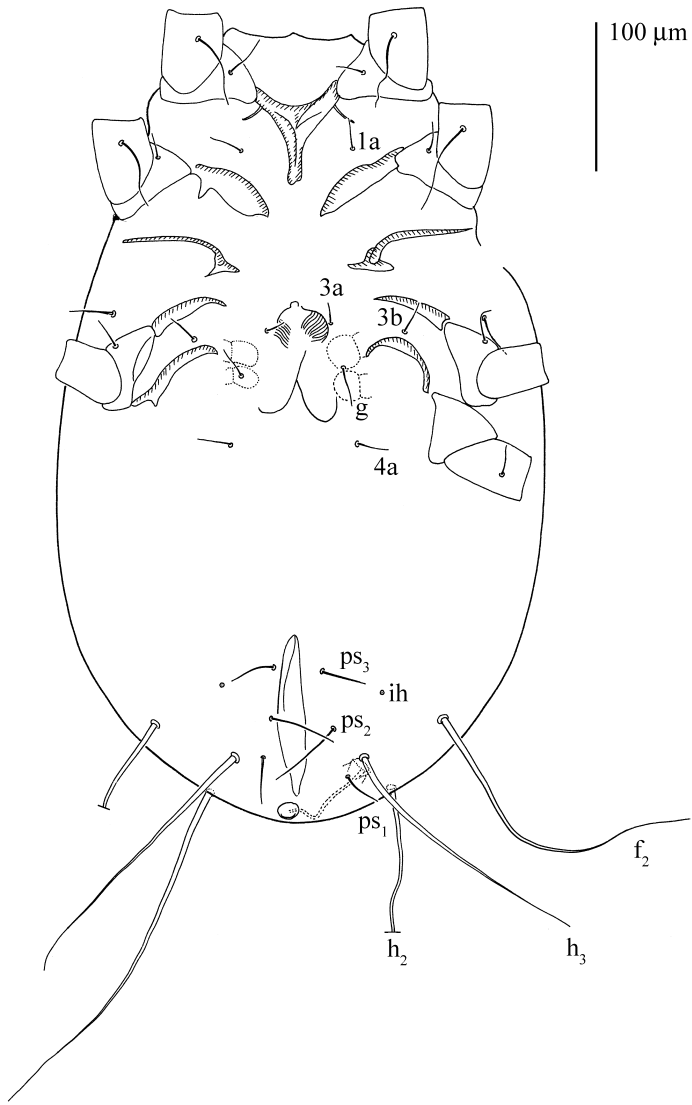

FIGURE 2. *Rhizoglyphus caladii* Manson (adult female). Ventral view of idiosoma.

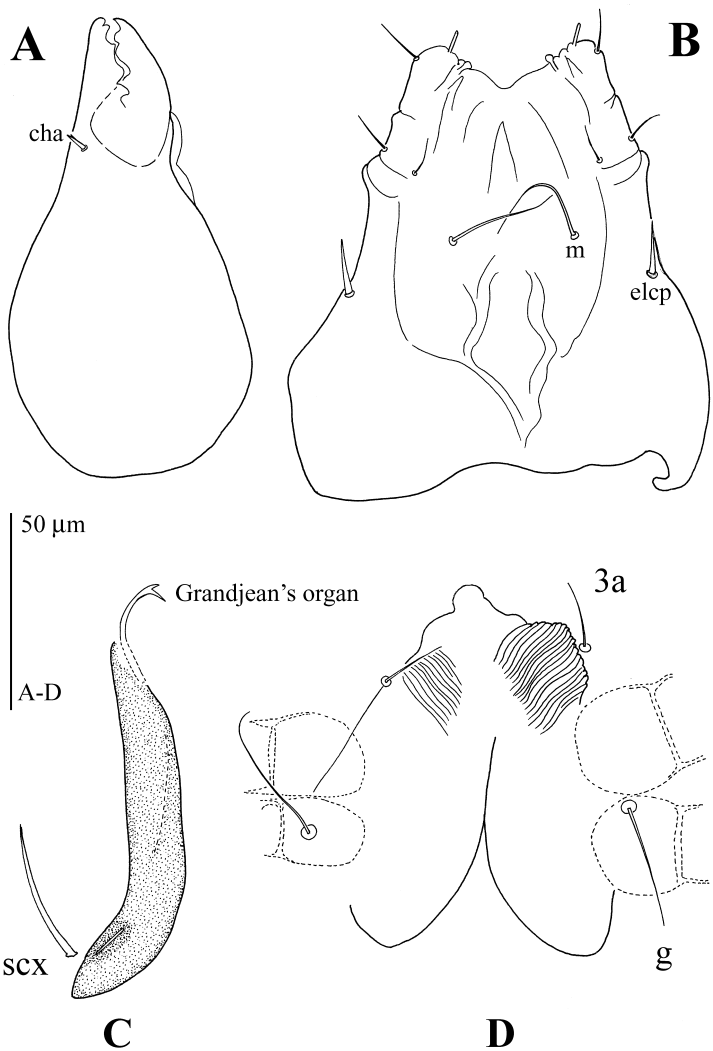

FIGURE 3. *Rhizoglyphus caladii* Manson (adult female). A, ventral view of chelicera; B, infracapitulum; C, left lateral sclerite and associated structures; D, genital opening.

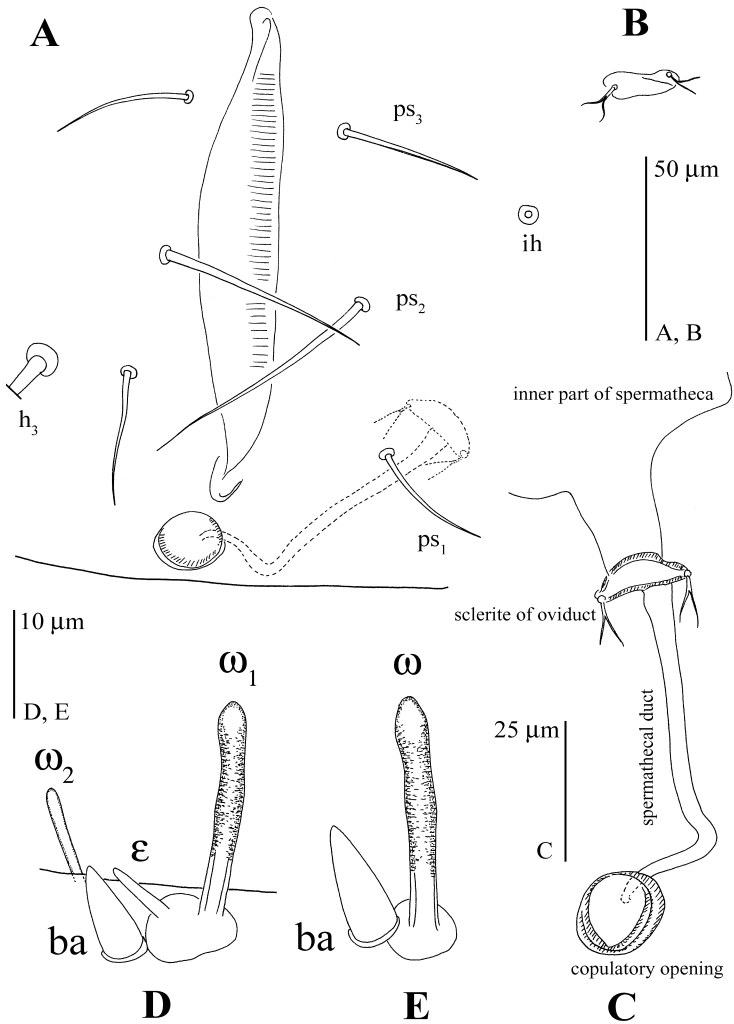

FIGURE 4. *Rhizoglyphus caladii* Manson (adult female). A, anal opening; B, sclerites of oviducts; C, copulatory opening and spermatheca; D, solenidia, famulus and spine of tarsus I; E, solenidion and spine of tarsus II.

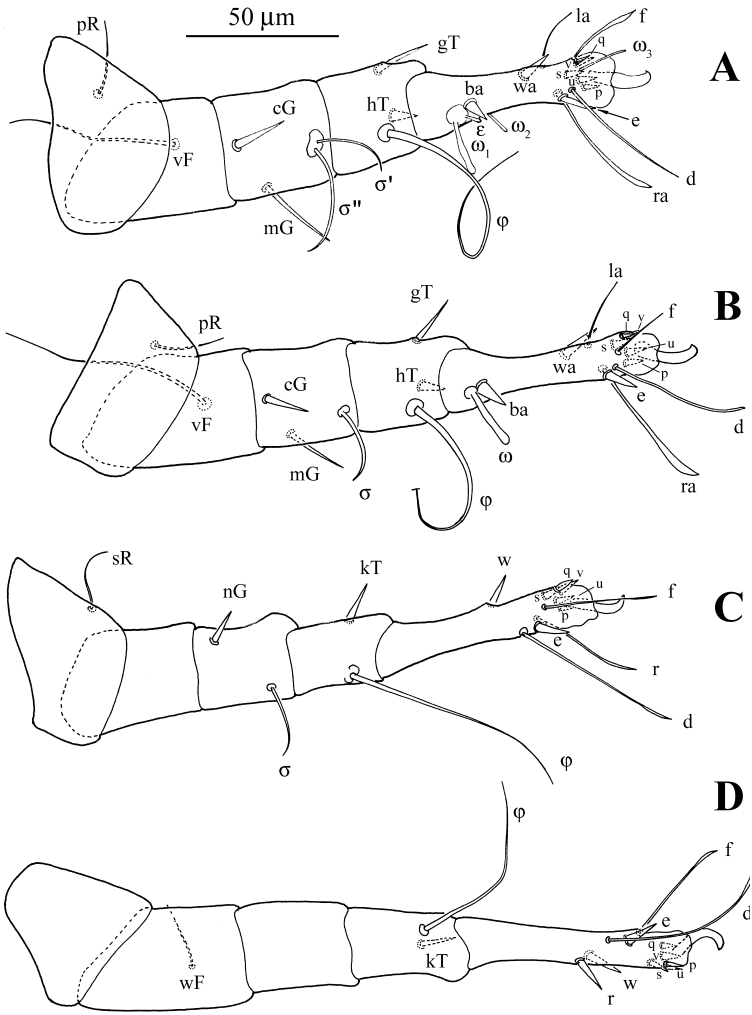

FIGURE 5. *Rhizoglyphus caladii* Manson (adult female). A, leg I; B, leg II; C, leg III; D, leg IV.

Venter. Setae *1a* 27 (27–40), *3a* 17 (17–23), *3b* 28 (37–40), *g* 30 (30–40), *4a* 27 (27–32). Anal opening with 3 pairs of long and strong setae; ps_1 32 (32–70) long, 0.8 (0.8–1.7) times of length of genu IV; ps_2 61 (61–80) long, 1.6 (1.6–2.0) times of length of genu IV; ps_3 33 (33–57) long, 0.9 (0.9–1.4) times of length of genu IV; ad_1, ad_2 and ad_3 absent. Copulatory opening ring-shaped. Spermathecal duct thin and long, slightly expanded near base of inner part of spermatheca, 70 (65–70) long. Base of inner part of spermatheca with a small triangular scleritised structure; distance between sclerites of oviducts 17 (12–17). Sclerites of oviducts Y-shaped, basal part slightly shorter than branches, basal part 4 (4–5), branches 6 (5–6).

Leg I 225 (225–260) long. Femur I 59 (59–72) long, *vF* whip-like, 70 (68–80). Genu I 32 (32–45), ratio σ' : σ'' = 0.7 (0.7–0.9), σ' 29 (29–37), σ'' 43 (40–45), *cG* slender, 20 (20–25), L/W = 8 (6–8), *mG* slender, 30 (27–35), L/W = 12 (9–12). Tibia I 33 (33–38) long, solenidion φ 162 (142–162), *gT* slender, 17 (17–30), L/W = 8 (7–8), *hT* 10 (10–15), L/W = 4 (4–5). Tarsus I 90 (90–100) long, 2.7 (2.6–2.7) times of length of tibia I, *ba* 11 (11–14), L/W = 3 (2–3), 0.5 (0.5–0.6) times of length of ω_1, ω_1 thin and long, slightly broadened at its middle part, 22 (21–22), ε 8 (7–8), ω_2 10 (7–10), ω_3 20 (17–22), *e* 13 (13–16), *wa* 14 (14–17).

Leg II 234 (234–263). Femur II 60 (60–75), *vF* whip-like, 75 (75–97). Genu II 37 (37–45), σ 30 (30–35), *cG* 17 (16–18), L/W = 7 (4–7), *mG* slender, 25 (25–27), L/W = 10 (10–12). Tibia II 33 (33–37), φ 126 (126–149), *gT* slender, 20 (20–27), L/W = 9 (9–10), *hT* 10 (10–16), L/W = 4 (3–4). Tarsus II 92 (92–103), 2.8 (2.6–2.8) times of length of tibia II, *ba* 11 (11–16), L/W = 2 (2–3), ω 22 (22–25), *e* 14 (14–17), *wa* 15 (15–19).

Leg III 222 (222–277). Femur III 50 (50–60). Genu III 37 (37–42), σ 25 (22–25), *nG* 12 (12–18), L/W = 5 (4–5). Tibia III 32 (32–37), φ 95 (95–132), *kT* 22 (17–22), L/W = 6 (4–6). Tarsus III 90 (90–105), 2.8 (2.5–2.9) times of length of tibia III, *e* 13 (13–16), *w* 13 (13–17).

Leg IV 255 (255–288). Femur IV 58 (57–62), *wF* 20 (20–35). Genu IV 38 (38–42). Tibia IV 37 (37–39), φ 70 (65–95), *kT* 15 (14–20), L/W = 6 (6–7). Tarsus IV 99 (99–107), 2.7 (2.7–2.8) times of length of tibia IV, *e* 14 (14–16), *w* 14 (14–19).

ADULT HOMEOMORPHIC MALE (Figs. 6–10, n = 2)

Gnathosoma. Chelicerae 99 (99–115), *cha* bifurcate, 5 (5–6); *elcp* 9 (7–9); infracapitular setae 32 (32–37).

Dorsum. Idiosoma 462 (462–526) long, 305 (305–361) wide. Prodorsal shield evenly punctulate, posterior margin slightly concave, 95 (95–107) long, distance between *ve-ve* 72 (72–80). Setae *vi* thick and blunt, with minute denticules at terminal half, 92 (92–95) long, 2.6 (2.4–2.6) times of length of genu I, distance *vi-vi* 10 (10–12); *ve* minute, 4. Setae *sci* obviously long, 40 (40–57), distance between *sci-sci* 46 (46–52); *sce* prominently long, 247 (247–294), distance between *sci-sce* 30 (30–32), ratio *sci-sci* : *sci-sce* = 1.5 (1.5–1.6). Grandjean's organ thin and long, bifurcate but one branch may hide behind the other, 29 (29–30). Supracoxal setae *scx* slender and pointed, 40. Setae c_1 27 (27–42), 0.7 (0.7–0.9) times of length of d_2, distance between c_1-c_1 100 (100–132); setae c_2 44 (44–60); c_p 221 (221–245); c_3 35 (35–47); d_1 40 (40–57), 1.1 (1.1–1.2) times of length of d_2, distance between d_1-d_1 71 (71–92); d_2 37 (37–47), d_2-*gla* 27 (27–37); e_1 202 (20–255), 5.5 (5.4–5.5) times of length of d_2, distance between e_1-e_1 103 (103–125); e_2 >145 (282), 1.1 times of length of f_2; f_2 248 (248–268); h_1 321 (308–321); h_2 335 (271–335); h_3 203 (203–267).

Venter. Setae *1a* 30 (30–32), *3a* 18 (18–23), *3b* 30 (30–40), *g* 33 (33–44), *4a* 25 (25–30); ps_1 short, 17 (17–26), 0.5 (0.5–0.6) times as long as genu IV; ps_2 20 (20–27), 0.5 (0.5–0.6) times as long as genu IV; ps_3 thin, 10 (10–15), 0.3 times of length of genu IV. Anal suckers 42 (37–42) × 40 (40–42). Anal discs with 7–9 radiating lines, 22 (20–22) × 23 (23–24). Aedeagus tapered, 52 (52–53), lumpy internally.

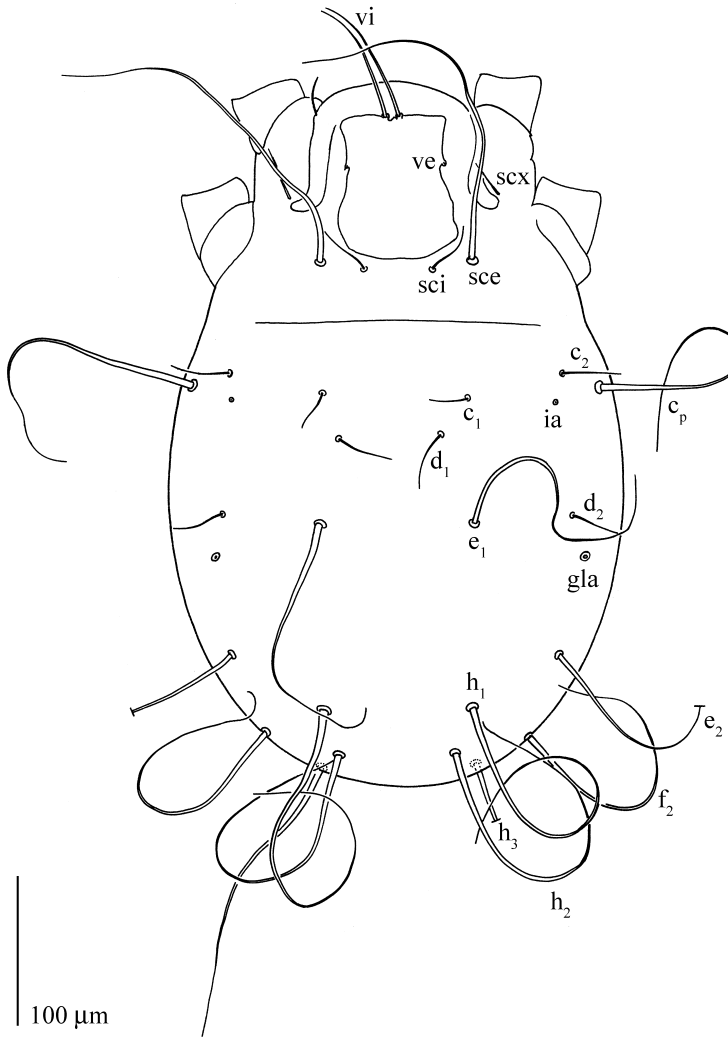

FIGURE 6. *Rhizoglyphus caladii* Manson (adult homeomorphic male). Dorsal view of idiosoma.

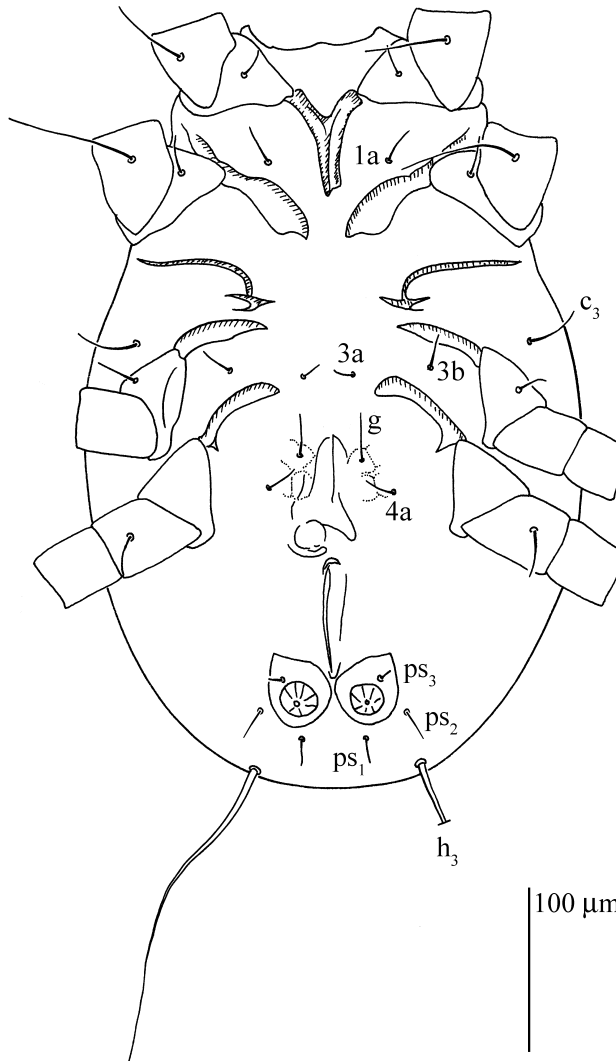

FIGURE 7. *Rhizoglyphus caladii* Manson (adult homeomorphic male). Ventral view of idiosoma.

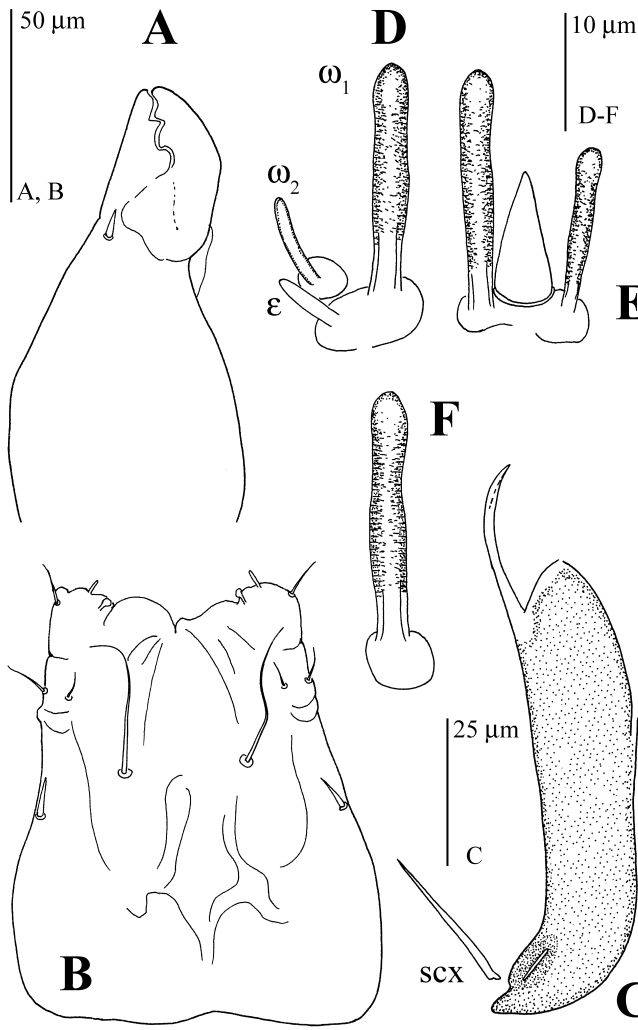

FIGURE 8. *Rhizoglyphus caladii* Manson (adult homeomorphic male). A, ventral view of chelicera; B, infracapitulum; C, left lateral sclerite and associated structures; D, solenidia and famulus of tarsus I; E, abnormal solenidia of tarsus II; F, normal solenidion of tarsus II.