

***Crematogaster gadagkari* sp. nov. (Hymenoptera: Formicidae), a New Species of an Acrobat Ant from India**

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ABSTRACT

We describe a new species *Crematogaster gadagkari* sp. nov. based on worker specimens from the North East Himalaya, India collected in 2019. It resembles *C. rogenhoferi* Mayr, 1879 and *C. himalayana* Forel, 1902, but can be distinguished from both species on the basis of sculpture and propodeal spine length. Also updated an identification key to the Indian *Crematogaster* species. In addition, a DNA barcode for the newly described species is also provided with Genbank accession number "OP807010".

Keywords: Myrmicinae, morphology, DNA barcoding, key, taxonomy.

INTRODUCTION

Crematogaster Lund, 1831 is a diverse genus of ants that is distributed worldwide. It is represented by 522 valid species and 260 subspecies from all over the world (Bolton, 2023). *Crematogaster* ants exhibit a wide range of ecological adaptations, living in habitats ranging from tropical rainforests to deserts (Hölldobler & Wilson, 1990). They are also known for their diverse behaviors, such as tending to honeydew-producing insects, building nests in a variety of substrates, and engaging in territorial defense (Madden & Young, 1992; Longino, 2003). These ants commonly found in the forest areas and prefer to live in shrubby habitats. Mostly *Crematogaster* species build arboreal nests but some species belonging to the subgenus *Orthocrema* nests in ground (Hosoishi, Yamane, & Ogata, 2010; Blaimer, 2012a, b; Palmer & Brody, 2013). Phylogenetic analysis has classified the genus into two subgenera *Crematogaster* and *Orthocrema* (Blaimer, 2012c, d). Recent advances in molecular techniques and morphological analysis have provided new insights into the evolutionary history and relationships of these ants, leading to a renewed interest in their taxonomy (Hosoishi et al, 2023)

The taxonomy of *Crematogaster* ants has been a topic of debate and revision for many years. While the genus was originally established by Lund, P.W. in 1831 on the basis of type species *Crematogaster scutellaris* (Olivier, 1792) and subsequent designation by Bingham, in 1903 and has undergone several revisions since then, with new species being added and old ones being reclassified. However, some taxonomic contributions to the genus include; Buren (1959, 1968) from North America; Longino (2003) from Costa Rica; Blaimer (2010, 2012a, b) from Madagascar; Hosoishi & Ogata (2008, 2009, 2015, 2017) from South East Asia; Fernández & Serna (2019), Pedraza & Fernández (2019) from Colombia; Sharaf, Aldawood, & Hita Garcia, 2019, Sharaf & Aldawood (2022) from Arabia.

From India, the genus is currently represented by valid 34 species and subspecies (Akbar, Bharti, & Wachkoo, 2023). Despite previous research on the diversity and distribution of ants in India, the taxonomy of the *Crematogaster* genus is an area of ongoing research, with much still to be learned about their classification. During the present study, we describe a new species *Crematogaster gadagkari* sp. nov. from India. This study also updates the identification key to the known species of the genus, providing a valuable resource for future research in this field. In addition, a DNA barcode for the newly described species is provided with GenBank accession number "OP807010". These findings contribute to the ongoing research on the taxonomy of the *Crematogaster* genus in India and demonstrate the importance of continued exploration and discovery in this area.

MATERIALS AND METHODS

Taxonomic analysis was conducted using a Nikon SMZ 1500 stereo zoom microscope with a maximum magnification of 112.5 x. Digital images of the specimens were prepared using a Nikon SMZ 1500 stereomicroscope fitted with an MP (Micro

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Publisher) digital camera and Auto Montage (syncroscopy, a division of Synoptics Ltd.) software. All the images were cleaned with Adobe Photoshop CS5 and Helicon Filter 5. Morphological measurements were recorded in millimetres with an oculo micrometer fitted on a Nikon SMZ 1500 stereomicroscope. Additional images (CASENT0914078 and CASENT0908582) were provided by <http://www.antweb.org/>. Morphological terminology and standard measurements follow Hosoiishi (2020).

Head Width (HW): Maximum width of head in full-face view, excluding the eyes.

Head Length (HL): Perpendicular distance from vertex margin to line tangent anterior most projections of clypeus in full-face view.

Scape Length (SL): Length of the first antennal segment, excluding the neck and basal condyle.

Eye Length (EL): Maximum length of the compound eye. Pronotal Width (PW): Maximum width of the pronotum in dorsal view.

Weber's Length of the mesosoma (WL): Diagonal length, measured in lateral view from the anterior margin of the pronotum (excluding the collar) to the posterior extremity of the propodeal lobe.

Propodeal Spine Length (PSL): Measured from tip of propodeal spine to closest point on outer rim of propodeal spiracle.

Petiole Length (PtL): Length of the petiole in lateral view.

Petiole Width (PtW): Maximum width of petiole in dorsal view. Petiole Height (PtH): Height of the petiole in lateral view.

Petiole Height (PtH): Height of the petiole in lateral view

Postpetiole Length (PpL): Length of the postpetiole in lateral view.

Postpetiole Width (PpW): Maximum width of postpetiole in dorsal view, excluding the helcium.

Indices

Scape Index (SI): $SL/HW \times 100$

Cephalic Index (CI): $HW/HL \times 100$.

Eye Index (EI): $EL/HW \times 100$.

Petiole Height Index (PtHI): $PtH/PtL \times 100$.

Petiole Width Index (PtWI): $PtW/PtL \times 100$.

Postpetiole Width Index (PpWI): $PpW/PpL \times 100$.

Waist Index (WI): $PpW/PtW \times 100$

Molecular Analysis: DNA was extracted from whole ant specimens using QiagenDNeasy® kit, following the manufacturer's protocols. Rest of the respective individuals were kept as voucher specimens at PUPAC. Mitochondrial cytochrome oxidase 1 (COI) gene barcoding region (658 bp) near the 5' terminus of the *cox1* gene was amplified by following standard protocol (Hebert et al, 2003). Standard primers used were: forward primer (LCO 1490: 5'-GGTCAACAAATCATAAAGATATTGG-3'),

and reverse primer (HCO 2198: 5'-TAAACTTCAGGGTGACCAAAAAATCA-3'). PCR reactions were carried out in 96-well plates. Thermo cycling consisted of an initial denaturation of 94°C for 5 min, followed by 30 cycles of denaturation at 94°C for 1 min, annealing at 55°C for 1 min and extension at 72°C for 1 min. PCR was performed using a C1000™ Thermal Cycler. The amplified product was sent to Medauxin Pvt. Ltd., India. DNA sequence obtained was checked for homology, insertions and deletions, stop codons, and frame shifts by using NCBI BLAST.

Depositories: Specimens were deposited in PUAC “Punjabi University Patiala Ant Collection” at Department of Zoology and Environmental Sciences, Punjabi University, Patiala, Punjab, India.

RESULTS

COX I sequence was submitted to GenBank and the Barcode of Life Database (BOLD, <http://www.boldsystems.org>) and available publically with accession number “OP807010.”

Family: Formicidae Latreille, 1809

Subfamily: Myrmicinae Lepeletier de Saint-Fargeau, 1835

Genus: *Crematogaster* Lund, 1831

Type-species: *Formica scutellaris* (obsolete combination of *Crematogaster scutellaris*), by subsequent designation of Bingham, 1903: 124.

Crematogaster gadagkari sp. nov. (Fig. 2)

Type Material. Holotype (worker): India: Sikkim: Namchi, 1300 m, 27.16° N, 88.36°E, handpicking, 09.xi.2019 [PUAC-T 501]. Paratypes: 10 (w.) (PUAC- T 502-T 512), same data as holotype; 7 (w.), Sikkim: Dentam, 1500 m, 27.25° N, 88.13° E, 15.xi.19, hand picking method, leg. Tarun Dhadwal [PUAC T 515-T 522] (Fig. 1).

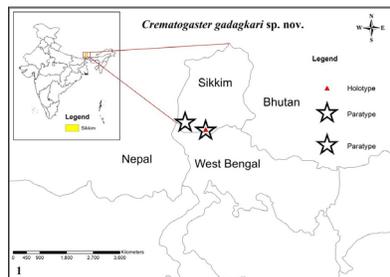


Figure 1. A map of India showing locations of Holotype and Paratypes of *Crematogaster gadagkari* sp. nov.

Measurements: (Worker mm, n = 10; given are ranges; holotype measurements in parentheses):

HW 0.99-1.02 (1.01mm); HL 0.96-1.05 (1.05 mm); SL 0.66-0.72 (0.70 mm); EL 0.48-0.51 (0.49 mm); WL 1.11-1.14 (1.12 mm); PSL 0.23-0.25 (0.25 mm); PtL 0.39-0.42 (0.40 mm); PtH 0.20-0.23 (0.23 mm); PtW 0.33-0.36 (0.36 mm); PpL 0.26-0.30 (0.30

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mm); PpW 0.30-0.33 (0.33 mm); CI 97.14-103.12 (96.19 mm); SI 66.66-70.58 (66.66); PtHI 51.28-54.76 (57.50); PtWI 84.61-85.71 (90); PpWI 110.00-115.38 (110); WI 90.90-91.66 (91.66); EI 48-50 (48.51) .

Diagnosis: Head coarsely, very finely longitudinally striate and mesonotum reticulated. Mesopleuron and lateral sides of the propodeum reticulated, petiole and postpetiole smooth, Propodeal spine long and straight, petiole is longer than broad with lateral margins weakly convex; postpetiole bilobed with a longitudinal median sulcus in dorsal view; subpetiolar process developed forming a spine directed anterior-ventrally. Head, mesosoma and gaster are black and shiny; Legs and scape brownish red. However few specimens are completely Jet black and shiny. Body generally without any erect or suberect hair.

Description: Head in full face view, as long as broad with almost straight posterior margin and rounded occipital corners, lateral sides are convex; frontal carinae short not extending up to midlength of head; mandible with five teeth; Anterior clypeal margin feebly convex except medially; eyes small (EI 48-50), projecting slightly beyond the mid length of the head; antennae 12-segmented, with a club of an apical 3-larger segment, scape short (SI 66.66-70.58) reaching almost up to the posterior corners of the head.

In lateral view, pronotum higher than metanotum; meso-metanotal groove distinct forming a deep concavity; metanotum with distinct ridges; propodeal spine long, pointed diverging posterolaterally; propodeal spiracles dorsoventrally oval in shape. In dorsal view, petiole is longer than broad with lateral margins weakly convex; postpetiole bilobed with a longitudinal median sulcus in dorsal view; subpetiolar process developed forming a spine directed anterior-ventrally.

Sculpture: Head coarsely, very finely longitudinally striate. Mandibles and clypeus longitudinally striate; pronotum reticulate and striated at sides, mesonotum reticulated, metanotum longitudinally striate; mesopleuron and lateral sides of the propodeum reticulated, petiole and postpetiole smooth, dorsal gastral tergites smooth.

Pilosity and pubescence: Body sparsely pilose, short suberect hair present over the head; scape with abundant suberect to decumbent setae; clypeus with suberect setae, anterior clypeal margin with two to three pairs of longer setae, mixed with some shorter setae on the sides.

Head, mesosoma and gaster are black; Legs and scape brownish red. However few specimens are completely black.



Figure 2. *Crematogaster gadagkari* sp. nov. a) head in full face view, b) body in lateral view, c) body in dorsal view.

Remarks: The species is closely related to the *C. rogenhoferi* Mayr, 1879 (Figs. 3a, b, 4a) and *C. himalayana* Forel, 1902 (Figs. 3c, d, 4b). having head entirely sculptured not smooth, pronotum reticulated and propodeal spine is distinctly longer than metanotum.

From *C. rogenhoferi* Mayr, 1879, it can be distinguished by following characteristics; pronotum convex, metanotum forming a distinct ridges (pronotum flat, metanotum depressed in *C. rogenhoferi*); petiole is longer than broad with lateral margins weakly convex (petiole as broad as long with sides angular in the middle in *C. rogenhoferi*); propodeal spine long and straight in dorsal view (propodeal spine short and curved inward in dorsal view in *C. rogenhoferi*); in dorsal view postpetiole is not bulbous and enlarged (in dorsal view postpetiole is bulbous/enlarged in *C. rogenhoferi*) head and mesosoma longitudinally striate (head and mesosoma longitudinally rugulose in *C. rogenhoferi*); Head and mesosoma and gaster black and shiny (Head, mesosoma and gaster reddish brown to dark brown and opaque in *C. rogenhoferi*)

From *C. himalayana* Forel, 1902, it can be distinguished by the following characteristics; head coarsely, very finely longitudinally striate (head irregularly striated and reticulated in *C. himalayana*); pronotum reticulate (pronotum coarsely rugulose at sides in *C. himalayana*); petiole node weakly convex at margins (petiole node rounded in *C. himalayana*); petiole and postpetiole smooth and shiny (petiole and postpetiole reticulated in *C. himalayana*), propodeal spines straight and do not arc outwards (propodeal spine arc outwards in *C. himalayana*), Head and mesosoma and gaster black and shiny (Head, mesosoma ferruginous red and gaster somewhat black and opaque in *C. himalayana*).

Etymology: The species is named in honour of “Prof. Raghavendra Gadagkar” a distinguished Evolutionary biologist based at Centre for Ecological Sciences, Indian Institute of Science in Bangalore, India.

Ecological and biological notes: The workers were handpicked from a tree trunk and ground in Namachi, a village located in the Indian state of Sikkim. Namchi is situated at an average elevation of 1600 meters above sea level, and despite being located in a tropical region, it experiences a relatively cooler climate than other areas in the region. The average daily temperature in Namachi is around 28 degrees Celsius. The village is surrounded by dense forest areas, which provide an excellent habitat for ants and other insects. These forests also contribute to the region’s biodiversity and provide a natural source of beauty.

Identification key to the known species of genus *Crematogaster* Lund, 1831 from India.

The identification key to the known species of genus *Crematogaster* from India was recently provided by Akbar et al (2023). The new species runs to couplet 14 and the key is modified as follows.

14a. Pronotum reticulate; propodeal spines directed downward.....14b
 Pronotum longitudinally striate; propodeal spines upcurved*C. flava* Forel, 1886

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14b. Petiole as long as broad, sides angular in the middle in dorsal view; propodeal spine curved posteriorly in dorsal view*C. rogenhoferi* Mayr, 1879

Petiole longer than broad, sides weakly convex in dorsal view; propodeal spines straight, directed posterolaterally in dorsal view.....*C. gadagkari* sp. nov.

[**Note:** From couplet 15 onwards there are no changes to the key presented by Akbar et al (2023) and we refer to that publication].

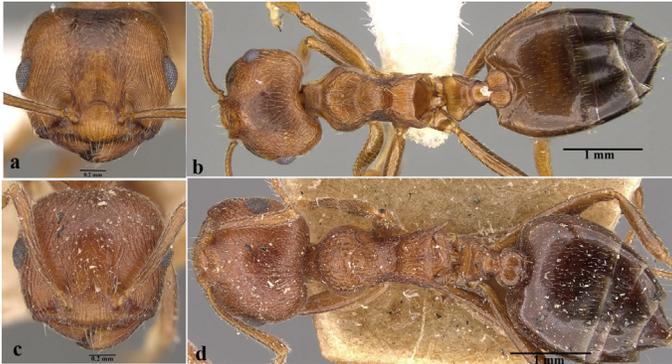


Figure 3. Head in full face view and body in dorsal view, a, b) *C. rogenhoferi* Mayr, 1879 (AntWeb-CASENT0914078, Photographer- Z. Lieberman), c, d) *C. himalayana* Forel, 1902 (AntWeb-CASENT0908582, Photographer- Will Ericson).



Figure 4. Body in profile view, a) *C. rogenhoferi* Mayr, 1879 (From AntWeb- CASENT0914078, Photographer- Z. Lieberman), b) *C. himalayana* Forel, 1902 (from AntWeb- CASENT0908582, Photographer- Will Ericson).

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