JOURNAL OF NATURAL HISTORY
2020, VOL. 54, NOS. 5–6, 351–365
https://doi.org/10.1080/00222933.2020.1762013

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Nesomyrmex micheleae, a new ant species (Hymenoptera: Formicidae) from the Dhofar Governorate, Oman, with a synoptic list, distribution map and key to the Arabian *Nesomyrmex*

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ABSTRACT

A new species of the myrmicine ant genus *Nesomyrmex* Wheeler, 1910, *N. micheleae* Sharaf sp. nov., is described and illustrated from Oman based on the worker caste. The new species is a member of the *N. angulatus* species group and can be diagnosed by the golden yellow gaster that contrasts with the dark brown body; the irregular longitudinal rugulose sculpture on the cephalic surface; and the finely punctate mesonotum and propodeal dorsum. A synoptic species list, an updated key and a distribution map to the Arabian *Nesomyrmex* species are presented. Continued ant species discoveries are central to large-scale diversity patterns, conservation biology and macroecology.

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ARTICLE HISTORY
Received 11 April 2020
Accepted 22 April 2020

KEYWORDS
Afrotropical region; Arabian Peninsula; description; endemic; Middle East; Myrmicinae; taxonomy

Introduction

The myrmicine ant genus *Nesomyrmex* was originally described by Wheeler (1910) with the type species *N. clavipilis*, by monotypy, and later was treated by Emery (1915) as a subgenus or junior synonym of the genus *Leptothorax* Mayr, 1855 (e.g. Wheeler 1922; Kempf 1959; Bolton 1982) and later it was revived from the mentioned synonymy and elevated to the generic level by Bolton (2003) in the tribe Crematogastrini (Ward et al. 2015).

Currently, the genus includes 81 described species, one valid subspecies, *N. angulatus lybica* (Menozzi 1934), and two extinct species, *N. caritatis* (De Andrade et al. 1999) and *N. dominicanus* (De Andrade et al. 1999), from the Dominican Amber (De Andrade et al. 1999; Bolton 2020). The genus is one of the taxonomically best studied genera in the subfamily Myrmicinae, with numerous published contributions on the fauna of most zoogeographical regions including the Afrotropical (Bolton 1982; Mbanyana and Robertson 2008; Hita Garcia et al. 2017), the Malagasy (Wheeler 1922; Csősz and Fisher 2015, 2016a, 2016b, 2016c), the Nearctic

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Published online 27 Jul 2020

(Guénard and Economo 2016), the Neotropical (Kempf 1959, 1972; Brandão 1991), and the Palearctic (Collingwood 1985; Collingwood and Agosti 1996; Sharaf et al. 2017). A detailed taxonomic history of the genus is given by Hita Garcia et al. (2017). The bionomics and sociobiology of the genus are still not fully understood, but most species are generalised foragers (Brown 2000) preferring dry habitats, and build nests directly in the soil, under stones or in rotten branches (Collingwood 1985; Collingwood and Agosti 1996), while a few are tropical dry forest and rainforest dwellers (Kempf 1959; Hita Garcia et al. 2017; Castro et al. 2018).

Member species can be diagnosed by the combination of the following characters in the worker caste (Fisher and Bolton 2016): antennae with 11 or 12 segments, terminating in a three-segmented club; masticatory margin of mandibles armed with 3–5 teeth; posterior clypeal portion broadly inserted between frontal lobes and anterior margin without paired median setae; eyes well developed. The closest relative myrmicine genus to *Nesomyrmex* is the *Temnothorax* Mayr 1861, from which it can be separated by the presence of an anterior clypeal apron that fits tightly over the dorsal surface of mandibles when seen in profile.

The previous records of the *Nesomyrmex* fauna of the Arabian Peninsula are scattered in the literature under the genus *Leptothorax*. The first record was presented by Collingwood (1985) for the species *N. angulatus* (Mayr 1862) from the south-western mountains of the Kingdom of Saudi Arabia (KSA). A faunal treatment of the Arabian Formicidae (Collingwood and Agosti 1996) reported two species, *N. angulatus* from the KSA and Yemen, and *N. humerosus* (Emery, 1896) from Yemen. Recently, Sharaf et al. (2017) fully revised and illustrated the Arabian *Nesomyrmex*, recognising three species and describing *N. zaheri* Sharaf, Akbar and Hita Garcia, 2017 from Yemen based on the worker caste.

In the present work we describe a new species from the Dhofar Governorate, Oman, based on the worker caste and present an updated key to the Arabian *Nesomyrmex*.

Material and methods

Measurements (Figure 1 a–c).

The following measurements and indices follow Hita Garcia et al. (2017). The terminology used to describe surface sculpture follows Harris (1979). All measurements are expressed in millimeter.

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

HL Head length: maximum distance from midpoint of anterior clypeal margin to midpoint of posterior margin of head, measured in full-face view.

HW Head width: maximum width of head behind eyes in full-face view.

PPH Postpetiole height: 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 at an orthogonal angle to the ventral outline of the node.

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

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

PH Pronotal height: maximum height of the pronotum measured in lateral view.

PW Pronotal width: maximum pronotal width in dorsal view.

PSL Propodeal spine length: in dorsocaudal view the tip of the measured spine, its base and the centre of the propodeal concavity between spines must all be in focus.

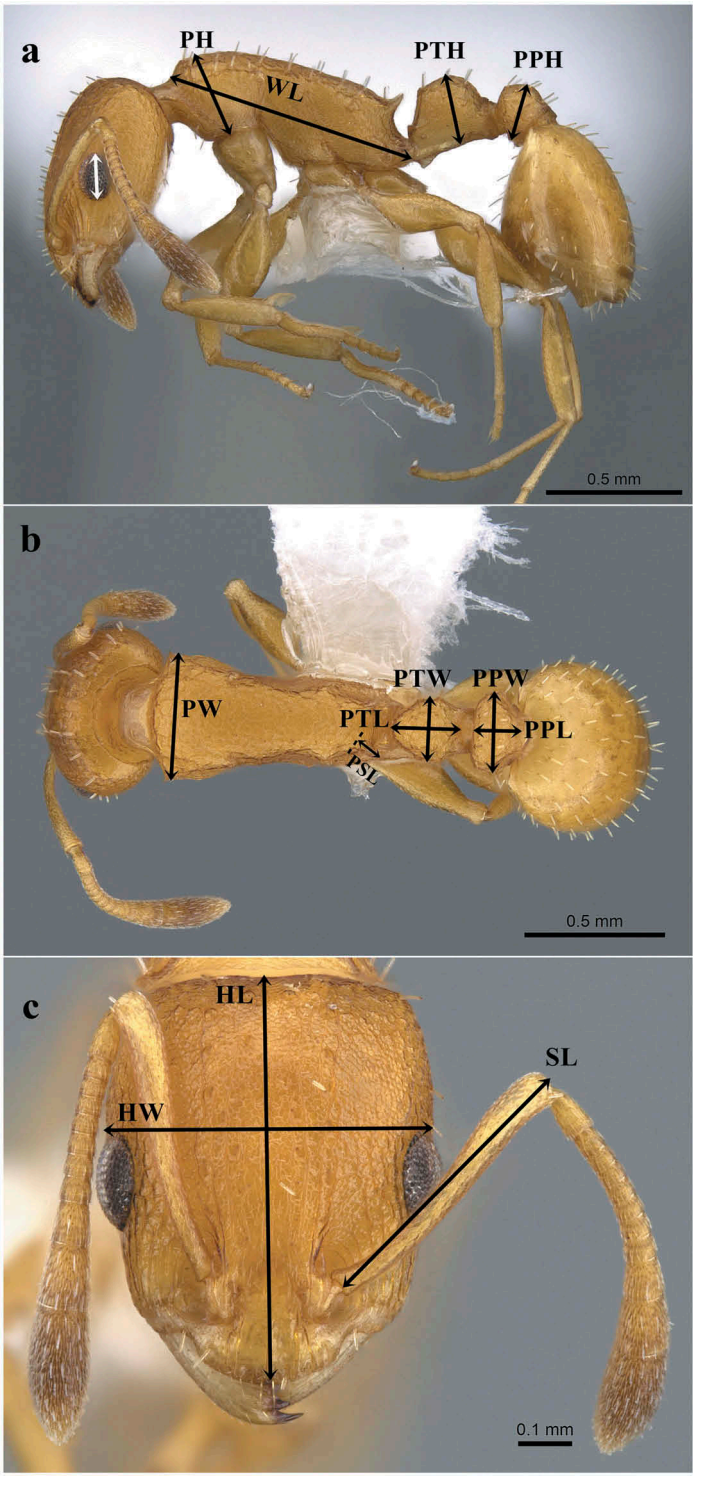

Figure 1. Automontage images of *Nesomyrmex angulatus* illustrating the measurements used: (a) body in profile; (b) body in dorsal view; (c) head in full-face view. CASENT0922010 (Zach Lieberman), https://www.antweb.org/citing_antweb.jsp.

Using a dual-axis micrometer, the spine length is measured from tip of spine to a virtual point at its base where spine axis meets orthogonally with a line leading to median point of concavity.

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

PTL Petiolar node length: maximum length of dorsal face of petiolar node from antero-dorsal to posterodorsal angle, measured in dorsal view excluding peduncle.

PTW Petiolar node width: maximum width of dorsal face of petiolar node measured in dorsal view.

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

TL Total length: outstretched body length from mandibular apex to gastral apex in profile.

WL Weber's length: diagonal length of mesosoma in profile from posteroventral margin of propodeal lobe to anterior-most point of pronotal slope, excluding neck.

Indices

OI Ocular index: EL/HW × 100

CI Cephalic index: HW/HL × 100

SI Scape index: SL/HW × 100

DMI Dorsal mesosoma index: PW/WL × 100

LMI Lateral mesosoma index: PH/WL × 100

PSLI Propodeal spine index: PSL/HL × 100

LPeI Lateral petiole index: PTL/PTH × 100

DPeI Dorsal petiole index: PTW/PTL × 100

LPpI Lateral postpetiole index: PPL/PPH × 100

DPpI Dorsal postpetiole index: PPW/PPL × 100

PPI Postpetiole index: PPW/PTW × 100

Automontage colour images of the treated species were taken using a Leica DFC450 digital camera with a Leica Z16 APO microscope and LAS (version 3.8) software. These images are also available online on AntWeb (www.AntWeb.org) and are accessible using the unique identifying specimen code. The taxonomic histories of the treated taxa follow the online catalogue of ants of the world (Bolton 2020). Distribution maps were made using DIVA-GIS (version 7.5.0.0).

Results

Synoptic list of Arabian Nesomyrmex *species*

Nesomyrmex angulatus (Mayr, 1862) [Oman, Saudi Arabia, Yemen]
= *Nesomyrmex angulatus ilgii* (Forel, 1894)
= *Nesomyrmex latinodis* (Mayr, 1895)
= *Nesomyrmex angulatus concolor* (Santschi, 1914)
Nesomyrmex humerosus (Emery, 1896) [Yemen]
Nesomyrmex zaheri Sharaf, Akbar and Hita Garcia, 2017 [Yemen]
Nesomyrmex micheleae Sharaf sp. nov. [Oman]

Key to the Arabian *Nesomyrmex* species (workers), modified after Sharaf et al. (2017).

1. Anterior clypeal lobe short, flat-margined and never convex, lobe with a small median triangular projection (Figure 2a); dorsal pronotum, seen from above, anterolaterally sharply marginate, with dentate corners (Figure 2b); in profile mesosomal outline strongly concave (Figure 2c); propodeal spines exceptionally long, about 3_X longer than its base and blunt apically (Figure 2c); petiole barrel-shaped with weakly developed, short and triangular petiolar node (Figure 2c) .. .. *N. humerosus* (Emery)
- Anterior clypeal lobe always conspicuously developed, convex and rounded, never with a small median triangular projection (Figure 2d); dorsal pronotum, seen from above, anterolaterally weakly marginate without dentate corners (Figure 2e); in profile mesosomal outline flat and uninterrupted (Figure 2f); propodeal spines distinctly shorter, about as long as its base and acute apically (Figure 2f); petiole with well-developed petiolar node (Figure 2f) 2
2. Clypeus without median longitudinal carina (Figure 3a); scapes when laid back from their insertions surpass posterior margin of eyes by about the length of the first funicular segment (Figure 3a) ..... *N. zaheri* Sharaf, Akbar and Hita Garcia
- Clypeus with a median longitudinal carina (Figure 3b); scapes distinctly longer, when laid back from their insertions either reach posterior margin of head or surpass posterior margin of eyes by about one-third the length of the scape (Figure 3b) ... 3
3. Head in full-face view with scapes when laid back from insertions reach posterior margin of head (Figure 3b); mesosoma with fewer pairs of longer hairs (about 10) (Figure 3c); uniform yellow (Figure 3c) ..... *N. angulatus* (Mayr)
- Head in full-face view with scapes when laid back from insertions fail to reach posterior margin of head (Figure 3d); bicoloured species, head black-brown to black, mesosoma, petiole and postpetiole dark brown, gaster golden yellow conspicuously contrasting with rest of body (Figure 4a) .... *N. micheleae* Sharaf sp. nov.

Nesomyrmex micheleae Sharaf sp. nov.
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(Figure 4a–c)

Holotype worker: OMAN: DHOFAR: Ayn Sahlanoot, 17.14766°N, 54.17878°E, alt. 151 m, 16 November 2017, BS, M.R. Sharaf leg., King Saud University Museum of Arthropods, Plant Protection Department, College of Food and Agriculture Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia (KSMA).
Paratype workers: Same data as the holotype, 2 w, CASENT0922872 (KSMA).

Measurements

Holotype worker: HL 0.75; HW 0.67; SL 0.62; EL 0.20; PRH 0.37; PRW 0.40; WL 1.0; PSL 0.07; PTL 0.25; PTH 0.27; PTW 0.25; PPL 0.17; PPH 0.25; PPW 0.30; TL 3.25; OI 30; SI 93; CI 89; DMI 40; LMI 37; PSLI 9; LPeI 93; DPeI 100; LPpI 68; DPpI 176; PPI 120.
Paratype workers: HL 0.77–0.82; HW 0.60–0.66; SL 0.53–0.62; EL 0.15–0.17; PRH 0.25–0.37; PRW 0.44–0.45; WL 0.97–0.98; PSL 0.05–0.06; PTL 0.17–0.21; PTH 0.20–0.22; PTW 0.20–0.23; PPL 0.17–0.18; PPH 0.21–0.22; PPW 0.27–0.28; TL 3.12–3.22; OI 23–28; SI 80–103; CI 78–80;

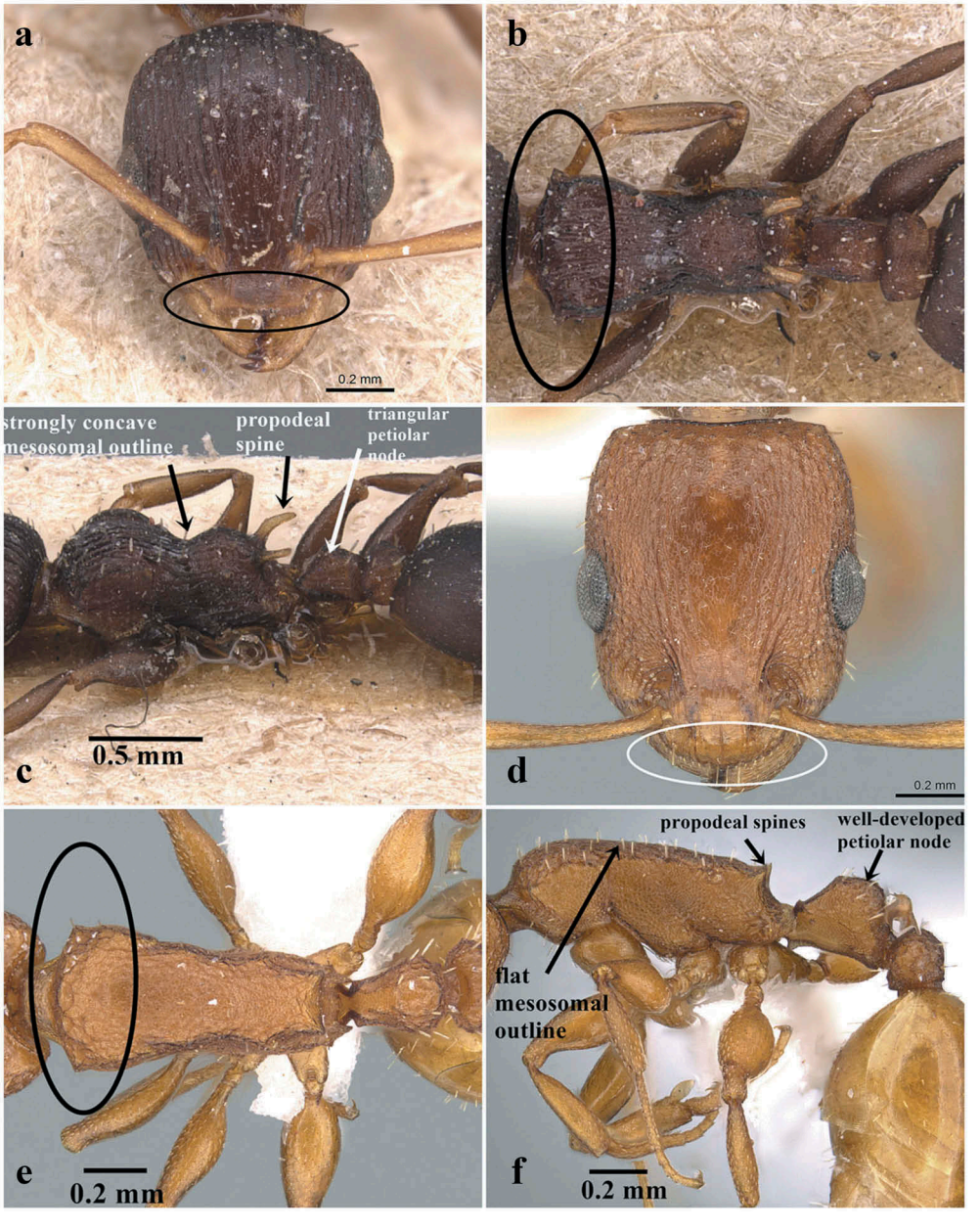

Figure 2. Key illustrations: (a) clypeus of *Nesomyrmex humerosus*, CASENT0904729 (Alexandra Westrich); (b) mesosoma of *N. humerosus* in dorsal view, CASENT0904729 (Alexandra Westrich); (c) mesosoma of *N. humerosus* in profile, CASENT0904729 (Alexandra Westrich); (d) clypeus of *N. angulatus*, CASENT0906378 (Estella Ortega); (e) mesosoma of *N. angulatus* in dorsal view, CASENT0906378 (Estella Ortega); (f) mesosoma of *N. angulatus* in profile, CASENT0906378 (Estella Ortega), https://www.antweb.org/citing_antweb.jsp.

DMI 45–46; LMI 26–38; OI 23–30, PSLI 6–7; LPeI 85–95; DPeI 110–118; LPpI 77–86; DPpI 156–159; PPI 122–135 (n = 2).

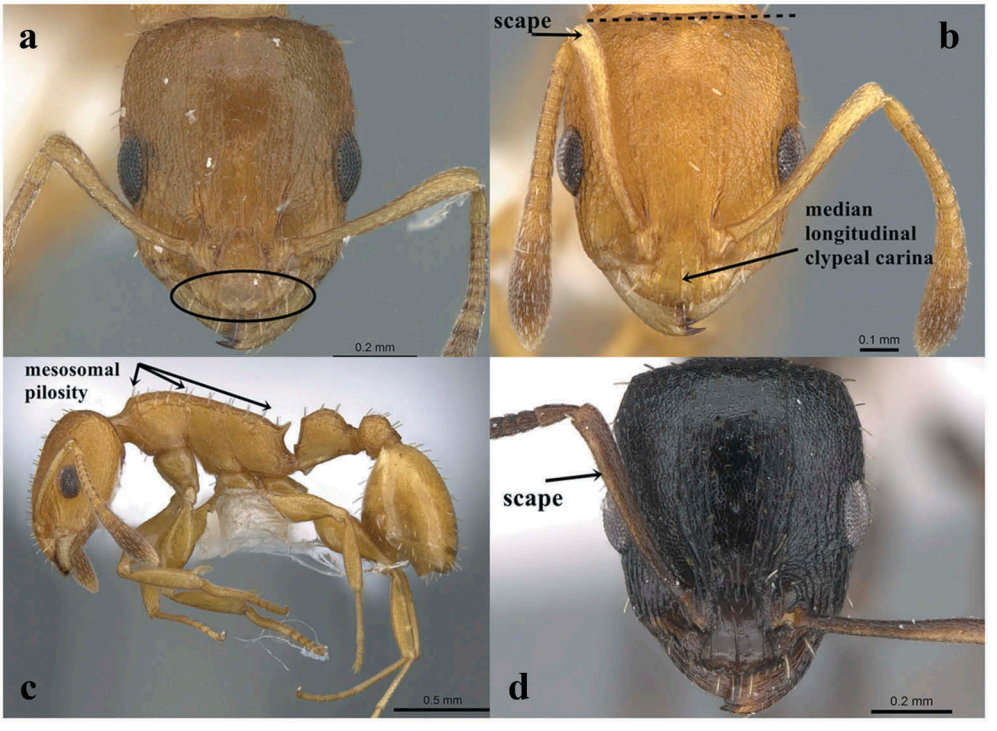

Figure 3. Key illustrations: (a) clypeus of *N. zaheri*, CASENT0906379 (Estella Ortega); (b) clypeus of *N. angulatus*, CASENT0922010 (Zach Lieberman); (c) body of *N. angulatus* in profile, CASENT0922010 (Zach Lieberman); (d) head of *N. micheleae* sp. nov. in full-face view, CASENT0922872 (Michele Esposito), https://www.antweb.org/citing_antweb.jsp.

Diagnosis. *Nesomyrmex micheleae* sp. nov. can be distinguished from regional congeners by the combination of the following characters: median clypeal carina distinct; petiolar node nearly hexagonal in dorsal view; area in front of eyes and median cephalic surface irregularly, longitudinally rugulose; body covered with erect, blunt, stout and moderately short setae; bicoloured species with head black-brown, mesosoma, petiole, postpetiole and appendages brown, gaster golden yellow.

Description

Worker. Head. Head distinctly longer than broad (CI 78–89) with straight or feebly convex posterior margin and lateral sides, broader posteriorly behind eye level in full-face view; lateral sides of head making a feeble but distinct obtuse angle with posterior margin of head in full-face view; antennal scapes relatively short (SI 80–103), when laid back from insertions fail to reach posterior margin of head in full-face view; masticatory margin of mandible with five teeth, decreasing in size from largest, acute apical tooth to smallest basal denticle; eyes of moderate size (OI 23–30) located at mid-length of head; anterior clypeal margin rounded; median clypeal carina distinct; frontal carinae and antennal scrobes absent. Mesosoma. In profile mesosomal outline absolutely flat without promesonotal suture or metanotal groove; pronotal corners acutely angular in dorsal view; propodeum armed with short and acute propodeal teeth (PSLI 6–9); metapleural

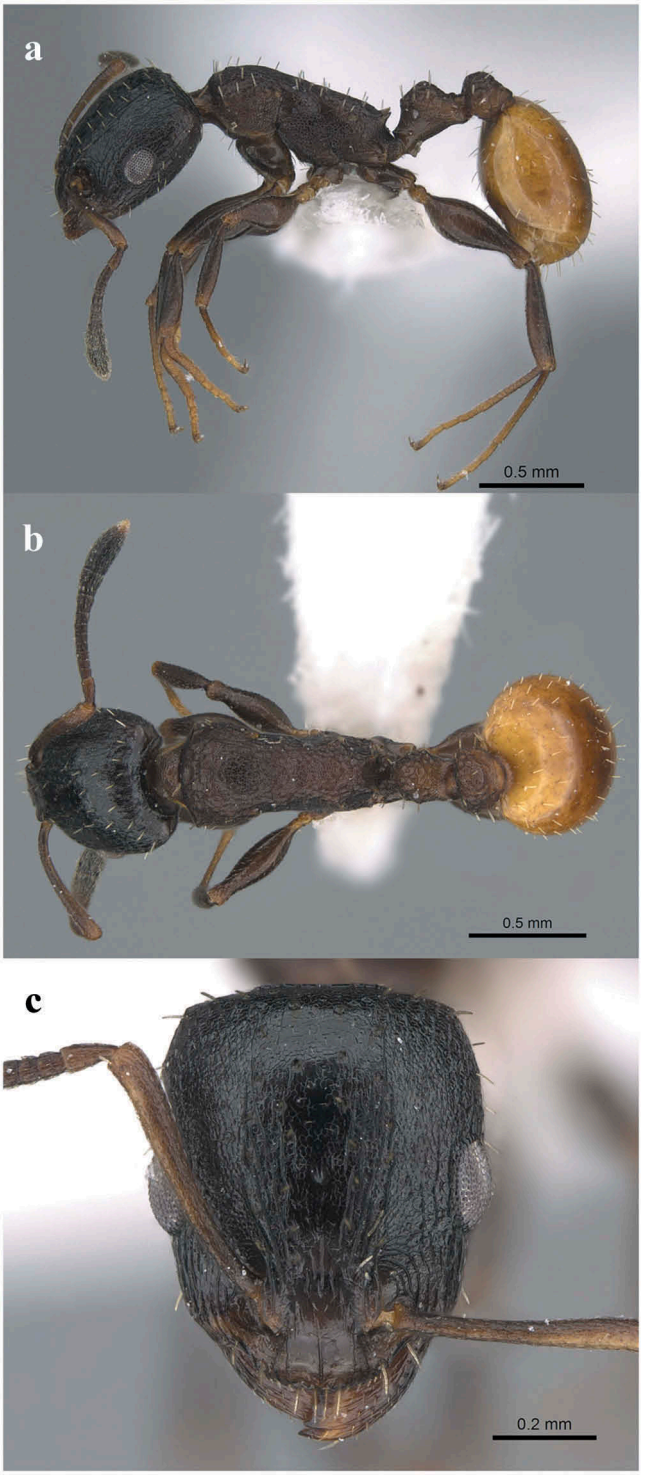

Figure 4. *Nesomyrmex micheleae*, sp. nov., paratype worker: (a) body in profile; (b) body in dorsal view; (c) head in full-face view, CASENT0922872 (Michele Esposito), https://www.antweb.org/citing_antweb.jsp.

lobe low and rounded. Petiole. In profile, petiolar peduncle short; node relatively high (LPeI 85–95) with straight-sloping anterior face; petiolar node nearly hexagonal in dorsal view and almost as broad as or little broader than long (DPeI 100–118); anteroventral process triangular and blunt. Postpetiole. Distinctly broader than long in dorsal view (PPI 122–135) with node lower than petiolar node in profile; postpetiole globular in profile distinctly higher than long (LPpI 68–86); in dorsal view, postpetiolar node more than 1.5× broader than long (DPpI 156–176); in dorsal view, postpetiolar node distinctly broader than petiolar node (PPI 120–135). Sculpture. Mandibles longitudinally striated; area in front of eyes and median cephalic surface irregularly longitudinally rugulose; ground sculpture between cephalic rugae and remaining cephalic surface finely and superficially imbricate; median clypeal carina distinct, two lateral feebly distinct longitudinal rugae present; mesosomal, petiolar and postpetiolar sides finely reticulate-punctate; seen from dorsal view, mesosomal margins, petiolar and postpetiolar nodes distinctly reticulate-rugulose; mesonotum and propodeal dorsum finely punctate; gaster smooth and shining. Pilosity. Head, mesosoma, petiole, postpetiole and gaster dorsally with erect, blunt, stout and moderately short setae; funiculus with dense appressed pubescence; anterior clypeal margin with fine long setae; mandibles with fine shorter setae. Colour. Strongly bicoloured species with head black-brown, mesosoma, petiole, postpetiole, antennae, femur and tibia brown or dark brown, tarsi yellow, gaster golden yellow, with brown tints dorsally on first gastral tergite.

Etymology. The patronym for *N. micheleae* sp. nov. has been chosen in honour of Michele Esposito, California Academy of Sciences (CAS), San Francisco.

Differential diagnosis. As defined by Hita Garcia et al. (2017), *N. micheleae* sp. nov. is a member of the *N. angulatus* species group with which it shares the following characters: antennae 12-segmented; anterior clypeal margin convex and without anterior projections; propodeal spines well developed; petiole and postpetiole without lateral projections; body pilosity short and blunt. Within the *N. angulatus* species group, *N. grisoni* (Forel 1916) from Democratic Republic of Congo is apparently morphologically similar to *N. micheleae* sp. nov., sharing the sharply angular pronotal corners, the distinctly reticulate-rugulose petiolar and postpetiolar nodes, the smooth gaster, the short and acute propodeal spines, the short petiolar peduncle, and the blunt and short body pilosity. However, *N. micheleae* sp. nov. is readily distinguished from *N. grisoni* by the golden yellow gaster that contrasts with the dark brown body; the irregular longitudinal rugulose sculpture on cephalic surface; the finely punctate mesonotum and propodeal dorsum. *Nesomyrmex grisoni* has a unicolourous brown or black-brown body, and strong reticulate rugae on cephalic, mesonotal and propodeal surfaces. Among the Arabian species, *N. micheleae* sp. nov. appears superficially similar to *N. zaheri* but the former species can be separated by the relatively longer scapes that fail to reach the posterior margin of the head in full-face view, and the obtusely angled pronotal corners when seen in dorsal view, whereas *N. zaheri* has distinctly shorter scapes that surpass the posterior level of the eyes by about the length of the first funicular segment in full-face view, and distinctly rounded pronotal corners.

Nesomyrmex micheleae sp. nov. also looks similar to *N. angulatus* but the latter species has relatively longer scapes that reach the posterior margin of head in full-face view, one

pair of small acute dents on pronotal corners when seen in dorsal view, and higher ocular and dorsal postpetiole indices (OI 27–35, DPpI 154–188) versus (OI 23–28; DPpI 156–159) in *N. micheleae*. Additionally, *N. micheleae* sp. nov. is easily separated from all Arabian *Nesomyrmex* species by its strongly bicoloured body which has a black to black-brown head, and the mesosoma, petiole and postpetiole are dark brown, contrasting with the golden yellow gaster.

Ecological and biological notes. The three collected workers of *N. micheleae* sp. nov. were foraging on a large tree in Ayn Sahalnoot of the Dhofar Governorate in the south of Oman (Figure 5), and were collected using a beating sheet. Additional collections in a broad range of habitats in the Dhofar Governorate were not successful in obtaining additional material. The type locality, Ayn Sahalnoot or Wadi Sahalnoot, has spectacular natural scenery. The Dhofar Governorate is a rich, biodiverse region shaped by climate factors (the average annual temperature and precipitation in Salalah are 25.8°C and >94 mm, respectively) and vegetated with frequent areas of small- to medium-sized perennial shrubs, scattered between broader areas of loam, gravel and rocks and semi-evergreen grassland.

Geographic range. Known only from Oman.

Discussion

The distribution of the Arabian *Nesomyrmex* species is confined to the south-western mountains of the Arabian Peninsula including Yemen and extending eastward to the

Figure 5. Ayn Sahlanot, type locality of *Nesomyrmex micheleae* sp. nov. (Annette Patzelt).

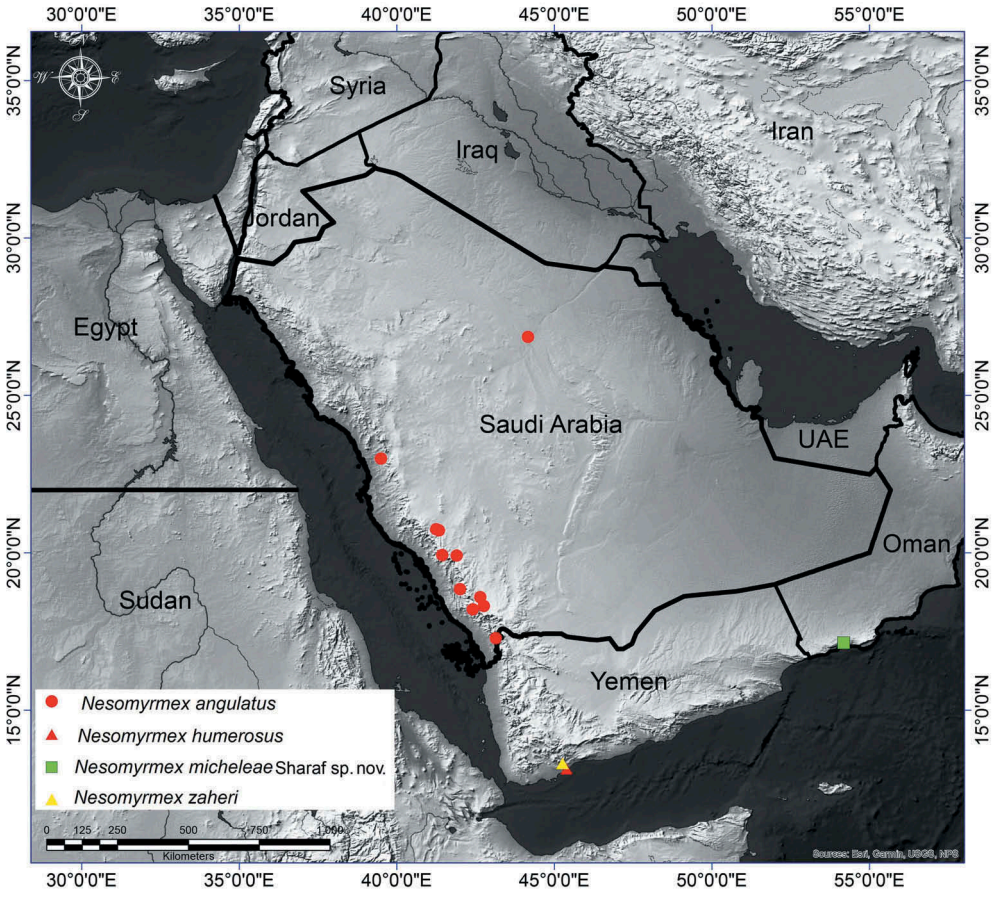

Figure 6. Distribution map of Arabian *Nesomyrmex*.

Dhofar Governorate (Figure 6). There is a noticeable scarcity of material of the Arabian *Nesomyrmex* species, where most published records for all species, except *N. angulatus*, are based on a small number of specimens, including *N. humerosus* (1 specimen), *N. micheleae* sp. nov. (3) and *N. zaheri* (1) (Collingwood 1985; Collingwood and Agosti 1996; Sharaf et al. 2017). This observation was mentioned in Bolton's (1982) revision of Afrotropical fauna of *Nesomyrmex* including *N. humerosus* (2), *N. innocens* (Forel, 1913) (1), *N. simoni* (Emery, 1895) (1) and *N. stramineus* (Arnold, 1948) (1), and was attributed to the direct competition from the extremely diverse and successful Tetramoriine faunal members.

Nesomyrmex micheleae sp. nov. appears to be a geographically isolated species; therefore, it is most probably endemic to Dhofar and the southern Arabian Peninsula, where only three specimens were collected despite the remarkably extensive sampling efforts, with multiple observations of many other ant genera (Collingwood and Agosti 1996). It is also expected that this is a cryptic species due to the lack of baseline data related to the species' biology and bionomics. This may be due to the effectiveness of conservation efforts in areas like Ayn Sahalnoot, in preserving this unique arid fauna (Waterston and Pittaway 1991; Hájek and Reiter 2014). However, Dhofar is zoo- and geographically close

to Yemen, as it lies in Southern Oman and is located on the eastern border with Yemen's Al Mahrah Governorate, and the two zones share Afrotropical affinities (e.g. Guichard 1980; Larsen and Larsen 1980; Larsen 1984; Collingwood 1985; Cowie 1989; Collingwood and Agosti 1996; Pesenko and Pauly 2009). Therefore, it is anticipated that *N. micheleae* sp. nov. is likely to be recorded from Yemen.

The Dhofar Governorate, however, has a notable proportion of apparently endemic species (5 spp. or 9%, out of total 55 species), namely *Lepisiota dhofara* Collingwood and Agosti, 1996, *L. elbazi* Sharaf and Hita Garcia, 2020 (Sharaf et al. 2020), *Crematogaster jacindae* Sharaf and Hita Garcia, 2019, *Meranoplus mosalahi* Sharaf, 2019, and *Nesomyrmex micheleae* sp. nov. Along with the south-western mountains of the Arabian Peninsula that extend to Yemen, the Dhofar Governorate is one of the biodiversity-rich regions that harbour a high number of endemic taxa of numerous faunal groups including amphibians (Arnold 1980), reptiles (Šmíd 2010; Melnikov and Pierson 2012), birds (Ball 2014; Ball et al. 2015) and arthropods of different groups including Isopoda (Taiti et al. 2000), Lepidoptera (Larsen and Larsen 1980; Hausmann 2009), Isoptera (Cowie 1989), Odonata (Waterston and Pittaway 1991; Schneider and Krupp 1993), Coleoptera (Hájek and Reiter 2014) and Hymenoptera (Collingwood and Agosti 1996; Pesenko and Pauly 2009; Sharaf and Aldawood 2019; Sharaf et al. 2019).

The results of the present study reveal more hidden diversity in the Arabian Peninsula, with an emphasis on Southern Oman, and stress iteratively the importance of this unique semi-isolated geographical region as a hotspot of semi-arid ecosystem diversity and a priority focal point for insect biodiversity.

Acknowledgements

We are grateful to Kadri Kiran and an anonymous reviewer for valuable comments. We thank Annette Patzelt for the appreciated permission to use the image of Ayn Sahlanot, Saif Al-Hatmi (Oman Botanic Garden) for support during the field work in Oman, Brian Fisher for help in imaging the new species, Said M. Said for creating the distribution map, and Mahmoud Abdel-Dayem for useful discussions on the biogeography of the Arabian Peninsula.

Disclosure statement

The authors declare there are no competing interests. The funder had no role in the experimental design, data collection, data analysis or manuscript preparation.

Funding

This work was supported by the Deanship of Scientific Research at King Saud University [RG-1438-010].

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