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Ant diversity of Eastern Black Sea Region of Türkiye, including five new national records (Hymenoptera: Formicidae)

Kadri Kiran*, Celal Karaman and Volkan Aksoy

[1]Department of Biology, Faculty of Sciences, Trakya University, Balkan Campus, 22030, Edirne, TÜRKİYE

*Corresponding author: kadrikiran@trakya.edu.tr

ABSTRACT. The Eastern Black Sea Region of Türkiye is one of the biologically richest parts of the country due to its humid climate, topographic complexity, and diverse habitats, yet its ant fauna remains insufficiently known. In this study, we surveyed the ant fauna of the region based on material collected by hand and an aspirator from 287 localities between 2000 and 2016. A total of 141 species were recorded. Of these, 62 are new records for the Eastern Black Sea Region. Additionally, five species, *Nylanderia colchica, Proformica caucasea, Solenopsis juliae, Temnothorax tergestinus,* and *T. volgensis* are newly recorded for the ant fauna of Türkiye, increasing the known number of ant species from Türkiye from 388 to 393. Species richness peaked at mid-elevations and was highest in heterogeneous habitats such as riverbanks, oak, mixed, and *Pinus sylvestris* forests. However, rarefaction and extrapolation analyses indicated that oak forests had the highest expected richness after standardization for sampling effort. These results provide a quantitative framework for understanding patterns of ant diversity in the Eastern Black Sea Region and expand current knowledge of Turkish myrmecofauna.

Keywords	Entomology, biodiversity, new records, species richness, zoogeography, taxonomy.
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INTRODUCTION

Türkiye, occupying the Anatolian peninsula and Eastern Thrace, exhibits pronounced climatic heterogeneity, including arid, warm-temperate, and continental climates (Öztürk *et al.* 2017). A humid environment prevails in northern Türkiye, whereas the southeast is dominated by hot and semi-arid conditions. This ecological contrast contributes to the region's rich flora and fauna. Another important factor contributing to Türkiye's exceptional biodiversity is its position at the intersection of the Mediterranean, Irano-Turanian, and Euro-Siberian floristic regions. In northern Türkiye, the Euro-Siberian region comprises the Euxine and Colchic provinces. While the Euxine province is characterized by high species richness and increasing endemism toward the east, the Colchic province exhibits stronger floristic affinities with the Caucasus (Avcı 1993). This biogeographical connection is particularly important because the Caucasus is recognized as one of the world's major biodiversity hotspots, highlighting the conservation significance of northeastern Türkiye (Mittermeier *et al*. 2011).

The Black Sea Region of Türkiye extends along the southern coast of the Black Sea and into northeastern Anatolia near the Georgian border. Within this broader region, the Eastern Black Sea Region corresponds largely to the Colchic area and represents one of the biologically richest parts of the country (Atalay 1989). Owing to favorable rainfall and temperature conditions, the region supports extensive and lush forest vegetation. The mountains rise steeply from the coastline and exceed 3000 m in elevation. The Giresun Mountains constitute the western part of the Eastern Black Sea mountain belt, where glacial lakes and broad glacial valleys occur, whereas the Rize and Karçal Mountains form the eastern part (Atalay & Mortan 2008).

Despite the evident biogeographic importance of the Eastern Black Sea Region, its ant fauna has remained insufficiently known. Previous studies have mainly provided records for particular taxa, such as *Cardiocondyla* (Seifert 2003), *Strumigenys* (Karaman *et al.* 2014), *Tetramorium* (Wagner *et al.* 2017), and *Lasius* s. str. (Seifert 2020). More comprehensive data for the Eastern Black Sea Region were provided by Aktaç (1976), who reported 22 species from Trabzon. Later, Kiran and Karaman (2020) documented 62 species based on museum specimens collected by various researchers and deposited in the Entomological Museum of Trakya University (EMTU). However, such region-wide assessments remained lacking.

The present study documents the myrmecofauna of the Eastern Black Sea Region of Türkiye, quantifies species richness across habitats and elevations, and reports new regional records.

MATERIAL AND METHODS

Specimens were collected by hand and an aspirator between 2000 and 2016 from 287 localities in the Eastern Black Sea Region of Türkiye (Table S1, Fig. 1). For richness analysis, each locality number was treated as a single sampling unit, even when multiple sampling events or macrohabitat records were associated with the same localities (Table S1).

Because sampling targeted colonies/nests and the number of individuals collected per colony was not standardized, abundance-based diversity indices were not used. Instead, analyses were based on species occurrences (presence–absence data). Observed species richness (Sobs) for each habitat was defined as the number of unique species recorded across all sampled localities within each habitat. To summarize elevational patterns in species richness, localities were grouped into 500-m elevational intervals, and the number of unique species recorded within each interval was calculated.

Analyses were conducted in R (version 4.0.3; R Core Team 2020) using the packages vegan, iNEXT, readxl, dplyr, and tidyr. To provide a graphical assessment of sampling completeness across localities, a locality-based randomized species accumulation curve was generated from a site × species incidence matrix constructed from species occurrences per locality. The accumulation curve was computed using randomized permutations of locality order (999 permutations) with the function specaccum (method = "random") implemented in vegan. To quantify sampling completeness, Chao2 and first-order Jackknife richness estimators were calculated from the locality × species incidence matrix, and observed richness was compared with the estimated total richness.

Habitat categories were defined directly from field observations at each sampling locality. Each locality was assigned to a habitat category according to the dominant vegetation structure and current land-use characteristics observed in the immediate surroundings of the sampled ant nest or colony. No formal habitat classification system (e.g., EUNIS or CORINE) was applied. Similar habitat types were subsequently grouped into ecologically meaningful categories for comparative analyses. To compare species richness among habitat types while accounting for unequal sampling effort, sample-based rarefaction and extrapolation analyses were additionally performed using the package iNEXT, based on incidence-frequency data. Species richness comparisons were based on Hill numbers of order $q = 0$ (observed species richness), which gives equal weight to all species regardless of their frequency. Extrapolation for each habitat category was extended to a maximum of twice the observed reference sample size, following the recommendations of Chao *et al.* (2014), and did not exceed this limit. Ninety-five percent confidence intervals were estimated using bootstrap resampling with 50 bootstrap replicates implemented in iNEXT. For each habitat type, the total number of sampled localities was used as the number of sampling units, and species frequencies were calculated as the number of localities in which each species was recorded. Only habitat categories represented by at least 15 sampled localities were included in the rarefaction and extrapolation analyses. This threshold was selected to ensure sufficiently reliable incidence-frequency estimates while maintaining adequate representation of habitat types, thereby providing a reasonable balance between statistical robustness and habitat coverage. Because the data were derived from long-term faunistic surveys rather than a standardized biodiversity sampling design, habitat comparisons should be interpreted as comparative occurrence-based patterns rather than absolute estimates of habitat diversity.

Species names largely follow Bolton (2026). The generic revisions proposed by Ward *et al.* (2015) including the placement of socially parasitic genera *Anergates* within *Tetramorium* and *Chalepoxenus*, and *Myrmoxenus* within *Temnothorax*, have been defended or supported by subsequent phylogenetic treatments (Ward *et al.* 2016; Prebus 2017). However, because these changes remain debated in the literature (Seifert *et al.* 2016; Seifert 2018; Werner *et al.* 2018) we here retain the more conservative generic treatment for these socially parasitic taxa.

Zoogeographical categorization was based on the currently known distributions of the recorded ant species and the chorotype framework proposed by Vigna Taglianti *et al.* (1999), with minor modifications to accommodate the regional biogeographic context of the Eastern Black Sea Region. For clarity, closely related chorotypes were grouped into broader categories, including Palaearctic, Mediterranean, European, Caucasian, Asiatic, Balkan, endemic, and cosmopolitan elements.

Species photographs were taken using a Nikon D800E camera with 3.2× and 8× microscope objectives. Images were focus-stacked using the Helicon Focus software (Helicon Soft Ltd., Kharkiv, Ukraine). Distribution maps were prepared using SimpleMappr (Shorthouse 2010).

Detailed information on the number of collected individuals and their castes as well as locality data, including coordinates and altitudes, collection dates, and museum numbers is provided in the Supplementary Material.

The examined material is deposited in the Entomological Museum of Trakya University (EMTU), Edirne, Türkiye.

The following abbreviations are used for castes: ♀, queen; ♂, male; ☿, worker; ♃, soldier.

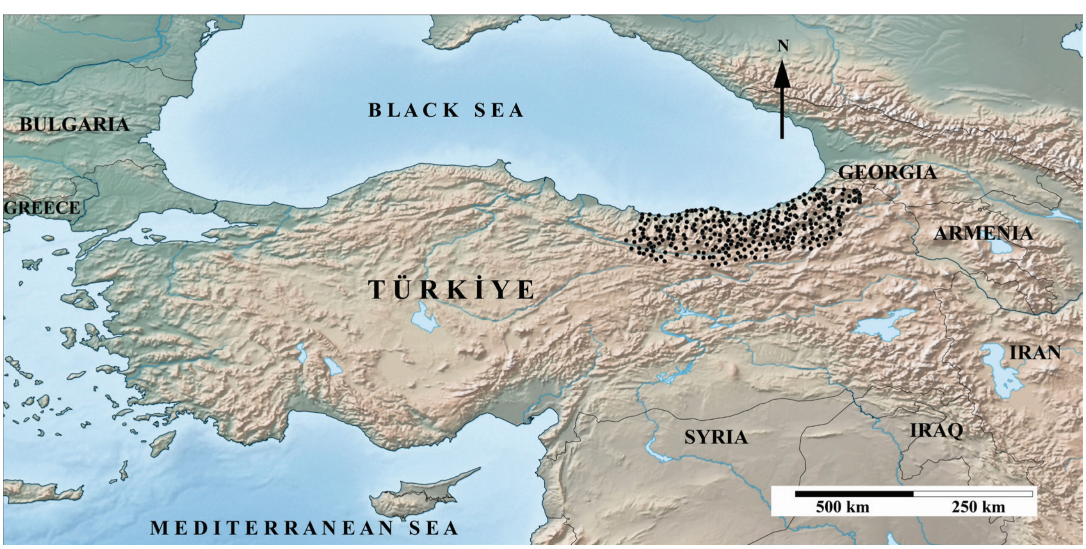

Fig. 1. Map showing the study region. The black solid circles represent localities where samplings were performed.

RESULTS

A total of 5,560 samples were collected from 287 localities across nine provinces of the Eastern Black Sea Region. The surveyed localities encompassed 47 habitat types and spanned an elevational range from 0 to 2,965 m a.s.l. Sampling effort was greatest in Artvin (64 localities), followed by Giresun (54) and Erzurum (49). Most sampling localities were concentrated between 1,500 and 2,000 m a.s.l. (Table 1).

In total, 141 ant species were identified. Of these, 62 represent new records for the Eastern Black Sea Region, and five are newly recorded for the ant fauna of Türkiye.

Species diversity varied markedly across elevational intervals. The highest number of species was recorded between 1500–2000 m (100 species), followed closely by 1000–1500 m (98 species). Richness decreased towards both lower and higher elevations, with 52 species recorded below 500 m and only seven species above 2500 m (Fig. 2).

When data were grouped by habitat, both sampling effort (sampling localities) and occurrence-based species richness (presence/absence) varied markedly among habitat types (Table 2). Riverbanks supported the highest richness (95 species), followed by *Pinus sylvestris* forests (84), oak forests (76) and mixed forests (72). Open habitats such as pastures were moderately species-rich (65 species), whereas intensively managed agro-ecosystems showed lower richness, particularly tea plantations (24 species) and apple orchards (18 species). Habitats represented by fewer sampled localities generally contributed fewer species, with the lowest richness observed in spruce–beech forests (5 species) and marshlands (4 species). Habitat-specific occurrence records underlying these summaries are provided in Table S1.

To account for unequal sampling effort among habitats, species richness was further evaluated using sample-based rarefaction and extrapolation based on locality-level incidence-frequency data. Only habitat categories represented by at least 15 sampled localities were included in this analysis. This threshold was selected *a priori* to minimize unstable richness estimates and excessively wide confidence intervals associated with sparsely sampled habitats, while retaining a sufficient number of habitat categories for meaningful comparisons. Under standardized sampling effort, oak forests showed the highest expected richness, followed by mixed forests, riverbanks, and *Pinus sylvestris* forests. In contrast, tea plantations and other less species-rich habitat categories remained comparatively low even after standardization. Extrapolation curves for riverbanks, *Pinus sylvestris* forests, oak forests, and mixed forests continued to rise, indicating that additional sampling in these habitats would likely reveal further species (Fig. 3)

Table 1. Summary of sampling effort by province in the Eastern Black Sea Region, showing the number of sampling localities and the minimum–maximum elevation (m) covered in each province.

Province	Sampling localities	Elevation (m)
Artvin	64	45–2361
Bayburt	24	1487–2365
Erzurum	49	764–2371
Giresun	54	0–2086
Gümüşhane	45	832–2491
Ordu	14	214–1914
Rize	38	22–2965
Sivas	16	746–2044
Trabzon	37	4–2019

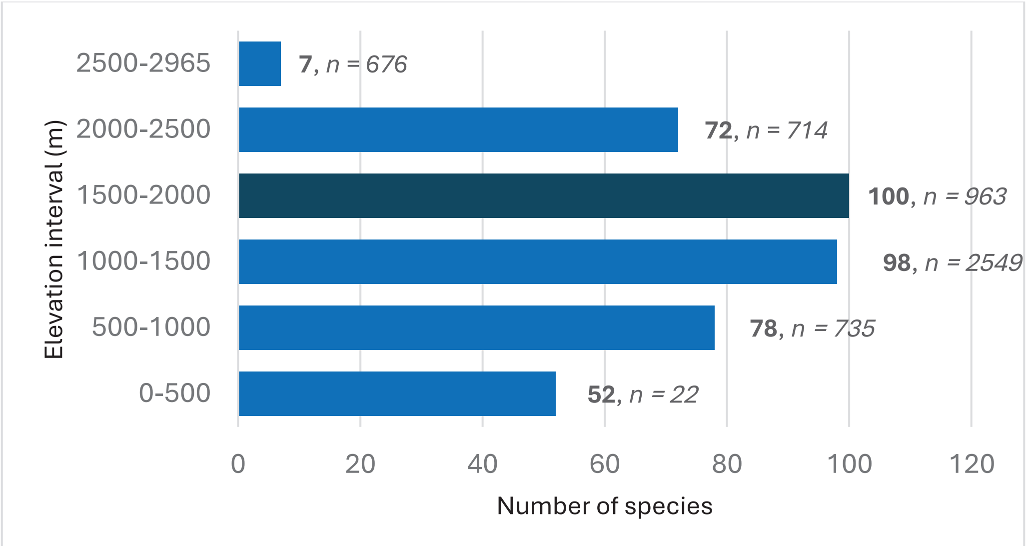

Fig. 2. Distribution of recorded ant species across elevational intervals. Bold numbers indicate species richness, and italic values indicate the number of sampling events (n) within each elevational interval.

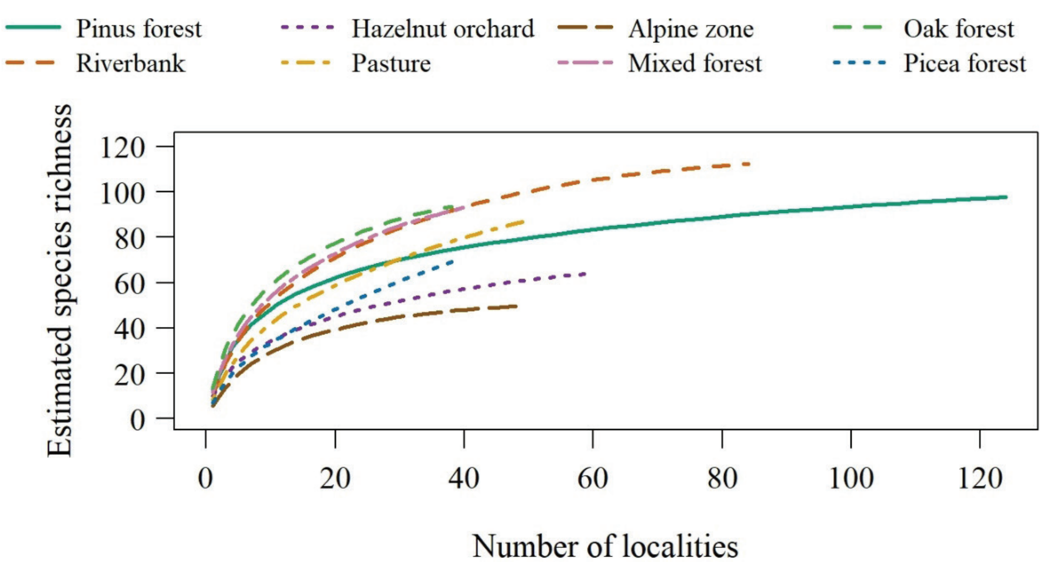

Fig. 3. Sample-based rarefaction and extrapolation curves of ant species richness across habitat types in the Eastern Black Sea Region based on locality-level incidence-frequency data. Only habitat categories represented by at least 15 sampled localities were included. Habitat types are distinguished by colour and line type, as indicated in the legend.

A locality-based randomized species accumulation curve (999 permutations) showed a clear tendency toward saturation (Fig. 4). The survey recorded 141 species, while the estimated total richness was 155.3 species according to the Chao2 estimator and 160.9 species according to the first-order Jackknife estimator. Consequently, the observed richness represents approximately 90.8% and 87.6% of the estimated fauna, respectively, indicating a high level of sampling completeness. Nevertheless, the slight continued increase of the accumulation curve suggests that additional sampling may still reveal further species.

Table 2. Habitat-level sampling effort and recorded ant species richness (occurrence-based).

Habitats	**Number of samplings**	**Occurrence-based Species richnes**
Riverbank	703	95
Pinus sylvestris forest	1269	84
Oak forest	417	76
Mixed forest	416	72
Pasture	426	65
Hazelnut orchard	525	51
Poplar area	250	51
Picea forest	228	46
Oak–*Pinus sylvestris* forest	122	43
Alpine zone	251	41
Shrubland	92	37
Pseudomaquis	76	34
Juniper forest	78	28
Fagus forest	118	25
Elm forest	44	24
Tea plantation	111	24
Pinus brutia forest	35	22
Pinus nigra forest	47	21
Picea–Pinus sylvestris forest	41	20
Barren area	40	20
Oak–elm forest	25	19
Apple orchard	27	18
Young oak woodland	28	18
Oak forest–juniper scrub	20	16
Pinus sylvestris–fir forest	37	16
Pinus sylvestris–Pinus nigra forest	28	16
Oak scrub	23	15
Pinus sylvestris–poplar area	21	14
Fagus–elm forest	37	14
Oak scrub–*Pinus sylvestris* forest	17	14
Oak–maple forest	25	12
Fagus–chestnut forest	27	11
Chestnut forest	18	10
Acacia forest	19	9
Picea–Fagus Forest	12	5
Marshland	6	4

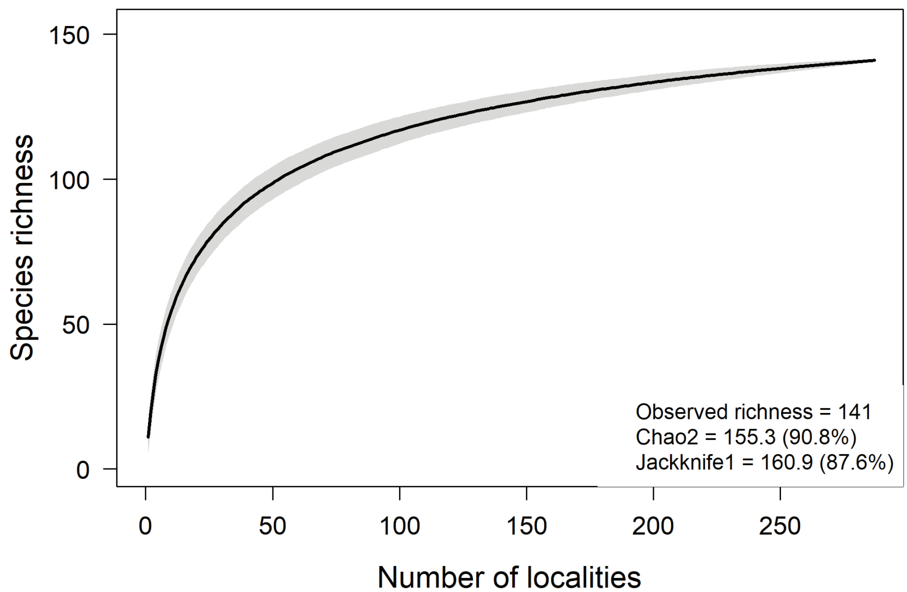

Fig. 4. Locality-based species accumulation curve based on occurrence (presence/absence) data. The observed richness (141 species) corresponds to 90.8% of the Chao2 estimate (155.3 species) and 87.6% of the first-order Jackknife estimate (160.9 species).

The recorded fauna comprised nine chorotype categories (Table 3). The Palaearctic chorotype was the most represented, with 52 species (36.9%), followed by Mediterranean (25 species; 17.7%) and European (22 species; 15.6%) chorotypes. Caucasian and Asiatic chorotypes each comprised 10 species (7.1%), whereas endemic taxa accounted for 14 species (9.9%). Balkan (5 species; 3.5%) and cosmopolitan (1 species; 0.7%) chorotypes were represented by comparatively few species. A complete list of species and their chorotype assignments is provided in Table 3.

In total, 62 species represent new records for the Eastern Black Sea Region, additionally five species are recorded for the first time from Türkiye (Table 3). Locality-level occurrence data and voucher information for all new records are provided in Table S1.

To support the interpretation of the species list and new records, we provide brief taxonomic and faunistic notes for selected species under the following criteria: (i) species representing first records for Türkiye, (ii) taxa associated with notable range extensions or previously undocumented regional occurrence, and (iii) cases where identification is provisional due to membership in a species complex or the absence of diagnostic castes. Full locality-level data and voucher details for these taxa are provided in the Supplementary Material.

Cataglyphis aenescens and *C. hellenica* (Forel, 1886) are two closely related species within the *Cataglyphis cursor* species complex in the Eastern Mediterranean region (Salata *et al.* 2023). Kuhn *et al.* (2020) have shown that *C. aenescens* tends to represent a complex of cryptic species in the Balkans and adjacent regions that differ from the true *C. aenescens* described in southern Russia (see also in Borowiec and Salata (2022)). The material investigated by Kuhn *et al.* (2020) from the Eastern Mediterranean region comprises specimens from Crete, mainland Greece, and Iran. Although no members of the *C. cursor* species complex from Türkiye were included in that study, they reported the presence of *C. aenescens* in Iran. Considering the localities of the study area in Türkiye in this paper, we provisionally determine the material here as *C. aenecens* and emphasize the need for taxonomic investigation of the Turkish *C. cursor* species complex in this regard.

Table 3. List of ant species recorded in the Eastern Black Sea Region, with chorotype assignments and evidence of previous regional records (*New record for the Eastern Black Sea Region (EBSR). **New record for Türkiye).

No	Species	Chorotypes	Previous record(s)
1.	*Aphaenogaster holtzi**	Endemic	New for Eastern Black Sea Region (this study)
2.	*Aphaenogaster obsidiana*	Mediterranean	(Karavaiev 1926; Kiran & Karaman 2020)
3.	*Aphaenogaster subterranea*	Palaearctic	(Donisthorpe 1950; Aktaç 1976; Karaman et al. 2014)
4.	*Bothriomyrmex communista**	Mediterranean	New for Eastern Black Sea Region (this study)
5.	*Camponotus aegaeus*	Endemic	(Kiran & Karaman 2020)
6.	*Camponotus aethiops*	Mediterranean	(Aktaç 1976, 1988)
7.	*Camponotus armeniacus**	Caucasian	New for Eastern Black Sea Region (this study)
8.	*Camponotus atricolor*	European	(Forel 1904)
9.	*Camponotus baldaccii**	Mediterranean	New for Eastern Black Sea Region (this study)
10.	*Camponotus fallax**	Palaearctic	New for Eastern Black Sea Region (this study)
11.	*Camponotus gestroi**	Mediterranean	New for Eastern Black Sea Region (this study)
12.	*Camponotus herculeanus*	Palaearctic	(Forel 1904; Aktaç 1976)
13.	*Camponotus lateralis**	Mediterranean	New for Eastern Black Sea Region (this study)
14.	*Camponotus lateralis* morph 2*	Endemic	New for Eastern Black Sea Region (this study)
15.	*Camponotus ligniperda**	European	New for Eastern Black Sea Region (this study)
16.	*Camponotus oertzeni**	Palaearctic	New for Eastern Black Sea Region (this study)
17.	*Camponotus piceus*	Mediterranean	(Karaman et al. 2014; Kiran et al. 2017)
18.	*Camponotus samius**	European	New for Eastern Black Sea Region (this study)
19.	*Camponotus sanctus**	Mediterranean	New for Eastern Black Sea Region (this study)
20.	*Cardiocondyla sahlbergi**	Asiatic	New for Eastern Black Sea Region (this study)
21.	*Cataglyphis aenescens*	European	(Karaman et al. 2014; Kiran et al. 2017)
22.	*Cataglyphis albicans**	Mediterranean	New for Eastern Black Sea Region (this study)
23.	*Cataglyphis machmal**	Asiatic	New for Eastern Black Sea Region (this study)
24.	*Cataglyphis nodus**	Palaearctic	New for Eastern Black Sea Region (this study)
25.	*Cataglyphis viaticoides**	Asiatic	New for Eastern Black Sea Region (this study)
26.	*Chalepoxenus muellerianus**	Mediterranean	New for Eastern Black Sea Region (this study)
27.	*Colobopsis truncata**	Mediterranean	New for Eastern Black Sea Region (this study)
28.	*Crematogaster ionia**	Mediterranean	New for Eastern Black Sea Region (this study)
29.	*Crematogaster schmidti*	European	(Forel 1904; Akyıldırım *et al.* 2014; Karaman et al. 2014)
30.	*Crematogaster sordidula*	Palaearctic	(Kiran & Karaman 2020)
31.	*Dolichoderus quadripunctatus**	Palaearctic	New for Eastern Black Sea Region (this study)
32.	*Formica candida**	Asiatic	New for Eastern Black Sea Region (this study)
33.	*Formica clara*	Palaearctic	(Seifert & Schultz 2009; Kiran et al. 2017)
34.	*Formica cunicularia*	Palaearctic	(Aktaç 1976; Seifert & Schultz 2009)
35.	*Formica exsecta*	Palaearctic	(Kiran & Karaman 2020)

No	Species	Chorotypes	Previous record(s)
36.	*Formica foreli*	Palaearctic	(Aktaç 1988; Kiran & Karaman 2020)
37.	*Formica fusca*	Palaearctic	(Aktaç 1978; Seifert & Schultz 2009; Wagner et al. 2018)
38.	*Formica gagates*	European	(Aktaç 1976; Kiran & Karaman 2020)
39.	*Formica georgica*	Caucasian	(Kiran & Karaman 2012)
40.	*Formica lemani*	Palaearctic	(Kiran & Karaman 2020)
41.	*Formica rufa*	Palaearctic	(Aktaç 1987; Bračko *et al.* 2014; Dubovikoff & Yusupov 2017; Kiran & Karaman 2020)
42.	*Formica rufibarbis*	Palaearctic	(Forel 1904; Akyıldırım et al. 2014)
43.	*Formica sanguinea*	Palaearctic	(Aktaç 1976; Karaman et al. 2014; Akyürek *et al.* 2016)
44.	*Harpagoxenus sublaevis*	Palaearctic	(Kiran & Karaman 2020)
45.	*Hypoponera eduardi**	Mediterranean	New for Eastern Black Sea Region (this study)
46.	*Lasius alienus*	Palaearctic	(Donisthorpe 1950; Aktaç 1976; Akyıldırım et al. 2014)
47.	*Lasius balcanicus/ distinguendus**	Palaearctic	New for Eastern Black Sea Region (this study)
48.	*Lasius bicornis**	Palaearctic	New for Eastern Black Sea Region (this study)
49.	*Lasius bombycina*	Endemic	(Kiran & Karaman 2020)
50.	*Lasius brunneus*	Palaearctic	(Aktaç 1988)
51.	*Lasius carniolicus**	Palaearctic	New for Eastern Black Sea Region (this study)
52.	*Lasius flavus*	Palaearctic	(Wagner et al. 2018; Kiran & Karaman 2020)
53.	*Lasius fuliginosus**	Palaearctic	New for Eastern Black Sea Region (this study)
54.	*Lasius illyricus*	Asiatic	(Aktaç 1976; Kiran & Karaman 2020; Seifert 2020)
55.	*Lasius myops*	Mediterranean	(Kiran & Karaman 2012)
56.	*Lasius niger*	Palaearctic	(Forel 1904; Karaman et al. 2014)
57.	*Lasius platythorax*	Palaearctic	(Seifert 2020)
58.	*Lasius psammophilus**	European	New for Eastern Black Sea Region (this study)
59.	*Lasius schulzi**	Endemic	New for Eastern Black Sea Region (this study)
60.	*Lasius turcicus*	Endemic	(Akyıldırım et al. 2014; Kiran & Karaman 2020)
61.	*Lasius umbratus*	Palaearctic	(Kiran & Karaman 2020)
62.	*Leptothorax acervorum*	Palaearctic	(Kiran & Karaman 2020)
63.	*Leptothorax muscorum**	Palaearctic	New for Eastern Black Sea Region (this study)
64.	*Leptothorax scamni*	Caucasian	(Heinze *et al.* 1993)
65.	*Manica rubida*	Mediterranean	(Emery 1908; Aktaç 1978; Wagner et al. 2018)
66.	*Messor incorruptus**	Asiatic	New for Eastern Black Sea Region (this study)
67.	*Messor oertzeni**	Balkan	New for Eastern Black Sea Region (this study)
68.	*Messor orientalis*	Mediterranean	(Aktaç 1988)
69.	*Messor structor*	Mediterranean	(Aktaç 1988; Kiran et al. 2017)

No	Species	Chorotypes	Previous record(s)
70.	*Messor sultanus**	Asiatic	New for Eastern Black Sea Region (this study)
71.	*Messor wasmanni**	European	New for Eastern Black Sea Region (this study)
72.	*Myrmecina graminicola*	Palaearctic	(Karaman et al. 2014)
73.	*Myrmica anatolica*	Endemic	(Elmes *et al.* 2002)
74.	*Myrmica caucasicola*	Mediterranean	(Kiran & Karaman 2020)
75.	*Myrmica hellenica*	Palaearctic	(Seifert *et al.* 2009; Karaman et al. 2014)
76.	*Myrmica jennyae*	Caucasian	(Elmes et al. 2002)
77.	*Myrmica lobicornis*	Palaearctic	(Aktaç 1976, 1988)
78.	*Myrmica lonae**	Palaearctic	New for Eastern Black Sea Region (this study)
79.	*Myrmica ravasinii*	Mediterranean	(Karaman et al. 2014)
80.	*Myrmica ruginodis*	Palaearctic	(Karavaiev 1926; Aktaç 1976; Akyıldırım et al. 2014)
81.	*Myrmica sabuleti**	Palaearctic	New for Eastern Black Sea Region (this study)
82.	*Myrmica salina*	Asiatic	(Seifert 2011)
83.	*Myrmica scabrinodis*	Palaearctic	(Aktaç 1976, 1978)
84.	*Myrmica schencki*	Palaearctic	(Karaman et al. 2014)
85.	*Myrmica specioides*	European	(Seifert 2011)
86.	*Myrmica sulcinodis*	Palaearctic	(Aktaç 1976; Kiran & Karaman 2020)
87.	*Myrmica tulinae**	Palaearctic	New for Eastern Black Sea Region (this study)
88.	*Myrmoxenus stumperi**	Mediterranean	New for Eastern Black Sea Region (this study)
89.	*Nylanderia colchica***	Caucasian	New for Türkiye (this study)
90.	*Pheidole balcanica**	Endemic	New for Eastern Black Sea Region (this study)
91.	*Pheidole indica**	Cosmpolitan	New for Eastern Black Sea Region (this study)
92.	*Plagiolepis pallescens*	Mediterranean	(Aktaç 1976, 1988; Kiran & Karaman 2020)
93.	*Plagiolepis perperamus**	Palaearctic	New for Eastern Black Sea Region (this study)
94.	*Plagiolepis pygmaea*	European	(Aktaç 1976)
95.	*Plagiolepis xene**	European	New for Eastern Black Sea Region (this study)
96.	*Polyergus rufescens**	Palaearctic	New for Eastern Black Sea Region (this study)
97.	*Ponera coarctata*	Mediterranean	(Karaman et al. 2014; Kiran & Karaman 2020)
98.	*Ponera testacea**	European	New for Eastern Black Sea Region (this study)
99.	*Prenolepis nitens**	Mediterranean	New for Eastern Black Sea Region (this study)
100.	*Proformica caucasea***	Caucasian	New for Türkiye (this study)
101.	*Proformica pilosiscapa*	Pontic	(Wagner et al. 2018)
102.	*Solenopsis fugax*	Mediterranean	(Aktaç 1976; Kiran & Karaman 2020)
103.	*Solenopsis juliae***	Caucasian	New for Türkiye (this study)
104.	*Stenamma debile*	Palaearctic	(Kiran & Karaman 2020)
105.	*Stenamma striatulum*	Palaearctic	(DuBois 1998; Rigato 2011)

No	Species	Chorotypes	Previous record(s)
106.	*Strongylognathus rehbinderi*	Caucasian	(Kıran et al. 2014)
107.	*Strongylognathus testaceus*	Palaearctic	(Kıran et al. 2014)
108.	*Tapinoma festae**	Asiatic	New for Eastern Black Sea Region (this study)
109.	*Tapinoma glabrellum**	European	New for Eastern Black Sea Region (this study)
110.	*Temnothorax affinis*	Palaearctic	(Kiran & Karaman 2020)
111.	*Temnothorax antigoni**	Endemic	New for Eastern Black Sea Region (this study)
112.	*Temnothorax artvinensis*	Endemic	(Seifert 2006; Csősz et al. 2015; Wagner et al. 2018; Kiran & Karaman 2020)
113.	*Temnothorax balcanicus**	Balkan	New for Eastern Black Sea Region (this study)
114.	*Temnothorax bulgaricus**	Balkan	New for Eastern Black Sea Region (this study)
115.	*Temnothorax crasecundus*	Palaearctic	(Seifert & Csősz 2015)
116.	*Temnothorax dessyi**	Balkan	New for Eastern Black Sea Region (this study)
117.	*Temnothorax graecus**	Balkan	New for Eastern Black Sea Region (this study)
118.	*Temnothorax interruptus*	Palaearctic	(Kiran et al. 2017)
119.	*Temnothorax nigriceps*	European	(Kiran & Karaman 2020)
120.	*Temnothorax parvulus*	Mediterranean	(Csősz et al. 2015)
121.	*Temnothorax satunini*	Caucasian	(Schulz *et al.* 2007)
122.	*Temnothorax strymonensis**	Endemic	New for Eastern Black Sea Region (this study)
123.	*Temnothorax subtilis**	Asiatic	New for Eastern Black Sea Region (this study)
124.	*Temnothorax tergestinus***	European	New for Türkiye (this study)
125.	*Temnothorax tuberum*	Palaearctic	(Karaman et al. 2014)
126.	*Temnothorax turcicus**	European	New for Eastern Black Sea Region (this study)
127.	*Temnothorax unifasciatus*	Palaearctic	(Heinze 1988; Wagner et al. 2018)
128.	*Temnothorax volgensis***	Asiatic	New for Türkiye (this study)
129.	*Tetramorium anatolicum**	Endemic	New for Eastern Black Sea Region (this study)
130.	*Tetramorium bellerophoni**	Endemic	New for Eastern Black Sea Region (this study)
131.	*Tetramorium caespitum*	Palaearctic	(Forel 1911; Aktaç 1976)
132.	*Tetramorium caucasicum**	Caucasian	New for Eastern Black Sea Region (this study)
133.	*Tetramorium chefketi*	Palaearctic	(Schulz 1996; Akyıldırım et al. 2014; Karaman et al. 2014)
134.	*Tetramorium diomedeum**	European	New for Eastern Black Sea Region (this study)
135.	*Tetramorium ferox*	Palaearctic	(Kiran et al. 2017; Kiran & Karaman 2020)
136.	*Tetramorium flavidulum**	European	New for Eastern Black Sea Region (this study)
137.	*Tetramorium galaticum**	Endemic	New for Eastern Black Sea Region (this study)
138.	*Tetramorium immigrans*	European	(Wagner et al. 2018)
139.	*Tetramorium impurum*	European	(Karaman et al. 2014)
140.	*Tetramorium indocile**	European	New for Eastern Black Sea Region (this study)
141.	*Tetramorium moravicum*	European	(Csősz *et al.* 2007; Kiran et al. 2017)

Lasius balcanicus and *Lasius distinguendus* are recorded in Türkiye but the current information does not justify separating the two species based on workers. Definitive identification is only possible for the queen caste (Seifert 2007). Because of the lack of queens in the collected material, we tentatively assigned those specimens under *Lasius balcanicus/distinguendus*.

Nylanderia colchica is considered an endemic species as it has only been recorded in Georgia and Abkhazia-Northern Caucasus to date (Pisarski 1960; Gratiashvili & Barjadze 2008). The Turkish specimens are assigned to *N. colchica* based on the combination of sparse pubescence on the gaster and the presence of numerous erect setae on the occipital corners of the head. This character combination separates *N. colchica* from *N. jaegerskioeldi*, which has denser gaster pubescence, and from the tramp species *N. flavipes*, which is known from Georgia, southwestern Russia, and Iran and differs in the arrangement and density of erect setae on the head, particularly around the occipital corners. This record is the first record of Turkish ant fauna, and with this record, its distribution is enlarged to north of Anatolia. (Fig. 5, Fig. 6).

Proformica caucasea has previously been recorded only from Georgia and Armenia. The Turkish material is assigned to *P. caucasea* based on a combination of worker and queen characters. In workers, the pilosity on the second gastral tergite is intermediate in density, being less abundant than in *P. kobachizei* but not as sparse as in *P. nitida* and *P. striaticeps*. Queens and most large workers lack erect setae on the scapes and tibiae, unlike *P. pilosiscapa*. In addition, both minor and major workers have a broad and deep median notch on the anterior margin of the clypeus, a character separating them from *P. korbi* and *P. kosswigi*. Our record represents the first for the Turkish ant fauna, which extends the species' range to northeastern Türkiye (Fig. 7, Fig. 8, Fig. 9, Fig. 10).

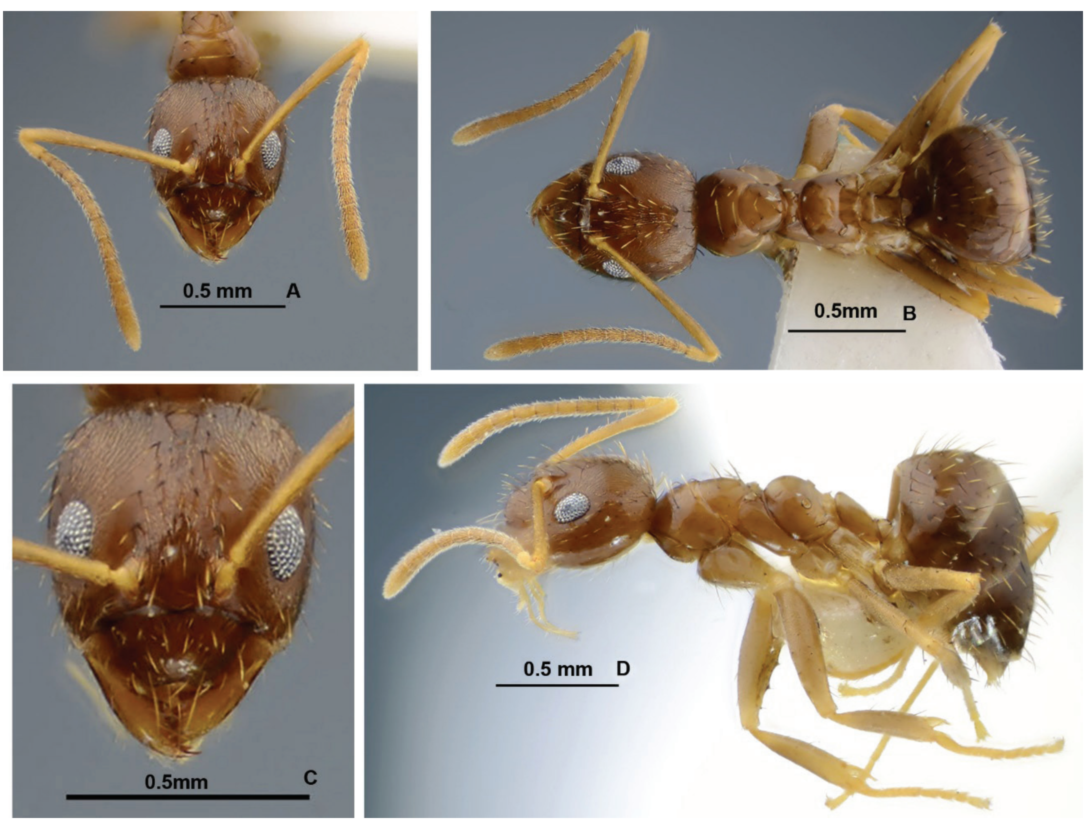

Fig. 5. Worker of *N. colchica*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

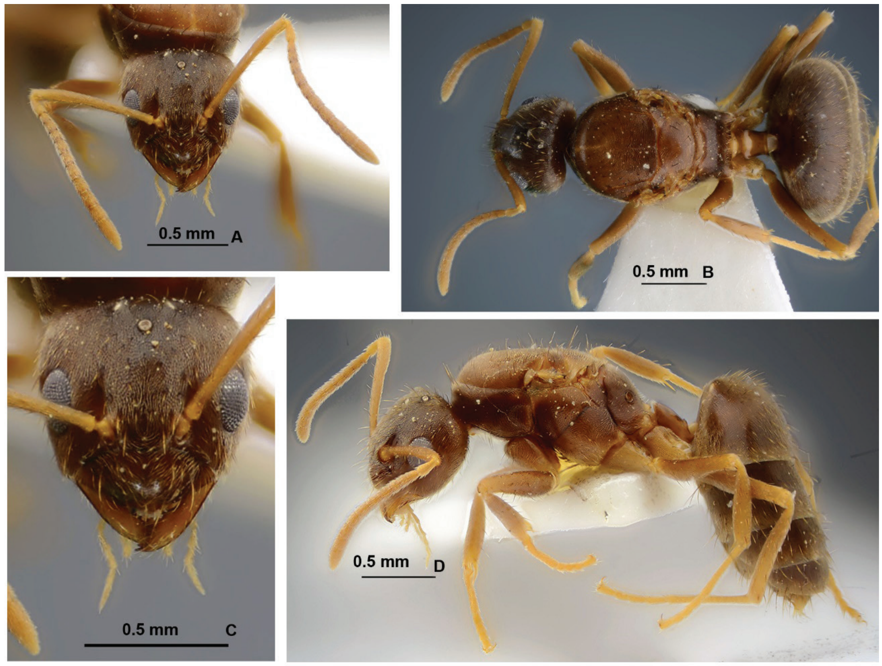

Fig. 6. Queen of *N. colchica*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

Fig. 7. Minor worker of *P. caucasea*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

Fig. 8. Major worker of *P. caucasea*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

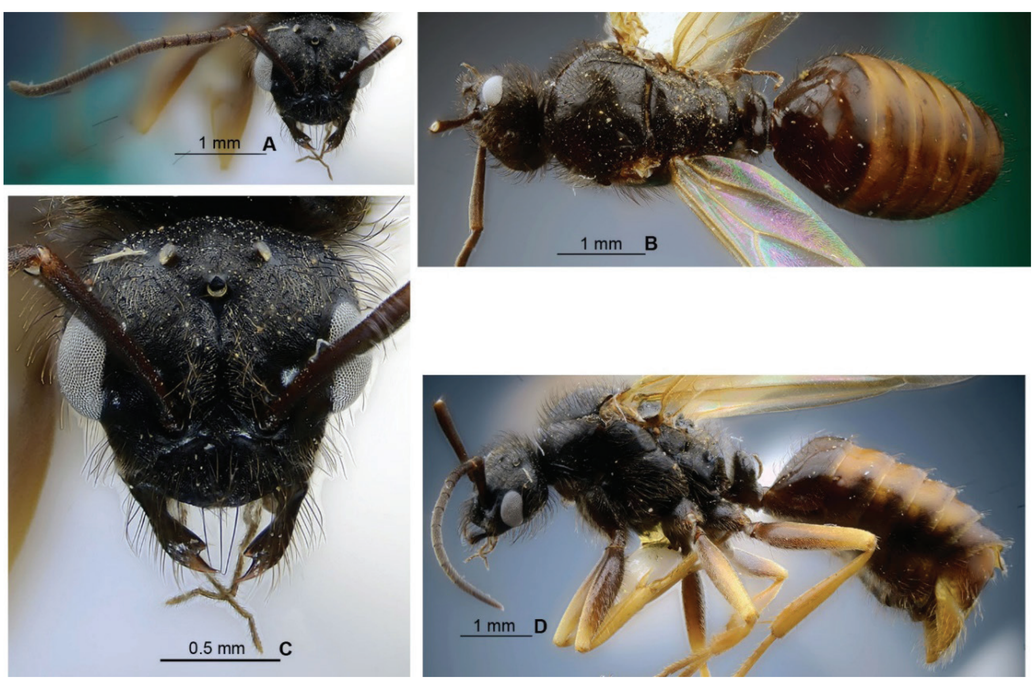

Fig. 9. Male of *P. caucasea*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

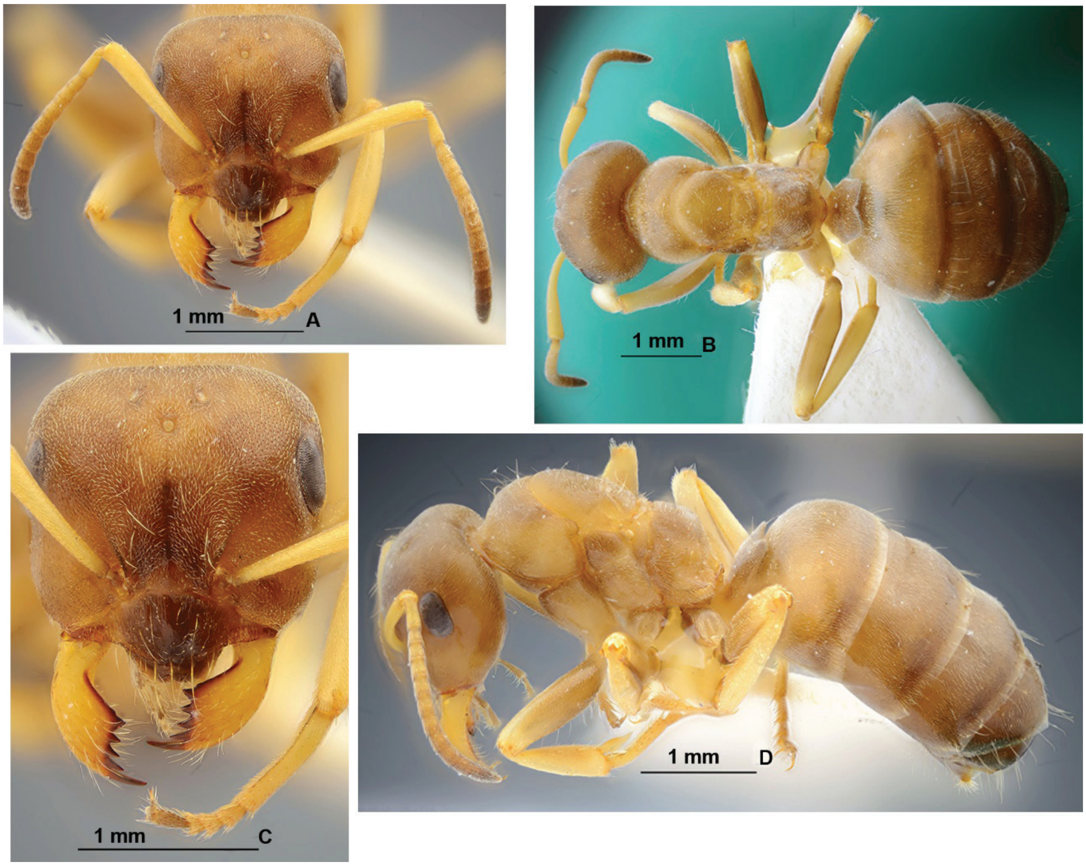

Fig. 10. Queen of *P. caucasea*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

Solenopsis juliae was first described by Arakelian in 1991 from Armenia (Arakelian 1991). In 2023, Csősz *et al.* conducted a revision study, suggesting that records of *Solenopsis* from eastern regions might represent *S. juliae*. They provided diagnostic differences separating this species from *S. fugax*, the most widespread species of the genus (Csősz *et al.* 2023). Their study identified the absence of sculpture on the median area of the vertex as the sole distinguishing character between the two species. Additionally, Borowiec and Salata noted in their study on the identification of the ant fauna of Cyprus that *S. juliae* had previously been described as *S. cf. fugax, S. cf. lusitanica, S. wolfi*, and *S. cf. wolfi* among the specimens re-examined from mainland Greece and some of its islands (Borowiec & Salata, 2025). In the present study specimens of *Solenopsis juliae* were collected from 19 nests representing 13 different habitat types in the Eastern Black Sea Region (Supplementary Material). Thus, this represents the first record of this species from Türkiye (Fig. 11).

Csősz *et al.* (2015) redescribed *Temnothorax tergestinus* and limited its distribution from France to Bulgaria and Greece. More recently Salata and Borowiec (2018) indicated that the species is quite common species in mainland Greece. The material was assigned to *T. tergestinus* following the diagnostic framework of Csősz *et al.* (2015). In particular, *T. artvinensis* is distinguished from *T. tergestinus* by its very dark body colour and by the D4 discriminant function of Csősz *et al.* (2015). In our study, although not quite common, we also found 42 nests of the species. This is the first record of the species for the Turkish ant fauna. These records extend the known distribution of the species eastwards from its European range into the Anatolian Plateau, representing its first documented occurrence in this biogeographic region (Fig. 12, Fig. 13, Fig. 14).

Fig. 11. Worker of *S. juliae*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

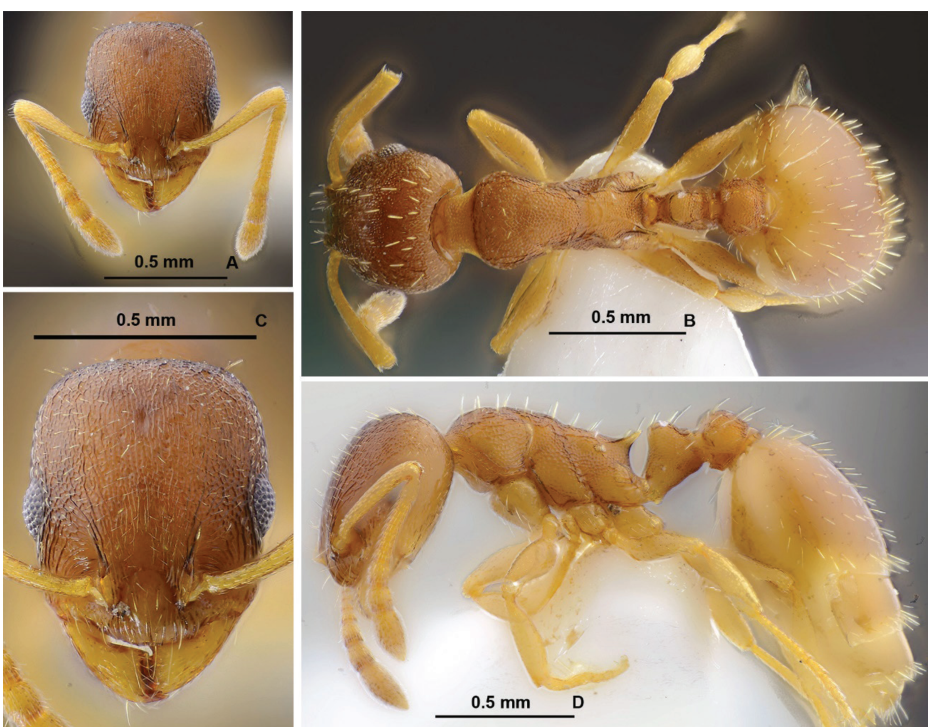

Fig. 12. Worker of *T. tergestinus*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

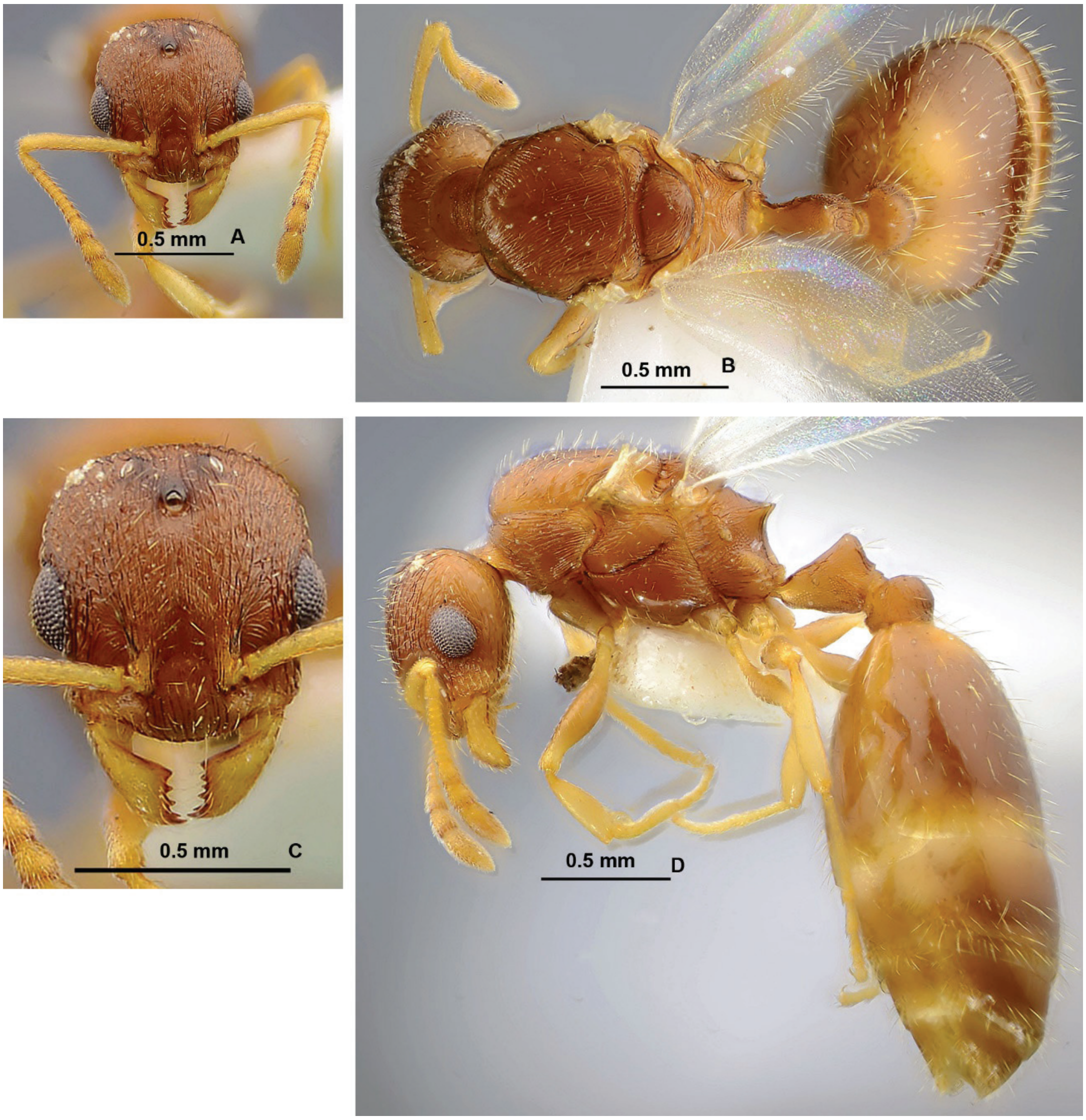

Fig. 13. Queen of *T. tergestinus*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

Radchenko (1995) gave the distribution of *Temnothorax volgensis* from west coasts of Black Sea to western Kazakhstan steppes. Therefore, the first record identified for Turkish ant fauna indicates the westernmost locality in the southern Black Sea of this species. *Temnothorax volgensis* belongs to the *T. interruptus* species group, characterized by the frontal carinae anteriorly forming a strong, angulate lateral extension. Within this group, the examined material is assigned to *T. volgensis* based on the uniformly brown body colour and the absence of a dark band on the gaster (Fig. 15, Fig. 16).

The Eastern Black Sea material supports not only a morphological but also an ecological separation between *Ponera coarctata* and *P. testacea*, with the former being more tolerant of anthropogenic habitats and soil-based microhabitats, whereas the latter is largely confined to humid, stone-rich environments (see the Supplementary Material text).

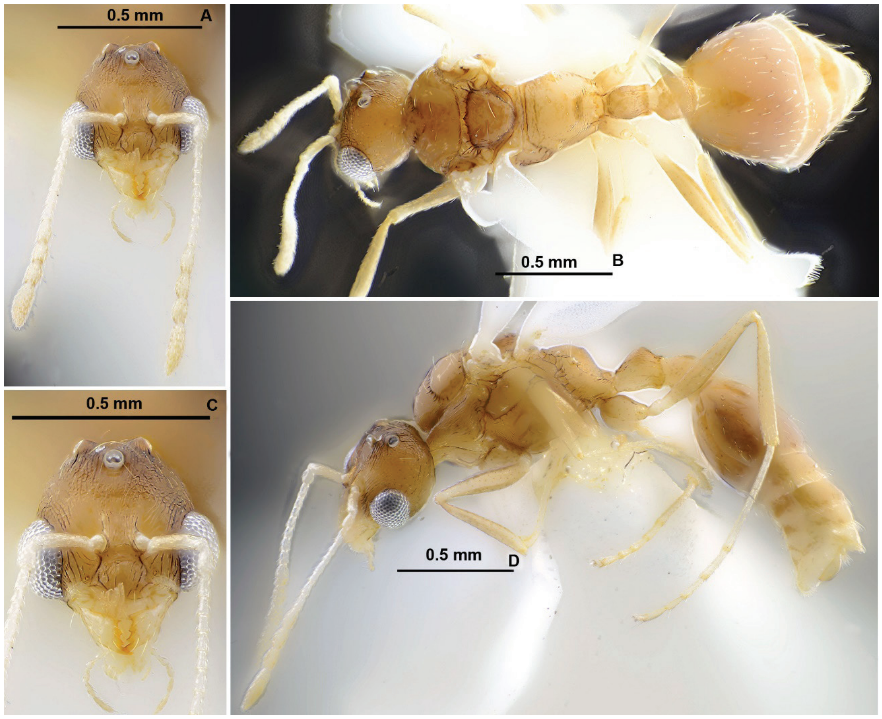

Fig. 14. Male of *T. tergestinus*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

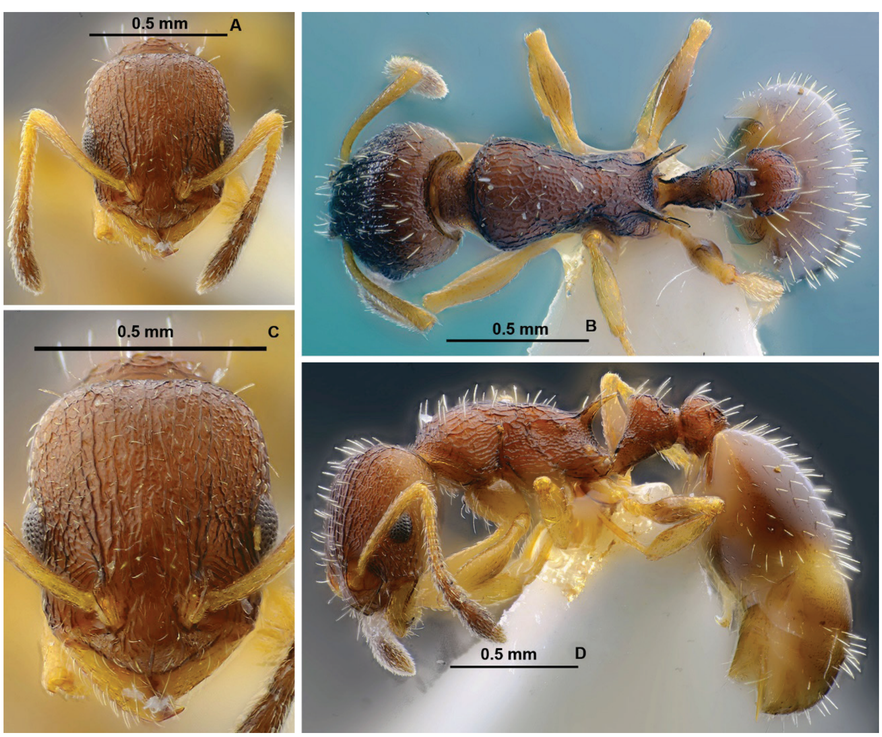

Fig. 15. Worker of *T. volgensis*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

Fig. 16. Queen of *T. volgensis*. A. Head in frontal view; B. Body in dorsal view; C. Head in close-up frontal view; D. Body in lateral view.

DISCUSSION

In the present study, 141 species belonging to four subfamilies (Dolichoderinae, Formicinae, Myrmicinae and Ponerinae) were recorded from the Eastern Black Sea Region, where only 74 species had previously been reported. Thus, the present survey substantially expands the known regional fauna and highlights how incompletely documented the region remained despite earlier studies. 62 species were recorded for the first time in the region of which five species (*Nylanderia colchica*, *Proformica caucasea*, *Solenopsis juliae*, *Temnothorax tergestinus*, *T. volgensis*) were recorded for the first time for Turkish ant fauna by increasing the total number of ant fauna from 388 to 393.

Beyond the faunistic increase documented here, the quantitative results also reveal a clear ecological pattern in ant richness across the Eastern Black Sea Region. Species richness peaked at mid-elevations, with the highest number of species recorded between 1500–2000 m and a very closely by the 1000–1500 m, whereas richness declined towards both lower and higher elevations (Fig. 2). This pattern suggests that mid-elevation belts in the region may provide a favourable combination of habitat heterogeneity, vegetation complexity, and climatic moderation for ant assemblages. In contrast, lower elevations are more strongly affected by agricultural land use and urbanization, whereas the highest elevations are likely constrained by lower temperatures, prolonged snow cover, a shorter growing season, and reduced vegetation complexity. The locality-based species accumulation curve approached an asymptote, suggesting that a substantial proportion of the regional fauna was sampled. However, because no formal completeness estimator (e.g. sample coverage or Chao2) was calculated, the curve should be interpreted as a graphical indication rather than a quantitative estimate of sampling completeness (Fig. 4) .

Habitat-level comparisons also highlight the importance of interpreting observed richness in the context of sampling effort. Riverbanks showed the highest recorded richness, followed by *Pinus sylvestris* forests, oak forests, and mixed forests (Table 2). However, rarefaction and extrapolation analyses demonstrated that, after standardizing for unequal sampling effort, oak forests consistently showed the highest expected richness in the present dataset, followed by mixed forests, riverbanks, and *Pinus sylvestris* forests (Fig. 3). While riverbanks yielded high species richness in absolute terms, this pattern is likely linked to higher sampling intensity and the accessibility of these habitats. Conversely, oak-dominated habitats support particularly rich ant assemblages, likely driven by their structural complexity, specifically litter accumulation, dead wood availability, and the coexistence of open and shaded microsites. The continued upward trend of the extrapolation curves suggests that these habitats remain unsaturated and are likely to yield additional records with further intensive survey effort. Nevertheless, because these analyses were based on long-term faunistic occurrence records rather than a standardized biodiversity survey, the habitat-level comparisons presented here should be interpreted as relative occurrence-based patterns rather than definitive estimates of habitat quality or species richness. Future standardized ecological surveys will be valuable for testing these patterns under controlled sampling designs.

The evaluation of distributional patterns of the species according to zoogeographic chorotypes revealed that the most represented chorotype in the region is the Palaearctic chorotype with 52 species, followed by the Mediterranean chorotype with 25 species and the European chorotype with 22 species (Table 3). Türkiye is located in the Western Palaearctic part of the Holarctic Region. Accordingly, it is expected that a large proportion of the species recorded in the study area belong to widespread Palaearctic chorotypes. Mediterranean chorotypes were more numerous than European chorotypes. This pattern may reflect the arid steppe character of the southern parts of the region, which favors Mediterranean elements. In addition, extensive agricultural conversion in the coastal belt may have reduced the number of species associated with more humid European-type habitats.

The relatively high proportion of endemic taxa (14 species) should be interpreted with caution, because the assessment of endemism depends not only on the faunal knowledge of Türkiye but also on the completeness of data from neighboring countries. Given the still incomplete knowledge of ant faunas in adjacent regions, especially the Balkans, some currently accepted endemic statuses may require revision in the future.

The representation of Asian chorotypes by only 11 species depends on eremial chorotypes which cannot reach the Eastern Black Sea Region in the northeast of the country, which is largely isolated by the Anatolian diagonal, and those that do reach cannot survive in these regions due to the subtropical climate they encounter. Therefore, the ant fauna of the Eastern Black Sea Region contains very few species from the Asian ant chorotypes.

The borders of the region shared with the Caucasus may suggest that the identification of 10 Caucasian species is quite insufficient at first glance. However, considering that the Euro-Caucasian, Ponto-Caucasian-Eastern Mediterranean, Mediterranean and Pontic chorotypes we have grouped within the Palaearctic region are also distributed in the Caucasus, it can be seen that the number of species included in the Caucasian fauna may be higher.

Balkan chorotypes are represented by only 5 species in the Eastern Black Sea Region. This can be explained by the distance of this region from the Balkans.

One species recorded in the study area is cosmopolitan. *Pheidole indica* is an ant species originating from the Indomalayan biogeographic region that has managed to survive in open outdoor populations outside its natural habitat (Sarnat *et al.* 2015). It generally prefers to live in habitats closely associated with humans. Interestingly, the individuals obtained in the study area were collected from an area quite distant from human settlements. However, since no other nests were found either in the same area or in nearby areas, the possibility of human transport arises. This population may be temporary and could disappear if local food resources become insufficient.

Sixteen of the recorded species were identified as social parasites, comprising nine temporary social parasites and seven obligate social parasites. Social parasite species are always much rarer than free-living ants and live in limited areas (Hölldobler & Wilson 1990). Previously, 19 temporary and 24 obligate social parasites were known from Türkiye based on a series of faunistic and taxonomic studies (Borowiec & Salata 2012; Karaman 2012; Kiran & Karaman 2012; Borowiec 2014; Kıran *et al.* 2014; Heinze *et al.* 2015; Karaman *et al.* 2015; Kiran *et al.* 2017; Wagner *et al.* 2018; Kiran *et al.* 2021). Our study also revealed three new host ant species for the first time (*Bothriomyrmex communista*-*Tapinoma glabrellum*; *Formica sanguinea*-*F. georgica; Plagiolepis xene*-*P. perperamus*, the letters being the parasite taxa for each pair) (Table 4).

The species composition suggests the existence of two ecologically distinct subregions within the study area. These areas are the coastal region in the north and the inland region in the south, separated from each other by a barrier formed by the Eastern Black Sea Mountains, which reach an altitude of approximately 4000 m, and the Giresun Mountains, which are over 3000 m high (Fig. 17).

Table 4. Social parasitic ant species and their hosts collected from the study area.

Socially parasitic ant species	Status	Known host(s)	Observed host(s)
Bothriomyrmex communista	Temporary	*Tapinoma* spp.	*Tapinoma glabrellum*
Formica exsecta	Temporary	*Formica fusca* group	*F. fusca*
Formica foreli	Temporary	*Formica fusca* group	-
Formica rufa	Temporary	*Formica fusca* group	*F. fusca*
Formica sanguinea	Dulosis	*F. fusca, F. cunicularia, F. cinerea, F. picea, Coptoformica*	*F. fusca, F. cunicularia, F. georgica*
Lasius balcanicus/distinguendus	Temporary	*L. paralienus (for both species)*	*L. bombycina*
Lasius bicornis	Temporary	*L. brunneus*	-
Lasius carniolicus	Temporary	*L. flavus, L. psammophillus, L. niger*	-
Lasius fuliginosus	Temporary	*Chthonolasius*	-
Lasius umbratus	Temporary	*L. niger, L. platythorax, L. brunneus*	-
Plagiolepis xene	Inquilinism	*P. pygmaea, P. taurica, P. schmitzi*	*P. perperamus*
Polyergus rufescens	Dulosis	*Serviformica*	*F. cunicularia*
Harpagoxenus sublaevis	Dulosis	*L. acervorum, L. muscorum, L. gredleri*	*Leptothorax muscorum*
Strongylognathus rehbinderi	Dulosis	*Tetramorium caespitum, T. forte*	*Tetramorium caespitum*
Strongylognathus testaceus	Dulosis	*Tetramorium caespitum*	*Tetramorium caespitum*
Chalepoxenus muellerianus	Dulosis	*Temnothorax bulgaricus, T. unifasciatus, T. recedens, T. nigriceps, T. flavicornis, T. exilis, T. tuberum, T. affinis, T. semiruber, T. interruptus, T. racovitzai, T. pyrenaeus. T.* cf. *rottenbergi*	*Temnothorax unifasciatus*

When the boundaries of these two regions were drawn and the species composition on both sides was examined, species richness was considerably higher in the inland region than in the coastal region (Table 5). Several factors may have contributed to the lower species richness observed in the coastal region. Extensive agricultural conversion, particularly the replacement of natural habitats by hazelnut orchards and tea plantations, has probably reduced habitat heterogeneity. Almost all the region's flat areas and nearly all natural areas with slopes of up to approximately 55-60% have been cleared of forests and converted into actively used hazelnut and tea gardens, resulting in the formation of monocultures. However, climatic conditions, topography, and historical biogeographic processes may also have influenced the observed pattern.

The rarefaction/extrapolation results strengthen this interpretation by showing that even after standardization for sampling effort, agriculturally transformed habitats—especially tea plantations—remain among the least species-rich habitat types under the present sampling design in the region. In contrast, oak forests, mixed forests, riverbanks, and *Pinus sylvestris* forests consistently rank among the richest habitats, suggesting that structurally heterogeneous and relatively less disturbed habitats maintain a much larger share of the regional ant diversity. This large-scale land conversion has likely reduced habitat heterogeneity and contributed to the lower species richness observed in the coastal zone. A total of 29 hazelnut orchards and 8 tea plantations were surveyed in the coastal part of the region, and 51 and 24 species were recorded in them, respectively. Hazelnut orchards are intensively managed agricultural habitats that are frequently cleared and disturbed. Tea plantations are also intensively managed and generally do not allow the development of diverse accompanying vegetation. As a result of this type of monoculture, the ant fauna in the coastal areas is represented by a significantly reduced number of species.

Table 5. Comparison of ant species richness and species turnover between the coastal and inland subregions of the Eastern Black Sea Region.

Region	Species
Coastal	78
Inland	131
Exclusive to coastal	10
Exclusive to inland	63
Shared	68

Fig. 17. The barrier formed by the Eastern Black Sea Mts and Giresun Mts (dashed lines indicate the highest points of these mountains. Map modified from Google Earth Ver. 7.1.2.2041).

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