



Contents lists available at ScienceDirect

Journal of Asia-Pacific Biodiversity

journal homepage: <http://www.elsevier.com/locate/japb>



Original Article

A new species of *Crematogaster* Lund, 1831 (Hymenoptera: Formicidae) from Iran with an identification key to Iranian *Crematogaster* species



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ARTICLE INFO

Article history:

Received 1 June 2023

Received in revised form

7 August 2023

Accepted 16 August 2023

Available online 9 September 2023

Keywords:

Ants

Taxonomy

new species

Crematogaster

Iran

ABSTRACT

A new species of *Crematogaster* Lund, 1831, *Crematogaster gypsophila* Mohseni, sp. nov., is described based on museum and worker specimens from Iran collected in 2022. *Crematogaster gypsophila* appears to be well-adapted to gypseous soils. It was found only at one site, a gypsum arid dryland covered with sparse but diverse vegetation, suggesting it may have a narrow niche breadth. Additionally, we present a synoptic list and an identification key to the Iranian *Crematogaster* species.

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Introduction

The genus *Crematogaster* Lund, 1831, includes 521 extant species, three fossil species, and 260 valid subspecies and is among the most hyperdiverse ant genera (Blaimer 2012a; Antcat 2023). The genus is cosmopolitan in tropical and subtropical areas (Hölldobler and Wilson 1990; Longino 2003). Even with its considerable regional abundance and ecological significance, the genus *Crematogaster* is one of the most taxonomically overlooked species-rich ant genera (Sharaf et al. 2019). To date, extensive work on this genus has been limited to North America (Buren 1959, 1968; Ward and Blaimer 2022), Costa Rica (Longino 2003), Madagascar (e.g., Blaimer 2010, 2012b, 2012c), and parts of Southeast Asia (e.g., Hosoiishi and Ogata 2008, 2009, 2015, 2017). However, studies are lacking in much of the rest of the world, including western Asia, including Iran (Paknia et al. 2008; Mohseni 2018; Mohseni et al. 2019; Mohseni and Pashaei Rad 2021; Pashaei Rad and Mohseni 2023).

Iran has a combination of diverse ecosystems, including dense forests, mountainous areas, vast grassy plains, and dry deserts and salt pans (Alizadeh-Choobari and Najafi 2018). This wide range of habitats leads to a high diversity and distribution of different animal species, including ants (Taheri and Reyes-López 2015; Mohseni and Pashaei Rad 2019). However, the myrmecofauna of Iran has been inadequately researched (Paknia et al. 2010; Mohseni and Pashaei Rad 2021; Pashaei Rad and Mohseni 2023) and requires further study. Only 270 ant species in 37 genera have been recorded from Iran (Antmaps 2023; Janicki et al. 2016; Guénard et al. 2017; AntWeb 2023, and Antwiki 2023), and it is expected that this number will significantly increase, given the range of biomes still to be thoroughly explored (Mohseni 2018; Pashaei Rad and Mohseni 2023).

The genus *Crematogaster* is widespread in Iran with 14 recorded species: *C. afghanica* Pisarski, 1967, *C. antaris* Forel, 1894, *C. auberti* Emery, 1869, *C. bogojawlenskii* Ruzsky, 1905, *C. hezardadjatica* Pisarski, 1967, *C. inermis* Mayr, 1862, *C. laestrygon* Emery, 1869, *C. melanogaster* Emery, 1895 (reported by Parsa in 2012 and awaiting validation), *C. oasium* Santschi, 1911, *C. schmidti* (Mayr, 1853), *C. sordidula* (Nylander, 1849), *C. sorokinii* Ruzsky, 1905, *C. subdentata* Mayr, 1877, and *C. warburgi* Menozzi, 1933, recorded from the country (Crawley 1920; Paknia 2002; Paknia et al. 2008; Ghahari et al. 2009; Ghahari et al. 2011; Gholami et al. 2012; Parsa 2012; Borowiec and Salata 2012; Shiran et al. 2013; Ghahari and Collingwood 2013; Bracko et al. 2014; Borowiec 2014; Safariyan

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Peer review under responsibility of National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

2015; Afshari 2015; Mortazavi et al. 2015; Ghahari et al. 2015; Moradloo et al. 2015; Mohseni 2018; Pashaei Rad et al. 2018; Khalili-Moghadam et al. 2019; Mohseni et al. 2019; Mohseni and Pashaei Rad 2021).

Crematogaster specimens can be challenging to identify to species (Sharaf et al. 2019). Moreover, based on Kreft and Jetz's findings in 2010 about discontinuities in the taxonomic composition of assemblages due to boundaries and transition zones between areas and considering the biogeographical associations of Iran in the south of the Palearctic realm with those belonging to the Afrotropical region (Wallace 1876), the study of Iranian *Crematogaster* taxonomy is even more complex than the other parts of the world. Furthermore, a considerable number of *Crematogaster* species have large female reproductives, which would, in many cases, result in extensive distribution spans because of remarkable dispersal capabilities (Sharaf et al. 2019). Consequently, scrutinizing and comparing a plethora of Palearctic- and Afrotropical-type specimens from natural history collections must be considered to ensure any Iranian *Crematogaster* material identification. While this study does not attempt this immense task, we hope to make a fundamental stride toward comprehending the Iranian *Crematogaster* fauna and pave the way for further myrmecological research.

This paper describes *C. gypsophila* Mohseni sp. nov. from Iran and provides a synoptic list of all known Iranian *Crematogaster* species and an identification key based on the worker caste, which would cover all the *Crematogaster* specimens that have been recorded from Iran.

Material and methods

Geographic origins and sampling

Iran lies in a transition zone between three biogeographic regions, including the Palearctic, Afrotropical, and Oriental (Paknia et al. 2010), resulting in a diverse fauna. Iran also has a range of climactic zones. For example, the average annual precipitation from the Western Caspian Sea coast and Western mountains to the uninhabitable Eastern deserts ranges from 1800 mm to less than 50 mm (Amiri and Eslamian 2010). This leads to diverse vegetation and a corresponding diversity in animal species, including ants. The combination of high biodiversity, together with poor knowledge of Iran's myrmecofauna (Paknia et al. 2010; Mohseni and Pashaei Rad 2021), inspired us to study the ant fauna.

During fieldwork in Qom province, carried out in 2022, a number of species belonging to *Crematogaster* were collected, of which, one appears to be undescribed. This undescribed species was collected by hand and pitfall traps only in a gypsum mine soil on 2 and 3 May 2022 (Figure 1, 3). Specimens were stored in 96% ethanol prior to being mounted and visually analyzed.

Sampling site

The gypsum mine study area in the south part of Qom Province has a dry and cold six-month period from October to March and a dry and warm period from May to August. Despite its arid climate and poor vegetational coverage (Figures 1, 3), various types of gypsophiles, gypsovags, and harsh plants can be found in this area. The zone, which is at an elevation of 1582–1588 meters above the sea level and surrounded by rocky mountains, is characterized by its gypseous (high-gypsum) soil.

Morphological study

Worker ants were examined with a Novel NSZ-405 Binocular Zoom Stereo Microscope, photographed using PenPix Z5 Optics

Digital Microscope, and drawings were made with Adobe Illustrator CC 2022/Adobe Illustrator CC 2022 v26.5.0.223. The images, illustrations, and scales were also processed and adjusted using Adobe Photoshop CS6 13.0 (Adobe Inc., San Jose, CA, USA). Specimen measurements were taken with an accuracy of 0.001 mm and rounded to the nearest 0.01 mm, using a standard outside micrometer and Image software (Schindelin et al. 2012). To read the micrometer in 0.001 increments, the number of vertical separators observable on the sleeve was multiplied by 0.025, then the value was added to the number of thousandths demonstrated by the line on the thimble, which best coincided with the long central line on the sleeve.

In order to confirm our findings, we used a wide range of *Crematogaster* identification keys and references, including Mayr (1879), Ruzsky (1905), Crawley (1920), Collingwood and Agosti (1996), Cagniant (2006), Heterick (2009), Blaimer (2012a), Hosoiishi and Ogata (2012), Hosoiishi and Ogata (2016), Blaimer et al. (2018), Sharaf et al. (2019), Kiran and Karaman (2020), as well as Iranian identification keys and references including Paknia (2002), Paknia et al. (2008), Paknia et al. (2010), Ghahari et al. (2009), Ghahari et al. (2011), Gholami et al. (2012), Parsa (2012), Shiran et al. (2013), Ghahari and Collingwood (2013), Afshari (2015), Mortazavi et al. (2015), Ghahari et al. (2015), Safariyan (2015), Moradloo et al. (2015), Ghatei Kalashami (2016), Torabi (2016), Mohseni (2018), Khalili-Moghadam et al. (2019), Mohseni et al. (2019), Mohseni and Pashaei Rad (2019), Mohseni and Pashaei Rad (2021), and Pashaei Rad and Mohseni (2023) and our personal experience to identify the specimens. Noteworthy, the taxonomic histories of the taxa and general information of the species follow the online catalog of ants of the world by Bolton (Antcat 2023), and the reference portals of Antmaps (<https://www.antmaps.org>; Janicki et al. 2016; Guénard et al. 2017), AntWeb (<https://www.antweb.org>), and Antwiki (<https://www.antwiki.org>).

Preservation of specimens

Specimens were deposited in the following museums and private collection. Abbreviations follow Evenhuis (2023).

HMIM: Iran, Tehran, Hayk Mirzayans Insect Museum

OUMNH: United Kingdom, Oxford, University Museum of Natural History

MRMC: Iran, Qom, Mohammad Reza Mohseni's private collection

Terminology and measurements

Morphological description, terminology, measurements, and indices follow Harris (1979), Longino (2003), and Blaimer (2010). However, while Longino's and Blaimer's measurements of head width include the eyes, we took our measurement behind the eyes. All measurements are represented in millimeters recorded to the second decimal place.

TL: Total length: maximum distance from the anterior part of the head to the posterior part of the abdomen;

EL: Eye length: maximum diameter of compound eye in profile;

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

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

LHT: Length of metatibia: maximum metatibia length excluding the proximomedial condyle;

ML: Mesosomal length: diagonal length of mesosoma in profile from posteroventral margin of propodeal lobe to anterior most point of pronotal slope, excluding neck;



Figure 1. Locations of the holotype and paratypes of *Crematogaster gypsophila* Mohseni, sp. nov.

PPL: Postpetiole length: maximum length of postpetiole measured in dorsal view;

PPW: Postpetiole width: maximum width of postpetiole measured in dorsal view;

PRW: Pronotal width: maximum pronotal width in dorsal view;

PTH: Petiole height: measured from petiole sternum to apex, in profile;

PTL: Petiole length: measured in profile as distance from dorso-posterior margin of segment to anterior inflection point where petiole curves up to condyle;

PTW: Petiole width: maximum width of dorsal face of petiole node measured in dorsal view;

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

Indices

CI: Cephalic index: $HW/HL \times 100$.

OI: Ocular index: $EL/HW \times 100$.

SI: Scape index: $SL/HW \times 100$.

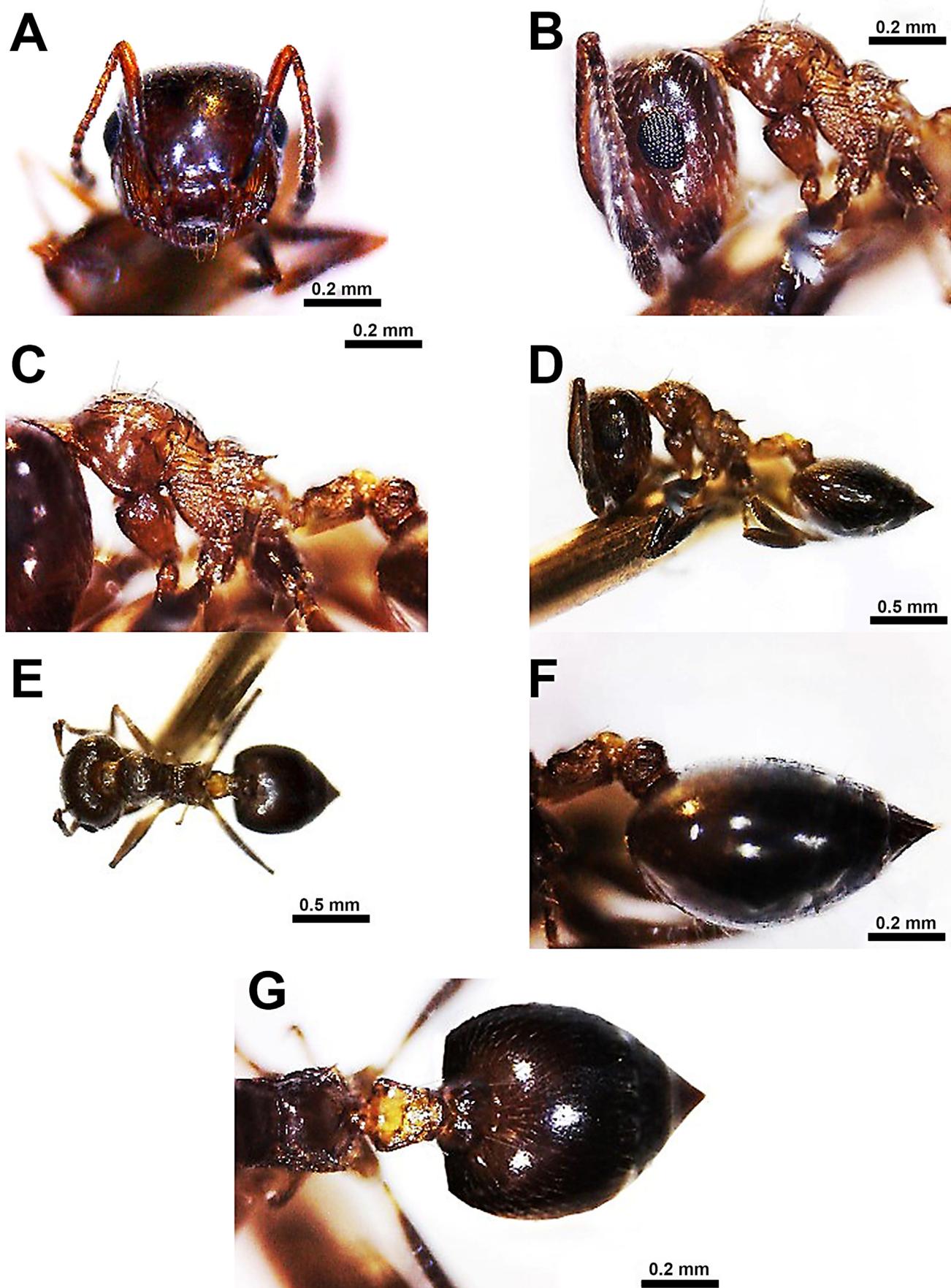


Figure 2. *Crematogaster gypsophila* Mohseni sp. nov. (Holotype): (A, H), head in full-face view; (B) head and mesosoma in profile; (C) mesosoma and waist in profile; (D, I) body in profile; (E, J) body in dorsal view; (F) waist and gaster in profile; (G) propodeum, waist, and gaster in dorsal view.

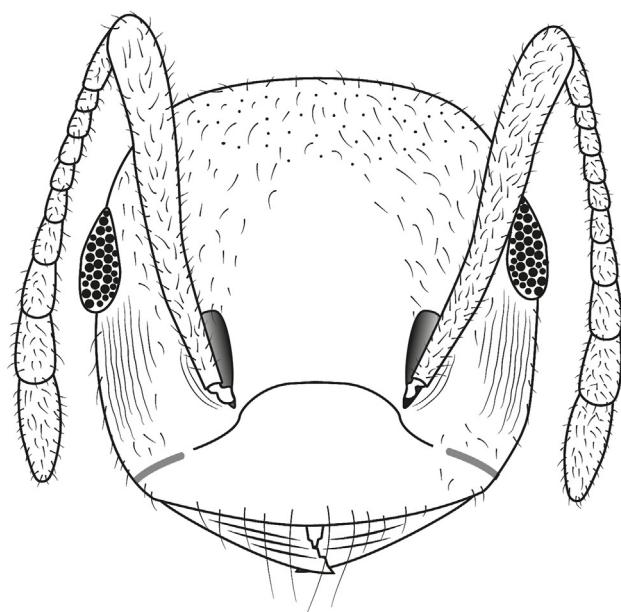
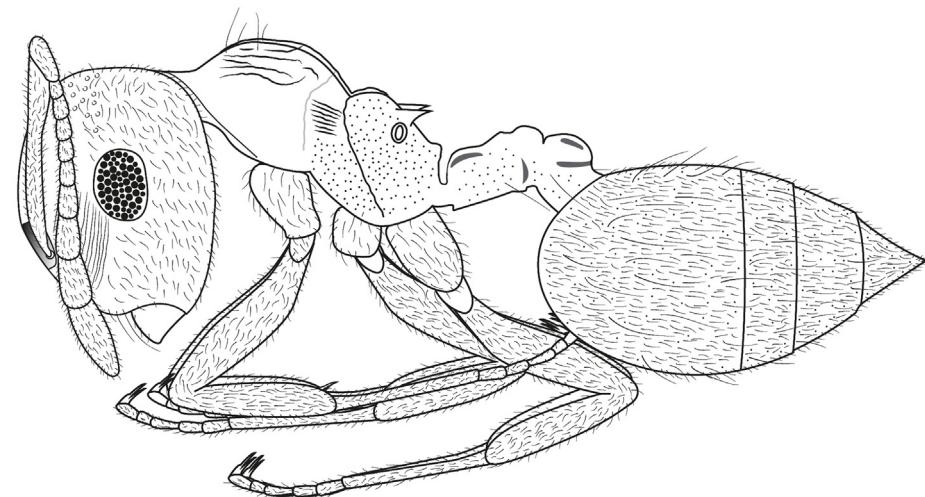
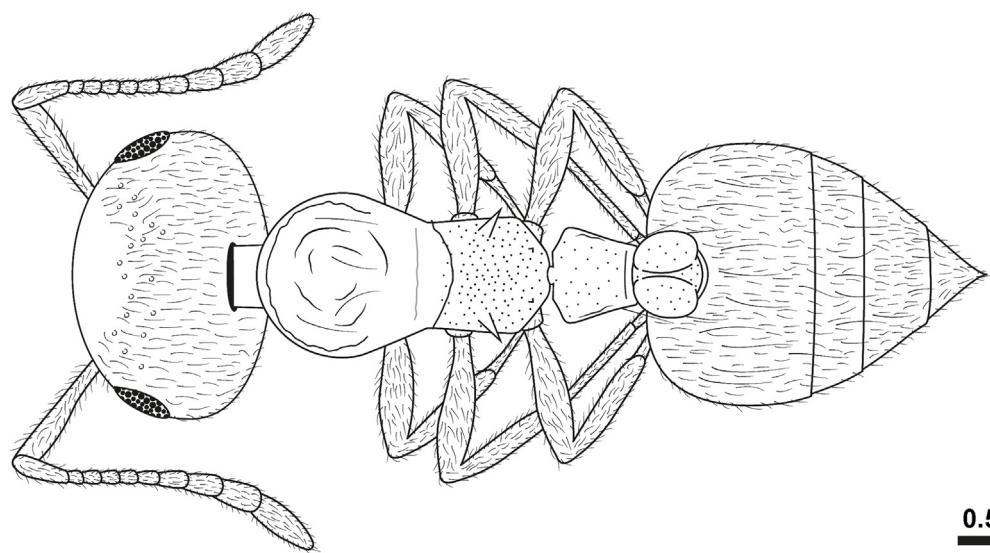
H**I****J**

Figure 2. (continued).



Figure 3. Qom Province, Gypsum Mine, Holotype locality of *C. gypsophila* Mohseni sp. nov.

PTHI: Petiole height index: PTH/PTL × 100.

PTWI: Petiole width index: PTW/PTL × 100.

PPI: Postpetiole index: PPW/PTW × 100.

Results

Synoptic list of Iranian Crematogaster species

Crematogaster afghanica Pisarski, 1967.....Validated by: Antmaps, Antweb, Antwiki

Crematogaster antaris Forel, 1894.....Validated by: Antmaps, Antweb, Antwiki

Crematogaster auberti Emery, 1869.....Validated by: Antweb, Antwiki

Crematogaster bogojawlenskii Ruzsky, 1905.....Validated by: Antmaps, Antwiki

Crematogaster gypsophila Mohseni sp. nov.

Crematogaster hezadadjatica Pisarski, 1967.....Validated by: Antmaps, Antweb, Antwiki

Crematogaster inermis Mayr, 1862.....Validated by: Antmaps, Antweb, Antwiki

Crematogaster laestrygon Emery, 1869.....Validated by: Antmaps

Crematogaster melanogaster Emery, 1895.....Recorded by Parsa (2012) and is awaiting validation

Crematogaster oasisum Santschi, 1911.....Validated by: Antmaps

Crematogaster schmidti (Mayr, 1853).....Validated by: Antmaps, Antweb, Antwiki

Crematogaster sordidula (Nylander, 1849).....Validated by: Antmaps

Crematogaster sorokinii Ruzsky, 1905.....Validated by: Antmaps, Antweb, Antwiki

Crematogaster subdentata Mayr, 1877.....Validated by: Antmaps, Antweb, Antwiki

Crematogaster warburgi Menozzi, 1933.....Validated by: Antmaps, Antwiki

Key to Iranian Crematogaster species

1. Postpetiole not divided into two lobes dorsally.....2
- Postpetiole divided by a median longitudinal furrow into two lobes dorsally (Figure 2E, G, J).....3
2. Body color uniformly dark brown; propodeum with at least a pair of long hairs; petiole with a distinct ventral tooth.....*C. sordidula* (Nylander)
- Body color nonuniformly light brownish-yellow, the color of the vertex, the end of the flagellum, the transverse bands of the gaster's segments, and the posterior part of the gaster brown; propodeum with no or very rare long hairs; petiole with a very small ventral tooth.....*C. bogojawlenskii* Ruzsky
3. Propodeum unarmed or with short spines.....4
- Propodeum with strong and well-developed spines (Figure 2B, C, D, G, I, J).....6
4. First segment of funiculus is as long as the two following segments together; mesosoma with no or few erect hairs but body with pubescence5
- First segment of funiculus longer than the two following segments together; mesosoma with erect hairs and body with pubescence.....*C. subdentata* Mayr
5. Body uniformly brown, covered with dense pubescence; maximum petiole width anterior.....*C. inermis* Mayr
- Bicolored, gaster always dark brown; mesosoma with sparse pubescence, somewhat more abundant in head and abdomen; maximum petiole width in the middle.....*C. warburgi* Menozzi
6. Head brighter than gaster.....7
- Head and gaster same color.....10
7. Pronotum moderately fine sculptured laterally
-*C. oasisum* Santschi
- Pronotum with strong longitudinal striae laterally.....8

8. Head and mesosoma light brown; head with fine sculpturing; second funiculus segment longer than third; pronotum without long hairs; gaster pubescent.....*C. schmidti* (Mayr)
- Head and mesosoma dark brown; head with strong sculpturing; second funiculus segment as long as third; pronotum with long hairs; gaster covered by pubescence and long hairs.....9
9. Pronotum with a pair of long hairs; gaster darker in posterior two-thirds.....*C. sorokinii* Ruzsky
- Pronotum at least with two pairs of long hairs; gaster dark brown.....*C. melanogaster* Emery
10. Promesonotum unsculptured or feebly imbricate in dorsal view; petiole with a concave anterior margin in dorsal view11
- Promesonotum longitudinally striated in dorsal view; petiole without a concave anterior margin in dorsal view13
11. Body color uniformly yellow; promesonotum with fine and confused sculpture.....*C. hezarakadjatica* Pisarski
- Body color uniformly dark brown; promesonotum with well-developed longitudinally striae.....12
12. Body color uniformly blackish brown; mesonotum strongly convex in profile; propodeal spines longer, about ca. 1.5× longer than bases.....*C. auberti* Emery
- Body color uniformly brown; mesonotum not strongly convex in profile; propodeal spines shorter, about ca. 0.5× longer than bases.....*C. antaris* Forel
13. Bicolored, head and gaster blackish brown and darker than mesosoma, petiole relatively lighter than other parts; cephalic surface, including frontal area unsculptured and without pubescence; scape with sparse pubescence; anepisternum strongly striated and katepisternum punctulated; petiole pentagonal form (Figure 2).....*C. gypsophila* Mohseni sp. nov.
- Head and gaster same color as mesosoma; cephalic surface, including frontal area sculptured and with pubescence; both anepisternum and katepisternum striated; petiole trapeziform.....14
14. Body color uniformly yellowish brown; pronotum shining in profile.....*C. afghanica* Pisarski
- Body color uniformly black or blackish brown; pronotum moderately sculptured in profile.....*C. laestrygon* Emery

Taxonomic accounts

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 gypsophila Mohseni, sp. nov. (Figure 2A–J)

LSID: <http://zoobank.org/DA835063-1D37-4610-BF3D-A0380B65E62A>

Type material. Holotype (worker). Iran, Qom Province, Gypsum Mine (34.239765° N, 50.595631° E); Elevation: 1584 m; 2 v 2022; Mohseni M. R. leg.; (CASENT0001714, HMIM); Queen and male: Unknown.

Paratypes. 5 workers from the same location, date, and nest of the holotype; 5 workers, Iran, Qom Province, Gypsum Mine (34.242046° N, 50.597275° E); Elevation: 1586 m; 2 v 2022; Mohseni M. R. leg.; (MRMC, HMIM); 10 workers, Iran, Qom Province, Gypsum Mine (34.242491° N, 50.597865° E); Elevation: 1587 m; 3 v 2022; Mohseni M. R. leg.; (MRMC, OUMNH).

Diagnosis. *Crematogaster gypsophila* is distinguished by the following morphological features: frons of head and coxa shining and without sculpturing and hairs; gena longitudinally striated in full-face view; scape with sparse short hairs; prothorax without striae laterally; with punctulate sculptured katepisternum and propodeum; propodeal spines short but completely developed in profile; petiole with only one pair of long pale hairs on posterior sides, from dorsal view, yellow; petiole lighter than other parts, petiole pentagonal form; gaster relatively brighter in the initial third part.

Measurements and indices. Holotype worker. TL ca 3 mm; EL 0.21; HL 0.90; HW 0.86; LHT 0.85; ML 0.98; PPL 0.15; PPW 0.20; PRW 0.56; PTH 0.20; PTL 0.33; PTW 0.35; SL 0.82; **Indices:** CI 96; OI 24; SI 95; PTHI 61; PTWI 106; PPI 57.

Paratype workers (n = 20). TL ca 2.8–3.1 mm; EL 0.18–0.23; HL 0.86–0.92; HW 0.82–0.90; LHT 0.82–0.88; ML 0.9–1.02; PPL 0.12–0.16; PPW 0.16–0.25; PRW 0.5–0.6; PTH 0.16–0.24; PTL 0.26–0.35; PTW 0.28–0.4; SL 0.75–0.86;

Indices. CI 95–98; OI 22–26; SI 91–96; PTHI 61–69; PTWI 108–114; PPI 57–63.

Description. Worker. Head. Head not or scarcely longer than broad; posterior margin of head smoothly rounded laterally; antennae with 11 segments, antennae with distal four or five segments forming somewhat indistinct club; in full-face view, antennal scapes reach the posterior margin of head; with relatively large compound eyes (OI: 22–26), situated above the midline of head in full-face view.

Mesosoma. Promesonotum and mesonotum forming relatively continuous curve in profile; promesonotal suture not well developed; mesonotal keel very slight; propodeal spines fairly short but acute and well developed; propodeal spiracle round-shaped.

Petiole. In lateral view, petiole longer than high (PTHI: 61–69; PTWI: 108–114); broader in anterior part than posterior in dorsal view; petiole pentagonal form; petiole wider than postpetiole; subpetiolar process well developed.

Postpetiole. Postpetiole bilobed by median longitudinal furrow in dorsal view.

Pilosity. Apart from frons, head with relatively abundant scattered fine suberect pubescence; clypeal margin with four long yellow setae in anterior part; frons and posterior part of clypeus with no hairs or pubescence; antennae and legs with abundant fine pubescence; pronotum with a few pale long hairs; petiole and postpetiole, each with a pair of long pale hairs on the sides and posterior part, respectively; from dorsal view, gaster with abundant appressed short and long hairs.

Sculpture. Cephalic surface, particularly frons, smooth; vertex sculpture superficial or feebly imbricate; gena with rather strong longitudinal striae in full-face view; clypeal surface smooth; mesoscutum with fairly distinct sculpturing; anepisternum with longitudinal striae; katepisternum and propodeum with punctulate sculpturing; pronotum and coxa smooth, laterally; petiole and postpetiole finely sculptured; gaster smooth with fine superficial sculpturing.

Color. General appearance shining; body relatively bicolored black-brown; head and the posterior two-thirds of the gaster blackish brown; mesosoma brown; petiole yellow; postpetiole and the basal third of the gaster brownish-yellow.

Ecological and biological notes. *Crematogaster gypsophila* appears to be restricted to gypseous soils, gypsum drylands poorly covered with herbaceous and plants such as *Alhagi maurorum*, *Artemisia sieberi*, *Bassia indica*, *Gypsophila aretioides*, *Gypsophila viscosa*, *Lepidium subulatum*, *Ononis tridentata*, and *Prosopis farcta* (Figure 1, 3). Foragers were found near the nests; specimens were sampled from gypsum powder and close to the gypsum stones situated near a gypsum mine.

Geographic range. *Crematogaster gypsophila* is only known from Qom Province, Gypsum Mine (34.239765° N, 50.595631° E) of Iran (Figure 1, 3).

Etymology. The species name *gypsophila* (gypsum loving) is a combination of Latin nouns in the nominative case used in apposition (Noun stem + feminine adjectival suffix in the nominative) and refers to the nesting preference in gypsum soil.

Remarks. *Crematogaster gypsophila* seems to be closely related to *C. laestrygon* as it has the same body color, same sculptured mesonotum, large compound eyes, similar propodeal spines, and same bilobed postpetiole. However, *C. gypsophila* can be separated by its hairless frons and coxa, nonsculptured sides of the prothorax, punctulate-sculptured katepisternum and propodeum, and the shape and color of the petiole; *C. laestrygon* possesses a hairy frons and coxa, prothorax punctulated laterally, and strong longitudinal-striated propodeum and katepisternum. Since no habitat overlap was found for *C. gypsophila* and *C. laestrygon*, and *C. laestrygon* in adjacent habitats with significantly lower gypsum gradient of soil was observed, considering detailed comparative morphological investigations, we firmly believe that *C. gypsophila* is an allopatric to the widespread *C. laestrygon*, and the gypseous soil, as a barrier, have had a decisive role in the speciation process.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors are sincerely grateful to Mr. Mohammad Sadegh Mohseni for drawings of the species. We thank Dr. Hossein Lotfizadeh, Dr. Brian L Fisher, Dr. Mostafa R. Sharaf, and Dr. Abdurrahman S. Aldawood for their valuable efforts and thoughtful guidance. We also wholeheartedly appreciate Fahimeh Montazeri, Atiye Montazeri, and the Mohseni family for their generous and kind support.

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