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Tetramorium boehmei sp. n. – a new ant (Hymenoptera: Formicidae) species from the Kakamega Forest, Western Kenya

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Abstract. *Tetramorium boehmei* Hita Garcia & Fischer sp. n. – a new ant species from the Kakamega Forest in Western Kenya is described. The new species can be placed in the *Tetramorium camerunense* species group and differs significantly from the other members of the group by its highly reduced sculpturation on head and mesosoma. With only two available specimens sampled in undisturbed primary forest, *Tetramorium boehmei* sp. n. seems to be a relatively rare endemic species. Additionally, a first key to the *Tetramorium* species groups found in the Kakamega Forest is provided.

Keywords. Ants, Kakamega Forest, species group key, taxonomy, *Tetramorium*, *Tetramorium camerunense* species group.

INTRODUCTION

The ant genus *Tetramorium* Mayr, 1855 is almost globally distributed, and with over 430 described species one of the most species-rich genera worldwide (Bolton 1995; B Bolton, Isle of Wight, pers. comm. 2010). The Afrotropical zoogeographic region holds the largest diversity with over 210 listed *Tetramorium* species (Bolton 1976, 1980, 1985, 1995; Hita Garcia et al. 2010).

The Kakamega Forest, one of the last indigenous forests in Kenya, and its animal diversity have received considerable scientific attention in the last decades (e.g. Clausnitzer 1999, 2005; Copeland et al. 2005; Hita Garcia et al. 2009; Kühne 2008; Schick et al. 2005; Tattersfield et al. 2001; Wagner & Böhme 2007; Zimmermann 1972). Generally, the forest is considered to be the eastern-most relict of the equatorial Guineo-Congolian lowland rain forest belt (Kokwaro 1988; Wagner et al. 2008; Zimmermann 1972). The strong biogeographic affinities to West and Central African forests can be clearly seen in some faunal elements like reptiles, dragonflies, and ants (Clausnitzer 2005; Hita Garcia et al. 2009; Wagner et al. 2008). The ant fauna proved to be remarkably diverse with 288 species from 52 genera and 11 subfamilies constituting the second highest species richness reported for the Afrotropical zoogeographic region (Hita Garcia et al. 2009). By far the most species-rich genus in Kakamega Forest was *Tetramorium* with more than 40 species belonging to 14 species groups (Hita Garcia et al. 2009; FHG, unpublished). The *Tetramorium camerunense* species group was well represented with four species: *Tetramorium lucayanum* Wheeler, W.M., 1905, *Tetramorium* cf. *gegaimi* Forel, 1916, and two undescribed species.

Recent taxonomic work was primarily focused on the *Tetramorium weitzeckeri* species group with the description of *Tetramorium snellingi* Hita Garcia, Fischer & Peters, 2010 and a species group revision for the whole Afrotropical region (FHG, unpublished). However, around 10 species or 25% of the *Tetramorium* fauna of the Kakamega Forest still remain undescribed. With this work we present a first preliminary key to the *Tetramorium* species groups present in the Kakamega Forest and describe a new species belonging to the *T. camerunense* species group.

MATERIAL AND METHODS

The type material has been deposited in the following institutions:

NMK: National Museums of Kenya, Nairobi, Kenya
ZFMK: Zoological Research Museum Koenig, Bonn, Germany

Both, holotype and paratype, were measured with an Olympus SZX 12 stereomicroscope equipped with a dual-axis optical micrometer at a magnification of 90x. The following measurements and indices, in parts adapted from Bolton (1980) and Güsten et al. (2006), were used:

Head length (HL): maximum distance from the mid-point of the anterior clypeal margin to the mid-point of the occipital margin, measured in full-face view.

Head width (HW): width of head directly behind the eyes measured in full-face view.

Scape length (SL): maximum scape length excluding basal condyle and neck.

Eye length (EL): maximum diameter of compound eye measured in oblique lateral view.

Pronotal width (PW): maximum width of pronotum measured in dorsal view.

Weber's length (WL): diagonal length of mesosoma in lateral view from the postero-ventral margin of propodeal lobe to the anterior-most point of pronotal slope, excluding the neck.

Propodeal spine length (PSL): in dorsocaudad view, the tip of the measured spine, its base, and the centre of the propodeal concavity between the spines must all be in focus. Using a dual-axis micrometer the spine length is measured from the tip of the spine to a virtual point at its base where the spine axis meets orthogonally with a line leading to the median point of the concavity.

Petiole length (PTL): maximum length of petiolar node measured in dorsal view.

Petiole height (PTH): maximum height of petiolar node measured in lateral view from the highest (median) point of the node to the ventral outline. The measuring line is placed in an orthogonal angle to the ventral outline of the node.

Petiole width (PTW): maximum width of petiolar node measured in dorsal view.

Postpetiole length (PPL): maximum length of postpetiole measured in dorsal view.

Postpetiole height (PPH): maximum height of the postpetiole measured in lateral view from the highest (median) point of the node to the ventral outline. The measuring line is placed in an orthogonal angle to the ventral outline of the node.

Postpetiole width (PPW): maximum width of postpetiole measured in dorsal view.

Ocular index (OI): EL / HW * 100
Cephalic index (CI): HW / HL * 100
Scape index (SI): SL / HW * 100
Propodeal spine index (PSLI): PSL / HL * 100
Petiolar node index (PeNI): PTW / PW * 100
Lateral petiole index (LPeI): PTL / PTH * 100
Dorsal petiole index (DPeI): PTW / PTL * 100
Postpetiolar node index (PpNI): PTW / PW * 100
Lateral postpetiole index (LPpI): PPL / PPH * 100
Dorsal postpetiole index (DPpI): PPW / PPL * 100
Postpetiole index (PPI): PPW / PTW * 100

Measurements and indices are presented as minimum and maximum values. Additionally, all measurements are expressed in mm and presented with three decimal places.

The digital colour images were produced with a QImaging Micropublisher 5.0 RTV camera attached on a LEICA Z6 APO stereo-microscope and mounted with Syncroscopy Auto-Montage software (version 5.03). The mounted images were processed for publication with Adobe Photoshop CS2 and ImageJ. All images presented in this work are also online available at Antweb (Fisher, 2002). Furthermore, holotype and paratype are uniquely identified with specimen-level codes (e.g. CASENT0217239) affixed to each pin.

Total genomic DNA was extracted from two dissected single legs of the holotype, using the Qiagen DNeasy®Blood&Tissue Kit, following the manufacturers` protocol. DNA was eluted with 50 µl buffer AE; this step was repeated once to maximize yield.

A ca. 650 bp long fragment of the 5´-region of the cytochrome c oxidase subunit I (COI), the standard DNA barcode-marker for animals, was amplified using the primers LCO 1490 and Nancy (5´-GGT CAA CAA ATC ATA AAG ATA TTG G-3´ and 5´-CCC GGT AAA ATT AAA ATA TAA ACT TC -3´; Folmer et al. 1994) and the Qiagen® Multiplex PCR Kit. Amplification reactions were carried out in a 20 µl volume containing 10 µl QIAGEN Multiplex PCR Mastermix, 2 µl Q-Solution, 1.6 µl of each primer (both 10 pmol/µl), and 2.5 µl DNA template, and filled up to 20 µl with sterile H_2O. The PCR temperature profile consisted of an initial denaturation at 95° (15 min), followed by 40 cycles at 94° (35 s, denaturation), 48.5° (90 s, annealing), 72° (90 s, extension), and a final extension at 72° (10 min). PCR success was checked by electrophoresis on an 1.5% agarose gel containing ethidium bromide. The PCR product was purified using 3 µl of the ExoSAP-IT® PCR purification reagent following the manufacturers` protocol.

The sample was bidirectionally sequenced by a commercial company (Macrogen Inc., Seoul, Republic of Korea; http://www.macrogen.com) using PCR primers. BLAST search confirmed belonging of the sequence to the genus *Tetramorium*. The sequence is deposited in GenBank (accession number HM753586).

KEY TO THE *TETRAMORIUM* SPECIES GROUPS FOUND IN KAKAMEGA

The following key to species groups is adapted from Bolton (1976, 1980) and specific for the Kakamega Forest, though it also works for Western Kenya in general:

1 Whole body covered with regularly branched hairs, either bifid or trifid, giving the ant a woolly or furry appearance. **2**
– Hairs generally simple, rarely bizarrely modified, but never regularly branched bifid nor trifid as above . **3**

2 Antennae 11-segmented; elongate simple hairs present along the antennal scapes and upper borders of the frontal carinae. ..... *T. ericae* group
– Antennae 12-segmented; elongate simple hairs absent along the antennal scapes and upper borders of the frontal carinae. ..... *T. gabonense* group

3 Antennae 11-segmented. **4**
– Antennae 12-segmented. **5**

4 Petiolar node squamiform to high nodiform, never blocky nodiform with sharply defined angles. ..... *T. weitzeckeri* group
– Petiolar node strongly blocky nodiform, generally with sharply defined angles. ... *T. angulinode* group

5 Lateral portion of clypeus prominent, raised to a tooth or crest in full-face view; in dorsal view the lateral clypeal portions rise to a high peak in front of the antennal insertions and then slope down towards the median part of the clypeus. ..... *T. sericeiventre* group
– Lateral portion of clypeus not modified as above. . **6**

6 Antennal scapes very long (always SI > 120); frontal carinae weakly developed and short, at most reaching the posterior eye margins. ..... *T. aculeatum* group
– Antennal scapes distinctly shorter than above (always SI < 110); frontal carinae variable. **7**

7 Propodeum armed with a pair of small triangular teeth or denticles which at most are as large as the propodeallobes. **8**
– Propodeum armed with a pair of medium-sized to long spines which are noticeably larger than the propodeallobes. **12**

8 Anterior clypeal margin with median impression. ..... *T. dumezi* group (in parts)
– Anterior clypeal margin entire. **9**

9 Tibiae with short appressed pubescence. **10**
– Tibiae with subdecumbent to erect pilosity or pubescence. **11**

10 Hairs on dorsal mesosoma and gaster usually sparse, short, stout, and blunted ..... *T. simillimum* group
– Hairs on dorsal mesosoma and gaster usually numerous, elongate and fine ..... *T. quadridentatum* group

11 Frontal carinae long, usually reaching occiput. ..... *T. dumezi* group (in parts)
– Frontal carinae short and weakly developed, ending at eye level. ..... *T. convexum* group

12 Anterior clypeal margin with median impression. .. **13**
– Anterior clypeal margin entire, without a median impression. **14**

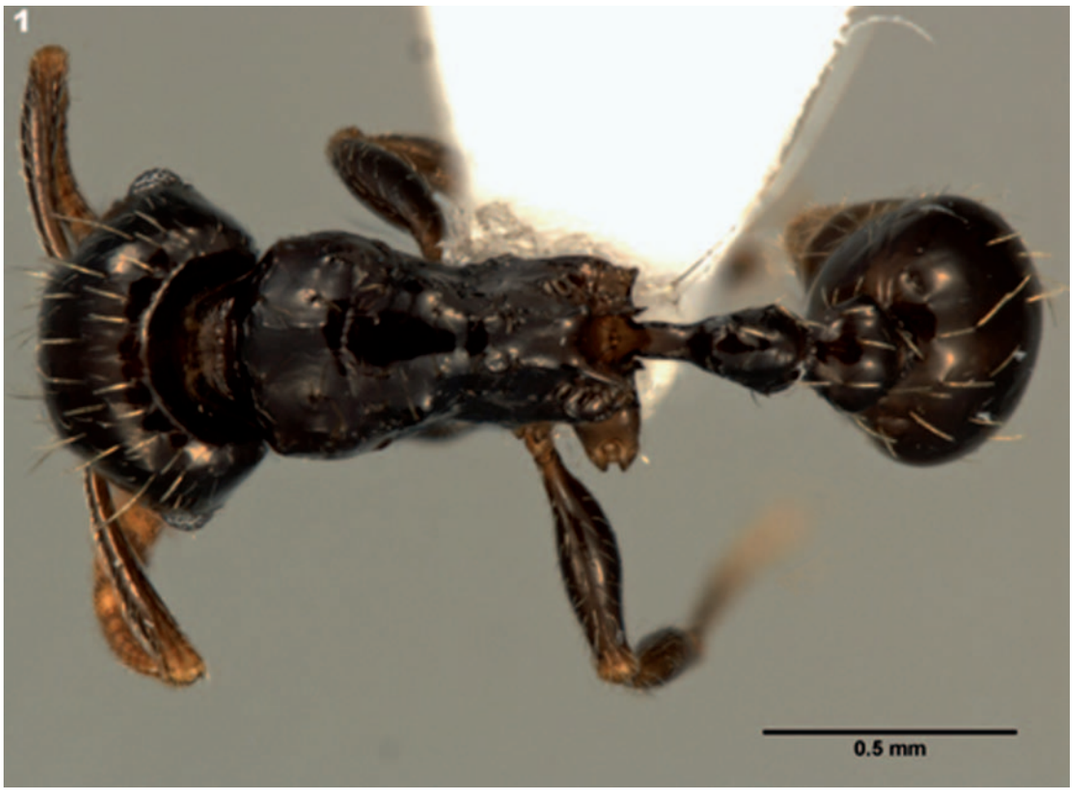
13 Occipital region of head variably rugose, rugulose or unsculptured, rarely with few anastomoses, without a rugo-reticulum. ..... *T. camerunense* group
– Occipital region of head distinctly rugo-reticulate. ..... *T. bicarinatum* group

14 Eyes larger, at least 9 ommatidia in the longest row. ..... *T. setigerum* group
– Eyes smaller, at most 7 to 8 ommatidia in the longest row. ..... *T. flabellum* group

Tetramorium camerunense species group

Examination of the new species led to the conclusion that it can be easily placed in the *T. camerunense* species group. Though the species group was well defined in Bolton (1980) it seems useful to reproduce it here:

1. antennae 12-segmented
2. antennal scape relatively small to moderate (SI < 90)
3. anterior clypeal margin generally with small median impression (absent in one species)
4. frontal carinae long and fine, generally reaching posterior eye margin, sometimes running to occipital margin
5. antennal scrobe weakly developed
6. propodeal spines of varying length, but always longer than propodeal lobes
7. mandibles generally smooth and shining, rarely finely striate
8. clypeus with three longitudinal rugae
9. cephalic dorsum usually finely longitudinally rugu-



Figs 1–2. *Tetramorium boehmei* sp. n., holotype worker, CASENT0217238. 1 dorsum of body; 2 body in profile.

Figs 3–4. *Tetramorium boehmei* sp. n.. 3 holotype worker, CASENT0217238, full-face view of head; 4 paratype worker, CASENT0217239, full-face view of head.

lose, without cross-meshes; occipital rugoreticulum never developed
10. all dorsal body surfaces with numerous standing hairs
11. dorsal surfaces of hind tibiae generally with decumbent to appressed pubescence only, in two species suberect
12. sting appendage triangular, dentiform or pennant-shaped

Prior to this study, the *T. camerunense* species group contained 12 species that were subdivided into two species complexes based on differences in sculpturation (Bolton 1980). The *T. lucayanum* complex, containing four species, can be characterized by the presence of sculptured mandibles, petiole and postpetiole. One or both of the waist segments are generally strongly sculptured. The other and larger complex, the *T. camerunense* complex with eight species, possesses typically unsculptured waist segments and mandibles.

Tetramorium boehmei Hita Garcia & Fischer sp. n.
(Figs 1–6)

Holotype worker, KENYA, Western Province, Kakamega Forest, Colobus, 00° 21’ 16’’ N, 34° 51’ 36’’ E, 1650 m, primary rain forest, hand collected, VII.2009, leg. G. Fischer (NMK: CASENT0217238). Paratype worker, KENYA, Western Province, Kakamega Forest, Salazar, 00° 19’ 36’’ N, 34° 52’ 14.6’’ E, 1650 m, Kakamega Forest survey 2007, Transect 6, primary forest, Winkler leaf litter extraction, 21.VI.2007, leg. M. Peters (ZFMK: CASENT0217239).

Diagnosis. The highly reduced cephalic and mesosomal sculpturation renders *Tetramorium boehmei* straightforwardly recognizable within the *T. camerunense* species group.

DESCRIPTION

HL 0.700–0.772; HW 0.633–0.711; SL 0.533–0.578; EL 0.122–0.139; PW 0.450–0.489; WL 0.822–0.900; PSL 0.150–0.189; PTL 0.194–0.200; PTH 0.211–0.239; PTW 0.178–0.189; PPL 0.189–0.200; PPH 0.194–0.222; PPW 0.250–0.267; CI 90–92; SI 82–84; OI 19–20; PSLI 21–24; PeNI 39–40; LPeI 84–92; DPeI 91–94; PpNI 55–56; LPpI 90–97; DPpI 132–133; PPI 141 (2 measured).

Head longer than wide (CI 90–92). Anterior clypeal margin with small but distinct median notch. Frontal carinae fine and relatively weak, even weaker behind eye level and significantly not reaching occipital margin. Antennal scrobe very weakly developed, nearly vestigial. Antennal scape of moderate length, not reaching posterior margin of head (SI 82–84). Eyes small to moderate (OI 19–20), with 8 to 9 ommatidia in longest row. Metanotal groove not impressed. Propodeal spines moderately sized (PSLI 21–24), relatively thin, spinose and straight. Propodeal lobes small, elongate-triangular and acute, always shorter than propodeal spines. Petiolar node nodiform, in profile weakly higher than long (LPeI 84–92), in dorsal view slightly longer than wide (DPeI 91–94) and posteriorly wider than anteriorly. Postpetiole rounded, in dorsal view around 1.3 times wider than long (DPpI 132–133), and around 1.4 times wider than petiole (PPI 141); in lateral view weakly higher than long (LPpI 90–97). Sting appendage triangular.

Figs 5–6. *Tetramorium boehmei* sp. n., paratype worker, CASENT0217239. 5 dorsum of body; 6 body in profile.

Mandibles either unsculptured, smooth and shining or finely striate. Clypeus with three longitudinal rugae, median ruga stronger developed than lateral rugae. Cephalic sculpturation greatly reduced, laterally with only weak partial rugulation, mostly smooth and shining; cephalic dorsum with 5–6 very weak and fine, widely spaced longitudinal rugulae between frontal carina, most of them broken along their length and never reaching occipital margin, occipital region unsculptured. Cephalic ground sculpturation absent, generally smooth and shining. Lateral mesosoma anteriorly mostly unsculptured, smooth and shiny, posteriorly with weak irregular rugulation; dorsum of mesosoma unsculptured or with few weak rugulae, or traces of rugulae only, generally smooth and shining. Petiole either completely unsculptured or with traces of sculpture; postpetiole and gaster completely unsculptured, smooth and shiny.

All dorsal surfaces of head, mesosoma, both waist segments and gaster with numerous long, simple, suberect to erect hairs. Fine pubescence on antennal scapes and tibia appressed to subdecumbent.

Head, mesosoma, waist segments, and gaster very dark brown to black, antennae, mandibles, and legs of lighter brownish colour.

Queen and male unknown.

Etymology. The new species is dedicated to Prof. Dr. Wolfgang Böhme from Bonn, Germany, in honour of his nearly four decades of passionate herpetological work at the Zoological Research Museum Koenig in Bonn. Furthermore, with his encouraging, and always interesting, lectures, courses and excursions he had a significant positive influence on the authors leading to their scientific dedication with zoological systematics and the Afrotropical zoogeographical region.

Notes. Generally, it is not recommendable for large and diverse genera as *Tetramorium* to describe single species based only on few specimens outside a comprehensive generic revision. Nevertheless, in the case of *T. boehmei* it seems justified for the following reasons. First, it does fit all group characters and can therefore easily be identified as a *T. camerunense* species group member, either by using the species group key presented above or the one in Bolton (1980). Within the *T. camerunense* species group it obviously belongs to the *T. camerunense* species complex because of the unsculptured petiole and postpetiole. Second, and more importantly, *T. boehmei* shows a remarkable character combination that varies significantly from the other members of the species group, and allows an easy and clear identification. The single best diagnostic character to separate *T. boehmei* from the rest of the group is the almost completely reduced sculpturation on head and mesosoma. This reduction to a few weak rugulae on the cephalic dorsum, and even less sculpturation on the mesosomal dorsum, is unique in the species group. All other species possess a distinctly longitudinally rugose or rugulose head and mesosoma, though variable from species to species, and sometimes irregularly shaped.

It has to be mentioned that the holotype and paratype differ in some aspects that could be considered as sufficient enough to divide them into two different species. First, the mandibular sculpturation is completely smooth and shiny in the holotype while it is longitudinally striate in the paratype. This character is usually species-specific and could be considered as a good diagnostic tool to divide them. Second, the paratype is larger and possesses more sculpture on head and mesosoma than the holotype which appears generally much more smooth and shining. Furthermore, the clypeal notch is distinct in both species but stronger developed in the paratype. However, at present, the observed variation is considered as intraspecific variation until more material becomes available. Apart from the noted differences there is a striking morphological similarity between both specimens and also the morphometric measurements of both are very close. Concluding, based on the analysis of two specimens, it would be premature to describe them as different species.

Currently, the new species seems to be endemic to the Kakamega Forest in Western Kenya where it was sampled in primary forest sites. Considering the high sampling effort to assess the ant fauna of the Kakamega Forest (Hita Garcia et al. 2009), and the only two available specimens of *T. boehmei*, it seems to be a rather rare species. In addition, only little information is available on its biology. One specimen was found in a Winkler leaf litter extraction sample and one was hand collected from the ground. Considering this, the new species could be regarded as a rare terrestrial species, living either in the ground or the leaf litter. Though, it might also be possible that *T. boehmei* lives in the lower vegetation or the canopy, and the two specimens were only accidentally collected by the mentioned methods (the canopy ant fauna was considerably less well sampled by the authors than the ground living ant fauna). At present, taking into account our knowledge of the leaf litter fauna of the Kakamega Forest, we consider the leaf litter hypothesis as more likely. The overall morphological appearance with small to moderate eyes and antennal scapes as well as the strongly reduced body sculpturation are within the genus *Tetramorium* more often found in the leaf litter than in the canopy where species tend to have larger eyes and scapes. However, more specimens from more sampling events are necessary to reveal the preferred stratum of *T. boehmei*. Furthermore, it should be noted that *T. boehmei* was sampled in the two least dis-

turbed primary forest sites examined in the Kakamega Forest (FHG, unpublished data). This might indicate that the new species prefers undisturbed primary forest and reacts negatively to anthropogenic disturbance like selective logging.

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