The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus (first part) Machadocepheus leoneae sp. n. and Machadocepheus rachii sp. n. from Gabon

Nestor Fernandez¹₂, Pieter Theron², Christine Rollard³, Sergio Leiva⁴

¹ National Council of Scientific and Technological Research, Argentina (CONICET). Subtropical Biological Institut (IBS). Evolutive Genetic Laboratory FCEQ y N, Misiones National University. Félix de Azara 1552, 6º, (3300) Posadas Misiones Argentina ² Research Unit for Environmental Sciences and Management, North-West University, Potchefstroom Campus, 2520, South Africa ³ Muséum National d’Histoire Naturelle, Département Systématique et Evolution, Unité OSEB, Section Arthropodes, 57 rue Cuvier. 75231, Paris cedex 05. France ⁴ Fellowship, National Institute Agricultural Technology (INTA). Experimental Rural Agency, Aimogasta 5310. La Rioja. Argentina

Corresponding author: Nestor Fernandez (nestorfernand51@yahoo.fr)

Academic editor: V. Pesic | Received 15 September 2014 | Accepted 20 October 2014 | Published @@ @@@@ 2014

Abstract

The genus Machadocepheus, being one of the more complex genera of the Carabodidae family, is briefly outlined to demonstrate this complexity. Descriptions of two new species from Gabon, M. leoneae sp. n. and M. rachii sp. n. are given.

Keywords

Carabodidae, Machadocepheus leoneae sp. n., Machadocepheus rachii sp. n., Gabon
Introduction

This genus was created by Balogh in 1958 (page 20), with type species *Machadoceph-eus excavatus* Balogh, 1958 (page 21), but in very brief text lacking figures. Mahunka (1986) redefined the genus (page 97) and supplied very succinct figures of dorsal, lateral and ventral views (Figures 42, 43, 44); the type species *M. excavatus* was redescribed (page 125) and figures 96 (anterior view) and 97 (bothridium and sensillus) added.

The species *Machadoceph-eus papuanus* Balogh, 1970 (from New Guinea), was instated as the type species of the genus *Guineobodes*, erected by Mahunka, 1987, and is considered by Subías (2004 updated 2014) to be a subgenus of *Pasocepheus* Aoki, 1976, as *Pasocepheus* (Guineobodes) (Mahunka 1987). *Machadoceph-eus manguati* Corpus-Raros, 1979 was designated the type species of *Philippobodes* J & P Balogh, 1992, considered by Subías (2004, updated 2014) as synonym of *Bathocepheus* Aoki, 1978, transferring the species to *Bathocepheus manguati* (Corpus-Raros, 1979).

*Machadoceph-eus foveolatus* Mahunka, 1978, was designated type species of the genus *Mauribodes* J & P. Balogh, 1992, and subsequently *Mauribodes* was considered by Subías (*op.cit*) as synonym of *Diplobodes* (*Kalloia*) Mahunka, 1985, Subías recombined *Mauribodes foveolatus* (Mahunka 1978) as *Diplobodes* (*Kalloia*) *foveolatus* (Mahunka 1978). The genus *Kalloia* was created by Mahunka, 1985, with *K. simpliseta* Mahunka, 1985 as type species, however at present, this species has been recombined as *Machadoceph-eus* (*Kalloia*) *simpliseta* (Mahunka 1985).

*Machadoceph-eus longus* Balogh, 1962 was subsequently designated type species of *Tuberocepheus* Balogh & Mahunka, 1969, while *Machadoceph-eus sagitta* Balogh & Mahunka, 1966 was designated type species of the genus *Sagittabodes* J & P Balogh, 1992.

More recently, Subías (*op.cit.*) divided *Machadoceph-eus* into two subgenera, *Machadoceph-eus* and *Sagittabodes*. The first subgenus with *Machadoceph-eus* (*Machadoceph-eus*) *excavatus* as type and the second with *Machadoceph-eus* (*Sagittabodes*) *sagitta* (Balogh & Mahunka 1966) as type.

With regard to Subías’s recombination of genera and currently accepted classification of *Machadoceph-eus*, the changes were published and necessitate justification. We studied type material in order to, in this paper, accurately establish a series of characters for the genus, and in future papers will discuss other problems in terms of classification, in order to state reasons why the authors agree with some changes and disagree with others.

The genus is also complex in terms of the deposition of the type *Machadoceph-eus excavatus* Balogh, 1958 (see above). Balogh indicated in page 1 of his paper that “Les types des formes nouvelles que je decris ici font partie des collections du Musee royal du “Congo Belge, a Tervuren”, without further indications, but Mahunka 1986 indicated rather confusingly in the text of the redescription (page 125) “Examined types series: Holotype and 62 paratypes. Ang.4370-1: Angola: Riv.Tchimboma, affl. E du Cuango-Muque, galerie forestière des sources. Alto Chicapa, I:VIII.1954. Station, Holotype and 30 paratypes: IRAT, 30 paratypes (1107-PO-55): HNHM, 2 paratypes: MHNG. Other material 1 specimen: Ang.16888: Angola, Environ de Dundo forêt
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

First of all, the type material is not housed at the Museum Tervuren, and Mahunka never differentiated between IRAT and MRAT; MRAT most probably refers to the Museum Royal de Congo Belge, Tervuren, and we suppose that the type material discussed by Balogh in 1958 and possibly that of Mahunka 1986, is housed in the latter.

Other problems with the type deposition include: Mahunka indicated: “Holotype and 62 paratypes (Holotype and 30 paratypes IRAT; 30 paratypes HNHM and 2 paratypes MHNG (total holotype, plus 62 paratypes)”; but in the last part of text indicated 6 paratypes: “Holotype and 2 paratypes MRAT, 3 paratypes HNHM and 1 paratype MHNG”.

Then, two holotypes are referred to, one in 1954 and another 1962, with 68 paratypes, 62 from 1954 and 6 from 1962.

We studied most species cited, except for Machadocepheus manguiati Corpuz-Raros, 1979, which we were unable to obtain, and Machadocepheus longus Balogh, 1964, which was not available on loan from HNHM. We were fortunate to later obtain large quantities of specimens (from Madagascar) in the Betsch Collection of the Museum National d’Histoire Naturelles (MNHN), Paris, France, and were able to conduct observations using both SEM and optical microscopy. The situation Machadocepheus longus Balogh, 1964 will be the subject of a subsequent paper.

This paper, the eighth in the series on the revision of the family Carabodidae will be structured as follows: initial studies of a series of new species, making use of SEM and optical microscopy in order to permit understanding of the structures involved. Thereafter, we aim to study type material where only optical microscopy studies are available (or possible), with the intention of clarifying the taxonomy of Machadocepheus and related genera.

**Material and methods**

Specimens studied by means of optical 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 using a Zeiss Axio Scope (Carl Zeiss Microscopy GmbH, Jena, Germany) compound microscope equipped with a drawing tube.

Specimens were also studied with the aid of Scanning Electron Microscopy (SEM). Specimens preserved in ethanol were carefully rinsed by sucking them into a Pasteur pipette several times, after which they were transferred to buffered glutaraldehyde (2,5 %) in Sörensen phosphate buffer (pH 7,4; 0,1 m) for two hours. After postfixation for two hours in buffered 2% OsO₄ solution and being rinsed in buffer solution; all specimens were dehydrated in a series of graded ethanols 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 & Fernandez 1988).
SEM observations were very complex, due to limited numbers and anatomic particularities shown by specimens. Two different types of SEM were used in order to obtain observations of adequate quality: 1) Tescan Vega II LSU (Tescan Orsay Holdings, Kohoutovice, Czech Republic) (Direction of Collections-SEM-EDS-MNHN) and 2) Hitachi SU3500 (Hitachi High-Technologies Europe, Krefeld, Germany) (Plateau technique de Microscopie Electronique et de Microanalyse (PMEM) (MNHN) using accelerating voltage of 15 Kv and 10 Kv respectively. The critical point apparatus used was an Emitech K 850 (Quorum Technologies Ltd., Ashford, Kent, United Kingdom) and the sputter a Jeol JFC-1200 (Jeol Ltd. Tokyo, Japan) (metalized 80”).

In the legends to Figures, images obtained with Tescan Vega II LSU are indicated with a small number 1 and those obtained with Hitachi SU3500, with a small number 2.

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

Leg chaetotaxy studies executed with the aid of standard, polarized and phase contrast microscopes are provisional, due to the fact that only adult specimens were available for study. Setal formulae of the legs include the number of solenidia (in parentheses); tarsal setal formulae include the famulus (ε).

**Morphological terminology and abbreviations**

Morphological terms and abbreviations used are those developed by F. Grandjean (1928–1974) (cf. Travé & Vachon 1975; Norton & Behan-Pelletier (in Krantz & Walter 2009); Fernandez et al. 2013; Fernandez et al. 2013a, b; Fernandez et al. 2013. For setal types Evans 1992:73; and for ornamentation of cuticular surfaces Murley 1951 (In: Evans op.cit: 9) were used.

**Institutions**

MNHN: Muséum National d’Histoire Naturelle, Paris, France; MNHG: Museum Natural History Geneva; HNHM: Hungarian National History Museum; MRAT: probably Museum Royal d’Afrique Centrale, Tervuren; IRAT: abbreviation unknown.

**New taxa descriptions**

*Machadocepehus leoneae* sp. n.  
http://zoobank.org/  
Figures 1–37

**Etymology.** The specific epithet is dedicated in homage to Mrs. Leone Hudson, our efficient and helpful collaborator who enormously facilitated our work.
Material examined. Holotype and four Paratype females. Holotype ♀ Makokou, northeastern province of Ogoové-Ivindo, 500 m. alt. dense evergreen humid forest, I. 1974, Y. Coineau, deposited in MNHN (Muséum National d’Histoire Naturelle, Paris).

Paratypes. Same data as holotype, 4 ♀ (2 in MNHN; 2 in MNHG). All specimens are preserved in 70% ethanol.

Type locality. Makokou, province of Ogoové-Ivindo, northeastern Gabon; situated at 0°34’0”N, 12°52’0”E. Material used for SEM observations not deposited.

Diagnosis (adult female). Elongate animals; ro, in, notogastral, sub-capitular, epimeral, genital, aggenital, anal, setae, simple; le, lanceolate, barbate. Prodorsum truncate pyramid shape; elevated interlamellar process, divided sagittally by a deep furrow into two promontories; in setae situated anteriorly, directing posteriorly. Deep posterior prodorsal depression. Sensillus uncinate, curving upward; bothridial ring and bothridial tooth present; ro setae curving, directing medially; le setae situated ventrally on lamellar apical zone. Lamellae lacking lamellar tip; lamellar furrow with deeper medial structure; superior cornea of naso convex elevation. Notogaster characteristic: notogastral anterior depression with three anterior transversely aligned parallel cuticular folds; posterior zone with two large cavities, separated by longitudinal ridge, terminating in e, setae, which are positioned on triangular convexity. Elevated medial notogastral zone with three pairs of aligned medial promontories with da, dm, dp setae and lateral semicircular promontories that bear la, lm, lp, h, h, setae. Behind elevated zone, posterior notogastral depression slightly concave; near circumgastric depression, a more or less flat zone with small protuberances present.

Notogastral setae, fifteen pairs (holotrichy unideficient): c, c, c, da, dm, dp setae and lateral semicircular promontories that bear la, lm, lp, h, h, setae. Behind elevated zone, posterior notogastral depression slightly concave; near circumgastric depression, a more or less flat zone with small protuberances present.

Supratutorial depression with three pocket depressions, one internal, another anterior and a third posterior to supratutorial depression. Bothridia cup-shaped with smooth bothridial ring and bothridial tooth. Lyrifissures ih, ips present. Subcapitular setae h on large promontories. Epimere 1 with two promontories; epimere 2, one promontory; epimere 3 two promontories; epimere 4 two promontories. Epimeral chaetotaxy 3-1-3-3; anterior aggenital furrow present. Genital plate small in relation to anal plate; four pairs of genital setae; two pairs of anal setae; aggenital and adanal setae similar in length and shape; lyrifissures iad well discernible between ad, and ad. Several large and small depressions visible on lateral anal plate.

Description. Measurements: SEM: 501 μm (515–424) × 310 μm (327–295) (measurements on four specimens). Light microscopy: 512 μm (519–443) × 318 μm (338–301) (measurements on five specimens).

Shape: Elongate ovoid (Figures 1, 7).

Colour: Specimens without cerotegument, light to dark brown, observed in reflected light.

Cerotegument: Thin layer (0.8–1.7 μm) covering entire body and legs (Figures 15, 32 indicated by ♀), permitting observation only of the more prominent cuticular microsculpture (Figures 13, 25, 32). When removed, detailed microsculpture becomes visible (Figures 16, 32), however complete removal was necessary for optical microscopy.
Figures 1–5. *Machadocephus leoneae* sp. n., adult female. SEM observations. 1 dorsal view (1) 2 anterior zone of prodorsum, dorsal view (1) 3 posterior notogastral zone, dorsal view (1) 4 prodorsum, dorsal view (1) 5 fovea, posterior notogastral zone, dorsal view (2). Abbreviations: see “Material and methods”. Scale bar: 1 = 100 μm; 2 = 30 μm; 3–4 = 50 μm; 5 = 20 μm.
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

Figures 6–8. Machadocepheus leoneae sp. n., adult female. Optical observations. 6 lateral view 7 dorsal view 8 ventral view. Abbreviations: see “Material and methods”. Scale bar: 6–8 = 145 μm.
**Integument.** Two sizes of ornamentations: Small: 0.7–1.7μm: 1) slightly foveate distributed throughout body (except notogastral zone near circumgastric depression s.c) (Figures 2, 13, 15, 17, 18 indicated by †); 2) small protuberances, notogastral zone near s.c (Figures 3, 27, 30 indicated by \(\heartsuit\)). Large: 5–10 μm. Foveate, two types: 1) simple rounded fovea, situated in the elevated zone of notogaster (Figures 1, 3, 5, 9, 27, 30, 31, 32 indicated by †); 2) polyhedral fovea (distributed side by side), situated on prodorsum, lateral notogastral zone, and near la setae (Figures 4, 9, 10, 13, 25, 28 indicated by ↓).

**Setation.** Setae ro, in, notogastral, sub-capitular, epimeral, genital, aggenital, adanal, anal: simple (Figures 4, 6, 7, 14, 17, 18, 19, 20, 21, 23, 24, 25, 28, 32); le, lanceolate, barbate (Figure 16, 21, 25).

**Prodorsum.** Shape: Truncate pyramid (Figure 6, 9, 10); truncate triangle in dorsal view (Figure 1, 4, 7); truncate inverted triangle in frontal view (Figures 19, 28).

Large elevated interlamellar process (e.i.p) (Figures 6, 9, 10,12), large deep furrow dividing e.i.p sagittally into two promontories (Figures 6, 9, 10, 19, 27, 28, indicated by †). Posterior prodorsal zone (p.p.d) deeply depressed (Figures 1, 7, 9, 10, 27, 29); depression continuous with notogastral anterior depression (n.a.d); dorsojejugal furrow (d.sj) (Figures 1, 7, 9, 10, 29) evidently separating p.p.d and n.a.d. Three pairs of setae; size in \(\geq\)le>ro (Figures 6, 19, 21). Sensillus uncinate, curving upward (Figure 13), bothridial ring (bo.ri) and bothridial tooth (bo.to) present.

Setae ro inserted slightly anteriorly or at level of le insertion (Figures 19, 21); curving, directing internally; apical tips not touching each other (Figures 2, 4); in setae inserted on anterior zone of e.i.p promontories, curving, directing backward, paraxial to medial plane; inserted slightly externally to ro insertion level (Figures1, 4, 6, 7, 10, 19, 28); le setae situated ventrally on lamellar apical zone (Figures 6, 16, 19, 21, 25, 26).

Rostral margin slightly rectangular to hexagonal (Figures 19, 28). Lamellae run dorso laterally, without lamellar tips (Figures 16, 21, 25, 26); le setae inserted ventrally (Figure 25); inner paraxial margin of lamellae demarcated by large deep furrow (l.l.f) (Figures 9, 10,12, 19, 28). In frontal view (Figures 19, 28) l.l.f showing deeper medial zone. The superior cornea of naso (cso) clearly visible as convex elevation situated at more or less same level as ro setal insertion (Figures 19, 25).

**Notogaster.** Shape: in dorsal view anterior part rectangular and posterior part oval (Figures 1, 7); in lateral view, anterior part clearly concave in medial zone and rectilinear exteriorly, rest convex with irregular promontories (Figures 6, 9, 10, 11, 12); d.sj narrow, rectilinear, well delimited (Figures 1, 7, 9); notogastral anterior depression (n.a.d) ovoid and conspicuous. Fifteen pairs (holotrichous, unideficient) of notogastral setae; c₁, c₂, c₃, da, dm, dp, la, lm, tp, h₁, h₂, h₃, p₁, p₂, p₃.

The notogaster has: anterior depression (n.a.d) occupying anterior notogastral zone; elevated zone situated in medial to posterior part of notogaster; posterior to elevated zone, slightly concave notogastral posterior depression (n.p.d) (Figures 1, 6, 7, 9, 27, 11), terminating in more or less flat slightly inclined zone with small protuberances (Figure 3 indicated by \(\heartsuit\)); Circumgastric depression (s.c) present anterior to zone of small protuberances (Figures 7, 9, 27).
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

Figures 9–10. *Machadocepheus leoneae* sp. n., adult female. SEM observations. 9 dorsal inclined view (2) 10 dorsal anteroposterior view (1). Abbreviations: see “Material and methods”. Scale bars: 9 = 200 μm; 10 = 100 μm.
Figures 11–12. Machadocephus leoneae sp. n., adult female. SEM observations. 11 lateral view 12 inclined lateral view. Abbreviations: see "Material and methods". Scale bar: 11 = 100 μm; 12 = 200 μm.

Complex n.a.d, three transversally aligned parallel cuticular folds situated posterior to d.sj (Figures 1, 7, 10 indicated by •). In posterior zone, two large concavities, separated by longitudinal ridge (Figures 1, 7, 9, 10, 14 indicated by ††). Ridge terminating in triangular shape, situated near first pair of protuberances on elevated zone bearing da setae. Triangular zone of cord termination bearing c₁ setae (Figures 1, 7, 10, 14).
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...  

Figures 13–18. Machadocepheus leoneae sp. n., adult female. SEM observations. 13 bothridium and sensillus, lateral view (1) 14 posterior zone of notogastral anterior depression (2) 15 promontories with and without cerotegmental layer (2) 16 lamellae anterior zone, lateral view (2) 17 promontories with dorso-central setae (1) 18 lateral promontories with lm, lp, setae (1). Abbreviations: see “Material and methods”. Scale bar: 13–14 = 20 μm; 15–16 = 10 μm; 17–18 = 30 μm.

Elevated zone presenting a series of aligned medial promontories (three pairs, variably developed) bearing setae da, dm, dp; and lateral semi-circular promontories bearing setae la, lm, lp, h₁, h₂. Setae c₃ situated on humeral apophysis (h.ap), c₂ laterally
Figures 19–21. Machadocephus leoneae sp. n., adult female. Optical observations. 19 frontal view 20 Promontories, lateral view 21 prodorsum anterior zone, lateral view. Abbreviations: see “Material and methods”. Scale bar: 19–21 = 100 μm.

situated near h.ap, but in the depression on n.a.d (Figures 1, 7, 9, 10, 27, 32). Four pairs of setae, h_3, p_1, p_2, p_3 situated marginally.

Humeral apophysis (h.ap) very long, clearly visible as a pronounced projection, giving characteristic shape to anterior zone of notogaster (Figures 6, 9, 10, 11, 12).

**Lateral region** (Figures 6, 9, 10, 11, 12). Lamellae (lam) easily discernible, large, without sharp la.ti, and with rounded elevated zone at level of le insertion (Figure 16, 21).

Tutorium (tu): rod-like curving ridge, clearly visible (Figures 11, 12). Between lamellae and tutorium, deep supratutorial depression (s.tu.d) running parallel to both structures; pocket depression (a.tu.d) anteriorly and posterior pocket depression (p.tu.d) present; small depressions posterior to p.tu.d as well as others situated on the interior of s.tu.d (Figure 21 indicated by ✐).

Bothridia cup-shaped with smooth bothridial ring (bo.ri); bo.ri incomplete, with bothridial tooth (bo.to) clearly discernible (Figures, 6, 9, 10, 11, 12, 13). Sensillus uncinate, arching apex (Figure 13). Pedotectum I: prominent extended lamina covering first acetabulum, rounded apex. Pedotectum II: small ovoid lamina (Figures 6, 9). Humeral apophysis (h.ap) long, extended structure, rounded apex, basally curved; anterior tip overlapping posterior of bothridium (Figures 11, 12 ).
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

Notogastral promontories bearing setae clearly discernible (Figures 11, 12, 17, 18); promontories show several internal layers as in Figure 20.

Only lyrifissures *ib* and *ips* clearly visible. Discidium easily discernible as triangular structure with rounded apex. Several large depressions (*dep*) clearly discernible behind acetabulum IV (Figures 6, 9).

Figures 22–26. *Machadocepheus leoneae* sp. n., adult female. Optical observations. 22 ventral view (2) 23 anal plate (1) 24 genital plate (1) 25 aspis frontal view (2) 26 infracapitulum and surrounding zone (1). Abbreviations: see “Material and methods”. Scale bar: 22 = 200 μm; 23–26 = 20 μm.
Figures 27–32. Machadocepehus leoneae sp. n., adult female. Optical observations. 27 posterior general view (1) 28 frontal view (1) 29 prodorsum and anterior notogastral zone, posterior view (2) 30 notogastral posterior view (2) 31 notogastral ornamentation, rounded fovea (2) 32 promontories with dm, dp setae (1). Abbreviations: see “Material and methods”. Scale bar: 27–29 = 100 μm; 28–32 = 50 μm.

Ventral region. Infracapitulum with setae h, m, a clearly visible; setae h situated on large promontories (Figure 29). Epimere slightly elevated, delimited by shallow furrow (bo.1, bo.2, bo.sj). Epimere1 with two well delimited promontories, bearing setae
1a, 1b; epimere 2 only one promontory, bearing setae 2a; epimere 3 with two promontories, bearing setae 3a and 3b; epimere 4 bearing two promontories with setae 4a and 4b (Sidorchuk & Norton 2010). Apodemes (apo.1, apo.2, apo.3 and apo.4) clearly discernible (Figures 8, 22). Epimeral chaetotaxy 3-1-3-3; Pd I, Pd II and dis easily discernible; aggenital furrow a.g.f clearly visible, situated anteriorly to genital plate. Genital plate small relative to anal plate (Figure 22); four pairs of long genital setae (Figure 24); anal plate with two pairs of setae; one pair situated anteriorly and the other posteriorly, both setae small, but well discernible; plate terminating in small sharp tip (Figure 23). Aggenital and adanal setae similar, long, simple; ag and ad3, situated on promontory; ad2, ad1, situated laterally at level of posterior tip of anal plate (Figure 8, 22). Lyrifissures iad clearly discernible, situated laterally between ad3 and ad2 outside dep Laterally to anal plate and marginally to ventral shield, several large and small depressions (Figures 8, 22).

**Posterior view.** This view is very important, permitting clarification of several interesting aspects such as: a) the cuticular microsculpture and the n. p.d (Figure 27); b) the p.p.d and its relation to the n.a.d, as well as the related position of d.sj. (Figure 29); c) the relative positions of e.i.p and p.p.d (Figure 27); d) related position of central and lateral notogastral promontories (Figures 27, 30); e) disposition of s.c (Figure 27) and f) shape and distribution of setae and promontories (Figure 32).

**Legs** (Figures 33-37). All legs monodactyle. Setal formulae I (1-4-3-4-15-1) (1-2-2); II (1-4-3-3-16-1) (1-1-2); III (2-3-1-2-15-1) (1-1-0); IV (1-2-1-2-12-1) (0-1-0). Figure 36 showing shape of anterior setae, tarsus II. Observation of the shape of especially (u), (p), difficult in optical observations. Setae fi absent from tarsus I, but present on tarsus II in all specimens studied.

Tibia I: solenidion φi on small apophysis; tibia I, II, setae d present, situated near solenidion. Femur IV presenting a conspicuous ventral carina.

**Machadocepheus rachii sp. n.**
http://zoobank.org/
Figures 38–72

**Etymology.** The specific epithet is dedicated in homage to Mr Rachid Kebir of Muséum National d’Histoire Naturelles, Paris, who assisted us with great kindness and friendship on many occasions over the past 20 years.

**Material examined.** Holotype and four Paratype females. Makokou, northeastern province of Ogoové-Ivindo, 500 m. alt.dense evergreen humid forest, I.1974, Y. Coineau, deposited in MNHN. Paratypes. Same data as holotype, 4 ♀ (2 in MNHN; 2 in MNHNG). All specimens preserved in 70 % ethanol. Type locality. Makokou, province of Ogoové-Ivindo, northeastern Gabon; situated at 0°34’0”N, 12°52’0”E. Material used for SEM observations not deposited.

**Diagnosis adult female.** Thin cerotegumental layer covering entire body, giving the impression of a smooth surface. Setae ro, in, notogastral, sub-capitular, epimeral, genital, aggenital, adanal, anal, simple sharply tipped; le lanceolate, barbate.
Polyhedral prodorsum; interlamellae process elevated, divided sagittally by large deep furrow; in setae situated anteriorly, directing posteriorly. Conspicuous deep posterior prodorsal depression present. Bothridium cup-shaped; bothridial ring and bothridial tooth present. Sensillus uncinate, upturned; le setae situated ventrally on apical zone of lamellae. Lamellae running dorsilaterally, lacking lamellar tip; large, deep, shallow lamellar furrow demarcating paraxial lamellar margin. Superior cornea of naso clearly visible as convex elevation situated anterior to insertion level of ro setae.

Anterior part of notogaster rectangular; posterior part oval with some irregularities and less conspicuous promontories, dorsosejugal furrow narrow, rectilinear, hardly discernible. Fifteen pairs of notogastral setae (holotrichy unideficient), c_p, c_q, c_r, da, dm, dp, la, lm, lp, h_1, h_2, h_3, p_1, p_2, p_3. Notogaster presenting: notogastral anterior depression; elevated zone; slightly concave posterior depression. Notogastral anterior depression simple, with transversally aligned parallel cuticular folds. Elevated zone with three pairs of poorly developed promontories that bear da, dm, dp setae; and lateral semicircular, poorly developed promontories, that bear la, lm, lp, h_1, h_2 setae. Humeral apophysis long, clearly visible.

Tutorium: rod-like curving cuticular thickening; supratutorial depression present; along with three pocket-shaped depressions, one anterior tutorial depression, one posterior tutorial depression and a small depression situated internally to supratutorial depression. Pedotecta I, prominent extended lamina, rounded apex; Pedotecta II small, ovoid lamina. Lyrifissures ih, ips clearly visible. Discidium: polyhedral structure with rounded apex. Depressions behind acetabulum IV; one of them elongated, concealing tarsus during folding legs process. Series of aligned depressions in medial zone. Epimeral chaetotaxy 3–1–3–3; anterior genital furrow clearly visible; four pairs of long genital setae; two pairs of small anal setae; anal plate terminating in small sharp tip; aggenital and adanal setae similar length; lyrifissures iad not discernible.

**Measurements:** Light microscopy: 421 μm (396–426) × 262 μm (238–268) (on six specimens). SEM microscopy: 416 μm (398–416) × 176 μm (173–181) (on six specimens, not deposited).

**Shape:** Ovoid (Figures 38, 41).

**Colour:** Specimens without cerotegument, light to dark brown, when observed in reflected light.

**Cerotegument:** Thin layer 1.5 μm (1.3–2.5) covering the entire body and legs (Figures 38, 41, 42, 44, 47, 48, 49 indicated by †, 52, 53, 56, 57, 58, 59, 63), permitting observation of only large cuticular microsculptures (Figures 44, 46, 48, 53, 58, 59, 62), giving the impression of a smooth surface. Complete removal was necessary for optical microscopy, once removed, detailed microsculpture became visible (Figure 63).

**Integument.** Two sizes of ornamentations: Small 1.2–3.5 μm, 1) small ovoid to irregular protuberances, distributed throughout prodorsum and notogaster (except notogastral zone near s.c) (Figure 49) 2) irregular elongate protuberances, notogastral zone near s.c (Figures 41, 58, 61 indicated by ♦). Large 7.2–7.9 μm, two types: 1) simple rounded fovea (Figure 63), situated on posterior part of elevated zone of notogaster (Figures 41, 58, 59, 62 indicated by ♦); 2) polyhedral fovea (distributed side by
Figures 33–37. Machadocepehus leoneae sp. n., adult female. Optical observations. 33 leg I antiaxial view 34 leg IV antiaxial view 35 leg II antiaxial view 36 apical zone, leg II(1) 37 leg III, antiaxial view. Abbreviations: see “Material and methods”. Scale bars: 35–37 = 50 μm; 36 = 10μm.

Description. Setation. Setae ro, in, notogastral, subcapitular, epimeral, genital, aggenital, adanal, anal: simple, sharply tipped (Figure 60) (Figures 38, 39, 40, 42, 44, 48, 52, 53, 57, 58, 59, 61); le lanceolate, barbate (Figures 44, 55, 56).

Prodorsum. Polyhedral (dorsal view) (Figures 38, 41); triangular (lateral view) with strong obliquely decreasing anterior part (Figures 40, 46, 47). Interlamellar process
Figures 38–40. Machadocephas rachii sp. n., adult female. Optical observations. 38 dorsal view 39 ventral view 40 lateral view. Abbreviations: see “Material and methods”. Scale bar: 38–40 = 90 μm.
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

Figures 41–45. Machadocepheus rachii sp. n., adult female. SEM observations. 41 dorsal view (2) prodorsum, frontal view (1) 43 gnathosoma, frontal view (1) 44 aspis, frontal view (1) 45 sensillus (1). Abbreviations: see “Material and methods”. Scale bar: 41 = 100 μm; 42 = 50 μm; 43–44 = 20 μm; 45 = 10 μm.

(e.i.p) elevated (Figures 40, 46, 47), divided sagittally into two promontories by large deep furrow (Figures 41, 42, 47, 58 indicated by △), in setae situated anteriorly and directing posteriorly (Figures 42). Conspicuously depressed posterior prodorsal zone (p.p.d) (Figures 38, 41, 47, 58). Three pairs of setae; sizes in>le>ro. Ro setae clearly
Figures 46–47. *Machadoceps rachii* sp. n., adult female. SEM observations. 46 lateral view (2) 47 inclined lateral view (1). Abbreviations: see “Material and methods”. Scale bar: 46–47 = 100 μm.

visible in frontal view (Figures 42, 44), situated in medial zone, inserted posterior to insertion level of *le*; rounded structure between *ro* setae, probably vestigial superior cornea of naso *cs* (Figures 42, 44); *bo* cup-shaped, *bo.ri* smooth; bothdial tooth present (Figures 46, 51). *Si* uncinate, upturned (Figures 46, 51); *le* setae situated ventrally on apical zone of lamellae (Figures 42, 44, 56).
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

Figures 48–53. Machadocepheus rachii sp. n., adult female. SEM observations. 48 elevated notogastral zone (1) 49 tegument (1) 50 palp (1) 51 bothridia (1) 52 promontory with da setae (1) 53 elevated lateral notogastral zone (1). Abbreviations: see “Material and methods”. Scale bar: 48 = 40 μm; 49, 51 = 5 μm; 50, 52 = 10 μm; 52; 53 = 50 μm.

Rostral margin slightly rectangular to hexagonal (Figures 42, 44). Lamellae running dorso laterally, lacking lamellar tip (Figures 42, 44, 56); large deep furrow (l.l.f) demarcating inner paraxial margin of lamellae (Figures 41, 42, 47). In frontal view (Figure 42), l.l.f showing a deeper medial zone. The superior cornea of naso (cso) clearly visible as convex elevation situated anterior to ro setal insertion level (Figures 42, 44).
Figures 54–57. *Machadocepheus rachii* sp. n., adult female. SEM observations. 54 ventral view (2) 55 subcapitulum, ventral view (1); 56 genito-anal zone (1) 57 lamellar tip (2). Abbreviations: see “Material and methods”. Scale bar: 54 = 100 μm; 55, 56 = 20 μm; 57 = 50 μm.

**Notogaster.** Shape: dorsal view, anterior part rectangular and posterior part oval (Figures 38, 41, 58); in lateral view, anterior part rectilinear, with clearly concave medial zone and rectilinear exteriorly, rest triangular to polyhedral with some irregularities and unremarkable promontories (Figures 40, 46, 47, 48, 53); *d.sj* narrow, rectilinear,
hardly discernible (Figures 41, 47); notogastral anterior depression (n.a.d), ovoid and conspicuous.

Fifteen pairs (holotrichy unideficient) of notogastral setae: $c_1$, $e_2$, $c_3$, da, dm, dp, la, lm, lp, $h_1$, $h_2$, $h_3$, $p_1$, p2, p3.
Figures 64–72. *Machadoceps rachii* sp. n., adult female. SEM observations. 64 leg II, antiaxial view (1) 65 solenidion $\varphi$ and dorsal setae of Tibia II (1) 66 solenidion $\sigma$ and dorsal setae of genu II (1) 67 leg I, antiaxial view (1) 68 solenidion $\varphi_1$ and dorsal setae of Tibia II (1) 69 leg IV, antiaxial view (1) 70 leg III antiaxial view (1) 71 femoral groove, femur leg III (2) 72 apical zone, tarsus III (1). Abbreviations: see “Material and methods”. Scale bars: 64, 67, 69, 70 = 50 $\mu$m; 65, 66, 71 = 10 $\mu$m; 68 = 20 $\mu$m, 72 = 2 $\mu$m.
Notogaster presenting: 1) *n.a.d* occupying anterior notogastral zone; 2) elevated zone situated in posterior third of notogaster; 3) slightly concave *n.p.d* situated posterior to elevated zone (Figures 41, 46, 47, 48); 4) slightly inclined more or less flat zone situated behind *s.c* with irregularly elongated protuberances (Figures 41, 58, 61 indicated by ‡); circumgastric depression (*s.c*) hardly discernible (Figures 53, 58, 61).

Simple *n.a.d* (Figures 38, 41, 47) with many hardly discernible transversally aligned parallel cuticular folds situated posterior to *d.sj* (Figures 47, 58, 59, 62 indicated by ●). Elevated zone presenting series of aligned flat medial promontories (three pairs, poorly developed) bearing setae *da, dm, dp* and lateral poorly developed semicircular promontories, bearing setae *la, lm, lp, h₁, h₂*.

Humeral apophysis (*h.ap*) very long, clearly visible (Figures 38, 41) but best observed in lateral view (Figures 46, 47).

**Lateral region** (Figures 40, 46, 47, 48). Palp clearly discernible (Figure 50), *sul₂ (ulk₂), acm₂*; solenidium ω very long, extending to level of eupathidia. Cheliceral setae *cbb* clearly visible (Figure 50).

Lamellae (*lam*) easily discernible, large, lacking sharp *la.ti*, with elevated zone at *le* insertion level (Figure 40, 46, 47, 56).

Tutorium (*tu*): rod-like curving ridge; *s.tu.d* a deep depression running between lamellae and tutorium; pocket depressions *a.tu.d, p.tu.d* present; another small depression situated internally to *s.tu.d* (Figure 40 indicated by ‡).

Bothridia cup-shaped, *bo.ri* incomplete, *bo.to* present, clearly discernible (Figures, 46, 47, 51). Sensillus uncinate, arched, curving upward (Figure 45, 46, 47). Pd I: prominent extended lamina, rounded apex; Pd II: small ovoid lamina (Figures 40, 46, 47); *h.ap* long extending structure, rounded apex, basally curved; anterior tip overlapping posterior bothridial posterior part (Figures 40, 46, 47).

Notogastral promontories and setae very clearly discernible (Figures 47, 52, 53).

Only lyrifissures *ih* and *ips* clearly visible. Discidium easily discernible as polyhedral structure with rounded apex. Several depressions (*dep*) clearly discernible behind acetabulum IV; one of them elongated, concealing the tarsus during leg folding process (Figure 40).

**Ventral region.** Infracapitulum with setae *h, m, a* clearly visible (Figures 39, 55). Epimeres slightly elevated, delimited by shallow furrow (*bo.1, bo.2, bo.sj*). In medial zone a series of aligned depressions (Figure 54 indicated by †); Apodemes (*apo.1, apo.2, apo.sj, apo.3*) well discernible (Figures 39). Epimeral chaetotaxy 3–1–3–3; *Pd I, Pd II* and *dis* well discernible; *a.g.f* clearly visible, situated anteriorly to genital plate (Figures 39, 54). Genital plate small relative to anal plate (Figures 54, 57); four pairs of long genital setae (Figure 57); anal plate with two pairs of small but clearly discernible setae; plate terminating in small sharp tip (Figure 57, indicated by †); *ag* and *ad₃* equal in length; *ad₂* and *ad₁* situated laterally at level of posterior end of anal plate (Figure 57). Lyrifissure *iad* not discernible. Particular depression behind acetabulum IV (Figure 39 indicated by ▲). Several large depressions laterally to anal and genital plates and marginally to ventral shield (Figures 39, 54, 57).
**Posterior view.** This view permits clarification of several aspects such as: a) shape of the e.i.p and large depression in the anterior medial zone (Figure 58 indicated by ↓); b) shape and depth of p.p.d (Figure 58); c) shape and disposition of d.sj (Figure 58, 62 indicated by ↓); d) disposition of the transversal cuticular folds situated behind d.sj (Figures 58, 59, 62, indicated by ◆); e) disposition, shape and distribution of setae and cuticular ornamentations on elevated notogastral zone (Figures 58, 59, 62). f) disposition of sc and the zone with irregularly elongated protuberances (Figures 58, 61 indicated by ◇).

**Legs** (Figures 64-72). All legs monodactyle. Setal formulae I (1-4-2-4-16-1) (1-2-2) (Figure 67); II (1-4-3-2-15-1) (1-1-2) (Figure 64) III (2-3-1-2-13-1) (1-1-0) (Figure 70); IV (1-2-2-2-12-1) (0-1-0) (Figure 69).

Seta d of tibia I associated with φ₂ (Figure 68). Setae d on tibia II small (Figure 65), situated behind φ, not associated with solenidion; setae d, genu II (Figure 66), large, situated behind and associated with σ. Femur III with femoral groove f.g, difficult to observe in antiaxial view (Figure 70), but well developed, containing seta v (Figure 71); disposition of setae on tarsus III: (u), s, (a) (Figure 72) particular s situated anterior to (a). Femur IV presenting a conspicuous ventral carina (Figure 69).

**Discussion**

Intricate structural shapes and the need to observe specimens from various angles and positions made many structures difficult to understand when only using optical observation. Comparing these species with others from the same genus was greatly complicated by very short and superficial original descriptions, and some errors were detected in descriptions of various species of the genus Machadocepheus as well as in related genera (Bathocepheus, see: Fernandez et al 2013; Tuberocepheus see: Fernandez et al 2014). Much care had to be taken not to create any further confusion in the genus Machadocepheus and related genera, and for the reasons cited above we deemed it necessary to continue our study of a number of related genera in a series, discussed in future papers, to try to understand the existing problems.

**Acknowledgements**

Our gratitude to the reviewers of the manuscript for valuable comments towards improving this paper.

This work is based on research supported in part by the National Research Foundation of South Africa (UID) 85288. Any opinion, findings and conclusions or recommendations expressed in the material are those of the authors and therefore the NRF does not accept any liability in regard thereto.
The family Carabodidae (Acari, Oribatida) VIII. The genus Machadocepheus...

References

Alberti G, Fernandez N (1988) Fine structure of a secondarily developed eye in the fresh water moss mite, *Hydrozetes lemnae* (Coggi, 1899) (Acari: Oribatida). Protoplasma 146: 106–117. doi: 10.1007/BF01405919

Aoki J (1958) Eine neue Gattung von Carabodidae aus der Insel Hachijo, Japan (Acarina: Oribatei). (jap.) Zoological Magazine (Dobutsugaku Zasshi) 67(12): 28–30.

Aoki J (1976) Oribatid mites from the IBP study area, Pasoh Forest Reserve, West Malaysia. Nature and Life in Southeast Asia. 7: 39–59.

Aoki J- (1978) New carabodid mites (Acari: Oribatei) from the Bonin Islands. Memoirs National Science Museum, Tokyo. 11: 81–89.

Balogh J (1958) Oribatides nouvelles de l’Afrique tropicale. Revue de Zoologie et Botanique Africaine 58(1–2): 1–34.

Balogh J (1962) Recherches sur la faune endogée de Madagascar.VII.Oribates (Acariens) Nouveaux. II. Naturaliste malgache 13: 121–151.

Balogh J (1970) New oribatids (Acari) from New Guinea II. Acta Zoologica Academiae Scientiarum Hungaricae 16(3–4): 291–344.

Balogh J, Balogh P (1992) The Oribatid mites Genera of the World Hungarian natural History Museum: 131 pp.

Balogh J Mahunka S (1966) New oribatids (Acari) from South Africa. Acta Zoologica Academiae Scientiarum Hungarica 12(1–2): 1–23.

Balogh, J Mahunka S (1969) The scientific Results of the Hungarina Soil Zoological Expedition to South America.10 Acari: Oribatids collected by the Second Expedition. I. Acta Zoologica Hungarica 15(1–2): 1–21.

Coineau Y (1974) Eléments pour une monographie morphologique, écologique et biologique des Caeculidae (Acariens). Mémoires du Muséum National d’Histoire Naturelle, 22 Zool. 81: 1–299 pp.

Corpuz-Raros LA (1979) Philippine Oribatei (Acarina). I. Preliminary list of species and descriptions of forty new species. Philippine Agriculturist 62: 1–82.

Evans GO (1992) Principles of Acarology. C.A.B International, Cambridge. 563 pp.

Fernandez N, Travé J (1984) La variabilité chaetotaxique et la néotrichie gastronotique des Hydrozetidae (Oribates). Acarologia 25(4): 407–417.

Fernandez N, Theron P, Rollard C (2013) The family Carabodidae (Acari: Oribatida) I. Description of a new genus, *Bovicarabodes* with three new species, and the redescription of *Hardybodes mirabilis* Balogh, 1970. International Journal of Acarology 39(1): 26–57. doi: 10.1080/01647954.2012.741144

Fernandez N, Theron P, Rollard C, Leiva S (2013a) Revision of the family Carabodidae (Acari: Oribatida) III. Redefinition of *Meriocepheus peregrinus* Aoki, 1973; *Bathocepheus concavus* Aoki, 1978; and *Opisthocepheus kirai* Aoki, 1976, International Journal of Acarology 39(4): 327–340. doi: 10.1080/01647954.2013.781675

Fernandez N, Theron P, Rollard C, Leiva S (2013b) The family Carabodidae (Acari: Oribatida) V. The genus *Congocepheus* (first part), with redescriptions of *Congocepheus heterotrichus* Balogh...
1958, *Congocepheus orientalis* Mahunka 1987 and *Congocepheus hauseri* Mahunka 1989. International Journal Acarology 39(8): 600–614. doi: 10.1080/01647954.2013.858771

Fernandez N, Theron P, Rollard C, Tiedt L (2013) Family Carabodidae (Acari: Oribatida) V. The genus *Congocepheus* Balogh, 1958 (second part), with a redescription of *Congocepheus involutus* Mahunka, 1997, and descriptions of two new species. Zoosystema 35(4): 551–579. doi: 10.5252/z2013n4a8

Fernandez N, Theron P, Rollard C, Tiedt L (2014) Revision of the family Carabodidae (Acari: Oribatida) VI. *Mangabebodes kymatismosi* gen. n., sp. nov and *Antongilibodes paulae* gen. n., sp. n., (Acari: Oribatida; Carabodidae) from Madagascar. International Journal Acarology 40(4): 296–319. doi: 10.1080/01647954.2014.914972

Grandjean F (1949) Observation et conservation des très petits Arthropodes. Bulletin du Muséum d’Histoire Naturelle, Paris. 21(2): 363–370.

Grandjean F (1965) Complément de mon travail de 1953 sur la classification des Oribates. Acarologia 7(4): 713–734.

Krantz GW, Walter DE (2009) *A Manual of Acarology*. 3rd ed. Texas Tech. University Press, Lubbock. 807 pp.

Mahunka S (1978) Neue und interessante Milben aus dem Genfer Museum XXXIV. A compendium of the Oribatid Acari fauna of Mauritius, Reunion and Seychelles Is. II. Revue Suisse Zoologie 85(2): 307–340.

Mahunka S (1985) Mites (Acari) from St. Lucia (Antilles). 2.Oribatida. Acta Zoologica Hungarica 31(1–3): 119–179.

Mahunka S (1986) A survey of the family Carabodidae, C.L. Koch, 1836 (Acari: Oribatida). Acta Zoologica Hungarica 32(1–2): 73–135.

Mahunka S (1986) Oribatids from Africa (Acari:Oribatida) III. Folia Entomologica Hungarica 47(1–2): 41–76.

Mahunka (1987) A survey of the family Carabodidae C.L.Koch 1836 (Acari: Oribatida) II. Acta Zoologica Hungarica 33(3–4): 399–434.

Norton RA, Behan-Pelletier VM (2009) Oribatida. In: Krantz GW & Walter DE (Eds), *A Manual of Acarology*. 3rd ed. Texas Tech University Press, Lubbock, Texas, pp. 430–564. doi: 10.1007/s10493-010-9408-2

Sidorchuk EA, Norton RA (2010) Redescription of the fossil oribatid mite *Scutoribates perornatus*, with implications for systematics of Unduloribatidae (Acari: Oribatida). Zootaxa, 2666: 45–67.

Subías LS (2004) (Database updated 2014) Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes, Oribatida) de mundo (excepto fósiles). Graellsia 60: 3–305. [cited 2013 May]. http://www.ucm.es/info/zoo/Artropodos/Catalogo.pdf

Travé J, Vachon M (1975) François Grandjean 1882–1975 (notice biographique et bibliographique). Acarologia 17(1): 1–19.