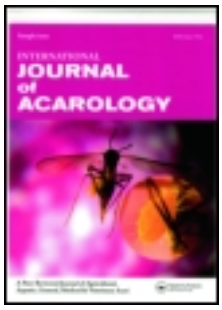

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Revision of the family Carabodidae (Acari: Oribatida) IV. Afticarabodes anjavidilavai gen. nov., sp. nov., Rugocepheus joffrevillei sp. nov. and redefinition of the genus Rugocepheus Mahunka, 2009

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Revision of the family Carabodidae (Acari: Oribatida) IV. *Afticarabodes anjavidilavai* gen. nov., sp. nov., *Rugocepheus joffrevillei* sp. nov. and redefinition of the genus *Rugocepheus* Mahunka, 2009

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Afticarabodes anjavidilavai **gen. nov.**, **sp. nov.** and *Rugocepheus joffrevillei* **sp. nov.**, both found on the island of Madagascar, are described and figured based on adult specimens, with the aid of optical and scanning electron microscopy. The genus *Rugocepheus* Mahunka, 2009 is redefined.

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Keywords: Oribatida; Carabodidae; revision; *Afticarabodes anjavidilavai* **gen. nov., sp. nov.**; redefinition *Rugocepheus*; *Rugocepheus joffrevillei* **sp. nov.**

Introduction

The present work is the fourth in a series revising the family Carabodidae. In the large collection from Madagascar (Coll. Betsch) in the Muséum National d'Histoire Naturelle (MNHN), Paris, France (for details see Fernandez and Cleva 2009; Fernandez et al. 2013b), we recovered several specimens. On commencing our study of all genera of the family, we concluded that some of this material included a new genus, for which we propose the name *Afticarabodes*.

The genus *Rugocepheus* was established by Mahunka (2009), with *Rugocepheus formosus* as type species. Amongst the MNHN Madagascar Collection were many specimens of a well-represented species which we have described and named *Rugocepheus joffrevillei* **sp. nov.** Both *Afticarabodes anjavidilavai* and *R. joffrevillei* were studied with optical and scanning electron microscopy. We decided to describe the latter species in detail in order to clarify doubts with regard to previous descriptions. We also conducted a thorough generic review, because we uncovered significant uncertainties in the definitions of the type genera.

Material and methods

Specimens studied with light microscopy were macerated in lactic acid, and observed in the same medium using the open-mount technique (cavity slide and cover slip) described by Grandjean (1949) and Krantz and Walter (2009). Drawings were made by use of an Olympus BHC compound microscope (Rungis, France), equipped with a drawing tube. Specimens were also studied under a scanning electron microscope (SEM). Specimens preserved in ethanol were carefully rinsed by sucking them several times into a Pasteur pipette, after which they were transferred to buffered glutaraldehyde (2.5%) in Sörensen phosphate buffer: pH 7.4; 0.1 M for 2 h. After postfixation for 2 h in buffered 2% OsO_4 solution and being rinsed in buffer solution, all specimens were dehydrated in a series of graded ethanol and dried in a critical point apparatus. After mounting on Al-stubs with double-sided sticky tape, specimens were gold coated in a sputter apparatus (Alberti and Fernandez 1988; Alberti et al. 1990a, 1990b; Alberti et al. 1991; Fernandez et al. 1991; Alberti et al. 1997; Alberti et al. 2007).

Measurements taken: total length (tip of rostrum to posterior edge of notogaster) and width (widest part of notogaster), in micrometres (µm).

Setal formulae of the legs include the number of solenidia (in parentheses); tarsal setal formulae include the famulus (ε).

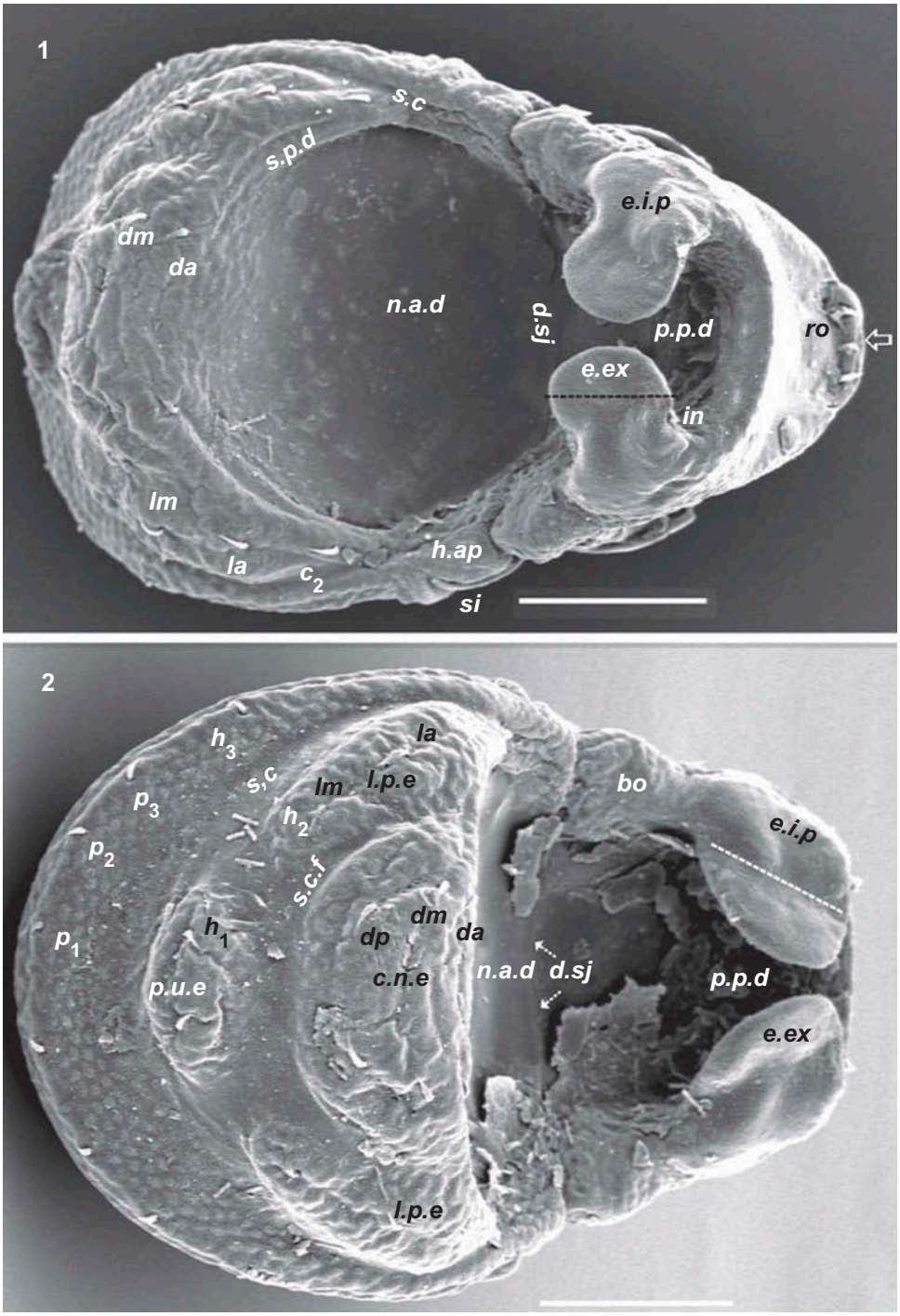
In order to study the structure of the mentum, specimens were dissected and monitored during the lactic acid maceration process (in warm 70% lactic acid), before being stained with chlorazol black E (Coineau 1974).

Morphological terminology

Morphological terms and abbreviations used are those developed by F. Grandjean (1928–1974) (cf. Travé and Vachon 1975), Norton and Behan-Pelletier (2009) and Fernandez et al. (Fernandez et al. 2011, 2013a, 2013b, 2013c).

For the setal types Evans (1992), and for ornamentation of cuticular surfaces Murley (1951 *ex*: Evans *op.cit*) were used.

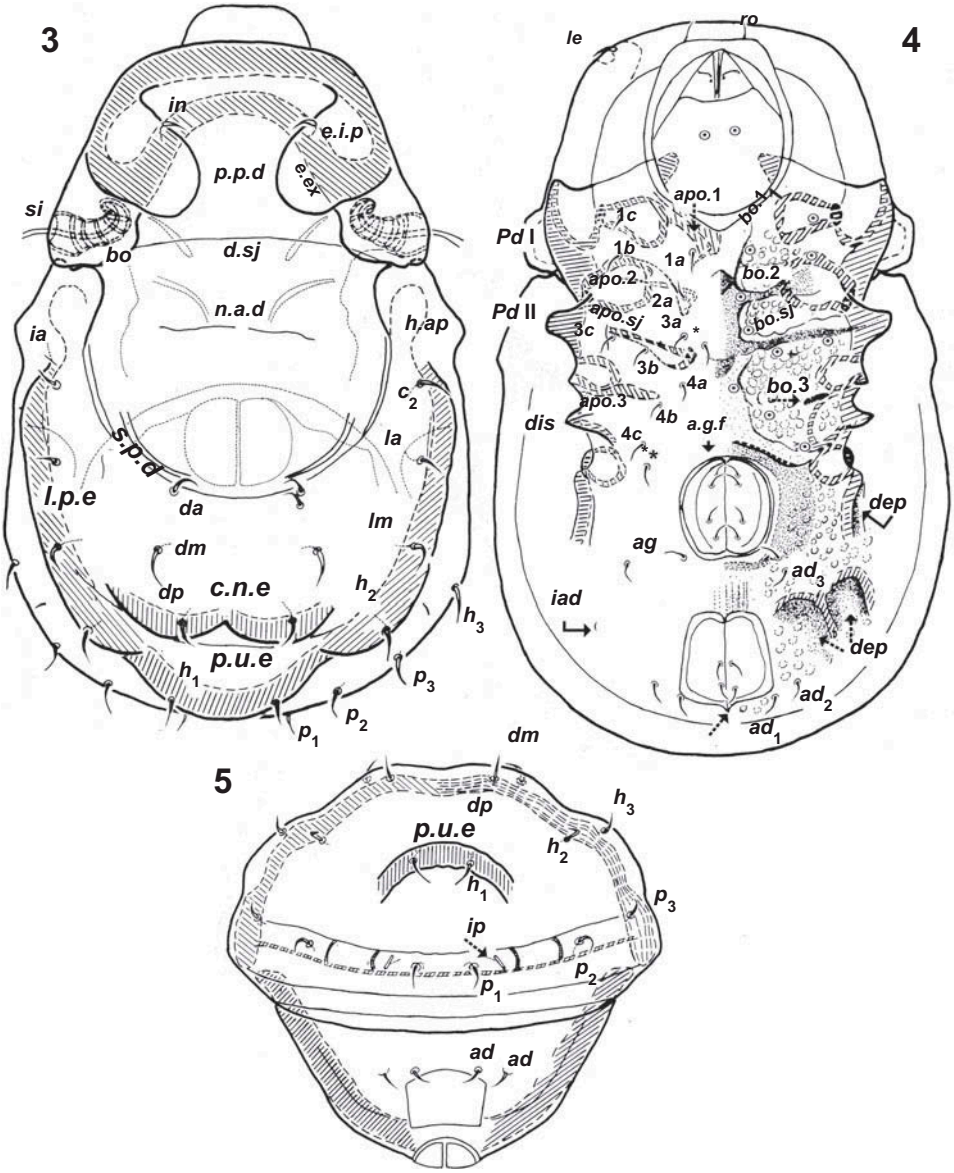
Many different terms were previously used for corresponding structures in generic or species descriptions, thus



Figures 1–2. *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.** adult (with cerotegument) scanning electron micrographs. **1**. dorsal aspect; **2**. Dorso-inclined to anterior. Inflexion zone indicated by stippled line. Abbreviations: See "Material and methods". Scale bar: 1–2 = 100 μm.

we found it necessary to create a standardized (homogenized) terminology to use when comparing confamilial genera and species. We used the terms strictly in the sense proposed by the authors cited above.

A number of specific morphological characters have not been previously described in detail and no terminology and/or abbreviations exist. For these, we have included the following in the text and on the figures for the sake of clarity: anterior tutorial depression (*a.tu.d*), central elevated notogastral area (*c.e.a*), central notogastral elevation (*c.n.e*); depressed zone of *dsj* (*d.dsj*); dorsal protuberances (*d.pr*); ear-like expansion (*e.ex*); posterior notogastral depression furrow (*s.p.d*); rod-shaped thickening on humeral apophysis (*h.t*); oblique posterior surface furrow on humeral apophysis (*s.fu*); lateral paired elevation (*l.p.e*); unelevated lateral notogastral area (*l.n.a*); longitudinal notogastral furrow (*c.fu*); thickened cuticular Y-shaped structure (*Ys*); paired lateral notogastral furrows (*l.fu*);



Figures 3–5. *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.**, adult. **3**. dorsal aspect (due to transparency it is possible to partially see the ventral side); **4**. ventral aspect; **5**. posterior view. Abbreviations: See "Material and methods". Scale bar: 3–5 = 100 μm

posterior zone of *Ys* structures (*p.Ys*); posterior prodorsal depression (*p.p.d*); posterior unpaired elevation (*p.u.e*); small circumgastric furrow (*s.c.f*); and teeth of *dsj* zone (*t.dsj*).

New taxa descriptions and redefinition of genus *Rugocepheus*

Genus *Afticarabodes* gen. nov.

Etymology

The generic prefix *aftí* derives from αντί (modern Greek) = ear because the elevated prodorsal interlamellar process resembles an ear-like structure.

Diagnosis (adult female)

Prodorsum:triangular, conical, truncate structure. Lateral view: slightly vertically inclined towards backward position, situated almost at similar level as more elevated notogaster; paired elevated interlamellar processes, round ear-like expansions directed backwards. Laterally situated short lamella; shallow lamellar furrow, not discernible. *Notogaster*: oval; large round-ovoid anterior depression, crossing *dsj* and without change, extending to prodorsum; *dsj* narrow, well delimited. Posterior elevated zone with four elevated areas: one pair lateral, unpaired central and unpaired posterior elevations; circumgastric furrows present on central elevation. Twelve pairs of lanceolate setae (c_2, *da, dm, dp, la, lm,* h_1, h_2, h_3, p_1, p_2, p_3); four pairs of lyrifissures (*ia, im, ip, ips*) clearly discernible; bothridial

zone rectangular; apical zone: humeral apophysis overlaps posterior part of bothridial zone. Tutorium, supratutorial depression, pedotecta I, II and discidium present. *Ventral*: epimera clearly defined by furrows; epimeric borders clearly visible; apodemes1, 2, *sj* and 3 clearly visible; chaetotaxy 3-1-3-3; anterior genital furrow deep; four pairs of genital setae; aggenital setae posterolateral; adanal setae lanceolate; two pairs of anal setae.

Remarks

Particular characteristics of the prodorsum, combined with notogastral shape, setal number and their position are unique to the family Carabodidae. The new genus is related to *Opistocepheus* (Aoki, 1977) in some aspects of notogastral shape, and to *Congocepheus* (Balogh, 1958) in relation to the characteristics of the notogastral anterior depression. However, *Afticarabodes* is easily distinguishable from *Opistocepheus* by the prodorsum, shape of notogastral anterior depression and number of notogastral setae; and from *Congocepheus* by prodorsal characteristics, notogastral shape and number of notogastral setae.

Type species *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.**

***Afticarabodes anjavidilavai* sp. nov.**

(Figures 1–25)

Etymology

The specific epithet is derived from the type locality.

Material examined

Holotype. 1 adult female "Madagascar, RCP. MAD.202. ANJAVIDILAVA – $FDHM_2$ (Fôret Dense Humide de Montagne) 1950 m. Litière". (see Paulian et al. 1971, pp. 186–266). J.-M Betsch coll. 27 xii 1970. Deposited in the Collection of the MNHN, Paris, France, preserved in 70% ethanol.

Paratypes. 1 adult female "Madagascar, RCP. MAD.288. ANJAVIDILAVA. FDSMP (Fôret Dense Sclérophylle de Montagne à *Phillipia*). 2000 m. Litière". J.-M Betsch coll. 7-i-1971. Deposited in the Collection of the MNHN, Paris, France, preserved in 70% ethanol. 1 adult, female, "Madagascar, RCP.MAD.114. ANJAVIDILAVA FDSMP (Fôret Dense Sclérophylle de Montagne à *Phillipia*) 2000 m, mousses au sol" J.-M Betsch coll. 20-xii-1970. Deposited in Collection of the Geneva Natural History Museum, Switzerland, preserved in 70% ethanol; 1 adult, "Madagascar, RCP. MAD.238.Eboulis sud du Plateau d'ANDOHARIANA 2100 m. 21-xi-1970. Petits mousses et litière sous *Philippia* sp. Berlese" preserved in 70% ethanol, deposited in Collection of the KwaZulu-Natal Museum, Pietermaritzburg, Republic of South Africa.

Diagnosis (adult female)

Prodorsum. Ear-like interlamellar expansion, paired, directed paraxially; without contact between extremities; *in* setae curving, directing dorsally; insertion zone, inflexion area, ear-like expansion curving upwards. Lamella short, only discernible from lateral or frontolateral view due to prodorsal shape; apical lamellar tip: small cuspis. Sensillus barbate, arching. *Notogaster*: circumgastric furrow clearly discernible. Lamellar inferior margin curving; tutorium: cuticular thickening, curving, rugose margin; supratutorial depression, deep, concave. Pedotectum I, prominent extending lamina, rounded tip. Pedotectum II, small lamina, rounded apex. Sejugal depression deep. Discidium: triangular protuberance. Lyrifissure *ips* between p_1 and p_2. Lateral to genital and anal opening, many cuticular thickenings and round-ovoid depressions; rhomboid depression, mid-epimeric zone and triangular depression in central zone posterior sejugal furrow. Aggenital setae near ad_3; lyrifissure *iad*: lens shaped, hardly discernible, lateral behind ad_3 setae.

Description

Measurements. SEM: 440 µm (435–480) × 280 µm (272–320). Light microscopy: 450 µm (435–496) × 291 µm (286–321). All specimens female.

Shape. oval (Figures 1–4).

Colour. Specimens without cerotegument: brown to dark brown; slightly shiny when observed in reflected light.

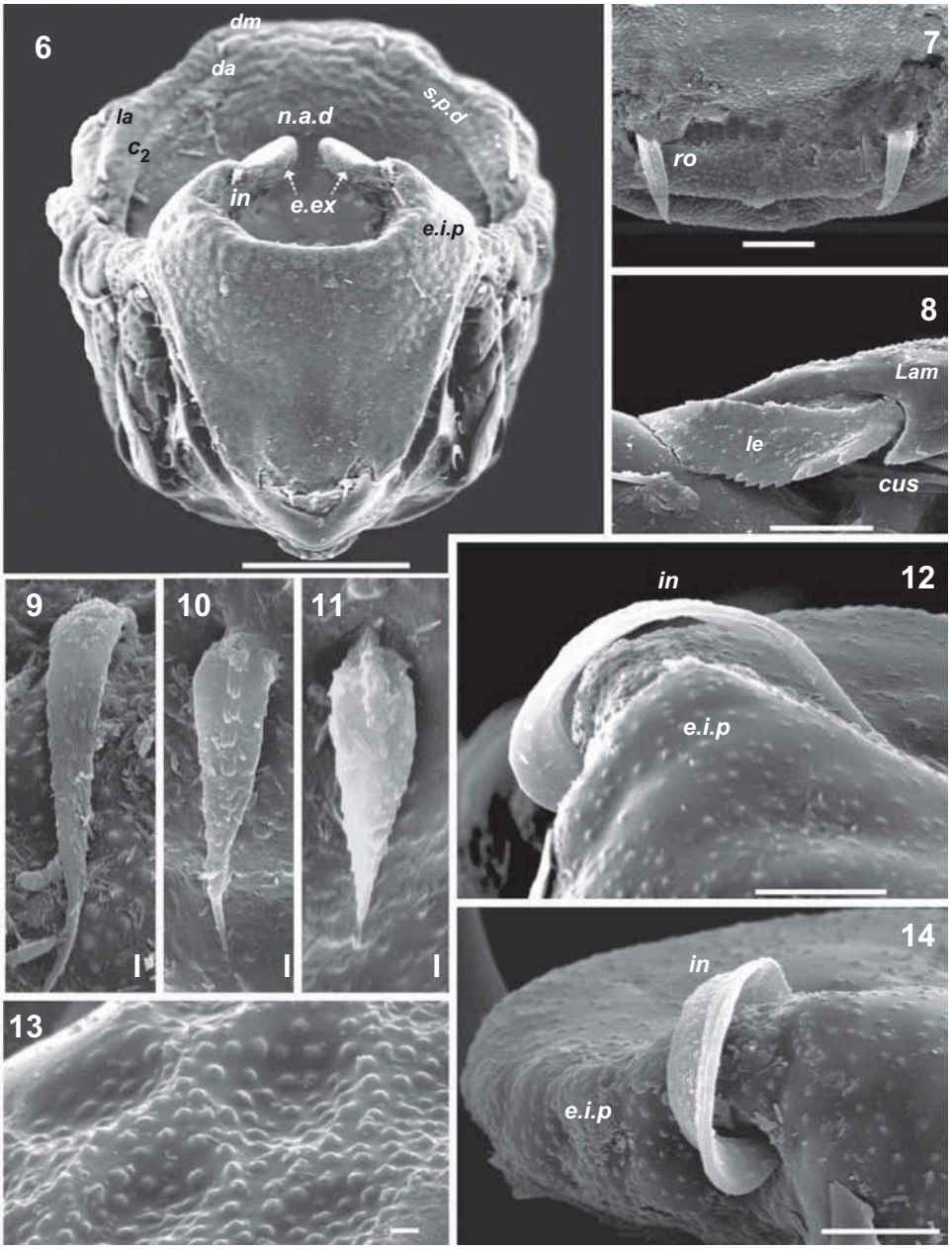
Cerotegument. Simple thick layer (0.5–1.2 µm), uniformly covering the entire body and legs (Figure 25). The cerotegumental layer creates a major problem for observation in optic microscopy due to separation from the cuticle, which forms round inflated structures around different areas of body, obscuring detailed observation.

Integument. Microsculpture complicated, varying according to body region and different leg segments.

Prodorsal microsculpture. Irregularly tuberculate (Figure 25): near bothridia, on elevated interlamellar process (*e.i.p*) (Figures 6, 16 and 17). *Granulate*: *e.i.p*. zone of round ear-like expansion (*e.ex*) (Figures 12 and 14). *Foveate*: inferior part of bothridia (Figure 19). *Foveolate*: zone around *ro* (Figure 7).

Notogastral microsculpture. Irregularly tuberculate (Figure 25): all over, principally situated on elevated zones (*c.n.e*, *p.u.e*, *l.p.e*), zone between *s.c* and notogastral margin and humeral apophysis (*h.ap)* (Figures 1, 2, 16 and 20). *Favulariate*: posterior zone of anterior notogastral depression (*n.a.d)* near furrow (*s.p.d*) (Figure 1). *Foveate*: zone medial posterior of *n.a.d.* (Figure 1). *Granulate* (Figure 13): anterior zone *h.ap* and zone of *s.c* and *s.c.f* (Figure 20).

Ventral microsculpture. Smooth to granulate: epimeral zone, discidium, zone around genital and anal openings (Figures 21 and 24).



Figures 6–14. *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.**, adult (with cerotegument) scanning electron micrographs. **6**. frontal aspect; **7**. rostrum; **8**. lamellae; **9.–11**. notogastral setae; **12**. interlamellar setae, lateral view; **13**. granulate microsculpture; **14**. interlamellar setae, frontal view. Abbreviations: See "Material and methods". Scale bar: 6 = 100 μm; 9, 10, 11, 13 = 1 μm; 7, 8, 12, 14 = 10 μm.

Leg microsculpture. Reticulate-foveate. Trochanters III, IV antiaxial, femur IV antiaxial (with exception of dorsal zone); femur III antiaxial, (not femoral groove); femur II, antiaxial (with exception of dorsal zone); femur I antiaxial anterior zone (neither dorsally). *Smooth*: tibiae and tarsi (I–IV).

Setation. Seta *in* long, lanceolate 50 μm (43–56 μm) (Figures 12 and 14) with very small barbs; *ro* 10 μm (9–13 μm) (Figure 7), lanceolate; *le* 30 μm (28–33 μm) (Figure 8) lanceolate serrate, slightly curving; notogastral setae 8 μm (6–9 μm) lanceolate, all setae of even length (Figures 9–11). Adanal and aggenital setae small, lanceolate, length approximately 10 μm. Epimeric, genital and anal setae simple 10 μm.

Leg setae (see "Legs").

Prodorsum. Very complex, described from different angles in order to properly interpret the structure.

Lateral view (Figures 15 and 16): prodorsum positioned vertically at a slightly backward inclination; relative position very elevated, terminating almost at the same level as the more elevated notogastral zone. Structurally, the prodorsum is a hollow truncate conical expansion, with paired elevated interlamellar processes (*e.i.p)*.

Each *e.i.p* terminating in a backward directing round ear-like expansion (*e.ex*) (see below). Extension of anterior notogastral depression (*n.a.d*) to prodorsum forming cavity of truncate conical expansion (*p.p.d*) (posterior prodorsal depression) as *n.a.d* crosses the *dsj*, extending to posterior prodorsal zone.

Frontal view (Figures 6 and 17). Prodorsum triangular. Backward extending *e.i.p* and each *e.ex* is clearly visible. Clearly visable *in* seta; inserted in a small cavity at the base of the *e.ex* (Figure 14) and situated in the internal zone of *e.i.p*, directed to the *p.p.d*. Curving *in* setae directed dorso-antiaxially (Figures 12 and 14).

Dorsal view (Figures 1–3). Both images in Figure 1, dorsal, but a slight inclination to either side makes an enormous difference to the interpretation.

Strictly dorsal position (Figure 1): *n.a.d* and *p.p.d* clearly visible; large rounded notogastral depression (*n.a.d*) crossing the *dsj* becoming a smaller rounded depression (*p.p.d*). Anterior zone of *p.p.d* situated in an elevated position and visible in frontal view (Figure 6). Paired ear-like expansions (*e.ex*) more elevated than anterior zone of *p.p.d* (Figure 1). Each ear-like expansion directing towards the paraxial zone, without contact between both structures. Insertion zone of *ro* setae is a small platform (indicated by arrow on Figure 1). Dorsal position inclined anteriorly (Figure 2): interpretation is very different; *n.a.d* crossing *dsj* becoming the *p.p.d* without any major structural change; *e.ex* curving upwards, and *in* setae occurring in the zone of inflexion (indicated by stippled line on Figures 1 and 2).

Posterior view (Figure 18). In this view, the *e.ex* noticeably curving upwards and the inflexion zone clearly visible; seta *in* > *le* > *ro*; *in* situated near anterior margin of the inflexion zone of *e.ex* (Figures 1 and 18); forward directing setae (Figures 6, 12, 14, 15 and 17); *le* setae situated latero-apically on lamellae (Figures 8 and 15); *ro* situated anteriorly to *le* setae (Figure 15).

Lamella (*lam*) laterally, short, hardly discernible in dorsal and frontal positions on account of prodorsal shape; only clearly visible in lateral or frontolateral position (Figures 16 and 17); shallow lamellar furrow (*l.l.f*) not discernible; *le* setae situated in circular depression; ventrolateral *le* insertion existing as a tiny cuspis (*cus*) (Figure 8) (the term "cuspis" is often used in a broad sense, we prefer to use the term lamellar tip (*la.ti*), reserving the term "cuspis", only for specific cases).

Rostral margin very complex, extending forward (Figures 1, 15 and 16), upper margin elevated (Figure 22, indicated by simple arrow); inferior margin w-shaped (indicated by double arrow), central zone with round depression, elevated antiaxially (Figures 21 and 22) *ro* setae situated in elevated zone. Anterior to *ro* setae, a small furrow (Figures 6 and 7). Bothridia: cup-shaped with bothridial ring (*bo.ri*), smooth, incomplete with bothridial tooth (*bo.to)* (Figures 15, 16 and 19).

Sensillus (*si*) barbated ventrally (Figures 15, 16 and 17), arching backward, in lateral position (Figures 15 and 16) barbs clearly visible.

Notogaster. Shape: oval (Figure 1); anterior zone with large anterior depression (*n.a.d*) round-ovoid in shape; posterior zone prominent, elevated (Figures 15 and 16); *n.a.d* continuing with the *p.p.d* and constitutes a very large depressed zone extending forward to the *dsj* (Figures 1–3). Conspicuous furrow (*s.p.d)* situated posteriorly on both sides of *n.a.d* running between c_2 and *da* setae

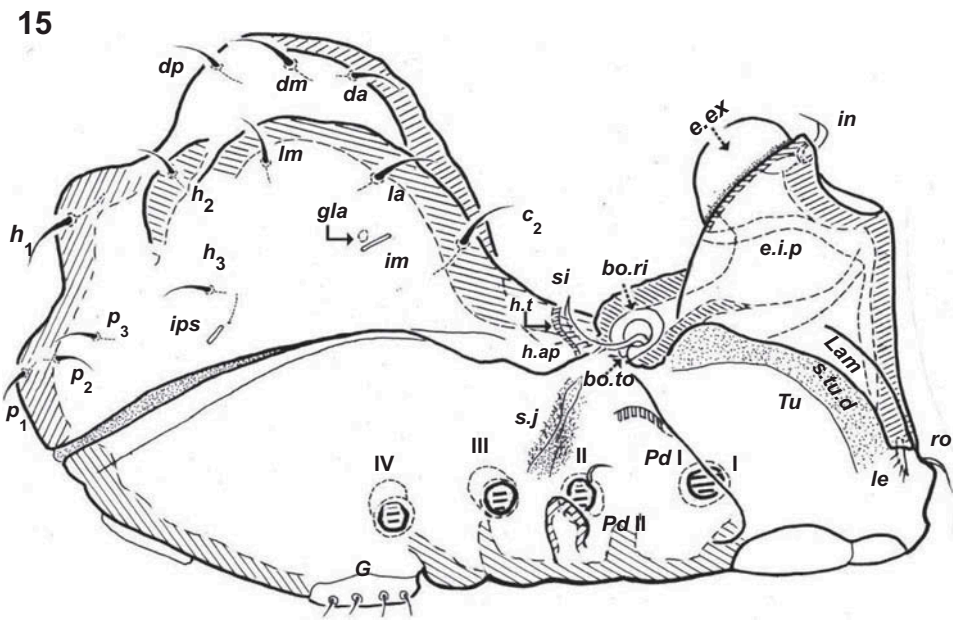
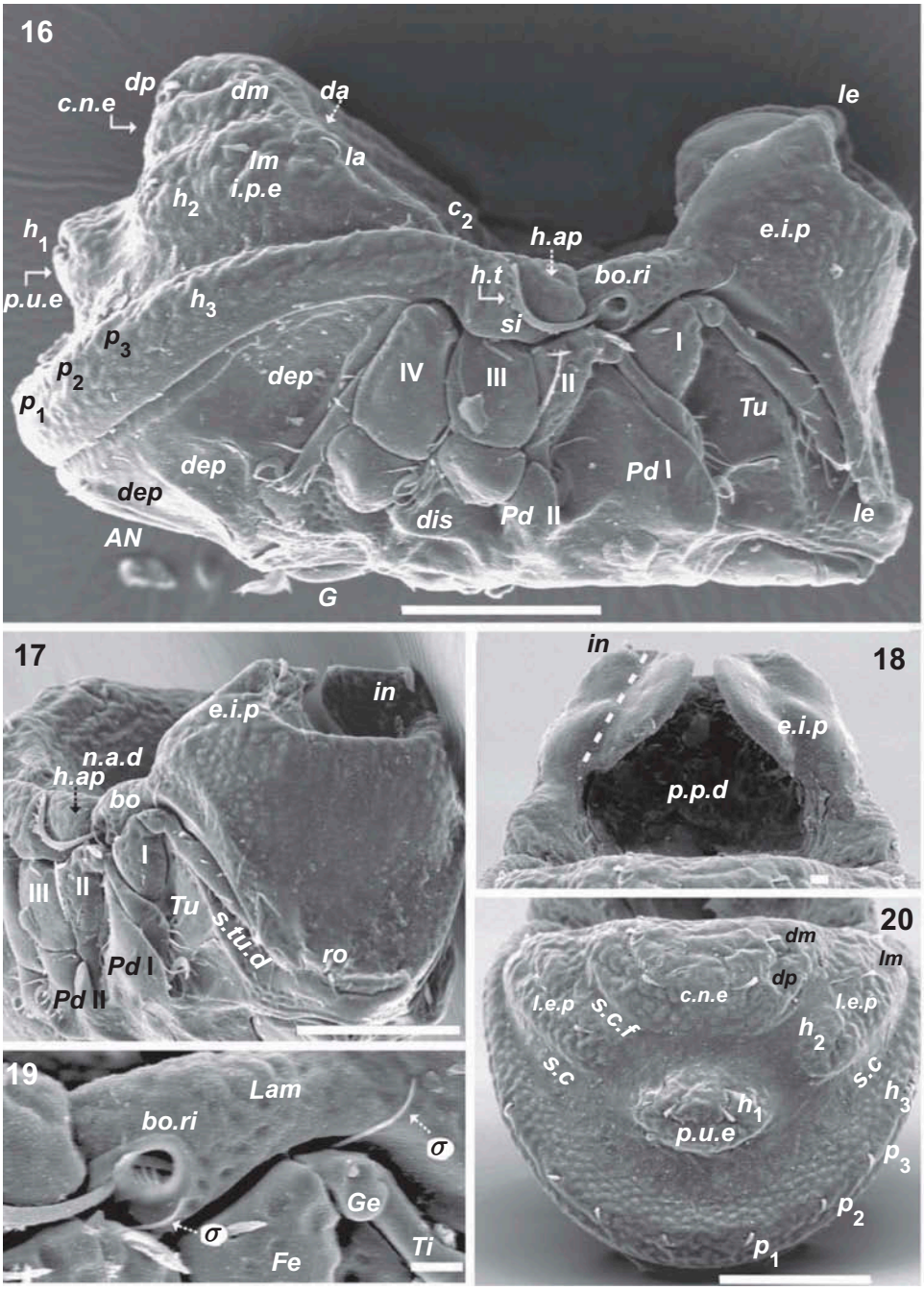


Figure 15. *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.**, adult. **15**. lateral aspect. Abbreviations: See "Material and methods". Scale bar: 15 = 100 μm.



Figures 16–20. *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.**, adult (with cerotegument) scanning electron micrographs. **16**. lateral aspect; **17**. frontal view; **18**. dorsal view, interlamellar elevated process; inflexion zone indicated by stippled line; **19**. genual solenidia; **20**. posterior notogaster inclined to ventral view. Abbreviations: See "Material and methods". Scale bar: 16, 17, 20 = 100 μm; 18 = 10 μm; 19 = 10 μm.

(Figures 1 and 3); *dsj* narrow, well delimited, curving slightly to the front.

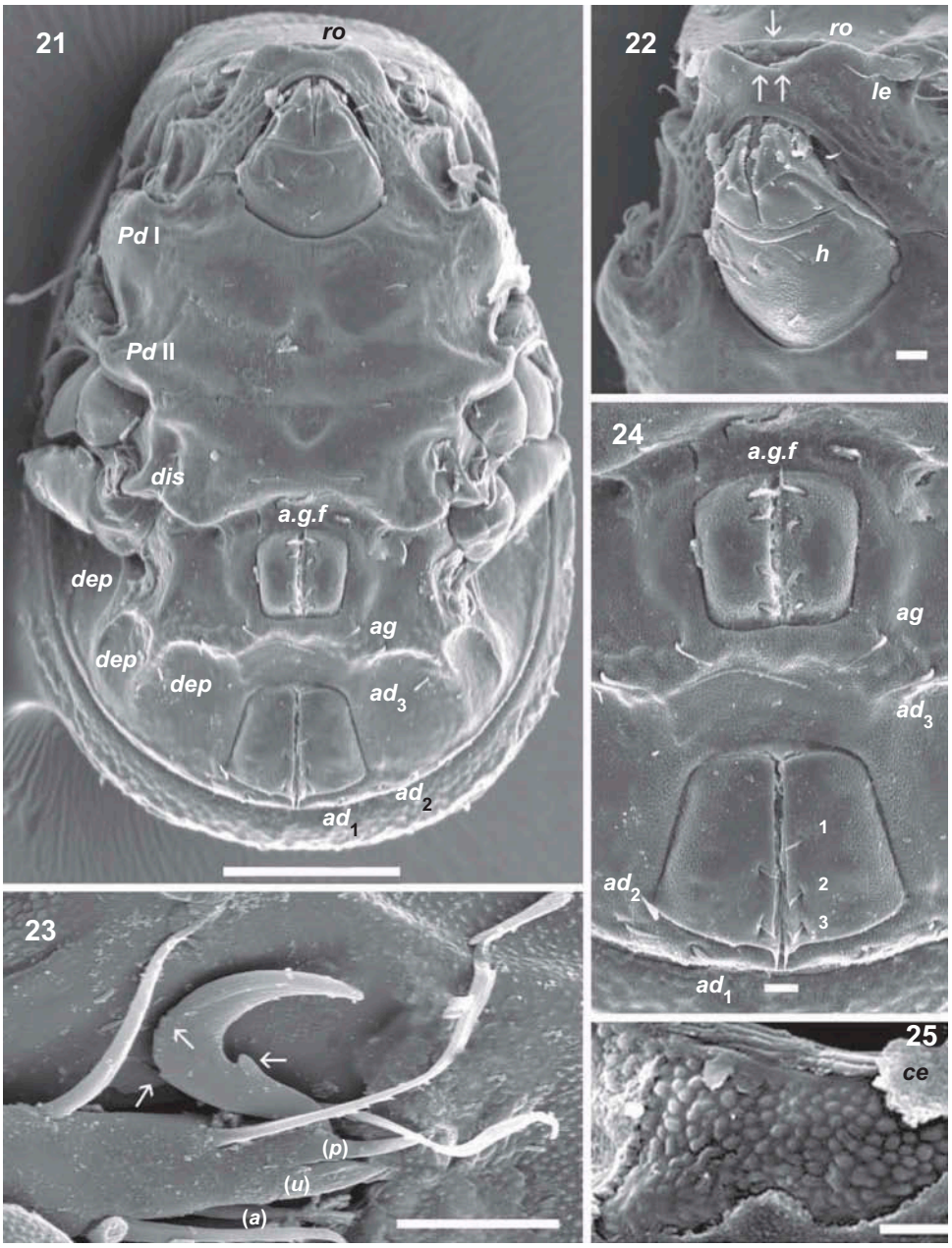
Posterior elevated zone consisting of four elevations: a pair of lateral elevations (*l.p.e*); unpaired central notogastral elevation (*c.n.e*) and posterior unpaired elevation (*p.u.e*) (Figures 2, 3 and 20); small circumgastric furrow (*s.c.f*) running behind *c.n.e* (Figure 20); *s.c* present, clearly discernible (Figures 1, 2 and 20); *s.c* running laterally to *l.p.e* and behind to *p.u.e*; the *s.c* delimiting a large plated zone up to setal insertion of p_1, p_2, p_3, h_3 (Figures 2, 16 and 20). In dorsal view, humeral apophysis (*h.ap*) hardly discernible, but depressed zone clearly visible (Figure 1), lodging the sensillus after activating protection mechanism (Fernandez et al. 2013b). Twelve pairs of setae (c_2, *da, dm, dp, la, lm,* h_1, h_2, h_3, p_1, p_2, p_3) all lanceolate; *gla* and four pairs of lyrifissures (*ia, im, ip, ips*) easily discernible; close to *ips* a spot exists (indicated by star in Figure 15), possibly *ih*, but as many doubt its existence, it is not indicated in figures.

Lateral region (Figures 15–17). A thorough study of the lateral aspect is imperative for observation and interpretation of several structures. Conical *e.i.p*, inclining slightly anteriorly; *e.ex* clearly visible on posterior part as a rounded projection. Short, clearly discernible *lam*; *le* situated in apical position in depressed zone, with ventral cuspis (*cus*); *bo* more or less rectangular zone with rounded tip; apical zone *h.ap* overlapping posterior part of *bo*; *h.ap* rectangular. Slightly visible rod shaped thickening (*h.t*) crossing *h.ap*, delimiting an oblique depression, lodging the *si* at protection mechanism activation.

Curving inferior lamellar margin clearly visible, continuing with inferior bothridial margin; *tu* curved cuticular thickening; tutorial margin rugose; *s.tu.d* deeply concave to permit to concealment of leg I (as in *Bovicarabodes deharvengi* Fernandez et al. 2013b). Pedotectum I large extending lamina, rounded tip. Pedotectum II small lamina, rounded apex. Sejugal depression (*sj*) deep, clearly visible; *lam* border, inferior part of *bo* and inferior part of *h.ap* forming an extended concave lateral expansion and fulfilling an important role during protection mechanism.

Discidium a triangular protuberance, clearly visible in ventral view (Figure 21).

Many circular to ovoid depressions, several delimited by cuticular thickenings, occurring above and below coxa IV, lateral to genital and anal openings.



Figures 21–25. *Afticarabodes anjavidilavai* **gen. nov.**, **sp. nov.**, adult (with cerotegument) scanning electron micrographs. **21**. ventral aspect; **22**. subcapitulum ventrolateral view; **23**. tarsus IV, apical zone; **24**. ventral view, genital and anal plates; **25.** integument microsculpture and cerotegument. Abbreviations: See "Material and methods". Scale bar: 21 = 100 μm; 22–24 = 10 μm; 25 = 5 μm.

Ventral region. Due to the notogastral and prodorsal depressions, these organisms are extremely dorsoventrally flattened, allowing, due to transparency, the observation of many ventral structures from a dorsal view (Figure 3).

Epimeres defined by furrows, easily discernible in animals with cerotegumental layer (Figure 21) or without (Figure 2). Epimeric borders clearly visible; in central zone: *bo.2*, rhomboid depression and *bo.sj*, triangular depression. Epimeral chaetotaxy complex, the more frequent formula is 3-1-3-3, but variations exist due to some setae not being visible, lost, or in asymmetric position; in Figure 4 (right hand side), an arrow indicates the most frequent variation 2-1-3-3; but in left side (with asterisk), the duplicate setae. We observed: setae *1a* very small and difficult to detect; when broken, difficult to locate by SEM or optical microscopy; seta *3a* unpaired, situated in central zone. The duplicate *4c* setae are frequently observed, varying in terms of symmetry between the left and right side (one or the other indistinct, symmetric or asymmetric).

Apodemes 1, 2, *sj* and 3 clearly visible (Figure 4); in front of genital plate, a deep anterior furrow (*a.g.f*) (Figures 4, 21 and 24); in optical observation, cuticular thickening delimiting *a.g.f* clearly visible (Figure 4). Four pairs genital setae in unique line (Figures 4, 21 and 24). Aggenital setae posterolateral, genital opening and near ad_3 (Figure 21).

Three pairs of adanal setae. Anal plate sharply tipped (Figures 21 and 24). Anal setae, variable number, more frequent 2–2, but many asymmetric variations (Figure 24), on one side 3 and on the other 2 setae; lyrifissure *iad* situated laterally behind setae ad_3, hardly discernible, lens-shaped and situated on the elevated area between two depressions (Figure 4). Many cuticular depressions clearly visible (Figures 4 and 24).

Posterior aspect. To place the organism exactly in posterior position was very difficult; two posterior positions are depicted. In the first image (Figure 5), only the posterior elevation (*p.u.e*) with h_1 is clearly visible; in the second image (Figure 20), four elevations are visible (pair, *l.p.e, c.n.e, p.u.e*) with $la,lm,h_2;dm;dp;h_1$; the *sc* easily discernible, as well as the plated zone between this furrow and the insertion of p_1,p_2,p_3 and h_3 setae. Marginally to *c.n.e* a deep furrow existing (*s.c.f*); between p_1 and p_2, lyrifissure *ip* (Figure 5).

Gnathosoma. Subcapitulum diarthric, three pairs of subcapitular setae (Figure 22).

Legs. Presents the same chaetotaxy as *B. deharvengi* (*op.cit*): I (1-3-3-4-16-1) (1-2-2); II (1-4-2-3-16-1) (1-1-2); III (2-3-1-2-2-15-1) (1-1-0); IV (1-2-2-2-13-1) (0-1-0). Many setae are lost, for this reason the chaetotaxy as indicated is provisory.

Protection mechanism. The protection mechanism is inherently of the same type as that of *B. deharvengi* (Fernandez et al. 2013b); but here the *h.ap*. is clearly visible in lateral position in the area where the superior part of femur III is placed (Figure 16) during leg folding. The shapes of femora are very different to those of *B. deharvengi*.

Redefinition of the genus *Rugocepheus*

Genus ***Rugocepheus***, original description (Mahunka 2009, p. 50):
***Rugocepheus* gen.nov**.

Diagnosis

Family Carabodidae. Body covered by secretion layer. Lamellae narrow with median transversal extension, lamellar setae arising on separate tubercles of the lamellar surface, translamella absent. Humeral apophyses small, no setae in humeral position. Ten pairs of large notogastral elevations bearing long, thin setiform setae. Fourteen pairs of thin setiform notogastral setae, among them 4 pairs in posteromarginal position.

Gnathosoma with median transversal protuberances. Epimeral region well sclerotized, sternal apodemes absent, sternal region very wide, with an annular ring-shaped formation anteriorly. All epimeres located far from each other. Four pairs of genital, 1 pair of aggenital, 2 pairs of anal and 3 pairs of adanal setae. Lyrifissures *iad* located far from the anal aperture. All legs tridactylous.

Type species: *Rugocepheus formosus* sp. n.

Remarks

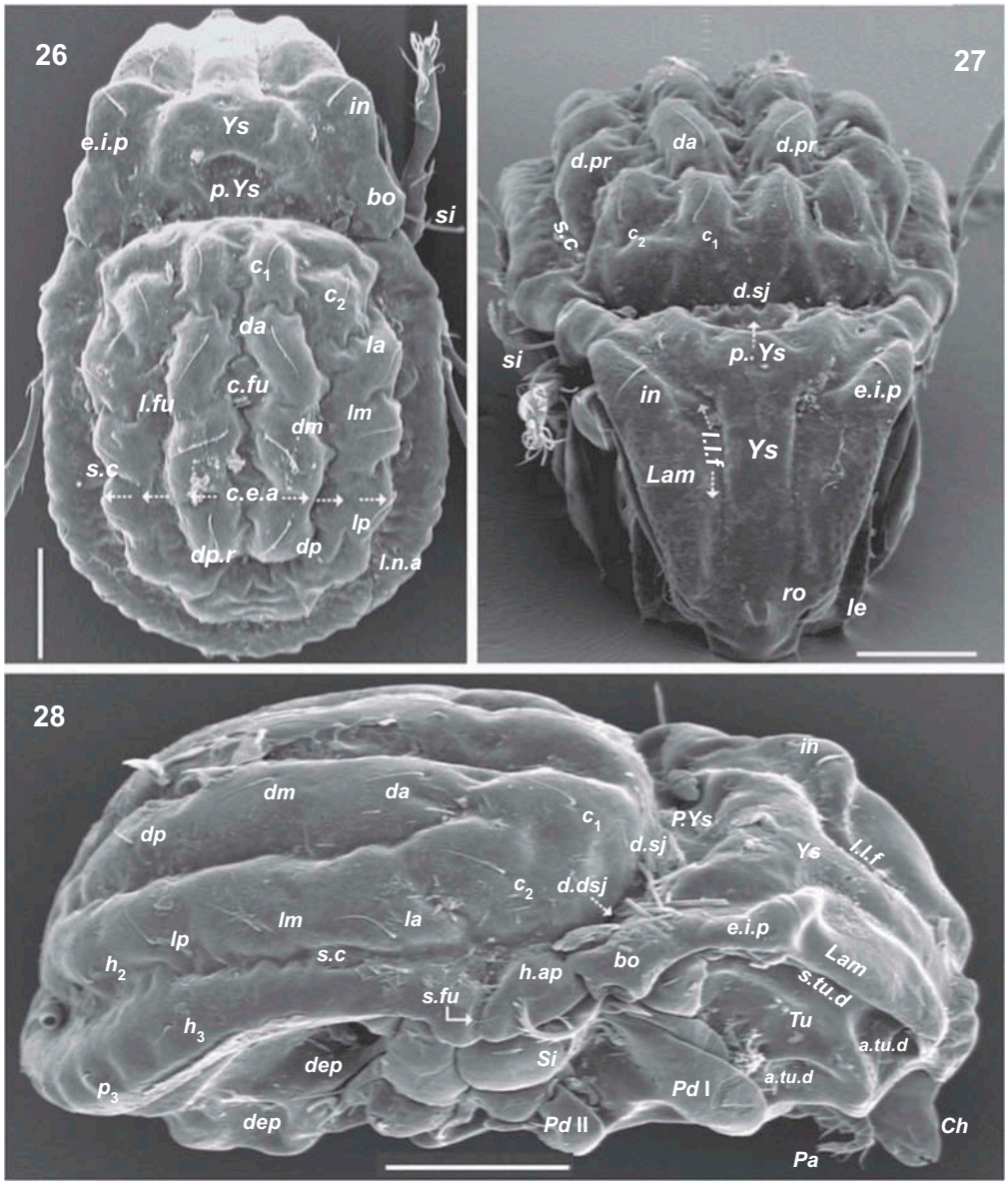
Form of the lamellar protuberances, the 10 pairs of notogastral elevations combined with the thin and long notogastral setae, the form of the epimeral structure and the well-sclerotized ventral region as a feature combination has been unknown in the family Carabodidae. First of all, the position of the lamellar setae and the form of the notogastral protuberances and the setae are unique in this family. On this basis, the new genus is well distinguishable from all other genera of the family.

Redefinition

Diagnosis

Prodorsum. triangulate; elevated semicircular interlamellar process. Lamella dorsolateral; *le* seta apically; shallow lamellar furrow prominent, together with elevated interlamellar process delineating Y-shaped structure (thickening). Bothridia cup-shaped; bothridial ring smooth, incomplete with bothridial tooth.

Notogaster: well delimited central elevated area, surrounded by an unelevated well-defined lateral area, more or less flat. Central area with unpaired central longitudinal furrow and paired lateral furrows. Ten paired dorsal protuberances; four pairs centrally and six pairs laterally; setae c_1, c_2, *da, dm, dp, la, lm, lp,* h_1, h_2 on dorsal protuberances. Lateral unelevated area with four pairs of setae (p_1, p_2, p_3, h_3). Four pairs of lyrifissures present (*im, ih, ip, ips*), *ia* probably exists. Humeral apophysis polyhedral, anterior part overlapping posterior bothridial part. *Pd* I, *Pd* II, tutorium, supra-tutorial depression and discidium present.



Figures 26–28. *Rugocepheus joffrevillei* **sp. nov.** adult (with cerotegument) scanning electron micrographs. **26**. dorsal aspect; **27**. frontal view; **28**. lateral aspect. Abbreviations: See "Material and methods". Scale bar: 26–28 = 100 μm.

Ventral region. with depressions, elevations and internal thickening. Epimera defined by furrows. Epimeral chaetotaxy 3-1-3-3. Four pairs of genital setae. Anal plate small sharp tip; two anal setae; lyrifissure *iad* far from anal opening, lateral, ad_3 setae.

Rugocepheus joffrevillei **sp. nov.**
(Figures 26–60)

Etymology

The specific epithet is derived from the type locality.

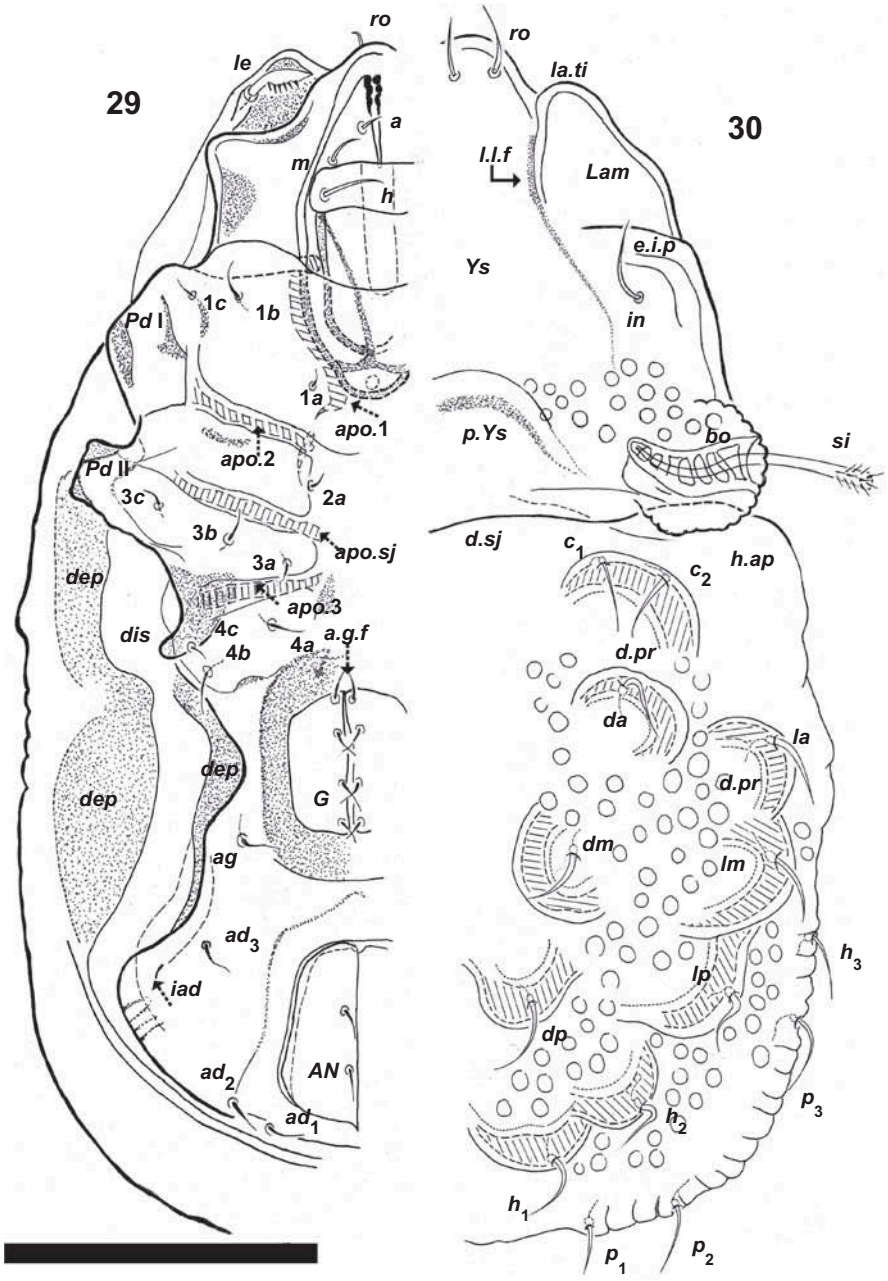
Material examined

Holotype. 1 adult female, "Madagascar, nord; Province de Diego-Suarez. Joffreville.PCP.MAD.628. FDHBA (Foret Dense Humide de Basse Altitude) 700 m. Litière. J.-M Betsch coll. 9 xii 1965". Deposited in the Collection of the MNHN, Paris, France, preserved in 70% ethanol.

Paratypes. 1 adult male, Madagascar, same locality and date (J.-M Betsch coll.) deposited in Collection of the MNHN, Paris, France, preserved in 70% ethanol. 1 Adult female, Madagascar, same locality and date (J.-M Betsch coll.) deposited in Geneva Natural History Museum, Switzerland, preserved in 70% ethanol; and 1 adult female, same locality and date (J.-M Betsch coll.) deposited in KwaZulu-Natal Museum, Pietermaritzburg, Republic of South Africa, preserved in 70% ethanol.

Diagnosis (adult female)

Setae. lanceolate: *in, le*; simple: *ro,* notogastral, adanal, aggenital, genital, anal, epimeric, adoral; *in* setae inserted on the posterior zone of elevated interlamellar process.



Figures 29–30. *Rugocepheus joffrevillei* **sp. nov.** adult (without cerotegument); **29**. ventral aspect; **30**. dorsal aspect. Abbreviations: See "Material and methods". Scale bar: 29–30: 70 µm.

Prodorsum. In dorsal view, more or less triangular; supratutorial depression well delimited, deep, with anterior tutorial depressions; posterior part Y structure curved depressed zone, semicircular anterior border; *la.ti* extending slightly dorsally as small beak-like shape. Rostrum beak-shaped (lateral view); sensillus barbate.

Lateral view. five semicircular parallel structures, prodorsal margin, lamellae, supratutorial depression, tutorium, pedotectum I; tutorium thickened, rod-like surface structure. Pedotectum I: curving extended lamina, finger-like tip, exceeding ventral surface. Pedotectum II: prominent lamina. Sejugal depression deep, zone situated at level of posterior Y structure, with four round tooth-like projections.

Humeral apophysis with two furrows, one oblique posterior situated far from the regular furrow position, delimited by humeral thickening; apical anterior zone bilobate, permitting overlap posterior part of bothridial zone and posterior bothridial zone extending to humeral apophysis; internally complex cuticular thickening, lyrifissure *ia* probably present; discidium finger–like structure. Several large ovoid depressions: sejugal zone, underneath acetabula III, IV, behind and lateral to genital and anal opening. Epimeric zone, medially with longitudinal furrow, anterior to and surrounding genital plate; deep anterior furrow; behind

genital zone a transversal cuticular wall. Apodemata 1, 2, *sj* and 3 clearly visible. Genital setae very long in relation to anal setae. Adanal, aggenital setae more or less equal in length; lyrifissure *iad* far from anal opening, laterally underneath ad_3 setae. Mentum: anterior central elevated zone, delimiting shield, *h* setae inserted on shield; lyre-like thickening on central zone, laterally flanked on each side by a deep depression. Preanal organ, double horseshoe- shaped structure with a mustache-like anterior chitinous structure. Femora all shaped differently.

Description

Measurements. SEM: females 565 μm (575–538) × 410 μm (350–425). Light microscopy: females 569 (575–476) × 421 μm (356–465).

Shape. Oval (Figures 26 and 30).

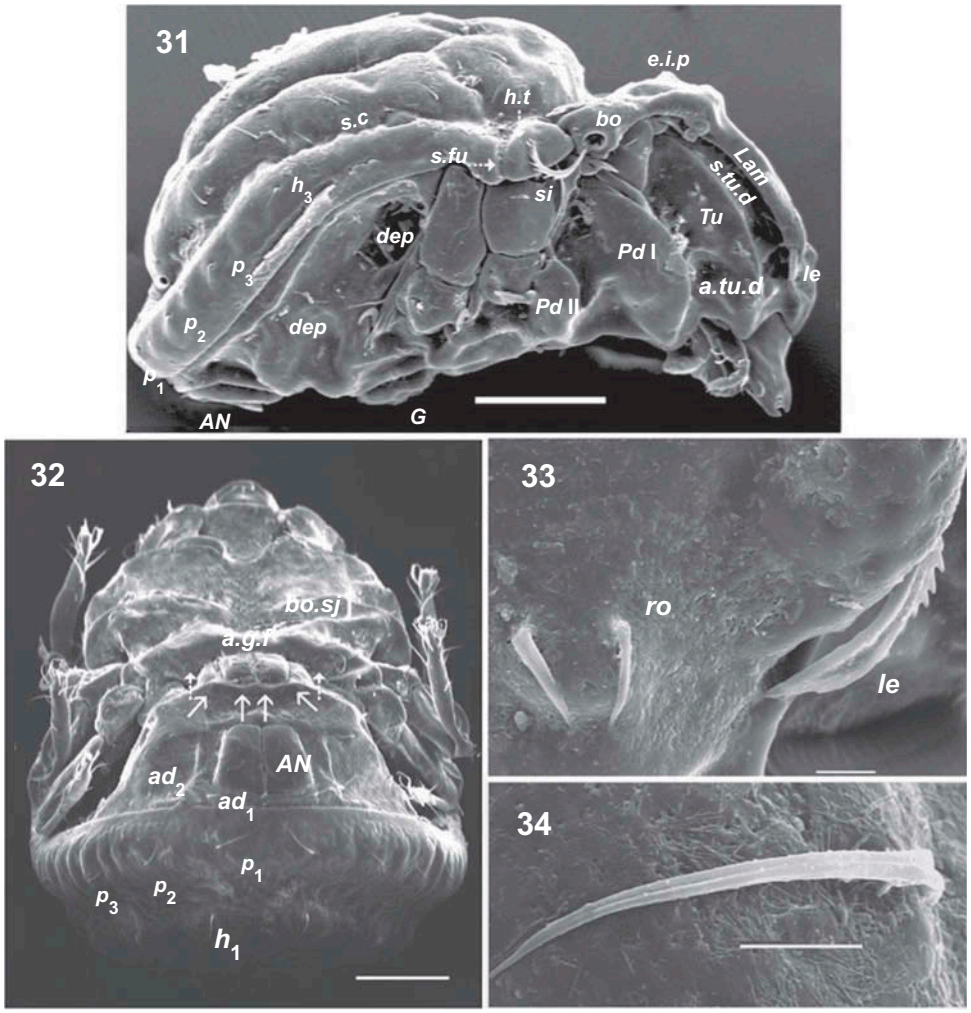
Colour. Specimens without cerotegument; females light brown to brown.

Cerotegument. Simple layer (± 0.5 μm) uniformly covering the entire body and legs. Irregular surface (Figures 43 and 44) due to adhering debris. Large number of pores observable on the surface (indicated by arrow on Figures 43 and 44). Cerotegument not obscuring or hampering observation.

Integument. Microsculpture complex, varying according to body region and leg segments.

Prodorsal microsculpture. Irregularly tuberculate (Figure 44): mixed with *foveate areas* near bothridia, on elevated interlamellar process (*e.i.p*) and lamellar apex (*la.ti*) (Figures 27, 28, 30 and 35). *Granulate mixed with foveate*: central zone from shallow lamellar furrow to near *ro* seta (Figures 30 and 35). *Foveate*: lamellae (Figures 27 and 28).

Notogastral microsculpture. Irregularly tuberculate: on dorsal protuberances laterally and on the posterior part of humeral apophysis (*h.ap)* (Figure 44). *Foveate*: area



Figures 31–34. *Rugocepheus joffrevillei* **sp. nov.** adult (with cerotegument) scanning electron micrographs. **31**. lateral aspect; **32**. ventral posterior inclined view. **33**. *ro* and *le* setae, in frontal view; **34**. *in* setae. Abbreviations: See "Material and methods". Scale bar: 31 = 100 μm; 32–34 = 10 μm.

between protuberances (Figures 30 and 35). *Granulate: dsj* depressed zone.

Ventral microsculpture. *Smooth to granulate*: epimeral zone and zone around genital and anal opening.

Legs microsculpture. Foveate: trochanters III and IV, antiaxials; femurs antiaxial, I, II, III and IV. *Smooth*: femoral groove, tibiae and tarsi (I–IV).

Setation. Lanceolate*: in* long 40 μm (36–44 μm) (Figure 34); *le* slightly curved, basally serrate, 40 μm (45–37 μm) (Figure 33). *Simple*: *ro* 20 μm (16–22 μm) (Figure 33); notogastral 53 μm (43–62 μm) (Figures 30, 31, 35, 47 and 49); adanal and aggenital 26 μm (21–29 μm) (Figures 29 and 47); anal 16 μm (13–18 μm); genital 30 μm (27–36 μm); epimeric ± 50 μm (setae were often broken); *h* 40 μm (36–45 μm); *m, a* between 10 μm to 17 μm, several setae were broken). Leg setae (see "Legs") (Figures 55–58).

Prodorsum. Very complex: to properly understand the structure, we include descriptions from different angles/views.

Frontal view. (Figure 27). more or less triangular in shape. Semicircular *e.i.p*, with posterior zone (near bothridia) elevated and more or less triangular in shape; setae *in* inserted posteriorly (see lateral inclined view); *l.l.f* well delimited as a conspicuous furrow, delineating (together with elevated posterior *e.i.p*. zone) Y-shaped structure (*Ys*). *Ys* originating posterior to insertion point of *ro* setae and terminating near the *dsj*. Curving posterior part of *Ys* (*p.Ys*); the *p.Ys*, is a depressed zone with a semicircular anterior border, posterior part terminating near the *dsj* (Figures 26 and 27) where four round tooth-like projections are visible (*t.dsj*) (Figure 50). Setae *ro* and *le* clearly discernible. Bothridium slightly visible.

Dorsal view (Figures 26 and 30). More or less triangular. Clearly visible *e.i.p*., semicircular. Lamellar zone and *Ys* clearly delimited by *l.l.f*; the posterior part of *Ys* semicircular, elevated, with a triangular posterior depression (*p.Ys*) (Figures 26, 30 and 50); *la.ti* extending slightly dorsally to *le* insertion, a small "beak-like" (Figures 31 and 35) structure; rostrum rounded; *ro*, *in* setae and *si* clearly visible; *dsj* depressed zone (*d.dsj*) (Figure 28, indicated by arrow).

Lateral inclined view (Figure 28). Five more or less parallel structures, prodorsal margin, *lam*, *s.tu.d*, *tu* and *Pd I*. Elevated semicircular *e.i.p*; *lam* well differentiated; *l.l.f*, conspicuous furrow with *e.i.p* clearly defined; *dsj* in depressed zone (*d.dsj*), wider at junction of *dsj* and *p.Ys*. Bothridial zone differentiated from *e.i.p* by shallow furrow; posterior part rounded, overlapping *h.ap*. Rostral zone elevated, end rounded; *s.tu.d* well delimited, deep, with two ovoid anterior tutorial depressions (*a.tu.d*), (Figure 28); *in*, *le* setae clearly visible. Bothridia (Figure 42) cup-shaped with bothridial ring (*bo.ri*), smooth, incomplete with bothridial tooth (*bo.to)*. Sensillus ventrally barbate (Figures 48), arching backward.

Notogaster. Oval. Four furrows present: one central unpaired longitudinal (*c.fu*); one lateral pair (*l.fu*), more or less parallel to *c.fu* and one unpaired semicircular (*s.c*). Two areas defined by *s.c*: one central, elevated (*c.e.a*) and second lateral, not elevated (*l.n.a*), more or less flat, surrounding *c.e.a*. Central elevated area (*c.e.a*) with unpaired *c.fu*, paired *l.fu* and ten paired dorsal protuberances (*d.pr*) (Figures 26, 30, 36 and 49). Dorsal protuberances (*d.pr*): four pairs centrally and six pairs laterally; each *d.pr* with a notogastral seta (c_1, c_2, *da, dm, dp, la, lm, lp,* h_1, h_2) (See "Remarks"). Observable laterally to the *d.pr* with *la* setae, and *d.pr* with *lm* setae, lyrifissure *im* and *gla* (Figure 35). Humeral apophysis (*h.ap*) difficult to discern in dorsal view (Figure 26).

Lateral unelevated area (*l.n.a*) with four pairs of setae p_1, p_2, p_3, h_3 (Figures 30). Lyrifissures *ih*, *ip*, *ips* clearly visible.

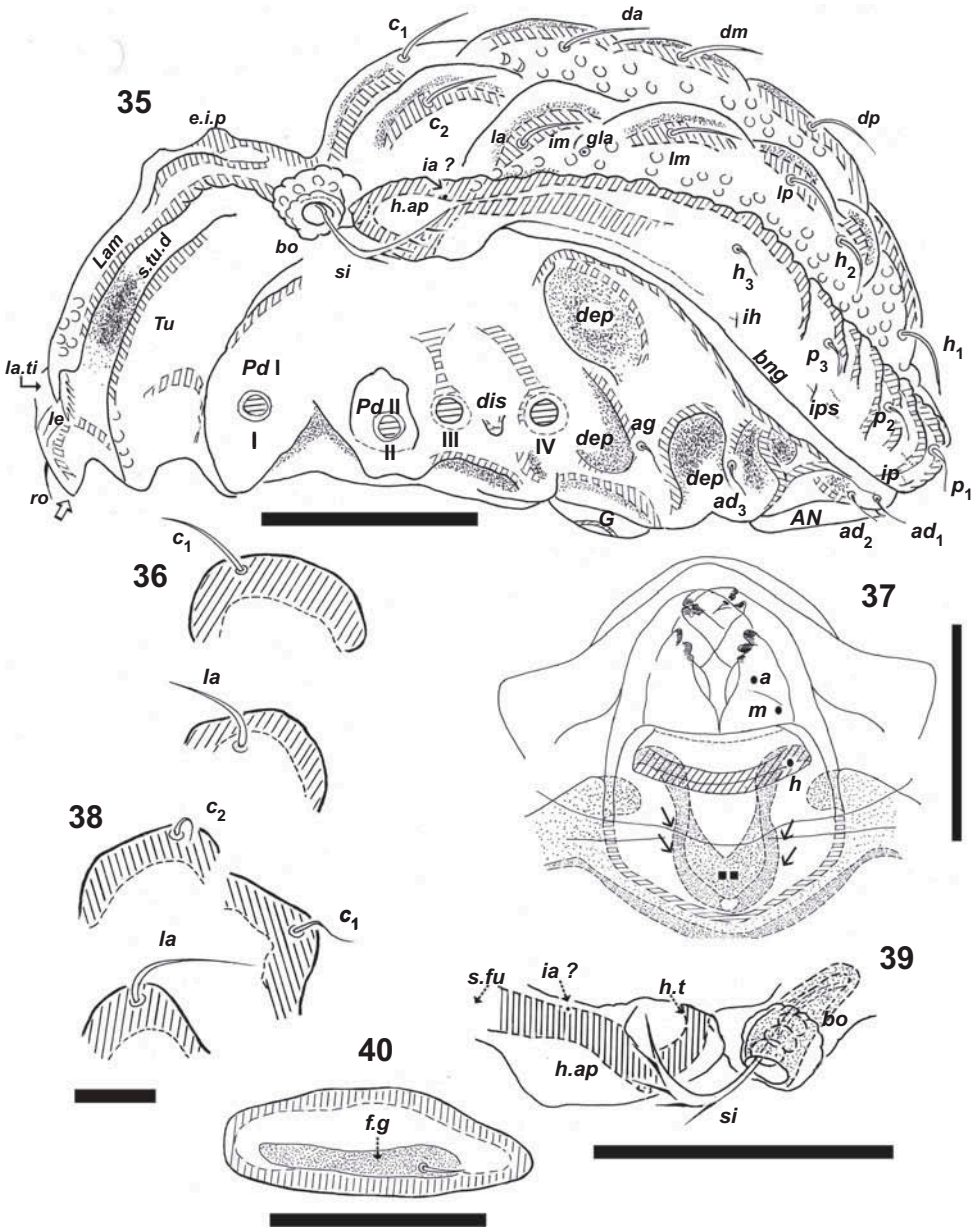
Lateral region (Figures 28, 31, 35 and 54). Humeral apophysis (*h.ap*) (Figures 28 and 31) large polyhedral structure, conspicuous oblique posterior furrow on surface (*s.fu*) (Figures 28 and 31). Situated far from the usual placement site of furrow, delimited by *h.t*; inconspicuous furrow situated anteriorly to *s.fu* (Figures 31 and 39); internally: complex cuticular thickening (Figure 39); a dark dot present (indicated by arrow and *ia?*, Figures 35 and 39), possibly lyrifissure *ia*; *h.ap* apical anterior zone bilobate, to permit overlapping of posterior part of bothridial zone (Figures 28, 31, 35 and 39), posterior bothridal zone touching *h.ap*.

Five parallel semicircular structures: prodorsal margin, lamellae, supratutorial depression, tutorium, pedotectum I; *Pd I*, *tu*, lamellae and rostrum (Figures 31 and 35); *lam*, clearly visible, with short conspicuous "beak like" *la.ti* Figures 35 and 54); *le* situated in apical circular depressed zone; *s.tu.d* a deep depression; *tu* clearly delimited by prominent thickening, exhibiting rod-like surface structure; anteriorly two *a.tu.d*. (Figures 28 and 31). Rostrum beak-like in shape (Figures 28, 31 and 35 indicated by arrow).

Inferior curved margin of lamella continuous with inferior bothridial part; both structures relating to *s.tu.d*, permitting concealment of tarsus, tibia and dorsal area of genu and femur of leg I after initiation of protection mechanism. Pedotectum I: large curved extending lamina, finger-like tip, exceeding ventral surface. Pedotectum II: large lamina, rounded apex. Sejugal depression (*sj*) deep. Discidium (*dis*) prominent fingerlike structure (Figure 35). Several large ovoid depressions existing in sejugal zone, underneath acetabula III and IV, behind and lateral to genital and anal opening.

Ventral region. Several depressions, elevations as well as surface and internal thickenings observable in this very complex region (Figures 29, 32, 41, 46 and 52).

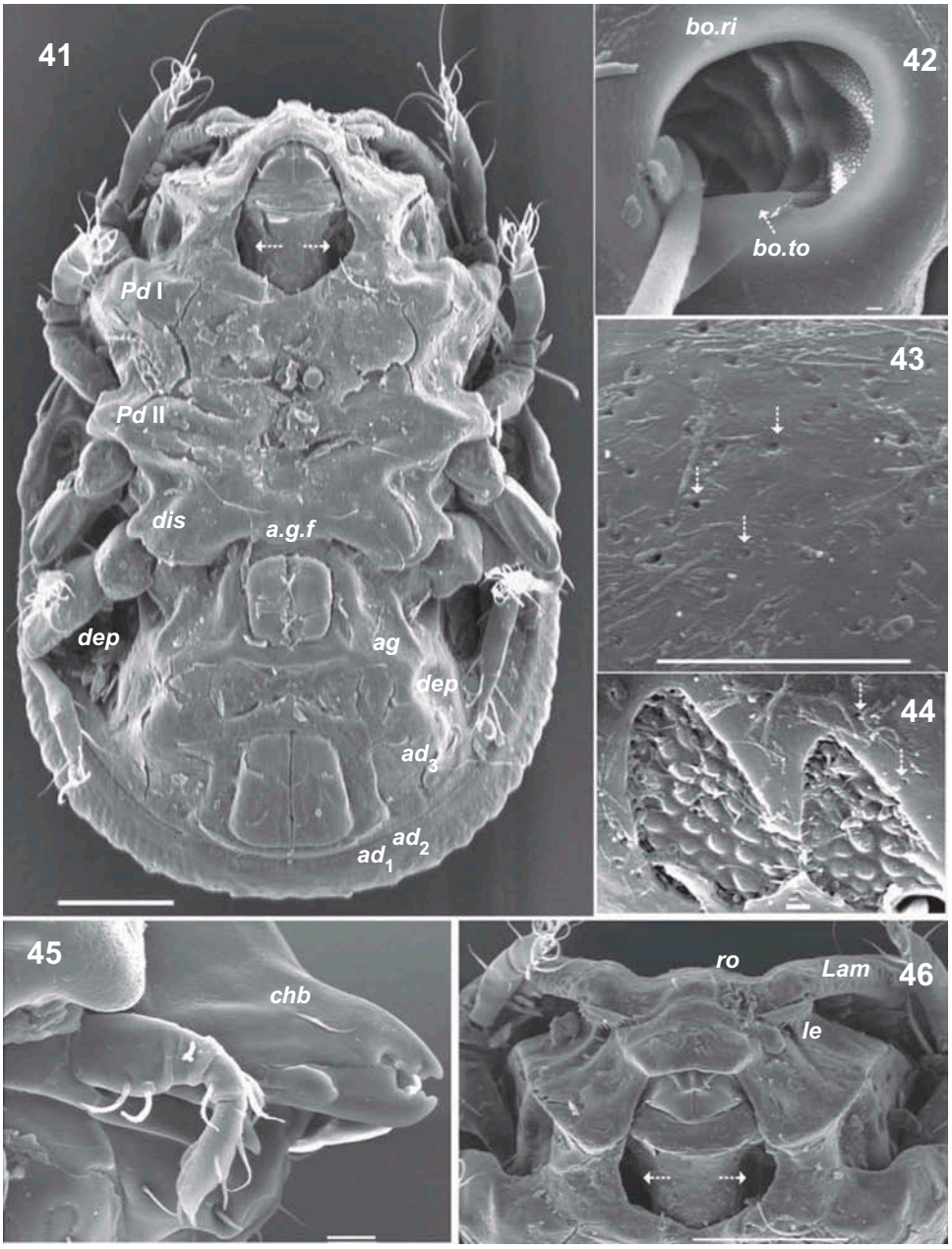
Epimera clearly defined by furrows, easily discernible in SEM observations, principally in ventroposterior inclined view (Figure 32.). Paraxial zone of epimera 1 and 2 with longitudinal furrow; epimeric border *bo.sj* crossing the medial plane (Figure 32). Clearly visible deep



Figures 35–40. *Rugocepheus joffrevillei* **sp. nov.** adult (without cerotegument). **35**. lateral aspect; **36**. **38**. notogastral protuberances (see text); **37**. subcapitulum; **39**. humeral process and bothridia, lateral view; **40**. femur III, ventral view. Abbreviations: See "Material and methods". Scale bar: 35, 37 = 100 μm; 36, 38, 40 = 50 μm; 39 = 50 μm.

furrow (*a.g.f*) anterior to and partially surrounding genital plate (Figures 29 and 32). Epimeral chaetotaxy 3-1-3-3 (Figure 29), long setae (Figure 41) but in many cases setae are broken and insertions are hardly discernible. Apodemes 1, 2, *sj* and 3 clearly visible (Figure 29). Four pairs of genital setae in a unique line (Figure 53). Adanal and aggenital setae more or less similar in length (Figures 29 and 35). Anal plate with small sharp tip (Figure 29, indicated by arrow); lyrifissure *iad* far from anal opening; situated laterally underneath ad_3 setae. Subcapitulum (Figure 52) very complex (see "Remarks").

Subcapitulum (Figures 29, 37, 41, 46 and 52). Different aspects observed depending on the angle, for example in SEM observation (Figures 41, 46 and 52). *Mentum*: elevated zone anterior of labiogenal articulation zone, with insertions of humeral setae *h*; towards the rear (on either side), a depression is observed (Figures 41, 46 and 52 indicated by arrow on all figures). In optical observation (Figure 37) elevated zone of mentum forming a thick cuticular structure, defined as a shield, on which *h* setae are inserted (both observations, optical and SEM, can be correlated). Depressed zone situated laterally and to the rear, clearly defined by lateral part of lyre-like thickening (Figure 37, indicated by double arrow) situated in the central zone of mentum behind the shield. Lyre-like thickening displaying intricate but less thickened cuticle (dark shaded in Figure 37).



Figures 41–46. *Rugocepheus joffrevillei* **sp. nov.** adult (with cerotegument) scanning electron micrographs. **41**. ventral aspect; **42**. bothridial ring, lateral view; **43**. cerotegument; **44**. cuticular surface (arrow); **45**. palp and chelicerae, lateral view; **46**. subcapitulum, ventral view. Abbreviations: See "Material and methods". Scale bar: 41, 46 = 100 μm; 43, 45 = 10 μm; 42, 44 = 1 μm. Arrow see text.

Preanal organ (*LF*) (Figures 59 and 60). Double horseshoe-shaped (Figure 59), both extremities of *LF* seem to be tightly attached to the anal plates. Tendon (*TaM*) attached to central part of *LF*. Anterior chitinous mustache-like structure (Figure 60 indicated by double arrow), attached to the anterior rectal wall, situated at the same level as *LF* (in Figure 60, the *LF* is dotted to show its relative position).

Posterior aspect (Figure 32). Epimeric zone: medially with longitudinal furrow, from epimera 1 to 4; *bo.sj*, furrow exceeding medial zone. Furrow delimited (both sides) by longitudinal crests; lateral depressed triangular zone between acetabula III and IV.

Depressed area (anteriorly (*a.g.f*)), (indicated by dotted arrow) surrounding elevated ring-like structure which in turn surrounds genital opening; transversal cuticular wall (indicated in Figure 32, black arrows) behind genital zone. Anal zone between transversal wall and anal plates, more or less rectangular depressed area (indicated by double arrow). Depressed area laterally to anal plate (indicated by white dot).

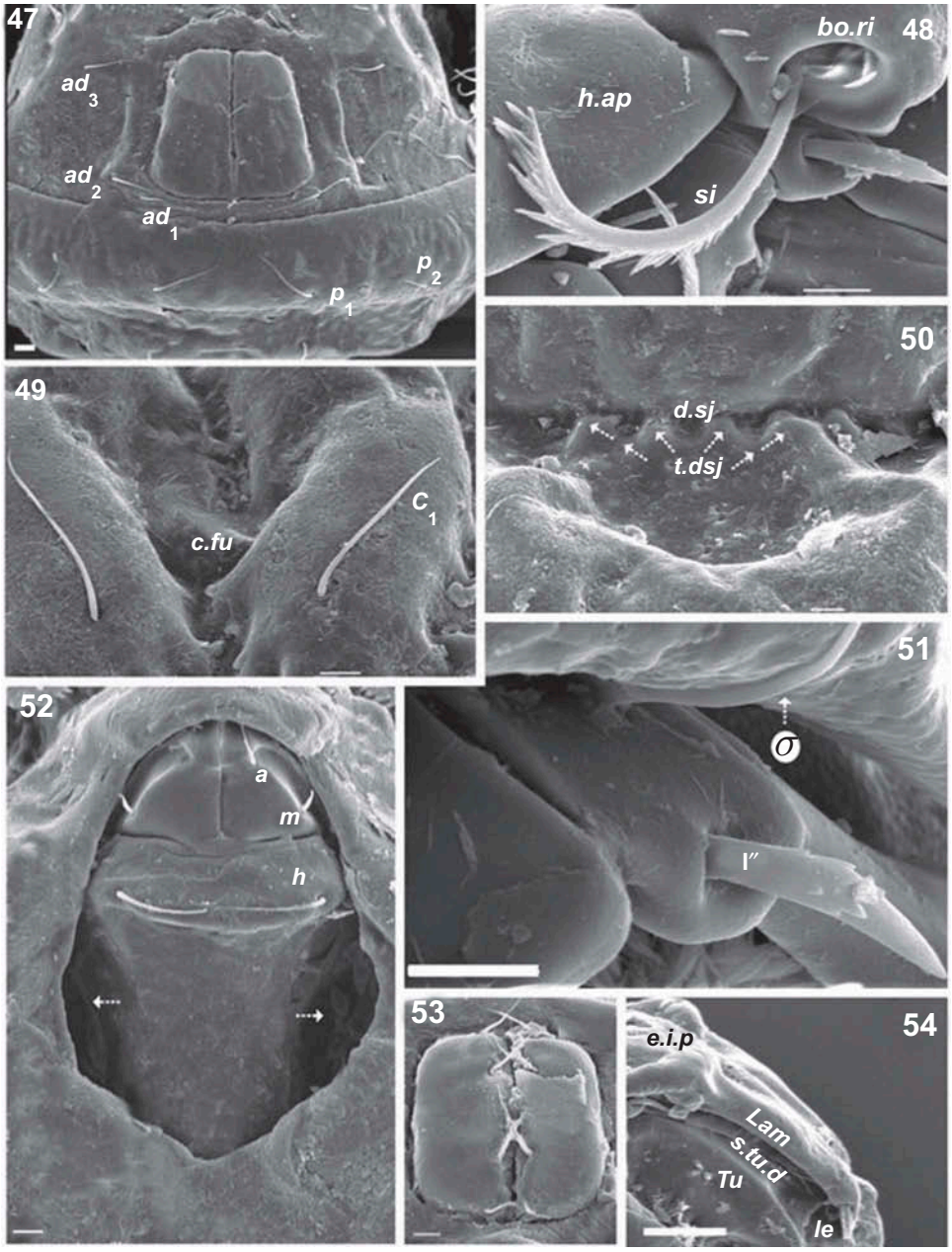
Lateral and behind acetabulum IV, conspicuous depressed area (indicated by white diamond shape on Figure 32). Notogaster: several alternating furrows and elevated rod-like structures.

Gnathosoma. Subcapitulum diarthric, three pairs of subcapitular setae. Mentum complex (see "Remarks"). Chelicera with barbeled *cha* and *chb* (Figure 45). Palps: chaetotaxy and segments similar to *B. deharvengi*.

Legs. Claws with small teeth. Genua III and IV small, hinge-like articulation with femur (Figures 55, 57 and 58); leg I longer (Figure 55), leg II shaped differently to all others (Figure 56). Femora I–IV all shaped differently.

Leg I (Figure 55). Femur: long; basal zone narrow; depressed antiaxial zone hardly discernible; paraxial central zone, ovoid porose area; all setae either not barbed or very faintly barbed. Genu, σ setiform, fine, medium length; ventral setae large, barbed; l" barbate. Tibia with φ_1 long, setiform, tactile, situated on apophysis; φ_2 medium length, setiform; with setae *d* not associated but close by. Tarsus with ω_1, ω_2 baculiform and ε small; setae (*u*) typical.

Leg II (Figure 56). Femur: long, large, strong; paraxial more or less central rounded porose area. Genu, σ medium length, setiform; l', strongly barbed; *v* long, barbed. Tibia, medium length. Tibiotarsus articulation a small synarthrodial skin, permitting limited movement (see *Malgachebates peyrierasi*, Fernandez et al. 2011, Figures 44–47); φ, σ



Figures 47–54. *Rugocepheus joffrevillei* **sp. nov.** Adult (with cerotegument) scanning electron micrographs. **47**. posterior view; **48**. sensillus. **49**. elevated zones, notogaster. **50**. dorsosejugal suture and posterior part of prodorsum. **51**. seta of genu and σ solenidion. **52**. subcapitulum, inclined view. **53**. genital plate. **54**. lamellae. Abbreviations: See "Material and methods". Scale bar 47–53 = 10 μm; 54 = 20 μm. Arrows see text.

setiform, medium length; *d* setae nearby φ. Tarsus: medium size, large at base; ω_1, ω_2, baculiform.

Leg III (Figure 57). Trochanter: more or less triangular, posteriorly rounded, same type as *Bovicarabodes dehavenghi* (Fernandez et al. 2013b; Figures 18 and 25). Femur unlike all others, with characteristics and function typical of "leg folding". Polyhedric in shape (but different to *B. deharvengi* Fernandez et al. (2013b), Figures 18 and 25); basal slightly antiaxial rectangular femoral groove (*f.g*); *v* setae small inner groove (Figure 40); all other characteristics similar to *B. deharvengi* (Fernandez et al. 2013b); setae equal in number but smooth or very slightly barbed. Genu: σ medium to small; only l' setae. Tibia: φ medium size; *v* setae pair. Tarsus normal shape; chaetotaxy: only lacking *Ad* seta.

Leg IV (Figure 58). Trochanter: polyhedric in shape. Femur, integument basal antiaxially foveate to reticulate-foveate pattern; dorsally smooth; prominent basal blades. Genu: small; σ baculiform. Tibia: thin; φ small baculiform. Tarsus: ω medium size.

Setal formulae (trochanter to tarsus): the formulae are provisory, poor conservation of setae made observation difficult. I (1-3-3-4-16-1) (1-2-2); II (1-4-2-3-16-1) (1-1-2); III (2-3-1-2-14-1) (1-1-0); IV (1-2-2-2-121). See Table 1.

Males

The males and females are very similar, but some external characteristics permit recognition of males. (For a precise determination of gender, dissection is necessary). Several dissections were done (for subcapitulum studies, see below) and in all cases the external characteristics correspond in males.

Colour. Brown to dark brown (observed in reflected light).

Measurements. Males small in relation to females. Light microscopy: 444 µm × 320 µm. Despite the large difference in size between males and females, the ratio of length of anal plate versus genital plate is exactly the same: 1:4.

In our samples, the sex ratio was 1:3 (male:female)

Remarks

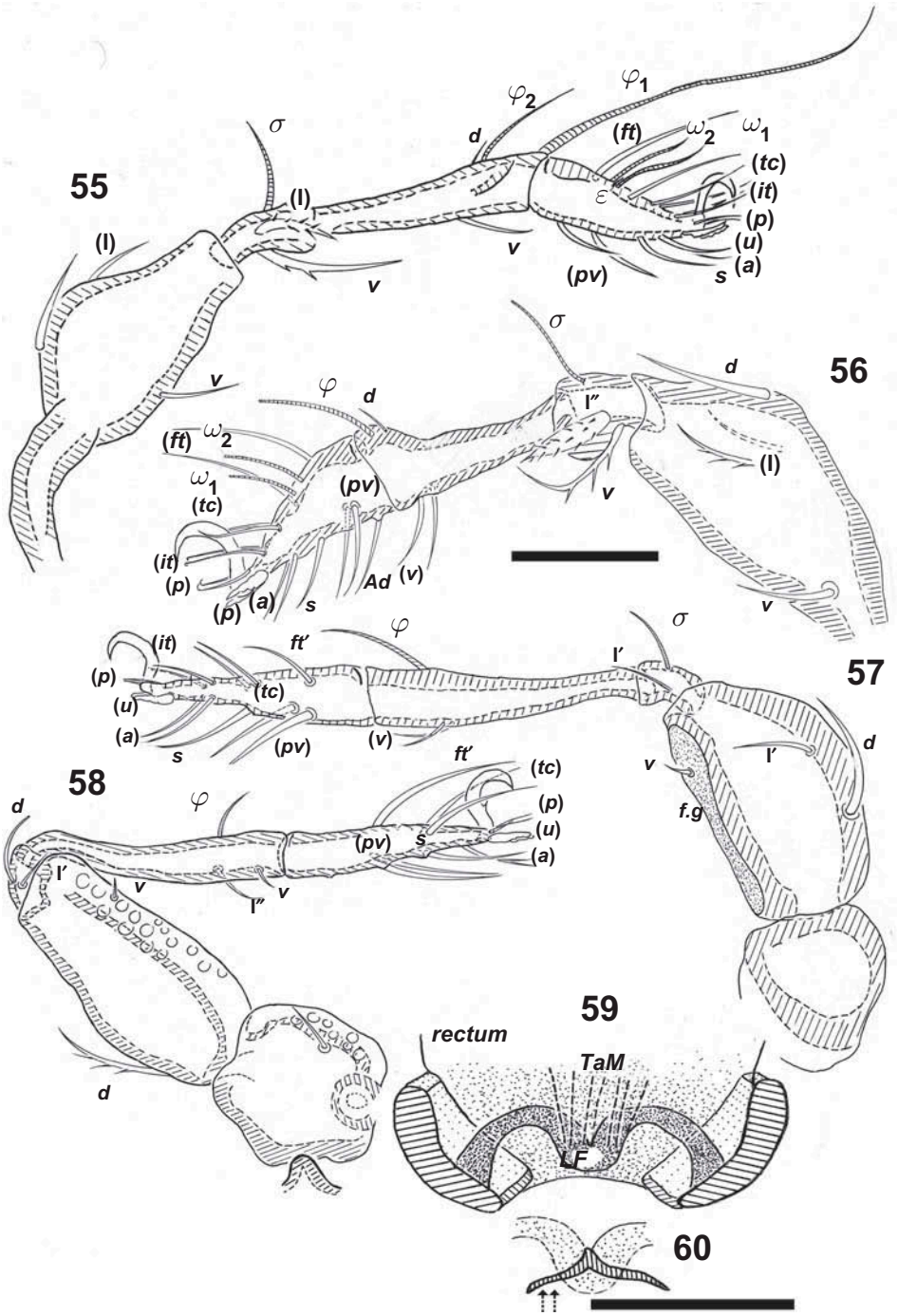
This species presents many interesting aspects:

(a) *Dorsal protuberances*. The central elevated zone of notogaster presents ten protuberances. Setae c_1, c_2, *da, dm, dp, la, lm, lp,* h_1 and h_2 are normally inserted one seta in each protuberance. We found differences in the c_1 and c_2 setal protuberances. The more common disposition is found in Figure 26 and also illustrated in Figure 36. In Figure 38, a slight difference: seta c_1 protuberance is slightly displaced and situated in proximity of c_2 setal protuberance. In Figure 30, interestingly, we observed one specimen with setae c_1 and c_2 in a unique protuberance. In all cases the number of notogastral setae is constant.

(b) *The mentum.* In SEM images, the structure is very particular, with a central elevated area and paired depressed zones (indicated by arrow, Figures 41 and 52). Initially we suspected deformation or contraction of the specimen and prepared several additional specimens for SEM observation. In all cases the depressions were observed. Due to remaining doubts, however, the subcapitulum was studied both in ventral and dorsal view.
In intact specimens, the subcapitulum was difficult to study due to several cuticular thickenings, ornamental structures and internal muscles and tendons hampering observation. Additionally, the small number of specimens at our disposal was a great limitation. Eventually a decision was made to use dissected specimens and to carefully monitor the lactic acid maceration process. Finally we stained specimens macerated for different periods of time with chlorazol black E. In ventral view, we found a lyre-like internal cuticular thickening (indicated double arrow, Figure 37) in the central zone of mentum, delimiting a depressed zone laterally on each side. Seta *h* was inserted in an elevated zone with a thick cuticle, defined

Table 1. Setae and Solenidia.

Legs I	Femur	Genu	Tibia	Tarse	Claw
Seta	*(l); v*	*(l); v*	*d; (l),v*	*(pv); s; (a); (u); (p); (it); (tc); (ft); ε*	1
Solenidia		σ	φ_1; φ_2	ω_1 ; ω_2	
Leg II					
Seta	*d;(l);v*	*l''; v*	*(v); d*	*Ad''; (pv); s; (a); (u); (p); (it); (tc); (ft).*	1
Solenidia		σ	φ	ω_1 ; ω_2	
Leg III					
Seta	*l'; d; v*	*(l)*	*(v)*	*ft''; (tc); (it); (p); (u); (a); s; (pv).*	1
Solenidia		σ	φ	*0*	
Leg IV					
Seta	*d; v*	*d; l*	*l'';v*	*ft'; (tc); (p); (u); (a); s; (pv).*	1
Solenidia		0	φ	0	



Figures 55–60. *Rugocepheus joffrevillei* **sp. nov.**, Legs. **55.** leg I, antiaxial; **56**. leg II, antiaxial **57**. leg III, antiaxial; **58**. Leg IV, antiaxial; **59**. pre-anal organs; **60**. anterior section, preanal organ. Abbreviations: see "Material and methods". Scale bar: 55–58 = 20 μm; 59, 60 = 50 μm.

as a shield. SEM and optical observations correspond. Unfortunately, despite careful observation, our doubts still remain: does a depressed zone really exist, or have preparation and observation techniques depressed a thin cuticular zone? The dorsal subcapitulum exactly resembles that of *Xenillus clypeator* (Grandjean 1957).

(c) *Preanal organ*. Dissected specimens used for subcapitulum studies afforded us the opportunity to observe the preanal organs. We used the staining technique cited above as the structure is uncoloured. The observed structure is double horseshoe-shaped. In *Hydrozetes ringueleti* Fernandez, 1984 (Figure 2F), the *LF* is a simple horseshoe-shaped structure, but both structures appear very similar: in both cases the extremities of the uncoloured structures seem to be tightly attached to the anal plate, and the *taM* and the

muscular insertion are of the same type. The chitinous moustache-like structure situated on the anterior rectal wall is very particular; and not observed anteriorly.

(d) *Protection mechanism. Rugocepheus joffrevillei* presents many differences in leg-shape and other structures involved in leg-folding (pedotecta, supratutorial depression, lamellar ventral border, humeral process, depressions on body surface) but the mechanisms are similar to those in *B. deharvengi* (Fernandez et al. 2013b) and the correlations between the structures involved in the process are perfect.

Comparison

Comparison between *R. formosus* (Mahunka, 2009) and *R. joffrevillei* **sp. nov.** is very difficult. With information recovered from drawings and in the description by Mahunka (2009, pp. 50–52), we can highlight the following differences to permit easy differentiation between the species: general shape differences on prodorsum and notogaster; posterior section of prodorsum shaped differently; pedotecta I, II and discidium very different in shape and extension; number, type and shape of body depressions; presence of anterior genital depression; differences in type of rostral insertion; insertions of lamellar setae different types. Interlamellar seta insertion zones differ between the species. Interlamellar setae: *R. formosus* setiform; *R. joffrevillei* lanceolate.

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