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Two new species of *Cavernocepheus* (Acari, Oribatida, Otocephaeidae) from Malawi

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Original research

**ABSTRACT**

The oribatid mite genus *Cavernocepheus* (Oribatida, Otocephaeidae) is recorded for the first time in Malawi. Two new species of the subgenus *Cavernocepheus* (*Paracavernocepheus*) — *C. (P.) hlavaci* n. sp. and *C. (P.) mulanjensis* n. sp. — are described from forest litter. Morphological comparison between known species of *Cavernocepheus* (*Paracavernocepheus*) and their distribution are presented.

**Keywords** otocephaeid mites; taxonomy; new species; morphology; distribution; Afrotropical region

**Zoobank** [http://zoobank.org/A717BB51-A40A-4336-A048-5310E5FC9614](http://zoobank.org/A717BB51-A40A-4336-A048-5310E5FC9614)

**Introduction**

The oribatid mite genus *Cavernocepheus* (Acari, Oribatida, Otocephaeidae) was proposed by Balogh and Mahunka, 1969 with *Cavernocepheus monstruosus* Balogh and Mahunka, 1969 as type species. At present, the genus comprises two subgenera and nine species (*Cavernocepheus* (*Paracavernocepheus*)) Balogh and Mahunka, 1969 — seven species; *C. (Paracavernocepheus)* Ermilov and Starý, 2018 — two species), which are distributed in the Afrotropical (*C. (Paracavernocepheus)*) and Neotropical (*C. (Cavernocepheus)*) regions (Subías 2004, updated 2021). The revised generic and subgeneric diagnoses and an identification key to known species of the genus were presented by Ermilov and Starý (2018).

Among the oribatid mite materials (all specimens were kindly provided by the Moravian Museum, Brno, Czech Republic) collected from Malawi, we found two new species of *C. (Paracavernocepheus)*. They are the first representatives of the genus recorded in this country. The main goal of the paper is to describe these two new species. Additionally, the morphological comparison between the known (four) species of the subgenus and their distribution are given.

**Methods**

**Observation and documentation** — Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the notogaster. Notogastral width refers to the maximum width of the notogaster in dorsal view. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter-femur-genu-tibia-tarsus (famulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu-tibia-tarsus. Drawings were made with a camera lucida using a Leica transmission light microscope “Leica DM 2500”.

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Terminology — Morphological terminology partially used in this paper follows that of Aoki (1965, 1967), Norton (1977), Ermilov and Starý (2018), and Ermilov and Khaustov (2020).

Abbreviations — Prodorsum: cos = costula; ro, le, in, bs, ex = rostral, lamellar, interlamellar, bothridial, and exobothridial setae, respectively; cpm, cpl = medial and lateral prodorsal condylyes, respectively; con = concavity. Notogaster: cnl = lateral notogastral condylye; cr = crista; c, la, ln, ip, h, p = notogastral setae; ia, im, ip, ih, ips = notogastral lyrifissures; gla = opisthgonal gland opening. Gnathosoma: a, m, h = subcapital setae. Epimeral and lateral podosomal regions: 1a–1c, 2a, 3a–3c, 4a–3c = epimeral setae; Pdl, Pdh = pedotectum I, II, respectively; dis = discidium. Anogenital region: g, ag, an, ad = genital, aggenital, anal, and adanal seta, respectively; vr = ventral ridge; iag, iad = aggenital and adanal lyrifissure, respectively; cvr = circumventral ridge; po = preanal organ. Legs: Tr, Fe, Ge, Ti, Tu leg trochanter, femur, genu, tibia, and tarsus, respectively; pa = porose area; o, φ, σ = solenidia; ε = fumulus; d, l, v, bv, ev, ft, tc, it, p, u, a, s, pv = leg setae.

Taxonomy

Cavernocepheus (Paracavernocepheus) hlavaci n. sp.

Zoobank: D4EF017C-EF51-4699-BFC6-A7012C72A447
(Figures 1a-c, 2a-d)

Diagnosis — Body length: 730–813. Rostral and lamellar setae long, setiform, barbed; interlamellar seta long, rod-like, barbed; bothridial seta spindleform, with long setiform apex, slightly barbed; exobothridial setae present. Lateral and medial prodorsal condylyes present; lateral notogastral condylye quadrangular, top slightly oblique. All notogastral setae long, rod-like, barbed. Epimeral setae setiform, slightly barbed. Genital setae setiform, roughened; other anogenital setae setiform, barbed.

Description of adult — Measurements — Body length: 813 (holotype, male), 730, 796 (two paratype males); body width: 365 (holotype), 315, 348 (two paratypes). Length/width ratio of body: 2.2–2.3.

Integument — Body color light brown. Body surface densely microgranulate and partially sparsely foveolate (diameter of foveola up to 8, poorly visible). Lateral part of body between bothridium and acetabula I–III densely tuberculate (diameter of tubercle up to 8).

Prodorsum — Rostrum broadly rounded. Costula long, reaching bothridium basally and insertion of lamellar seta distally. Rostral (102–106) and lamellar (110–114) setae setiform, barbed. Interlamellar seta (106–114) rod-like, barbed. Bothridial seta (135–147) spindleform, with long setiform apex, slightly barbed. Exobothridial seta (32–41) setiform, thin, slightly barbed. Tutorium absent. Paired lateral and medial prodorsal condylyes tubercle-like, located separately.

Notogaster — Concavity of dorsosejugal region large. Lateral notogastral condylye broadly quadrangular, top slightly oblique. Crista (extending from inner part of cnl) long, almost reaching the level of insertions of setae lm. Ten pairs of rod-like, barbed setae (86–98). Lyrifissures distinct, ia located lateral to c, im lateral to ln, ip between p3 and p5, ips between h3 and p5, ih anterior to h3. Opisthgonal gland opening located close to im.

Gnathosoma — Morphology of subcapitulum, palp and chelicera similar to the other representatives of Cavernocepheus (Paracavernocepheus) (see Ermilov and Starý 2018). Subcapitulum size: 147–159 × 102–114. Subcapitular setae (a: 20; m: 49–53; h: 57–61) setiform, barbed. Palp (102–110) setation: 0–2–1–3–8(+o). Solenidion of palp tarsus connected with setae ul′ and ul″ mediodistally. Postpalpal seta (6) spiniform, smooth. Chelicera (159–168) with two setiform, barbed setae (cha: 61; chhb: 28).

Epimeral and lateral podosomal regions — Apodemes I, II and sejugal apodeme well-developed; apodeme III also present, but poorly visible. Epimeral formula: 3-1-3-3. All setae
**Figure 1** *Cavernocepheus (Paracavernocepheus) hlavaci* n. sp., adult: a – dorsal view (legs omitted); b – ventral view (legs omitted); c – lateral view (legs omitted). Scale bar 100 μm.
Figure 2 *Cavernocephes* (*Paracavernocephes*) *hlavaci* n. sp., adult: a – leg I, right, antiaxial view; b – leg II, right, antiaxial view; c – leg III, left, antiaxial view; d – leg IV, left, antiaxial view. Scale bar 50 μm.
(1a, 2a, 3a, 4b: 24–32; 1b: 73–82; 3b: 61–69; 3c: 32–41; others: 57–65) setiform, slightly barbed. Pedotectum represented by large lamina. Discidium subtriangular.

Anogenital region – Aggenital lyrifissure located close and anterior to genital aperture. Genital setae (20–24) setiform, roughened. Aggenital (49–53), adanal (61–69) and anal (41–49) setae setiform, barbed. Distance ad 3–ad 3 larger than ad 2–ad 2 and ag–ag. Adanal lyrifissure located close and parallel to anal plate. Circumventral ridge slightly developed.

Legs – Claw of each leg strong, barbed on dorsal side. Dorsal side of all tarsi without teeth. Genua III, IV and femora I, II with one pair of teeth ventrodistally versus genua I, II and femora III, IV without teeth. Porose areas on all femora and on trochanters III, IV well visible. Formulas of leg setation and solenidia: I (1–4–3–4–16) [1–2–2], II (1–4–3–3–15) [1–1–2], III (2–3–1–2–15) [1–1–0], IV (1–2–2–2–12) [0–1–0]; homology of setae and solenidia indicated in Table 1. Seta u setiform on tarsus I versus thorn-like on tarsi II-IV. Seta ᵢ on genu II and pv'' on tibia IV phylliform.

Material examined — Holotype (male) and two paratypes (all males): sample #12, Malawi, Zomba, Mt. Zomba, 15°20′37.2″S, 35°16′40.2″E, 1846 m a.s.l., sifting forest litter, Winkler extraction, 27.XI.2012 (leg. P. Baňař & P. Hlaváč).

Type deposition — The holotype and two paratypes are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology — The species name is dedicated to our colleague, Dr. Peter Hlaváč (Prague, Czech Republic) renowned entomologist, specialist on Coleoptera, collector of large material of soil samples from Malawi.

Remarks — The new species clearly differs from all species of the subgenus in the presence of spindleform (versus clavate/fusiform) bothridial seta having long, setiform apex (versus without long, setiform apex).

### Cavernocepheus (Paracavernocepheus) mulanjensis n. sp.

Zoobank: 4093E79F-CC1C-474D-A8D8-B7D027526014

(Figures 3a-c)

Diagnosis — Body length: 630–747. Rostral and lamellar setae long, setiform, barbed; interlamellar setae long, rod-like, barbed; bothridial seta clavate, slightly barbed; exobothridial seta present. Lateral and mediad prodorsal condyles present; lateral notogastral condyle quadrangular, concave medially. Posterior notogastral setae setiform, with attenuate and flexible tip, barbed; others rod-like, barbed. Epimeral setae setiform, slightly barbed. Genital setae setiform, roughened; other anogenital setae setiform, barbed.

Description of adult — Measurements – Body length: 747 (holotype, male), 630, 747 (two paratype males); body width: 340 (holotype), 282, 340 (two paratypes). Length/width ratio of body: 2.2.

Integument – Body color light brown. Body surface densely microgranulate and partially sparsely foveolate (diameter of foveola up to 8). Lateral part of body between bothridium and acetabula I–III densely tuberculare (diameter of tubercle up to 8).

Table 1 Leg setation and solenidia of adult Cavernocepheus (Paracavernocepheus) hlavaci n. sp. and C. (P.) mulanjensis n. sp.

| Leg | Tr | Fe | Ge | Ti | Ta |
|-----|----|----|----|----|----|
| I   | v' | d, (l), bv" | (l), v', (l), (v), v', σ (l), (v), φ₁, φ₂ | (ft), (tc), (it), (p), (u), (a), s, (pv), ε, ω₁, ω₂ |
| II  | v' | d, (l), bv" | (l), v', (l), l', (v), σ | (ft), (tc), (it), (p), (u), (a), s, (pv), ω₁, ω₂ |
| III | v', l' | d, l', ev' | l', (v), σ | (ft), (tc), (it), (p), (u), (a), s, (pv) |
| IV  | v' | d, ev' | d, l' | (v), σ | (ft"), (tc), (p), (u), (a), s, (pv) |
Figure 3 *Cavernocepheus (Paracavernocepheus) mulanjensis* textbfn. sp., adult: a – dorsal view (legs omitted); b – ventral view (legs omitted); c – lateral view (legs omitted). Scale bar 100 μm.
Prodorsum – Rostrum broadly rounded. Costula long, reaching bothridium basally and insertion of lamellar seta distally. Rostral (86–98) and lamellar (98–110) setae setiform, barbed. Interlamellar seta (61–69) rod-like, barbed. Bothridial seta (102–114) clavate, slightly barbed. Exobothridial seta (24–28) setiform, thin, slightly barbed. Tutorium absent. Paired lateral and medial prodorsal condyle tubercle-like, located separately.

Notogaster – Concavity of dorsosejugal region large. Lateral notogastral condyle broadly quadrangular, concave medially. Crista (extending from inner part of cnl) long, almost reaching the level of insertions of setae lm. Ten pairs of notogastral setae (57–65); posterior setae (h₃, p₁–p₃) setiform, with attenuate and flexible tip, barbed; other setae rod-like, barbed. Lyrifissures distinct, ia located lateral to c, im lateral to lm, ip between h₃ and p₃, ips between h₃ and p₃, ih anterior to h₃. Opisthonotal gland opening located close to im.

Gnathosoma – Morphology of subcapitulum, palp and chelicera similar to the other representatives of Cavernocepheus (Paracavernocepheus) (see Ermilov and Starý 2018). Subcapitulum size: 139–147 × 86–94. Subcapitular setae (a: 20; m: 45–53; h: 53–61) setiform, barbed. Palp (86–94) setation: 0–2–1–3–8(ω). Solenidion of palp tarsus connected with setae ul’ and ul” mediodistally. Postpalpal seta (6) spiniform, smooth. Chelicera (151–159) with two setiform, barbed setae (cha: 57; chb: 28).

Epimeral and lateral podosomal regions – Apodemes I, II and sejugal apodeme well-developed; apodeme III also present, but poorly visible. Epimeral formula: 3-1-3-3. All setae (1a, 2a, 3a, 4b: 24–28; Ib: 53–61; others: 41–49) setiform, slightly barbed. Pedotectum I represented by large lamina. Discidium subtriangular.

Anogenital region – Aggenital lyrifissure located close and anterior to genital aperture. Genital setae (16–20) setiform, roughened. Aggenital (41–49), adanal (57–65) and anal (41–49) setae setiform, barbed. Distance ad₂–ad₃ larger than ad₁–ad₂ and ag–ag. Adanal lyrifissure located close and parallel to anal plate. Circumventral ridge slightly developed.

Legs – Generally, similar to Cavernocepheus (Paracavernocepheus) hlavaci n. sp., but: 1) all genua and femora without teeth ventrodistally; 2) seta l′ on genu II and pv” on tibia IV setiform.

Material examined — Holotype (male) and two paratypes (all males): sample #9, Malawi, Maloza, Mulanje Mts., Maloza stream valley, 16°0′3.9″S, 35°32′36.6″E, 972 m a.s.l., sifting litter, Winkler extraction, 24.XI.2012 (leg. P. Baňař).

Type deposition — The holotype and two paratypes are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology — The species name refers to the place of origin, Mulanje Mts., Malawi.

Remarks — The new species clearly differs from all species of the subgenus in the presence of posterior notogastral setae (h₃, p₁–p₃) having attenuate and flexible tip (versus posterior notogastral setae rod-like).

Morphological comparison

The known species of Cavernocepheus (Paracavernocepheus) can be distinguished from each other by the morphology of bothridial seta, lateral notogastral condyle, notogastral and adanal setae, leg tarsi, genua and femora, and leg seta l′ on genu II and pv” on tibia IV (see Table 2).

Distribution of Cavernocepheus (Paracavernocepheus)

Species of the subgenus are known from the Afrotropical region only and have a highly circumscribed geographic distribution, i.e. are endemic to a single country. 

Cavernocepheus (Paracavernocepheus) nortonroyi and C. (P.) concavus are known from Cameroon: forest litter and soil in Korup National Park (300 m a.s.l.), Rengo Camp, about 8 km NW of Mundemba South-West Province. Cavernocepheus (Paracavernocepheus) hlavaci and C. (P.) mulanjensis are known from Malawi: C. (P.) hlavaci was described from forest litter on Mt. Zomba (1846 m a.s.l.); C. (P.) mulanjensis from forest litter in Maloza stream valley on Mulanje Mts. (972 m a.s.l.).
Table 2 Morphological differences between *Cavernocepheus* (*Paracavernocepheus*) spp.

| Character                        | *C. (P.) nortonroyi* Ermilov and Starý, 2018 | *C. (P.) concavus* Ermilov and Starý, 2018 | *C. (P.) hlavaci* n. sp. | *C. (P.) mulanjensis* n. sp. |
|---------------------------------|---------------------------------------------|--------------------------------------------|--------------------------|-------------------------------|
| Bothridial setae               | Clavate, with three or four teeth distally  | Lanceolate, slightly barbed                | Clavate, slightly barbed  | Concave medially             |
| Lateral notogastral condyle     | Truncate                                    | Concave medially                           | Truncate                 | All setae similar in length, rod-like |
| Notogastral setae              | Setae *h* 3, *p* 1–*p* 3 longer than others, all setae rod-like | All setae similar in length, rod-like     | All setae similar in length, rod-like | All setae similar in length, *h* 3, *p* 1–*p* 3 with attenuate and flexible tip, others rod-like |
| Adanal setae                   | With flexible tip                           | Without flexible tip                       | Without flexible tip      | Without flexible tip          |
| Leg tarsi dorsally             | With small teeth                            | With small teeth                           | Without teeth             | Without teeth                 |
| Leg genua and femora ventrodistantly | Rounded                                    | Rounded                                    | Genua III, IV and femora I, II pointed | Rounded                      |
| Leg seta *l*’ on genu II and *pv”* on tibia IV | Setiform                                   | Setiform                                   | Phylliform                | Setiform                     |

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