

***Cardiocondyla hashemi* sp. n., a new species of the *C. batesii* species-group (Hymenoptera: Formicidae) from Saudi Arabia, with a key to the Saudi species**

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A new species, *Cardiocondyla hashemi* sp. n. is described and illustrated using a Scanning Electron Microscope (SEM) based on the worker caste. *Cardiocondyla hashemi* is a member of the *C. batesii* species-group with a resemblance to *C. tenuifrons* Seifert, 2003 from Jordan. *Cardiocondyla hashemi* can be readily distinguished by the uniform yellow body, the rare or distinctly scattered foveolae on the posterior third of cephalic surface, the broadly medially concave anterior clypeal margin, the sculptured mesosomal dorsum except for the mesonotum which is shallowly sculptured with faint longitudinal rugae, and petiolar node distinctly densely microreticulate. Ecological and biological remarks on the type locality are given. A key to the Saudi fauna of the genus *Cardiocondyla* is presented.

<http://www.zoobank.org/urn:lsid:zoobank.org:pub:1DB79558-0CE0-413B-A6EB-9E0ABB884882>

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Introduction

The Myrmicine ant genus *Cardiocondyla* Emery, 1869 includes 82 described species and two valid subspecies (Bolton, 2023), all native to the Old World (Brown, 2000; Seifert, 2003). Species of the genus are minute in size, and typically nest directly in soil or rarely under stones (Seifert, 2003). Several species of *Cardiocondyla* including *C. emeryi* Forel, 1881, *C. minutior* Forel, 1899, *C. obscurior* Wheeler, 1929, and *C. wroughtonii* (Forel, 1890), are successful tramp species. They possess the ability to invade anthropogenically or naturally disturbed, open, and xerothermous habitats beyond their native range, (Heinze et al., 2006).

Cardiocondyla species have long been notoriously difficult to distinguish morphologically (Bolton, 1982). The Afrotropical fauna of *Cardiocondyla* has been revised by Bolton (1982) who recognized and keyed nine species and described four new species. In a seminal taxonomic work, Seifert (2003) revised Palaearctic *Cardiocondyla* species-groups and described 20 new species. In an additional revision, Seifert et al., (2017) treated the taxonomy of the *Cardiocondyla nuda* species-group based on numerical morphology, alpha-taxonomy (NUMOBAT), and genetic analysis of mitochondrial DNA (mtDNA). Seifert (2023a) recognized 25 valid Palaearctic species of *Cardiocondyla*.

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dyla, which are classified into four species-groups: the *C. batesii*, *C. elegans*, *C. uliani*, and *C. stambuloffii* species-groups.

The *Cardiocondyla batesii* species-group can be defined by the following characters (Seifert, 2003, 2023a): eye very large; postocular distance very small; head distinctly long; metanotal groove always present, sometimes feebly impressed; propodeal spines short and acute; first gastral tergite with short pubescence; postpetiolar sternite without any protrusions. The species-group includes nine species: *Cardiocondyla batesii* Forel 1894, *C. nigra*, Forel 1905, *C. kushanica* Pisarski 1967, *C. brachyceps* Seifert 2003, *C. opistopsis* Seifert 2003, *C. rugulosa* Seifert 2003, *C. semirubra* Seifert 2003, *C. tenuifrons* Seifert 2003, and *C. verdensis* Seifert 2023. The native ranges of these species include southern Iberia, North Africa, the southern Balkans, Anatolia, the Arabian Peninsula, and western Asia. None of them have been reported as tramp species (Seifert, 2003). Herein, we describe a new species of the genus *Cardiocondyla* from the Kingdom of Saudi Arabia belonging to the *Cardiocondyla batesii* species-group.

Methods and Abbreviations

Measurements

All measurements are in millimeters and follow the standard measurements of previous works on the genus (Bolton, 1982; Seifert, 2003). Species names follow Bolton (2023).

EL	= Eye Length; maximum diameter of eye.
HL	= Head Length; maximum length of head, excluding mandibles.
HW	= Head Width; maximum width of head behind eyes in full-face view.
ML	= Mesosoma Length; length of mesosoma in lateral view from a point at which pronotum meets cervical shield to posterior base of propodeal lobes or teeth.
PH	= Petiole Height; maximum height measured in lateral view.
PL	= Petiole Length; maximum length measured in dorsal view, from anterior margin to posterior margin.
PPH	= Postpetiole Height; maximum height measured in lateral view.
PPL	= Postpetiole Length; maximum length measured in dorsal view.
PPW	= Postpetiole Width; maximum width measured in dorsal view.
PRW	= Pronotal Width; maximum width in dorsal view.
PH	= Petiole Height; maximum height measured in lateral view.
PL	= Petiole Length; maximum length of petiolar node measured in dorsal view, from anterior margin to posterior margin.
PW	= Petiole Width; maximum width measured in dorsal view.
SL	= Scape Length, excluding basal neck.
TL	= Total Length, outstretched length of ant from mandibular apex to gastral apex.

Indices

Images were taken under the scanning electron microscope (SEM) JSM-6380 LA (Physics department, College of Science, King Saud University).

CI	= Cephalic Index ($HW/HL \times 100$).
EI	= Eye Index ($EL/HW \times 100$).
SI	= Scape Index ($SL/HW \times 100$).

Museums

KSMA = King Saud University Museum of Arthropods, College of Food and Agriculture Sciences, King Saud University, Riyadh.

Taxonomy

Cardiocondyla species can be recognized by the combination of the following characters in the worker caste (Bolton, 1994; Seifert, 2003): small to minute, monomorphic; palp formula 5,3; mandible armed with five teeth that decrease in size from apical to basal; clypeus with flattened and well-developed lateral portions, which are fused to the raised projecting median portion to form a shelf that projects forward over mandibles; median clypeal portion broadened posteriorly and inserted between narrow frontal lobes; antennal scrobes absent; eye relatively large, situated in front of mid length of the head side; antenna with 11–12 segments, and a well-defined 3-segmented club; pronotal corner broadly rounded to bluntly angular; propodeum unarmed to strongly bispinose; metapleural lobe low and rounded; petiole usually with a moderate to long, anterior peduncle; postpetiole dorsoventrally flattened, in dorsal view always much broader than petiole; pilosity on dorsal surface sparse to absent.

Synoptic Checklist of the species of *Cardiocondyla* of Saudi Arabia

(Distribution follows Seifert, 2003)

Cardiocondyla batesii species-group

Cardiocondyla nigra Forel, 1905 (= *Cardiocondyla elegans* var. *torretassoi* Finzi, 1936): Algeria, Anatolia, Cape Verde Islands, Cyprus, Egypt, Morocco, Portugal, Tunisia.

Cardiocondyla hashemi sp. n.: Saudi Arabia (this paper).

Cardiocondyla bulgarica species-group

Cardiocondyla ulianini Emery, 1889: Afghanistan, Caucasus, Gobi Desert, Iran, Kazakhstan, Kyrgyzstan, Saudi Arabia, Ukraine.

Cardiocondyla emeryi species-group

Cardiocondyla emeryi Forel, 1881 (= *C. emeryi* var. *rasalamae* Forel, 1891; = *C. emeryi mahdii* Karavajev, 1911; = *C. mauritia* Donisthorpe, 1946): Angola, Botswana, Brazil, Burundi, Cameroon, Canary Islands, Cape Verde Islands, Caribbean, Chagos Island, Egypt, Florida, Hawaii, Israel, Madagascar, Madeira, Mauritius, Morocco, Nepal, Nigeria, Rwanda, Seychelles, South Africa, Sri Lanka, St. Helena, Sudan, Tanzania, Uganda, Yemen.

Cardiocondyla yemeni Collingwood & Agosti, 1996: Yemen.

Cardiocondyla minutior species-group

Cardiocondyla minutior Forel, 1899 (= *C. tsukuyomi* Terayama, 1999): Caribbean Islands, North America (Florida), Indonesia, Indian Ocean Islands, India, Japan, Nepal, New Guinea, Polynesia, Sri Lanka.

Cardiocondyla nuda species-group

Cardiocondyla mauritanica Forel, 1890 (= *C. ectopia* Snelling, 1974): Afghanistan, Arizona, California, Canary Islands, Egypt, Greece, Iran, Iraq, Israel, Jordan, Libya, Malta, N. India, Nepal, Oman, Pakistan, Puerto Rico, S. Portugal, S. Spain, Morocco, Tunisia, Ukraine, Turkey, United Arab Emirates, Zimbabwe.

Cardiocondyla shuckardi species-group

Cardiocondyla fajumensis Forel, 1913 (= *C. schatzmayri* Finzi, 1936; = *C. nilotica* Weber, 1952): Cape Verde Island, Egypt, Iran, Sudan, Yemen, Zimbabwe.

Cardiocondyla melana Seifert, 2003: Saudi Arabia, Yemen

Cardiocondyla shuckardi Forel, 1891 (= *C. shuckardoides* Forel, 1895): Madagascar, SE Africa.

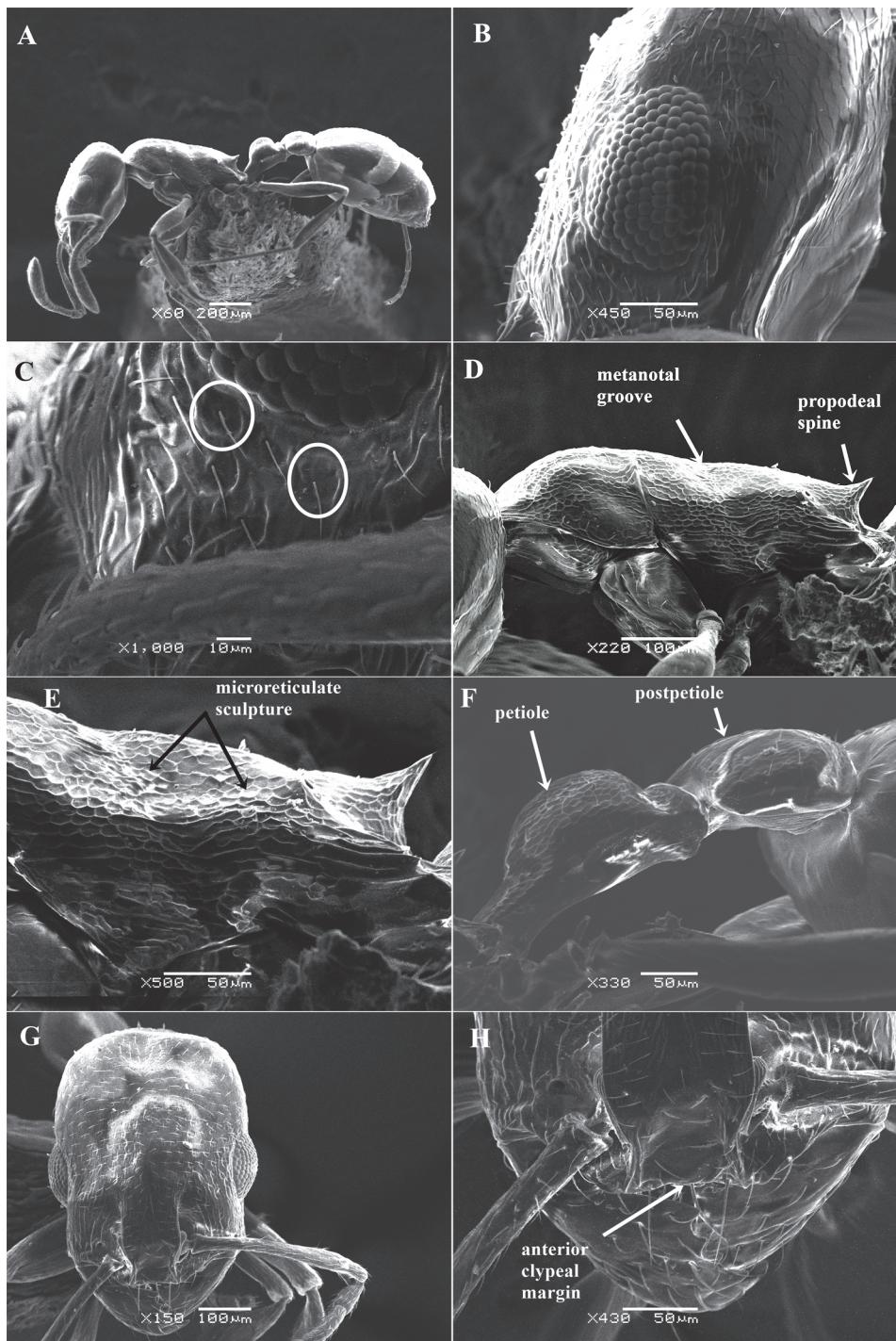


Figure 1. Scanning Electron Micrograph of *Cardiocondyla hashemi*, sp. n., A: Body in profile, B: Head in profile showing eye, C: Foveolae, D: Mesosoma in profile, E: Propodeum in profile, F: Waist in profile, G: Head in full-face view, H: Clypeus and mandibles.

***Cardiocondyla wroughtonii* species-group**

Cardiocondyla wroughtonii (Forel, 1890) (= *C. wroughtonii* var. *hawaiensis* Forel, 1899; = *C. wroughtonii* ssp. *quadraticeps* Forel, 1912; = *C. wroughtonii* var. *bimaculata* Wheeler, 1929; = *C. longispina* Karavajev, 1935; = *C. yamauchii* Terayama, 1999): Australia, Brunei, Florida, Hawaii, India, Indonesia, Japan, Louisiana, Nepal, Papua New Guinea, Sri Lanka, Singapore, Taiwan, Tanzania, Thailand, W. Malaysia.

Cardiocondyla obscurior Wheeler, 1929 (= *C. bicolor* Donisthorpe, 1930; = *C. wroughtonii*, Terayama, 1999): Brazil, Canary Islands, Florida, Germany, Hawaii, India, Israel, Japan, Kenya, Mariana Islands, Nepal, Puerto Rico, Taiwan, Virgin Islands.

Species description

Cardiocondyla hashemi Sharaf, sp. n. (Figures 1, 2)

Holotype worker. Saudi Arabia: Riyadh, Wadi Hanifa (24.603°N, 46.699°E), 751 m, 29.iv.2015, M. S. Abdel-Dayem et al. leg. (KSMA).

Diagnosis. Head distinctly longer than broad, eye large with about 14–15 ommatidia in longest row (EI 26), anterior clypeal margin broadly medially concave, metanotal groove feebly impressed, propodeal spines short and acute, postpetiole about 1.5 X broader than long in dorsal view, cephalic surface with shallow irregularly oval or not ideally circular foveolae.

Differential diagnosis. *Cardiocondyla hashemi* closely resembles *C. tenuifrons* Seifert 2003 from Jordan. Both species have remarkably long head, large eyes, with a convex inner margin and a straight outer one, feebly impressed metanotal groove, short, acute, and steep propodeal spines, semi-circular vertex foveolar margins, with foveolar interspaces distinctly broader than foveolar diameter, and with fine semireticulate microstructures. However, *C. hashemi* is readily separated by the concolorous yellow body, the rare occurrence of foveolae on the posterior third of cephalic surface, the broadly medially concave anterior clypeal margin, whereas *C. tenuifrons* has dark brown head and gaster, mesosoma, petiole, and postpetiole medium brown, evenly distributed foveolae on the entire cephalic surface; anterior clypeal margin with a small median notch.

Measurements (Holotype worker). EL 0.09; HL 0.49; HW 0.35; ML 0.56; PH 0.15; PL 0.14; PW 0.11; PPH 0.15; PPL 0.14; PPW 0.25; PRW 0.26; SL 0.42; TL: 2.07; Indices: CI 71; EI 26; SI 120.

Description (worker). *Head*. Head distinctly longer than broad (CI 71), with a shallowly convex posterior margin and straight sides in full-face view; eye large, with a convex inner margin and a straight outer one, and with about 14-15 ommatidia in longest row (EI 26); frontal carinae distinctly and strongly converging immediately caudal of FRS level; anterior clypeal margin broadly medially concave; scapes short (SI 120) when laid back from their insertions fail to reach posterior margin of head; masticatory margin of mandibles armed with five teeth gradually decreasing in size from apex to base; first funicular segment equal in length to the four proceeding segments together. – *Mesosoma*. Dorsal profile of promesonotum flat; metanotal groove shallowly impressed or indistinct; propodeal dorsum feebly and broadly convex with posterior margin steeply descending into the base of propodeal spines in profile; propodeal spines short, acute, making an angle of about 50° with longitudinal axis of mesosoma. – *Petiole*. Petiole distinctly higher than broad in dorsal view; in profile with thin peduncle, broadly

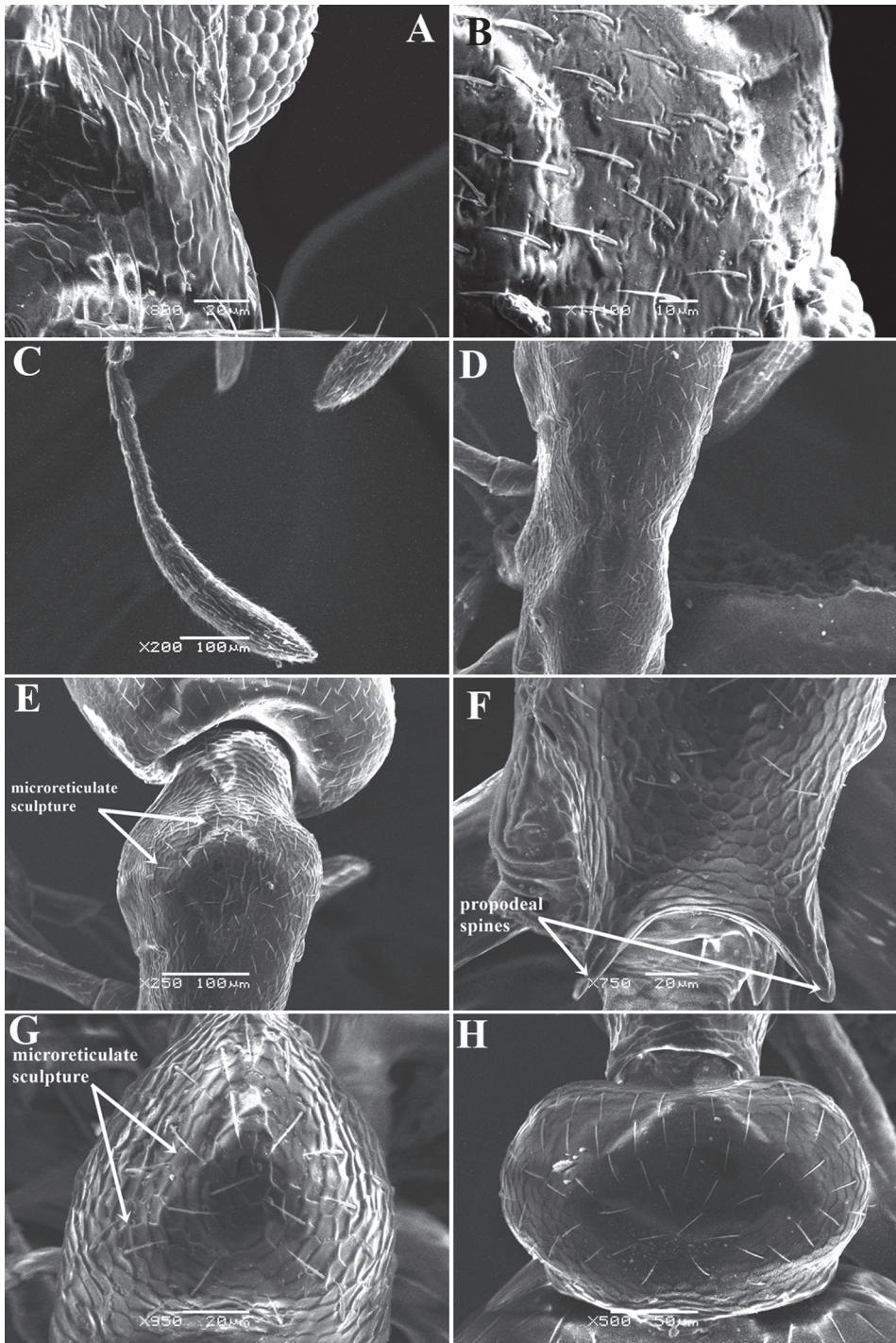


Figure 2. Scanning Electron Micrograph of *Cardiocondyla hashemi*, sp. n., A: Area in front of eyes showing sculpture and foveolae, B: Foveolae and setae, C: Antenna, D: Mesosoma in dorsal view, E: Promesonotum in dorsal view, F: Propodeum in dorsal view, G: Petiole in dorsal view, H: Postpetiole in dorsal view.

convex dorsum, steeply descending posterior face, and small subpetiolar process. – *Postpetiole*. Postpetiole about 1.5 X broader than long in dorsal view; in dorsal view with feebly concave anterior margin, strongly convex sides; postpetiolar sternite completely flat. – *Sculpture*. Body entirely shining; clypeus smooth; area between frontal carinae and in front of eyes to mandibular insertions longitudinally rugulose-carinulate; cephalic surface from mandibular insertions to the posterior level of eyes with shallow irregularly oval or not ideally circular foveolae; interspaces among foveolar broader than foveolar diameter; each foveola with a simple projecting seta at center; foveolae more dense around eyes; foveolae less dense on the posterior third of head; entire mesosoma and petiole with dense microreticulate, mesonotum shallowly sculptured with faint longitudinal rugae; postpetiole dorsum smooth medially, peripheral margins microreticulate; gaster smooth. – *Pubescence*. Body with sparse fine pubescence. – *Colour*. Uniform yellow.

Biology and Ecology. The type locality (Figure 3) is characterized by remnants of native vegetation interspersed with exotic plants. As part of the city's stormwater drainage system, groundwater accumulates in a surface flow channel that meanders through the urban landscape before reaching the area south of Al-Hair Town. A constant flow of water has created ideal conditions for a variety of plant life to flourish, including abundant algae and aquatic plants, thriving wildlife populations, and enhanced recreational opportunities. Tree species such as *Acacia* and *Prosopis* stand out among the diverse tree species. Wadi Hanifa is a complex ecosystem characterized by sandy clay loam soil with moderate organic content and alkaline pH, a diverse and rich vegetation cover, and urban features that indicate human activity. A combination of natural beauty and human influence can be found in this locality.

The type locality has a sandy clay loam soil, which is notable for its variety of composition and suitability for a variety of plants. The soil's texture comprises approximately 70.0% sand, 7.5% silt, and 22.5% clay, indicating good drainage while retaining adequate moisture and nutrients (Abdel-Dayem et al. 2021, 2023). The above values suggest that the soil contains a moderate amount of organic material that contributes to fertility and supports the activity of terrestrial arthropods and microorganisms as well.

Vegetation cover is predominantly natural, with 85% of the cover representing a lush and vibrant ecosystem. The litter cover is 21%, with a litter depth of 1.28 cm (Abdel-Dayem et al. 2021, 2023). This provides a protective layer that conserves soil moisture, adds organic matter as it decomposes, and provides a habitat for small terrestrial arthropods. Logs cover 45% of the land, contributing to the ecosystem by releasing nutrients as they decompose. There is a wide variety of plants and trees in the area, including the following species: *Sesuvium portulacastrum* (L.) L. (Aizoaceae), *Phoenix dactylifera* L. (Arecaceae), *Heliotropium curassavicum* L. (Boraginaceae), *Atriplex nummularia* Lindl. (Chenopodiaceae), *Albizia lebbeck* (L.) Benth., *Parkinsonia aculeate* (Jerusalem thorn (Fabaceae), *Vitex* sp., *Vitex trifolia* L. (Lamiaceae), *Acacia farnesiana* (L.) Wight et Arn., *Prosopis juliflora* (Sw.) DC., *Prosopis koelziana* Burkart (Leguminosae), *Panicum coloratum* L. (Poaceae), and *Rumex dentatus* L. (Polygonaceae). This diversity of shrubs and trees supports a diverse wildlife (Abdel-Dayem et al. 2021, 2023).

Etymology. The patronymic name honors the late Prof. Dr. Hashem Ali Abdel Rahman, Professor of Insect Ecology at Ain Shams University, Cairo, Egypt (1931-2014). The first author is greatly indebted to him for the unlimited advice and encouragement he gave during his early stages of ant research more than 25 years ago.



Figure 3. Wadi Hanifa, Type locality of *Cardiocondyla hashemi* sp. n. Photo by Ahmed Shams Al’Ola.

Key to *Cardiocondyla* species of Saudi Arabia

(modified after Seifert, 2003, 2023a)

- 1 Postpetiolar sternite in anterodorsolateral view with prominent anterolateral corners and its anterior margin appearing concave in this viewing position 2
- Postpetiolar sternite in anterodorsolateral view without prominent anterolateral corners 4
- 2 Uniform yellow; metanotal groove indistinct; propodeal spines in the form or blunt small dents *C. yemeni* Collingwood & Agosti, 1996
- At least gaster darker than head and mesosoma; with mesosoma in profile the mesonotal dorsum abruptly sloping posteriorly and descending steeply to a distinct metanotal groove; propodeal spines sharp and acute 3
- 3 First and following gastral tergites not equally dark *C. wroughtonii* (Forel, 1890)
- First and following gastral tergites equally dark *C. obscurior* Wheeler, 1929
- 4 Postpetiole in profile with a conspicuous ventral bulge *C. emeryi* Forel, 1881
- Postpetiole in profile without a ventral bulge 5
- 5 Metanotal groove absent or very shallow; gastral pubescence dense 6
- Metanotal groove distinct; gastral pubescence less dense 7
- 6 Eyes with notable micro setae, the longest measuring 6–10 µm; cephalic surface with dense, deeply impressed, flat-bottomed foveolae arranged as

- honey-comb; head, mesosoma, petiole and postpetiole dirty yellow to dark dirty brown, gaster dark to black-brown *C. minutior* Forel, 1899
- Eyes without micro setae of any description; cephalic surface from mandibular insertions to the posterior level of eyes with shallow irregularly oval or not ideally circular foveolae; body uniform yellow *C. hashemi* sp. n.
 - 7 Eyes large (EYE 0.249-0.283); postpetiole about 1.86 x broader than long in dorsal view *C. nigra* Forel 1905
 - Eyes of medium size (EYE 0.224-0.262); postpetiole broader, nearly twice as broad as petiole in dorsal view *C. ulianini* Emery, 1889
 - Eyes smaller (EYE 0.199-0.246); postpetiole narrow, about 1.5 x or less as broad as petiole in dorsal view 8
 - 8 Propodeal spines in lateral view appear as smaller angles of 60–95° with longitudinal axis; sides of postpetiole in dorsal view angulate-convex, appearing as a hexagonal; promesonotal and anterior propodeal profile not forming evenly convex outline; metanotal groove less distinct or absent *C. mauritanica* Forel, 1890
 - Propodeal spines in lateral view appear as blunt angles of 95–120° with longitudinal axis; sides of postpetiole in dorsal view rounded; promesonotal and anterior propodeal profiles feebly convex forming a distinct and broad metanotal groove 9
 - 9 Metanotal groove deeply impressed; petiolar node massive and as long as broad in dorsal view *C. fajumensis* Forel, 1913
 - Metanotal groove shallowly impressed; petiolar node of moderate size and slightly broader than long in dorsal view 10
 - 10 Head moderately elongated (HL/HW 1.166) with slightly concave posterior margin in full-face view; anterior clypeal margin slightly but distinctly concave *C. shuckardi* Forel, 1891
 - Head much elongated (HL/HW 1.25) with straight or feebly convex posterior margin in full-face view; anterior clypeal margin straight *C. melana* Seifert, 2003

Discussion

On the Arabian Peninsula, *Cardiocondyla* species are commonly encountered in leaf litter and open habitats (Collingwood, 1985; Collingwood & Agosti, 1996; Sharaf et al., 2017, 2018). Collingwood (1985) reported the first records of *Cardiocondyla* species from Saudi Arabia: *C. emeryi*, *C. mauritanica* Forel, 1890, *C. shuckardi* Forel, 1891, and *C. wroughtonii*. The Yemeni *Cardiocondyla* fauna includes 11 species namely, *C. emeryi*, *C. mauritanica*, *C. shuckardi*, *C. wroughtonii*, *C. yemeni*, *C. longiceps* Seifert, 2003, *C. minutior*, *C. bicoronata* Seifert, 2003, *C. longiceps*, *C. melana*, and *C. rugulosa* (Collingwood & Agosti, 1996; Collingwood et al., 2004, Sharaf et al., 2017; Seifert, 2003). The *Cardiocondyla* fauna of Oman and the United Arab Emirates (UAE) include five species each, namely *C. emeryi*, *C. gallagheri* Collingwood & Agosti, 1996, *C. breviscapa* Seifert, 2003, *C. mauritanica*, *C. yemeni* for Oman (Collingwood & Agosti, 1996; Sharaf et al., 2018), and *C. bicoronata*, *C. emeryi*, *C. gallagheri*, *C. mauritanica*, and *C. shuckardi* for UAE (Collingwood et al., 1997; Collingwood et al., 2011, Seifert, 2003). A single species has been recorded from Kuwait, *C. shuckardi*

(Collingwood & Agosti, 1996), and Qatar, *C. emeryi* (Sharaf et al., 2020). Recently, Sharaf et al. (2023) listed 11 species from Saudi Arabia, including four for the first time from the country, *C. bicoronata*, *C. minutior*, *C. melana*, and *C. yemeni*.

The present study raises the total number of *Cardiocondyla* species known from Saudi Arabia from 11 to 12. Although several of these are non-native tramp species living primarily around human settlements, it seems likely that *C. hashemi* is native to the region. Further *Cardiocondyla* species, both native and non-native are likely to be recorded from Saudi Arabia and other countries of the Arabian Peninsula, with further collection in poorly surveyed sites which will lead to the completion of the regional species list. It is hoped that this list will pave the way for a future comprehensive taxonomic revision of the Arabian *Cardiocondyla*.

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No potential conflict of interest is reported by the authors.

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