Diversity and Community Structure of the Ants (Hymenoptera, Formicidae) in Northcentral and Northeastern Mongolia

モンゴル中北部及び北東部におけるアリ類（膜翅目，アリ科）の多様性と群集構造

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Part 1. General Introduction

1.1. Brief History of myrmecology in Mongolia

The first publication on the history of entomological studies in Mongolia was prepared by Tsendsuren (1963, 1972). It was followed by an extensive literature review on the advances of entomology in Mongolia by Kerzhner (1972). In 2005 Namkhaidorj published a review titled “The development of the insect research in Mongolia”. The publication reviewed the achievement of entomology in Mongolia, covering the entire history of researches and expeditions made both by Mongolian and foreign scientists in many places in Mongolia.

The history of entomological studies in Mongolia is divided into 4 stages (Kerzhner, 1972). First stage covers 1830-1870. The foreign tourists and religious representatives conducted insect collections while travelling in Mongolia. For example, A. A. Bunge, a religious missionary in China in 1830-1831, collected insect samples in Mongolia. Later L. F. Faldermann, a German scientist, processed this collection. Second stage covers 1871-1916. In connection with research in central Asia, the Russian Institute of Geography, while studying nature, geography, history and anthropology of Mongolia, made collections of plants and animals including insects. This represents the pioneer step in the study of biodiversity of Mongolia. Data and information gathered by foreign researchers from Germany, Hungary, France and Norway during their travels through Mongolia also made important contributions. During this period, areas of Mongol Altai, Khangai, Khuvsgul, Khentii range, central and south parts of Mongolia as well as North Mongolia around Khyagt and Dornod were covered in entomological research. The third stage covers 1917-1958. Collaboration between scientific institutions of Russia and Mongolia had a great impact on scientific research development in Mongolia. A number of expeditions conducted by the Russian Academy of Sciences made substantial contribution in this field. These expeditions were conducted in the southern part of Khangai Mountain, depression of Orog Lake and valley of Tuin river, and along the Altai range of Gobi. Expeditions on the forest insects led by V. P. Grechkin were conducted in 1956 and 1957 (Grechkin, 1957).

With the establishment of the National University of Mongolia in 1942, Mongolian scientists began scientific activity. Collaboration with Moscow State University facilitated the grade-up of entomological specialists in Mongolia. In 1959 onwards the fourth stage started. The Mongolian Academy of Science, established in 1961, collaborated with international scientific groups and universities. The joint expeditions between Mongolia and Poland, and Mongolia and Germany were set up in 1962-1964; and Mongolian-Hungarian joint expeditions were conducted during 1963-1968, Mongolian-Czech expeditions during 1965-

1966, and Mongolian-Russian expeditions in 1970 (Tsendsuren, 1972). These expeditions brought about rich collection of insects from over Mongolia. In addition, another 20 or more expeditions were made throughout Mongolia by Hungarian, German, Polish and Czech scientists together with Mongolian counterparts.

In particular Zoltan Kaszab, a famous Hungarian scientist, conducted six expeditions between 1963-1968 collecting 486,342 individuals of animal, mainly insects (Namkhaidorj, 2005). Furthermore thousands of insect were collected by the joint expeditions organised between 1967-1969 and 1970-1984 respectively. This project was joined by many scientists including Mongolians such as B. Namkhaijantsan, K. Ulykpan et al. Among the specimens collected by the Mongol-Russian joint expeditions since 1960, 1300 species in 40 hymenopteran families were identified, 300 being new to Mongolia. Finally an eleven-volume series entitled “Insects of Mongolia” was published (Namkhaidorj, 2005).

The initial phase of myrmecological studies in Mongolia was mainly concerned taxonomy and distribution. The ant fauna of Mongolia was first studied by M. D. Ruzsky, who examined the samples collected by the expedition to Tibet and South Gobi (1900-1901) led by the captain P. K. Kozlov, then the head of the Russian Geographic Society (Ruzsky, 1914). Since this pioneer work, Holgersen (1943), Dlussky (1965), Pisarski (1969a,b, 1970), Dlussky and B. Pisarski (1970), and Pisarski and Krzysztofiak (1981) recorded ants from various parts of Mongolia.

In the more recent phase both community structure and taxonomy have been studied. Entomologists of the National University of Mongolia and Ulm University (Germany) collaborated in studying the latitudinal gradation of the community structure of ants (Pfeiffer, et al., 2003). Almost at the same time studies on the ant fauna of Northcentral and Northeastern Mongolia were started by a Mongol-Japanese team including Sk. Yamane, U. Aibek and his students. Pfeiffer et al. (2007) compiled a critical checklist of the ants of Mongolia and, recording a total of 67 species. Aibek and Yamane (2009, 2010) studied *Camponotus* and *Lasius*, reporting two subgenera of the latter new to Mongolia (also see Introduction in Part 2).

1.2. Objectives

The objectives of this study are as follows:

- To revise the ant fauna of the Northcentral and Northeastern Mongolia. Keys to genera and species are given. For each genus and species a diagnosis is presented followed by collecting data, distribution and bionomic information.
- To reveal and compare ant community structures in different habitat types in Northcentral Mongolia. Nest site and density, and foraging distance are also studied.

- To find major patterns of distribution and diversity of Mongolian ants, and compare them with those of European, Central Asian, Korean, Japanese ant faunas.

1.3. Areas covered

Topography and climate of Mongolia

Mongolia stretches across central and north-east Asia, and has several vegetation types, where the Siberian taiga forest meets the Central Asian steppe and desert. The largest north-south distance measures more than 1,200 km, and the largest east-west distance reaches approximately 2,370 km. Mongolia is an upland country, with an average elevation of 1,580 m alt., and about 85% of its area is over 1,000 m alt. (Murzaev, 1952).

Mongolia has an extreme continental climate, and temperature fluctuates greatly, both daily and annually (Fig. 1-1). The lowest temperatures are recorded in January, with monthly averages under -15°C and minimum temperatures as low as -30°C. July is the warmest month, with mean temperatures of 15°C in the mountains and 20-30°C in the southern semi-desert and desert areas.

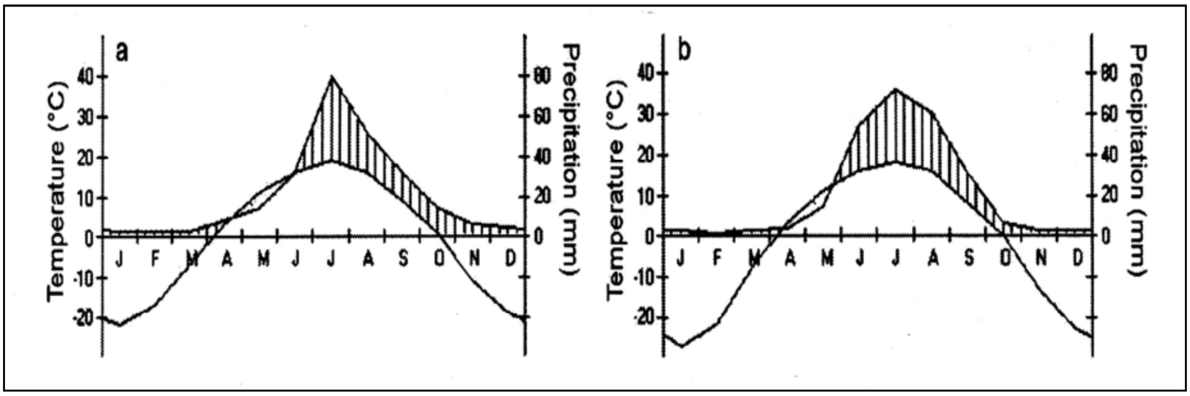

Fig. 1-1. Climate diagrams from the weather station (a) Bugant and (b) Eroo, Northcentral Mongolia (after Guinin et. al., 2010).

The highest yearly precipitation values do not exceed 600 mm in the northern mountains, whereas southern desert areas receive roughly 50 mm of precipitation. From north to south of the country, mean annual precipitation decreases steadily, this is a decisive factor for the distribution of vegetation formations. From north to south it not only gets drier, but warmer as well. From west to east some areas show a comparatively low precipitation because they are on the lee side of mountain chains. Such a lee effect is most pronounced in the depressions of larger lakes in western part, but it is also recognizable in central and eastern Mongolia (Hilbig, 1995). This complex set of parameters, together with the large area of the country, creates a large variety of habitats and has a distinct influence on the biodiversity of the region.

Temperature and vegetation show a similar pattern in altitudinal zonation. Thus, Mongolia involves several vegetation zones and vertical belts, i.e. from north to south we meet alpine meadow (alpine vegetation with upper limit of closed turf), mountain taiga-forest, forest-steppe, steppe, desert-steppe (semi-desert), and desert (Yunatov, 1950; Murzaev, 1952).

According to the vegetation, floral composition, topographic and climatic characteristics, Mongolia is divided into 16 phytogeographical regions (Yunatov, 1950; Murzaev, 1952; Grubov, 1953, 1982; Fig. 1-2). Two of these are mountain taiga forests (1. Khuvsgul, 2. Khentii), three are forest-steppes (3. Khangai, 4. Mongolian Dauria, 5. Great Khyangan), four are steppes (6. Khovd, 7. Mongolian Altai, 8. Middle Khalkh, 9. Eastern Mongolia), four are semi-deserts (10. Depression of Great Lakes, 11. Valley of Lakes, 12. Eastern Gobi, 13. Gobi Altai), and three are desert regions (14. Dzungarian Gobi, 15. Trans-Altai Gobi, 16. Alashan Gobi).

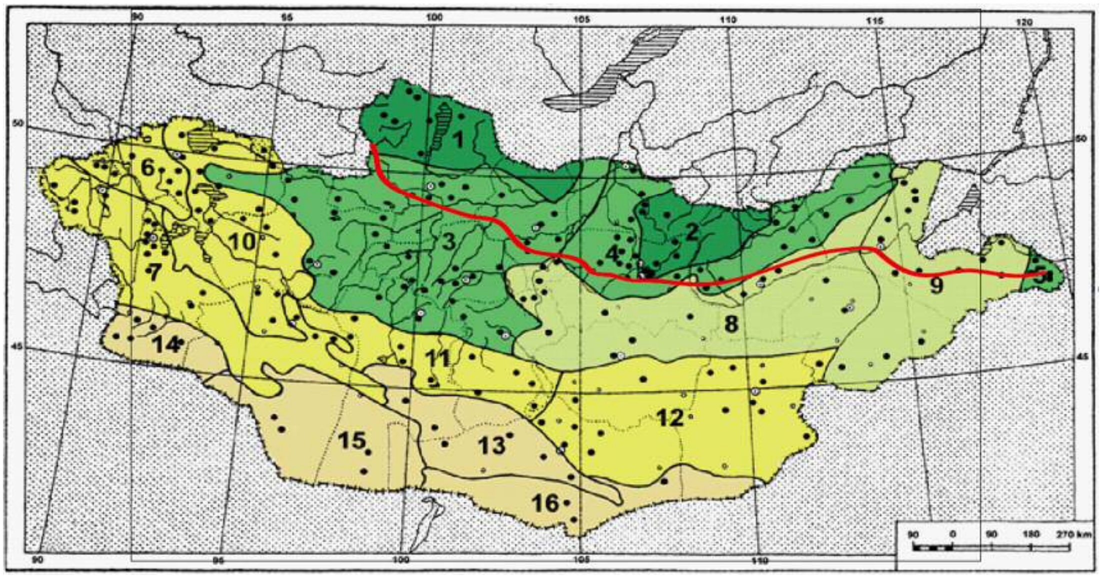

Fig. 1-2. Phytogeographical regions of Mongolia (modified from Yunatov, 1950).
The area covered in this study is the area above the red line.

Study areas

In this paper the area above the red line on the map (Fig. 2.2) is defined as Northcentral and Northeastern Mongolia. Six phytogeographical regions are involved in this area: Khuvsgul (1), Khentii (2), Northern and Central Khangai (3), Mongolian Dauria (4), and Great Khyangan (5), Eastern Mongolia (9). In this area are included three vegetation zones, namely, mountain taiga (Khuvsgul, Northern Khangai, Khentii and Great Khyangan), forest steppe (area between Khangai, Khuvsgul and Khentii, and Mongolian Dauria), and steppe (Eastern Mongolia). Three extensive mountain systems, namely, Altai-Sayan, Khentii and Khangai mountain systems are recognized.

Forest covers approximately 9.6 % of the total area of Mongolia. Large parts of the

Northern mountains (94.8 % of the whole forest area) are covered with needle-leaved forests, which are particularly extensive in parts of Khentii, Khuvsgul region and Khangai. The main needle-leaved species are *Larix sibirica* (72 % of total forest area), *Pinus sibirica* (12 %), *Pinus sylvestris* (7 %), and *Picea obovata* (0.25 %). *Abies sibirica* (0.02 %) occurs only in the Northwestern Khentii (Lesa, 1978). *Betula* forests and shrubs occur in lower mountain belts and along forest edges. Particularly in the lower mountain belt of North Mongolia the slopes facing north and higher parts are often covered with needle-leaved forests, whereas steppes are abundant on slopes facing south and in nearby valleys.

The materials for taxonomic studied have mainly been collected from the areas defined above by Ulykpan Aibek and Seiki Yamane, and deposited in the entomological collection at the National University of Mongolia and SKY collection (Kagoshima, Japan) (see *Materials and Methods* for Part 2). Surveys on ant community structure were conducted in several sites in Bogd Khan National Park located southeast of the capital city (Ulaanbaatar), Northcentral Mongolia. Additional data were collected in Khonin Nuga Nature Reserve located in Khentii mountains. Details of survey method are given in *Materials and Methods* for Part 3. For the discussion on the geographical distribution of the Mongolian ants all the specimens from whole Mongolia and records in the literature are used (Part 4).

Part 2. Taxonomy of ants in NC and NE Mongolia

2.1. Introduction

The ant fauna of Mongolia was first studied by M. D. Ruzsky, who examined the samples collected by the expedition to Tibet and South Gobi (1900-1901) led by the captain P. K. Kozlov, Head of the Russian Geographic Society (Ruzsky, 1914). Holgersen (1943) recorded six species based on the material collected by Orjan Olsen, a Norwegian, in Siberia and Mongolia in 1914. Dlussky (1965) revised the genus *Formica* in Mongolia and Northeast Tibet. Ant samples collected by four Mongol-Polish joint expeditions between 1962-1965 were identified by Bogdan Pisarski and 33 species were recorded (Pisarski, 1969a). Pisarski (1969b) also recorded 43 ant species based on the specimens collected by Z. Kaszab in 1963-1966. Dlussky and Pisarski (1970) recorded 29 species from the ant collection made by the Mongolian-German expedition. Pisarski and Krzysztofiak (1981) recorded 41 species using the material collected by Z. Kaszab in 1967-1968 in western part of Mongolia and Gobi.

More recently scientists from Ulm University (Germany) and Kagoshima University (Japan) have been working with Mongolian scientists to compile the complete inventory of ants in Mongolia. Pfeiffer, et al. (2007) listed 68 ant species in 17 genera based on the literature and recently collected materials. Aibek and Yamane (2009) revised the Mongolian *Camponotus*, reporting a species of the subgenus *Tanaemyrmex* for the first time from Mongolia and presenting important characteristics that differentiate *C.* (*Camponotus*) *aterrimus* from other species of the subgenus. Furthermore, Aibek and Yamane (2010) added two subgenera (*Austrolasius* and *Dendrolasius*) of the genus *Lasius* to the ant fauna of Mongolia. In a revision of the Old World *Myrmica* Radchenko and Elmes (2010) recorded 15 species from Mongolia, and Yamane and Aibek (2012) gave detailed distribution data for 14 species of this genus together with worker diagnoses for these species.

In this work all the ant species known from Northcental and Northeastern Mongolia (see Fig. 2.2) are taxonomically revised. This is a first step to understand the entire ant fauna of Mongolia. Distribution maps given for each species should play an important role in biodiversity conservation in Mongolia.

2.2. Materials and Methods

Materials examined

The present work relies mainly on the material collected during 2003 to 2012 by

Ulykpan Aibek and Seiki Yamane with the help of students from the Ecology Department, National University of Mongolia. Additional material was supplied by Prof. Martin Pfeiffer of Ulm University (Germany). These specimens are deposited in the entomological collection at the Ecology Department, National University of Mongolia and SKY collection (Kagoshima, Japan). I examined paratypes of *Formica pisarskii* Dlussky and *F. brunneonitida* Dlussky deposited in the entomological collection at the Mongolian Academy of Science. In preparing distribution maps records given in the literature were also used with careful attention to misidentification. Photographs of the ant specimens used in the text were taken by Prof. M. Pfeiffer, and kindly offerred to me. Pictures of ants in life were taken by Prof. Sk. Yamane.

Abbreviations. Collectors: Ulykpan Aibek (UA or UAi) and Seiki Yamane (SKY). Collector names are often omitted if the colony code is available. Caste and sex: Worker (w), queen (q), new queen (nq), founding queen (fq), and male (m).

2.3. Key to genera of Mongolian ants

The ant fauna of Mongolia comprises 17 native genera in 3 subfamilies, i.e., Dolichoderinae, Formicinae and Myrmicinae. One species of the myrmicine genus *Monomorium*, the tramp ant *M. pharaonis*, can be found in buildings that are kept warm year round. This species is separated from the other myrmicines by a combination of the following conditions: promesonotum roundly raised and higher than propodeum, clypeus with a pair of longitudinal carinae, and petiole with a distinct pedicel. A queen of a species of *Hypoponera* (Ponerinae) was collected in a restaurant in Ulaanbaatar. This might have been transported in a plant pot.

This key can be applied only to the Mongolian species. More complete key to the world genera is available in Bolton (1994). For the differentiation of *Leptothorax* from *Temnothorax*, apparently very similar to each other, Bolton (2003) is useful.

1. Waist consisting of two segments, i.e., petiole and postpetiole. 2
- Waist consisting of one segment, i.e., petiole. 9
2. Gaster seen from above roughly heart-shaped; postpetiole articulated on dorsal face of gastral segment 1. .... ***Crematogaster***
- Gaster seen from above differently shaped; postpetiole articulated on anterior face of gastral segment 1. 3
3. Antenna 11-segmented. 4
- Antenna 12-segmented. 5
4. Masticatory margin of mandible edentate; antennal scrobe present. .... ***Harpagoxenus***

- Masticatory margin of mandible with teeth; antennal scrobe absent. .... ***Leptothorax***
5. Mid- and hind tibiae with pectinate spurs; maxillary palp with 6, labial palp with 4 segments. .... ***Myrmica***
- Mid- and hind tibiae with simple spurs; maxillary and labial palps with different numbers of segments. 6
6. Larger species, measuring more than 4 mm in total length; in profile promesonotum distinctly higher than propodeum. .... ***Messor***
- Smaller species, measuring 3 mm or less in total length; in profile mesosoma with more or less flat dorsal outline. 7
7. Dorsa of head (except for mandible and clypeus) and mesosoma without standing hairs; postpetiole massive, seen from above 2 times as broad as petiole. .... ***Cardiocondyla***
- Dorsa of head and mesosoma with standing hairs; postpetiole not massive, seen from above at most 1.2 times as broad as petiole. 8
8. In profile petiole rectangular, with more or less flat dorsal portion; antennal socket margined anteriorly with sharp-edged wall of posterolateral margin of clypeus…………….
………………………………………………………………………..…... ***Tetramorium***
- In profile petiole roughly triangular, with rounded dorsal margin; antennal socket anteriorly not margined with such wall. .... ***Temnothorax***
9. Petiole flat, without node, usually hidden under gastral tergite 1. .... ***Tapinoma***
- Petiole with distinct node that is scale-like or globular in shape. 10
10. In profile posterior margin of propodeum concave; acidopore absent, apex of gaster slit-like; gastral tergites 1 and 2 with a pair of yellow spots. .... ***Dolichoderus***
- In profile posterior margin of propodeum straight to convex; almost circular acidopore present, often nozzle-like and margined with erect hairs; gastral tergites 1 and 2 differently colored. 11
11. Antenna 11-segmented. .... ***Plagiolepis***
- Antenna 12-segmented. 12
12. Antennal sockets situated well behind posterior margin of clypeus; with mesosoma in profile dorsal outline unbroken like arch; metapleural gland orifice absent……………….
…………….. .... ***Camponotus***
- Antennal sockets situated very close to posterior margin of clypeus; with mesosoma in profile dorsal outline interrupted between mesonotum and propodeum. 13
13. Mandible narrow, sickle-like, tapering to pointed apex. .... ***Polyergus***
- Mandible elongate triangular or triangular. 14
14. Propodeal spiracle generally near-circular; gastral sternite 1 without transverse sulcus just behind helcium. .... ***Lasius***
- Propodeal spiracle oval to elongate; gastral sternite 1 with transverse sulcus just behind

helcium. 15

15. Mandible usually with 8 teeth. .... ***Formica***

- Mandible with 5 teeth. 16

16. Pronotum finely sculptured and mat; clypeus with weaker sculpture, at most very densely and finely sculptured. .... ***Cataglyphis***

- Pronotum almost smooth and shiny; clypeus generally with distinct longitudinal striae over surface. .... ***Proformica***

2.4. Treatment by species

Subfamily **Dolichoderinae**

Genus ***Dolichoderus*** Lund, 1831

Dolichoderus, Lund, 1831: 130. Type species: *Formica attelaboides* Fabricius, 1775: 394, by monotypy; Kupyanskaya, 1995: 350.

This cosmopolitan genus comprises approximately 150 species, distributed mainly in Neotropical and Oriental regions (Dill et al., 2002). Two species occur in the Palaearctic region, one of which, *D. sibiricus*, is found in Northcentral Mongolia.

Antenna 11-segmented, without distinct club. In profile posterior margin of propodeum concave. Apex of gaster slit-like, without acidopore. Petiole with distinct node that is scale-like or globular in shape.

Dolichoderus sibiricus Emery, 1889

Dolichoderus quandripunctatus subsp. s*ibiricus* Emery 1889: 442 (type locality: Siberia, Russia).

Dolichoderus sibiricus: Yasumatsu, 1962: 96; Kupyanskaya, 1995: 350.

Worker diagnosis. Body length 3.0-4.2 mm. Mesosoma with quite coarse sculpture (punctuate or granulate). In profile propodeal declivity deeply concave. Petiole with distinct node that is scale-like. Gastral tergites 1 and 2 each with a pair of yellow spots.

Material examined. Unegt (800-900 m alt.), Selenge aimag, 2 VIII 2009, SKY & UA leg. (MG09-SKY-39) (w,q); Darkhan city, Darkhan-Uul aimag, 28 VII 2011, UA11-65 (w).

Distribution. Mongolia, South Khabarovsk, Amur, Sakhalin, China, North Korea, Japan.

Bionomics. *Dolichoderus sibiricus* occurs at relatively low altitudes between 900-1,200 m alt. I collected two colonies of this species in Northcentral part (Darkhan-Uul and Selenge aimag) of Mongolia from under the bark of twigs of living *Salix* sp. trees. Males were found in one of the colonies in early August.

 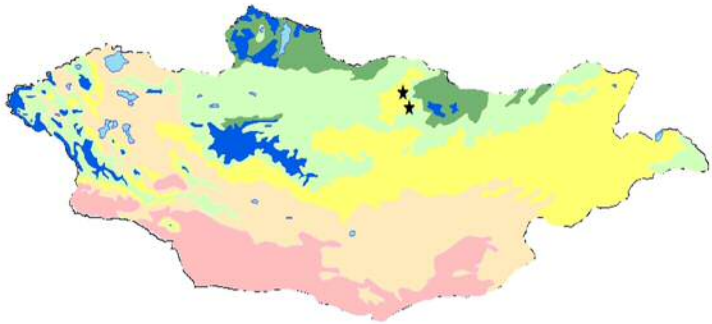

Fig. 2-1. Worker of *Dolichoderus sibiricus* and collection sites.

Subfamily **Formicinae**

Genus ***Camponotus*** Mayr, 1861

Camponotus Mayr, 1861:35. Type species: *Formica ligniperda* Latreille, 1802: 88, by subsequent designation of Bingham 1903: 347; Bolton, 2003: 27, 112.

Camponotus is one of the largest cosmopolitan genera in the World. The genus comprises 46 subgenera and no less than 1000 species, with the highest diversity in the tropics. Eight subgenera and more than 100 species are known from the Palaearctic region (Radchenko, 2005).

Worker diagnosis. Most species are large with a great size variation in the worker caste, in total body length the smallest workers generally measuring more than 5 mm and the largest ca. 11-12 mm in the Mongolian species. Dorsal outline of the alitrunk evenly convex and metanotal groove absent or very weak in most temperate Asian species. Antennae inserted just behind posterior clypeal margin. Antenna 12-segmented in the worker and queen, and 13-segmented in the male. Maxillary palp 6-segmented and labial palp 4-segmented. Ocelli absent in the worker, small but distinct in the queen and male.

Foraging activity of species of the subgenus *Camponotus* is seen in the daytime or throughout a day, while those of the subgenus *Tanaemyrmex* are principally nocturnal.

Keys to Mongolian species of Camponotus

Two *Tanaemyrmex* species in the key occur only in southern part of Mongolia, thus are excluded in species accounts.

1. Whole body black or blackish brown (sometimes partly reddish). Masticatory margin of mandible with 5 teeth. Clypeus usually without a distinct median carina, rarely with a weak carina. Head of major worker (mandibles excluded) broader than long. Gastral tergites with appressed pubescence. .... Subgenus ***Camponotus*** 2

- Whole body yellow or brownish yellow. Masticatory margin of mandible with 7 teeth. Clypeus with a distinct median carina. Head of major worker (mandibles excluded) as long as broad or distinctly longer than broad. Gastral tergites apparently without appressed pubescence. .... Subgenus ***Tanaemyrmex*** 4

2. Propodeum posteriorly with rather fine standing hairs down to midlength of its posterior (declivous) face. In the smallest workers the dorsal outline of alitrunk in profile almost constantly arched throughout. Even in larger workers basal half of mandible lacking striae (at most striae very feeble). With head in full-face view clypeus anteriorly tending to protrude often as a short lobe. …………………………………...***C.*** (***C.***) ***aterrimus*** Emery

- Propodeum posteriorly with thicker standing hairs that are generally restricted to the upper third of its posterior face. In the smallest workers propodeum in profile with a distinct steep posterior slope. In larger workers nearly whole mandible distinctly striate. With head in full-face view clypeus anteriorly not produced beyond the anterolateral angles of gena. ..……………………………………………………..……………….. 3

3. Propodeal declivity, petiole, legs and antennal flagellum (in smaller workers often alitrunk extensively) reddish brown. Gastral tergites with sparse and short pubescence; appressed hairs only 2-3 times as long as distance between them. ………….………………………………..……..…….. ***C.*** (***C.***) ***sachalinensis*** Forel

- Body almost wholly black; legs and antennal flagellum often with a reddish tinge. Gastral tergites with dense and long pubescence; appressed hairs 4-6 times as long as distance between them. ………………………………………………… ***C.*** (***C.***) ***saxatilis*** Ruzsky

4. Gena and ventral surface of head without standing hairs. Dorsal face of propodeum shallowly convex in larger workers. Mid- and hind tibiae below with sparse, suberect hairs. Mandibular teeth gradually decreasing in size from the apical to the basal, with basalmost (7th) tooth smallest. .... ***C.*** (***T.***) ***turkestanus*** André

- Ventral surface of head with long standing hairs; gena with a few short, standing hairs. Dorsal face of propodeum shallowly concave in larger workers. Mid- and hind tibiae below densely with almost appressed hairs. Mandible with 5th tooth smallest……………………………………….………….. ***C.*** (***T.***) ***tachcumiri*** Tarbinsky

Camponotus (***Camponotus***) ***aterrimus*** Emery, 1895

Camponotus pennsylvanicus var. *aterrimus* Emery, 1895: 478 (type locality: East Siberia, Russia).

Camponotus herculeanus L. subsp. *japonicus* Mayr var. *aterrima* (sic) Emery: Karavaiev, 1912: 594-595.

Camponotus herculeanus aterrimus Ruzsky, 1915: 419-420.

Camponotus japonicus aterrimus: Kupyanskaya, 1990: 170-171, 1995: 353;

Camponotus aterrimus : Ruzsky, 1926: 108; Aibek and Yamane, 2009: 99.

Worker. Body length 6-11 mm. With head in full-face view clypeus anteriorly often produced as a short lobe. Frons between frontal carinae very finely micropunctate;

macropunctures, if any, inconspicuous and confined to lateral zone close to frontal carina. Masticatory margin of mandible with five teeth. In the smallest workers the dorsal outline of alitrunk in profile almost constantly arched throughout, without a distinct steep slope posteriorly on propodeum. Body densely microsculptured and dull, with head laterally weakly shining. Mandible weakly to rather strongly shinning except in extreme basal part, punctate but without distinct striation in basal half even in larger workers. Occipital margin of head without standing hairs; clypeus and frons with long curved standing hairs. Ventral surface of head posteriorly with a few (2-4) short erect hairs. Alitrunk dorsally with long standing hairs; propodeum posteriorly with rather fine standing hairs down to midlength of its posterior (declivous) face. Gastral tergites abundantly with long standing hairs; number of standing hairs on second tergite 8-14. Gastral tergites with sparse short pubescence; appressed hairs only 2-2.5 times as long as distance between them. Body black, with anterior part of head and mandible often reddish brown; legs also sometimes tinged with reddish brown.

Q**ueen and male:** not available among the material from Mongolia.

Taxonomic remarks. It can be separated from *C. sachalinensis* and *C. saxatilis* by the following characteristics: 1) in the smallest workers the dorsal outline of alitrunk in profile almost constantly arched throughout; 2) even in larger workers the mandible basally without striae; 3) clypeus often produced anteriad as a short lobe. Kupyanskaya (1990, 1995) has treated this form as a subspecies of *C. japonicus*. Pfeiffer et al. (2007) considered (but not clearly stated) *aterrimus* as a junior synonym of *japonicus*. I treat *C. aterrimus* to be a distinct species since gastral pubescence in the worker is distinctly shorter and sparser than in *C. japonicus* (see also Emery, 1895). In other respects, including nesting habit, these two are not separable. Since any of previous papers on Asian *Camponotus* did not mention the most important recognition characteristics of *C. japonicus* + *C. aterrimus* (1 and 2 mentioned above), previous records of *C. aterrimus* from Mongolia should be reexamined.

In the queen *C. japonicus* is easily distinguished from *C. sachalinensis* and *C. saxatilis* by the clypeus when with the head in full-face view anteriorly often produced as a short lobe; gastral tergites with denser and longer pubescence; appressed hairs in length subequal the distance between them; anterior part of head, mandible and legs reddish. In the male *C. japonicus* is separated from *C. sachalinensis* and *C. saxatilis* by the following characteristics: 1) seen from back the upper margin of the petiole is almost straight, with dorsolateral corners round, but the petiole is postero-dorsally weakly produced at middle, 2) in both the queen and male of *C. japonicus* the forewing is almost wholly transparent, only slightly infuscated along the anterior margin.

Specimens examined. Bogd Khaan NP (Khurkhree valley), Tuv aimag, 9 VII 2007, Q-7 (w); same loc., 21 VIII 2007, MG07-SKY-44; Hustai NP (Khushuut valley), Tuv aimag, 21 VIII 2007, K. Hayashi leg (w); Hustai NP (Tuul river valley), 28 VIII 2010, UA10- 43 (w); Tujiin nars (685 m alt.), Selenge aimag, 15 IX 2010, SKY leg.; nr Dadal (1050 m alt.), Khentii aimag, 8 VIII 2009, MG09-SKY-55 (w,q); nr Dadal (940 m alt., pine forest), Khentii aimag, 9 VIII 2009, SKY leg.; nr Norovlin (pine forest), Khentii aimag, MG08-SKY-47 (w); Halkh gol sum, Dornod aimag, E. Mongolia, 24 VII 2008, MG08-SKY-41 (w); same data, SKY leg.; same data, UAi-08-135 (w); same data, Ulzii08-150 (w).

Distribution. Zabaikal, East Kazakhstan, North China, South Siberia, Mongolia.

Bionomics. *Camponotus aterrimus* is widely distributed in Northcental and Eastern Mongolia, but not very common. It is generally confined to altitudes below 1,600 m alt. In Numrug (Dornod aimag) foraging workers were commonly found, inhabiting open sites at relatively low altitudes between 600- 800 m. However, this species was also found in sparse pine forests. Nests were constructed in soil and the burrow was dug directly from the ground surface just as in cases observed for *C. japonicus* in Japan. One nest was found under a stone.

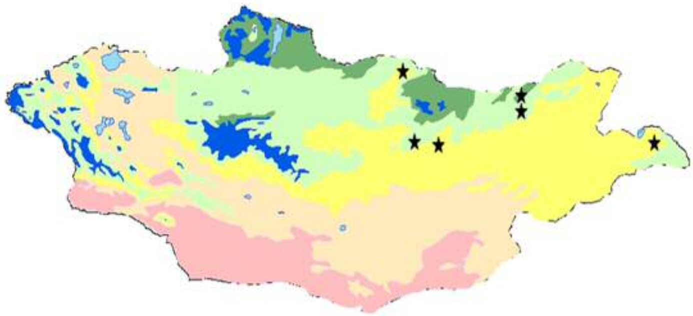

Fig. 2-2. Worker of *Camponotus aterrimus* and collection sites.

Camponotus* (*Camponotus*) *sachalinensis Forel, 1904

Camponotus herculeanus var. *sachalinensis* Forel, 1904: 381(14) (type locality: Sakhaline Russia).

Camponotus herculeanu sachalinensis: Ruzsky, 1926: 108; Collingwood, 1976: 306; Kupyanskaya, 1990: 166-167, 1995: 353; Radchenko, 1996: 1203, 1997a: 555-556; Radchenko, 2005: 158.

Camponotus sachalinensis: Collingwood, 1981: 29; Bolton, 1995: 121; Japanese Ant Database Group, 2003: 31; Aibek and Yamane, 2009: 101.

Worker. Large species with a marked size variation; body length ranging from 7-11 mm. With head in full-face view clypeus anteriorly not produced beyond the level of anterolateral angles of gena, usually without a distinct median carina, rarely with a weak carina. Mandible broad, subtriangular, and masticatory margin with five teeth. In the smallest workers propodeum in profile with a steep posterior slope that is more or less distinctly demarcated from dorsal face. Body densely with fine microsculpture; lateral part of head, alitrunk, and legs weakly shining. Frons between frontal carinae with several large punctures along each carina, and many smaller punctures in median part in addition to micropunctation (macropunctures less pronounced in smaller individuals). In larger workers mandible except in extreme basal portion distinctly striate but weakly shining. Occipital margin of head without standing hairs; clypeus, frons, vertex, ventral part of head and alitrunk, with long standing hairs. Propodeum posteriorly with relatively thick standing hairs that are generally restricted to the upper third of its posterior face. Tergites and sternites of gaster with long standing hairs. Gastral tergites with sparse and short pubescence; appressed hairs only 2-3 times as long as distance between them. Fore-coxa anteriorly and posteriorly, fore-femur ventrally, and mid- and hind coxa ventrally with standing hairs. Body black. Propodeal declivity, petiole, legs and antennal flagellum (in smaller workers often alitrunk extensively) reddish brown.

Queen. Body length 14-16 mm. Petiole in profile apically very acute and its anterior slope with a blunt angle in its lower part. Body wholly very finely sculptured and shining. Occipital margin of head without standing hairs; clypeus, frons, ventral surface of head posteriorly, alitrunk, and gaster with long standing hairs. Metanotum with more than 4 standing hairs. Standing hairs on gastral tergites tending to be shorter than in *C. saxatilis*. Pubescence on gastral tergites short and sparse; distance between appressed hairs subequal to hair length. Body wholly black, but legs often tinged with red. Forewing light brown, with the apical zone only slightly darker.

Male. Mongolian specimens not available. The following description is based on two Japanese and one Russian specimens. Body length 9-12 mm. Occipital corners of head round. Upper margin of petiole seen in posterior view widely and deeply concave at middle with lateral angles pointed apically. Scutellum not shining seen in dorsal view. Pubescence on gastral tergites short and sparse; distance between appressed hairs subequal to hair length. Body wholly black, but in the Japanese specimens side of mesosoma and legs more or less reddish. Forewing almost transparent, with anterior zone very weakly infuscated.

Taxonomic remarks. Various authors have treated this form as a subspecies of *C. herculeanus* or as a distinct species. Collingwood (1981) first raised this form to distinct species rank, but he did not mention any difference between the two. Radchenko (2005) argued that it is a subspecies of *C. herculeanus*, since *sachalinensis* and the typical form differ only in coloration, and intermediate specimens can be collected in Altai and Tuva. He mentioned that the two forms are indistinguishable also in the queen and male. The typical *C. herculeanus* is distinctly bicolored; especially in the queen caste the lateral part of mesonotum, whole propodeum, petiole and legs are reddish brown, while the queen of *sachaliensis* is almost wholly black except for legs. In the typical form, even the major worker has reddish brown alitrunk, petiole and legs, while the major worker of *sachalinensis* has wholly black alitrunk; only the propodeal declivity, petiole and legs are tinged with brown or red. Furthermore, in the worker of the typical form from Finland the pubescence on gastral tergites is longer and denser than in *sachalinensis*. Although the difference is minor, we tentatively follow Collingwood (1981) and Bolton (1995a).

Material examined. Bogd Khaan N.P. 1550m alt., Tuv aimag, NC. Mongolia, 27 VI 2003, MG03-SKY-05 (w); same loc., 28 VI 2003, UAi03-65 (w); same loc., 8 VII 2007, Ulzii-07-45(w, m) 9 VII 2003, MG03-SKY-83(w); same loc., 16 VII 2003, SKY leg., (q); same loc., 12 VII 2007, UAi-07-38 (q); same loc., 12 VII 2008, UAi-08-72 (w); same data, Ulzii-132 (w); same data, SKY leg.; Gorkhi, Terelj 1250m alt., Tuv aimag, NC. Mongolia, 29 VI 2003, MG03-SKY-40 (w); same data, UAi-03-53 (w); same loc. 30 VI 2003, SKY leg (q); same loc., 1 VII 2003, SKY leg (w); Khonin Nuga, 930m alt., Khentii Mts., Selenge aimag, N. Mongolia, 13 VIII 2004, MG04-SKY-90 (w); Khentii Mts. Selenge aimag, 14 VIII 2004, MG04-SKY-126 (w); Dalbaa, Huvsgul aimag, 5 VII 2007, Bayartogtokh leg. (w, q); Numrug, Dornod aimag, E. Mongolia, 25 VII 2008, UA leg. (q).

Distribution. Mongolia, East Siberia, Russian Far East, Northeast China, North Korea, Japan.

Bionomics. This boreal species lives at altitudes mostly above 1,200-1,300 m in Mongolia. It inhabits different kinds of forest (larch, birch and pine) and mountain meadows. Nests are built in rotten wood, stumps and tree hollows, and under log partly in soil. Males and winged queens are seen in July in nests, and some dealated queens were collected outside the nest in late June to July.

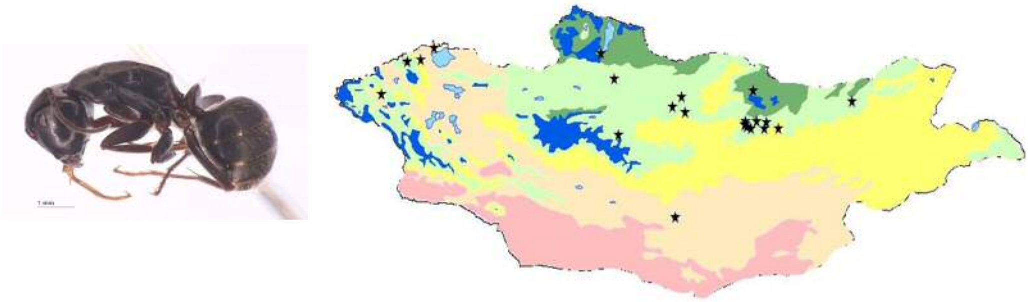

Fig. 2-3. Worker of *Camponotus sachalinensis* and collection sites.

Camponotus* (*Camponotus*) *saxatilis Ruzsky, 1895

Camponotus herculeanus saxatilis Ruzsky, 1895: 7 (type locality: Povolj`e, Russia).

Camponotus saxatilis: Ruzsky, 1926: 108; Kupyanskaya, 1990: 167-169, 1995: 353; Bolton, 1995a: 122; Radchenko, 1996: 1203, 1997: 557; 2005: 160; Aibek and Yamane, 2009: 103.

Worker. Large species, with body length ranging from 7 to 12 mm. Clypeus anteriorly not produced beyond the level of anterolateral angles of gena. Mandible broad and subtriangular; masticatory margin with five teeth. Even in the smallest workers propodeum in profile with a steep posterior slope that is more or less demarcated from dorsal face. Body finely microsculptured and dull. Frons between frontal carinae with several large punctures along each carina, and smaller and very superficial punctures along median line (macropunctures confined to area close to frontal carina and indistinct in smaller individuals). In larger workers whole mandible distinctly striate and dull. Occipital margin of head without standing hairs; clypeus, frons, ventral surface of head posteriorly, alitrunk, and gaster with long, yellowish curved standing hairs. Propodeum posteriorly with rather thick standing hairs that are generally restricted to the upper third of its posterior face. Clypeus, gena, and alitrunk with short pubescence; appressed hairs as long as distance between them. Gastral tergites with dense and long pubescence; appressed hairs 4-6 times as long as distance between them. Pilosity on legs almost same as in *C. sachalinensis*. Body almost wholly black; legs and antennal flagellum often with a reddish tinge.

Queen. Body length 14-17 mm. Petiole in profile apically very acute and anterior slope with a blunt angle in its lower part. Mandible striate, slightly shining. Head and propodeum dull; mesoscutum, scutellum and gaster smooth, shining. Occipital margin of head without standing hairs; clypeus, frons, ventral surface of head posteriorly, alitrunk, and gaster with long standing hairs. Metanotum with less than 4 standing hairs (rarely 4) or without standing hairs. Standing hairs on gastral tergites tending to be longer than in *C. sachalinensis*. Pubescence on gaster very short and sparse. Body wholly black. Forewing more strongly infuscated than in *C. sachalinensis*, with its anterior zone much darker than in the latter.

Male. Body length 10-12 mm. Head elongate with genae parallel-sided. Posterior outline of head between eyes in full-face view evenly and roundly convex. Scutellum and propodeal dorsum weakly sculptured and shining. Upper margin of petiole seen in dorsal view widely but only shallowly concave in the middle, with lateral angles rounded. Pubescence on gastral tergites sparse and short. Body wholly black; tibiae and tarsi often slightly reddish. Forewing transparent with anterior zone rather strongly darkened.

Taxonomic remarks. In the worker this species is easily distinguished from *C. sachalinensis* by the almost wholly black body and long and dense pubescence on gastral tergites; in the male by the shallower apical concavity of petiole with rounded lateral angles. In the queen both species are very similar, but metanotum has constantly fewer standing hairs (usually less than 4) in *C. saxatilis*. In both the queen and male, forewing is more strongly infuscated with its anterior zone rather strongly darkened in *C. saxatilis*.

Specimens examined. Terelj 1250 m alt., Tuv aimag, N 470 54` E 1070 23`, 8 VII 1997, M. Pfeiffer leg. 15 (w); same loc., 29 VI 2003 SKY leg (q); same loc., 30 VI 2003, MG03-SKY-38 (m); same loc., MG03-SKY- 39 (q); same loc., 1 VII 2003, MG03-SKY- 41 (w, q, m); same loc., MG03-SKY- 43 (w, m); same data UAi03- 28 (q); Bogd Khaan N.P., 1550m alt., Tuv aimag, 28 VI 2003, MG03-SKY-19 (w); same loc., 25 VI 2003, K. Ulykpan leg. (w); same loc., 12 VII 2008, SKY leg., (w), same data UA leg., (w); same loc., 16 VII 2008, MG03-SKY- 24 (w); same loc., 22 VII 2007, UAi-07-22 (q); Khandgait, Jiver Mt., 1650m alt., Ulaanbaatar, 7 VIII 2004, SKY leg (w); same data, UAi03-54 (w); Hustai N.P., 1850m alt., Tuv aimag, 4 VII 2003, MG03-SKY- 69 (w); Khonin Nuga, 930m alt., Khentii Mts., Selenge aimag, 12 VIII 2004, MG04-SKY-71 (w); same data UAi04-68 (w); same loc., 13 VIII 2004, MG04-SKY- 94 (w); Khentii Mts., Selenge aimag, 14 VIII 2004, MG04-SKY-125 (w); Numrug, Dornod aimag, 25 VII 2008, MG08-SKY-56 (w); same data, UAi-08-143 (w); same data, Ulzii08-156 (w).

Distribution. Russia (from Volga and Kama rivers to Far East), Mongolia, North Korea.

Bionomics. This species inhabits mostly open sites (forest steppe, mountain steppe, forest edge, grassland), and is also met in different kinds of forest (larch, birch, mixed forests). Nests are built mainly in dead wood (rotten wood, fallen wood, dead standing tree, base of dead tree), and under stone partly in soil. Nuptial flights were seen in July and August (15 July 2007 U.Aibek leg.).

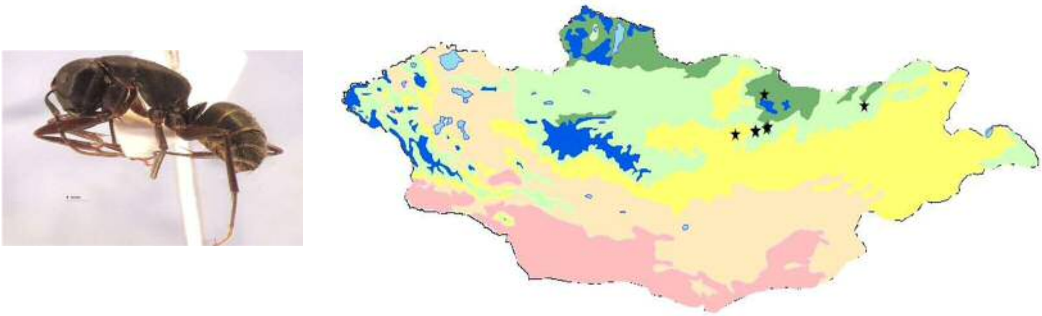

Fig. 2-4. Worker of *Camponotus saxatilis* and collection sites.

Fig. 2-5. Nest of *Camponotus saxatilis* in hard dead wood.

Fig. 2-6. Workers of *Camponotus saxatilis*.

Fig. 2-7. Nests of *Formica (Serviformica) candida*.

Fig. 2-8. *Formica candida* workers carrying a grasshopper.

Genus *Cataglyphis* Foerster, 1850

Cataglyphis Foerster, 1850: 493. Type species: *Cataglyphis fairmairei,* by monotypy; Agosti, 1990: 1461; 1994: 103.

The genus *Cataglyphis* includes about 100 species, and most species occur in the South Palaearctic. Only one species occurs in Mongolia.

Worker diagnosis. Body size highly variable. Antenna 12-segmented; antennal sockets situated very close to posterior margin of clypeus. Mandible elongate triangular or triangular, with 5 teeth. Basal segment of maxillary palp flattened. Petiole with distinct node that is scale-like or globular in shape. In profile posterior margin of propodeum straight to convex; propodeal spiracle elongate and slit-like; gastral sternite 1 with transverse sulcus just behind helcium. Circular acidopore present at tip of gaster, often nozzle-like and margined with erect hairs Pronotum finely sculptured and mat; clypeus with weaker sculpture, at most very densely and finely sculptured.

Cataglyphis aenescens (Nylander, 1849)

Formica aenescens Nylander, 1849: 37 (type locality: Russia).

Cataglyphis aenescens rocringeri: Dlussky and Pisarski, 1970: 89; Pisarski, 1969a: 235, 1969b: 315; Pisarski and Krysztofiak, 1981: 165.

Cataglyphis aenescens tancrei: Dlussky & Pisarski, 1970: 90.

Cataglyphis aenescens: Pfeiffer et al., 2007: 4 (in list).

Worker diagnosis. Body size variable, ranging from 3.0 to 5.5 mm in total length. Frons longitudinally striate or reticulate. In profile node of petiole relatively thin and high. Gastral tergites 1 and 2 with short pubescence. Body uniformly brownish-black to black, but mandible, antenna and tarsi of all legs brownish.

Taxonomic remarks. Small specimens of this species can be confused with *Proformica* specimens, but in the latter the spiracle is oval to round, and the basal segment of maxillary palp round.

Distribution records. Khatgal, Khuvsgul aimag, 1650 m alt., 18 VII 1968 (No. 1123) (Pisarski and Krzysztofiak, 1981).

Distribution. Middle and Central Asia, Russia, Kirghizia, Georgia, Turkestan, Turkey, Caucasus, North China, Mongolia.

Bionomics. *Cataglyphis aenescens* inhabits dry steppe, semi-desert and desert, and is mainly found in Gobi-desert. It is found at altitudes between 1,000 and 1,800 m alt. in Mongolia. A single record from Khuvsgul aimag is available in Northcentral Mongolia (Pisarski and Krysztofiak 1981). Nests are built in soil and sand.

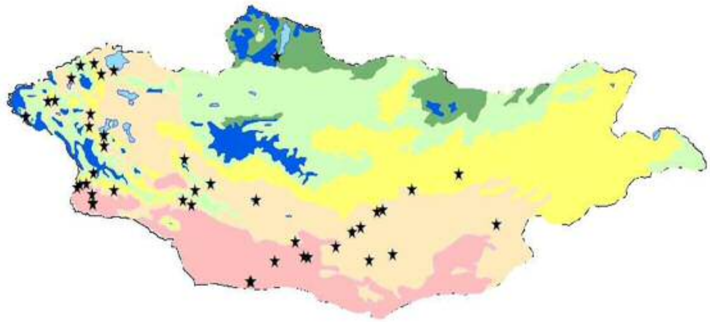

Fig. 2-9. Worker of *Cataglyphis aenescens* and collection sites.

Genus ***Formica*** Linnaeus, 1758

Formica Linnaeus, 1758. Type species: *Formica rufa* Linnaeus, 1761, by subsequent designation of Curtus, 1829: 752.

This genus comprises about 160 species that are mainly distributed in the Holarctic region. More than 50 species occur in the Palaearctic region, and 12 species belonging to 4 subgenera occur in Northcentral, Northeastern and Eastern Mongolia. Similar to the genera *Lasius* and *Myrmica*, *Formica* is a “keystone” ant genus in the myrmecofauna of the temperate zone of the Holarctic region.

Worker diagnosis. Ocelli distinct in all castes; mandible elongate triangular or triangular, with 5 teeth; maxillary palp 6-segmented, occasionally 5; labial palp 4-segmented; antennal sockets situated very close to posterior margin of clypeus; antenna 12-segmented in worker and queen, 13-segmented in male. With mesosoma in profile dorsal outline interrupted between mesonotum and propodeum; propodeal spiracle oval to elongate. Gastral sternite 1 with transverse sulcus just behind helcium. Wing with cubital and one discoidal cell. Male external genitalia large and conspicuous.

Key to species of Formica from Northcentral and Eastern Mongolia

1. In full-face view posterior margin of head strongly concave………………………………
   ……………………………………………………..…….. Subgenus ***Coptoformica***.… 4
- In full-face view posterior margin of head straight, convex or slightly concave…………….
   ……………………………………………………………………………………...…...… 2
2. Anterior clypeal margin distinctly notched medially ……….…………………………………
   …………………………………………………….…… ***F.*** (***Raptiformica***) ***sanguinea*** Latreille
- Anterior clypeal margin convex, not notched medially. ……………..………………….. 3
3. Frontal triangle shiny; all species bicolorous. ……...…........… Subgenus ***Formica*** 7
- Frontal triangle dull; body dark brown to black, or bicolorous……………………………...
   …………………………………………….................… Subgenus ***Serviformica*** 8
4. Eye with hairs; maxillary palp longer, surpassing or reaching midlength of distance from mouth to occipital hole. …………………………………………………......………... 5

- Eye without hairs; maxillary palp shorter, not reaching midlength of distance from mouth to occipital hole ……………………………………………………….......….…….... 6
5. Lateral and ventral faces of head with standing hairs; occipital corner of head with short standing hairs; maxillary palp surpassing midlength of distance from mouth to occipital hole; gastral tergites 1 and 2 with standing hairs…...................……***F.*** (***C.***) ***exsecta*** Nylander
- Lateral and ventral faces of head and occipital corner without standing hairs; maxillary palp reaching midlength of distance from mouth to occipital hole; gastral tergites 1 and often 2 without standing hairs. …………………....….....……… ***F.*** (***C.***) ***manchu*** Wheeler
6. Clypeus entirely with sparse setae; gastral tergites 1 and 2 always with standing hairs..….............................…...…***F.*** (***C.***) ***pisarskii*** Dlussky
- Clypeus with setae only in its anterior part, posteriorly setae always absent; gastral tergites 1 and 2 generally without standing hairs..............……….... ***F.*** (***C.***) ***forsslundi*** Lohmander
7. Head and alitrunk with dense standing hairs; only antennal scape without standing hairs. …………………………………………….....................….. ***F.*** (***F.***) ***lugubris*** Zetterstedt
- Head and alitrunk without standing hairs; only antennal scape and occipital margin of head with a few short erect and suberect hairs. …………..…….……. ***F.*** (***F.***) ***aquilonia*** Yarrow
8. Entire body dark brown to black ……………………….……………………………… 9
- Entire body not dark brown to black, bicolorous; mesosoma reddish or orangish and gaster brownish black. ……………………………………….…………………………….… 11
9. Entire body blackish and shiny; promesonotal dorsum with long curved standing hairs; gastral tergite 2 with very sparse pubescence, distance between appressed hairs longer than hair length. ………………………………………………...…… ***F.*** (***S.***) ***candida*** Smith
- Entire body somewhat shining with dense microsculpture, or dull .....….....................….... 10
10. Ventral face of head without standing hairs; gastral tergite 2 with very dense pubescence, distance between appressed hairs shorter than hair length.………..***F.*** (***S.***) ***lemani*** Bondroit
- Ventral face of head with standing hairs; gastral tergite 2 with sparse pubescence, distance between appressed hairs equal to hair length. ……...….. ***F.*** (***S.***) ***kozlovi*** Dlussky
11. Head and alitrunk reddish; pronotum with dense standing hairs.……………..…………… ….. ***F.*** ***(S.***) ***subpilosa*** Dlussky
- Head and gaster completely black. Pronotum with few standing hairs ……………………. ……………………………………………………...……. ***F.*** (***S.***) ***uralensis*** Ruzsky

Formica (***Coptoformica***) ***exsecta*** Nylander, 1846

Formica exsecta Nylander, 1846: 909 (type locality: Finland); Dlussky, 1965: 26; Seifert, 2000: 525.

Worker diagnosis. Body length 4.5-7.5 mm. In full-face view posterior margin of head strongly concave. Maxillary palps 6-segmented and surpassing midlength of distance from mouth to occipital hole. Eye with distinct hairs that are normally abundant. Lateral and ventral faces of head with standing hairs; occipital corners of head with short standing hairs. Dorsa of head, clypeus, pronotum and all gastral tergites with standing hairs.

Taxonomic remarks. This species is distinguished from *F. manchu* and *F. pisarskii* by the following characteristics: maxillary palps surpassing midlength of distance from mouth to occipital hole; lateral and ventral faces of head with standing hairs; occipital corner of head with short standing hairs.

Material examined. Bogd Khaan NP (Turgen valley), 13 VII 2008, MG08-SKY-17 (w); same loc., 1 VIII 2009, MG09-SKY-21 (w, nq); same loc., 1 VIII 2009, UA09-12 (w, nq); Bogd Khaan NP (Khurkhree valley), Tuv aimag, 8 VII 2007 (W-19) (w); same loc., 8 VII 2007, UA07-40 (w); same loc., 8 VII 2007, Tr-2 (honey bait) (w); same loc. (meadow), 8 VII 2007, MG07-SKY-13 (w); Bogd Khaan NP (plantation area), 6 VIII 2004, MG04-SKY-02 (w); Hustai NP, Tuv aimag, 22 VIII 2007, MG09-SKY-51) (w); same loc., 22 VII 2007, UA07-60 (w); Unegt (800-900 m alt.), Selenge aimag, 2 VIII 2009, MG09-SKY-28 (w); same loc., 2 VIII 2009, UA09-21 (w); 30 km from Choibalsan, Dornod aimag, 26 VII 2008, MG08-SKY-70 (w); 90 km S of Tuv (790 m alt.), Dornod aimag, 31 VII 2007, S. Kawaguchi leg. (M-123) (w).

Distribution. Europe, European Russia, Siberia, Russian Far East, NE China, Mongolia.

Bionomics. *Formica exsecta* mostly inhabits open sites (forest steppe, mountain steppe, forest edge), and is also met in different kinds of forest edge (larch, birch, mixed forests). In altitude, it ranges from 600 to 1600 m a.s.l. in Mongolia. Mounds are flat and built of tiny plant material. It is known as a temporary social parasite in nests of *Formica* (*Serviformica*) species in Poland (Czechowski et al., 2002). Nuptial flight occurs in late July and August in Northcentral Mongolia.


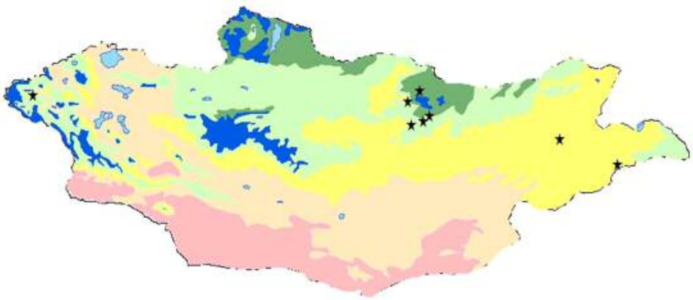

Fig. 2-10. Worker of *Formica exsecta* and collection sites.

Formica* (*Coptoformica*) *forsslundi Lohmander, 1949

Formica forsslundi Lohmander, 1949: 163 (type locality: Sweden); Seifert, 2000: 552.

Formica brunneonitida Dlussky, 1964: 1034 (type locality: Mongolia), 1965: 23; Pisarski, 1969b: 313; Pisarski and Krzysztofiak, 1981: 164; Bolton 1995: 192. Synonymy by Seifert, 2000: 552.

Formica fossilabris Dlussky, 1965. Synonym by Seifert, 2000: 552.

Worker diagnosis. Body length 4.0-6.5 mm. In full-face view posterior margin of head strongly concave. Maxillary palps shorter, not reaching midlength of distance from mouth to occipital hole.Eye without hairs. Clypeus with setae only in anterior part, posterior setae always absent. Standing hairs generally absent on gastral segments 1 and 2 in at least specimens from Northcentral Mongolia. Promesonotum frequently with blackish patch.

Taxonomic remarks. It can be separated from *F.* (*Coptoformica*) *pisarskii* by the following characteristics: 1) clypeus with setaeonly in anterior part, posterior setae always absent; 2) promesonotum frequently with blackish patch; 3) pubescence on gastral tergite 1 variable but usually sparse.

Material examined. Bogd Khaan NP (ca. 1550 m alt.), Tuv aimag, 3 IX 2003 (w); same loc., 27 vi 2003, MG03-SKY-07 (w); Bogd Khaan NP (Turgen valley, *Betula* forest gap), 13 VII 2008, MG08-SKY-16 (w); Bogd Khaan NP (Turkhurh valley, 1598 m alt.), 12 VII 2008, MG08-SKY-08 (w); Khonin Nuga (930 m alt.), Selenge aimag, 10 VIII 2004, MG04-SKY-58; nr Numrug (1006 m alt.), Dornod aimag, 25 VII 2008, MG08-SKY-67 (w).

Distribution. Europe, Northern Siberia, Tibet, Mongolia.

Bionomics. *Formica forsslundi* mostly inhabits open sites (forest steppe, mountain steppe, forest edge), and is also met in different kinds of forest edge (larch, birch, mixed forests). It is distributed at altitudes between 800 and 1800 m atl. in Mongolia. Small flat mounds are constructed with tiny plant material. New colonies are founded through temporary social parasitism in nests of *Serviformica* species in Poland (Czechowski et al., 2002).

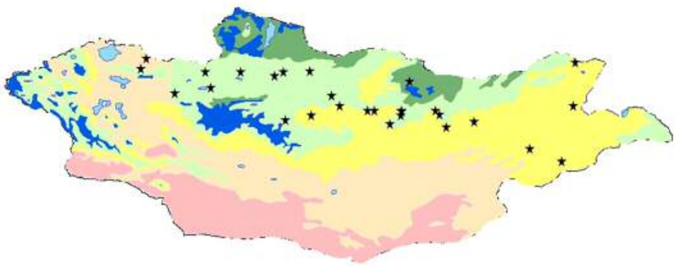

Fig. 2-11. Worker of *Formica forsslundi* and distribution map.

Formica* (*Coptoformica*) *manchu Wheeler, 1929

Formica manchu Wheeler, 1929: 10 (type locality: China); Bolton, 1995: 198; Seifert, 2000: 534.

Formica longiceps Dlussky, 1964: 1036 (junior primary homonym of *Formica longiceps* F. Smith, 1868, a species of *Camponotus*), 1965: 19; Pisarski, 1969b: 314; Pisarski and Krzysztofiak, 1981: 165; Kupyanskaya, 1990: 202, 1995: 360.

Formica dlusskyi: Bolton, 1995: 194 (new name for *F. longiceps* Dlussky).

Worker diagnosis. Body length 4.3-5.1 mm. In full-face view posterior margin of head strongly concave. Maxillary palps reaching midlength of distance from mouth to occipital hole. Clypeus with standing hairs only on its anterior margin. Eyes with hairs. Lateral margin and ventral face of head and occipital corner without standing hairs. Standing hairs on gaster beginning at posterior border of second to third tergite (tergite 2 often lacking standing hairs). Head and alitrunk with blackish brown or black patches.

Taxonomic remarks. In the worker this species is easily distinguished from *F. (Coptoformica) exsecta* by the maxillary palps reaching midlength of distance from mouth to occipital hole; lateral and ventral faces of head and occipital corner without standing hairs; eye hairs strongly developed; clypeus with standing hairs only on its anterior margin; and standing hairs on gaster beginning at the posterior border of second to third tergite.

Material examined. Altanbulag, Tuv aimag, 6 IX 2003, S. Kawaguchi leg., MA9-2 (w); Terelj NP (ca. 1250 m alt.), Tuv aimag, 2-3 IX 2003, S. Kawaguchi leg., MA4, 5 (w); same loc., 30 VI 2003, MG03-SKY-31, -58 (w); Bogd Khaan NP (Turkhurh valley, 1598 m alt.), Tuv aimag, 12 VII 2008, MG08-SKY-04 (w); same loc., 12 VII 2008, UA08-10 (w); Bogd Khaan NP (nr Turgen valley), 1 VIII 2009, MG09-SKY-24 (w); Bogd Khaan NP (Shajinkhurh), 31 VII 2009, Tr-17, 18 (w); nr Ulaanbaatar (nr Turgen valley), 19 VII 2008, cheese bait, MG08-SKY-28 (w); Unegt (800-900 m alt.), Selenge aimag, 2 VIII 2009, MG09-SKY-38 (w); same loc., 2 VIII 2009, UA09-29 (w); Khonin Nuga (930 m alt.), Selenge aimag, 10 VIII 2004, MG04-SKY-64 (w), -78 (w, m), -91 (w); same loc., 11 VIII 2004, UA04-52 (w).

Distribution. North Tibet, Manchuria, East Siberia, Southern Russian Far East, Mongolia.

Bionomics. *Formica manchu* inhabits mostly open sites (forest steppe, mountain steppe, grassland). It is distributed at altitudes between 900 and 2200 m atl. in Mongolia. Flat mounds are built with plant material.


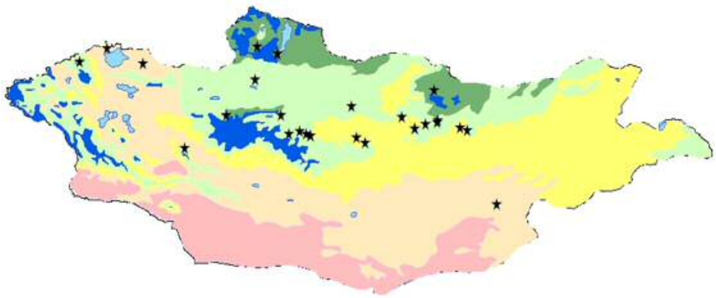

Fig. 2-12. Worker of *Formica manchu* and collection sites.

Formica* (*Coptoformica*) *pisarskii Dlussky, 1964

Formica pisarskii Dlussky, 1964: 1034 (type locality: Mongolia); Dlussky, 1965: 21; Pisarski, 1969b: 314; Pisarski and Krzysztofiak, 1981: 165; Kupyanskaya, 1990: 204; Seifert, 2000: 551

Worker diagnosis. Body length 3.5-4.5 mm. In full-face view posterior margin of head strongly concave. Maxillary palps shorter, not reaching midlength of distance from mouth to occipital hole. Clypeus almost entirely with sparse setae. Eyes without hairs. Standing hairs present on all gastral segments. Pronotum with standing hairs. Alitrunk brownish red; head and pronotum with black patches.

Taxonomic remarks. In the worker, this species is distinguished from *F. (Coptoformica) exsecta*, *F. (C.) manchu* and *F. (C.) pisarskii* by the following characteristics: clypeus with sparse setae from anterior to posterior parts; dorsal pronotum always with sanding hairs.

Material examined. Khuvsgul aimag, 13 VIII 2003, UA leg. (w); Hustai NP (1850 m alt.), 3 VII 2003, MG03-SKY-48 (w); Hustai NP, (Khushuut valley) 26 VIII 2010, UA10-66 (w); Hustai NP–Ulaanbaatar, Tuv aimag, 22 VIII 2007, MG07-SKY-50 (w); Terelj NP (ca. 1250 m alt.), Tuv aimag, 30 VI 2003, MG03-SKY-32, -34 (w); Argalant, Tuv aimag, 3 VII 2003, MG03-SKY-49, -53 (w); Bogd Khaan NP (nr Turgen valley), Tuv aimag, 1 VIII 2009, MG09-SKY-21 (w); Bogd mountains, Tuv aimag, 24 VI 2005, UA, 22Ai.05 (w); nr Dadal (1050 m alt.), Khentii aimag, 8 VIII 2009, MG09-SKY-58 (w); same loc., 8 VIII 2009, UA09-51 (w); 30 km e of Choibalsan, Dornod aimag, 26 VII 2008, MG08-SKY-69 (w); 30 km w of Huh uul, Dornod aimag, 11 VIII 1997, K. Ulykpan leg. (w).

Distribution. Amur, Yakut, Southern Siberia, Mongolia.

Bionomics. *Formica pisarskii* mostly inhabits steppe and steppe meadow, and is found at altitudes between 800 and 2000 m atl. in Mongolia.

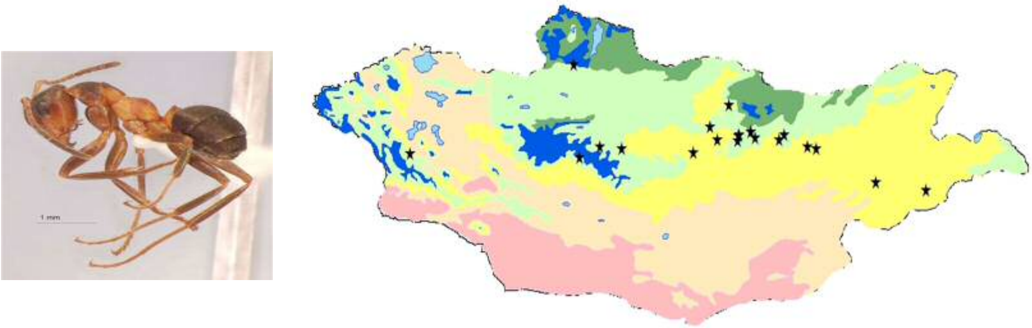

Fig. 2-13. Worker of *Formica pisarskii* and collection sites.

Formica* (*Formica*) *aquilonia Yarrow, 1995

Formica aquilonia Yarrow, 1955: 31 (type locality: Great Britain); Kupyanskaya, 1995: 359 (in key); Bolton, 1995: 191; Radchenko, 2005: 161.

Formica polyctena Foerster: Pisarski, 1969b: 313; Dlussky and Pisarski, 1970: 89.

Worker diagnosis. Body length 5.0-5.5 mm. In full-face view posterior margin of head convex; anterior clypeal margin convex, not notched medially; clypeus with distinct median carina. Frontal triangle shiny. Head and alitrunk without standing hairs; only antennal scape and posterior margin of head with a few short erect and suberect hairs. Head and pronotum of large workers with brown patches. Head, alitrunk reddish and gaster brownish black.

Taxonomic remarks. This species is easily distinguished from *F.* (*Formica*) *lugubris* by the following characteristics: head and alitrunk without standing hairs; only antennal scape and occipital margin of head with a few short erect and suberect hairs.

Material examined. Bulgan aimag, 25 VIII 2003, UA (w); Terelj NP (1250 m alt.), Tuv aimag, 2 IX 2003, S. Kawaguchi leg, MA5 (w); Terelj (Gorkhi), Tuv aimag, 29 VI 2003, MG03-SKY-26 (w); Bogd Khaan NP (1550 m alt.), Tuv aimag, 1 IX 2003, S. Kawaguchi, MA-3 (w); same loc., 6 VIII 2004, MG04-SKY-06, 07 (w); same loc., 6 VII 2007, MG07-SKY-08 (w); Bogd Khaan NP (Khurkhree valley), Tuv aimag, 12 VI 2012, UA12-09 (w); Khandgait, Tuv aimag, 2 IX 2003, S. Kawaguchi leg. (w); Mt. Khandgait Jiver (1650 m alt.), Tuv aimag, 7 VIII 2004, MG04-SKY-08, -09 (w); nr Ulaanbaatar, Tuv aimag, 6 VIII 2004, MG04-SKY-04 (w); Unegt (800-900 m alt.), Selenge aimag, 2 VIII 2009, MG09-SKY-30 (w), -35 (w); same loc., 14 VIII 2011, UA11-72 (w); Bereevin-hiid - Ulaanbaatar, Selenge aimag, 11 VIII 2009, MG09-SKY-99 (w,nq); nr Dadal (1050 m alt.), Khentii aimag, MG09-SKY-67 (w); Unegt (800-900 m alt.), Selenge aimag, 2 VIII 2009, MG09-SKY-31 (w).
Distribution. European Russia, Siberia, Russian Far East, China, North Korea, Mongolia.
Bionomics. This boreal species lives at altitudes mostly above 1200-1300 m in Mongolia. It inhabits different kinds of forest (larch, birch and pine). Large mounds are constructed with coniferous needles and small pieces of branches (often resin and tiny stones are mixed). The colonies are generally highly polygynous, with the population of one colony reaching several hundred thousand workers. Nuptial flights in early June in Northcentral Mongolia.

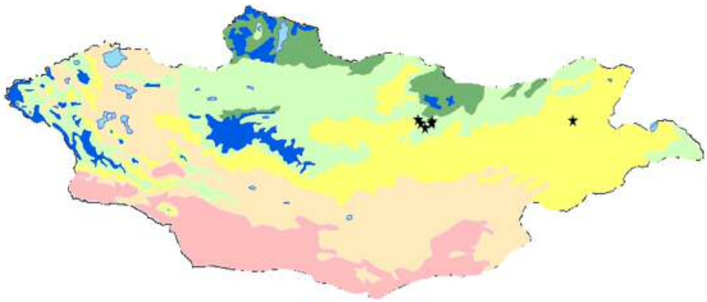

Fig. 2-14. Worker of *Formica aquilonia* and collection sites.

Formica* (*Formica*) *lugubris Zetterstedt, 1838

Formica lugubris Zetterstedt, 1838: 449 (type locality: Norway); Dlussky, 1967: 91; Pisarski, 1969b: 313; Kupyanskaya,1990: 198, 1995: 358; Bolton, 1995: 198; Kim B.-J, 1996: 185; Radchenkoi, 2005: 163.

Worker diagnosis. Body length 5.2-7.6 mm. In full-face view posterior margin of head convex; anterior clypeal margin convex, not notched medially; clypeus with distinct medial carina. Frontal triangle shiny. Head and alitrunk with numerous dense long standing hairs; only antennal scape without standing hairs. Head and pronotum of large workers with brown patches. Head, alitrunk reddish and gaster brownish black.
Taxonomic remarks. This species is easily distinguished from other Mongolian *Formica* species by the head and mesosoma with numerous dense long standing hairs.
Material examined. Hustai NP (1850 m alt.), Tuv aimag, 4 VII 2003, MG03-SKY-16, -64, -

67 (w); same loc., 4 VII 2003, UA03-46 (w); same loc., 14 VII 2008, UA08-19 (w); Bogd Khaan NP (1550 m alt.), Tuv aimag, 17 VIII 2004, MG04-SKY-141, -143 (w); Unegt (800-900 m alt.), Selenge aimag, 2 VIII 2009, MG09-SKY-35 (w,m); same loc., 2 VIII 2009, UA09-40 (w,m); Khonin Nuga (930 m alt.), Selenge aimag, 9 VIII 2004, MG04-SKY-37, -39, -60 (w); Altanbulag, Selenge aimag, V 2003, S. Kawaguchi leg. (w).

Distribution. Central and Southern Europe, introduced to North America, Russian Far East, North Korea, Mongolia,

Bionomics. This boreal species lives at altitudes between 800 and 2000 min Mongolia. It inhabits mainly in coniferous and mixed forests (larch, birch and pine). It also occurs in deciduous forest. Large mounds are constructed with tiny dead twigs and coniferous needles. Colonies are monogynous or polygynous with up to several hundred thousand workers (Czechowski et al., 2002).

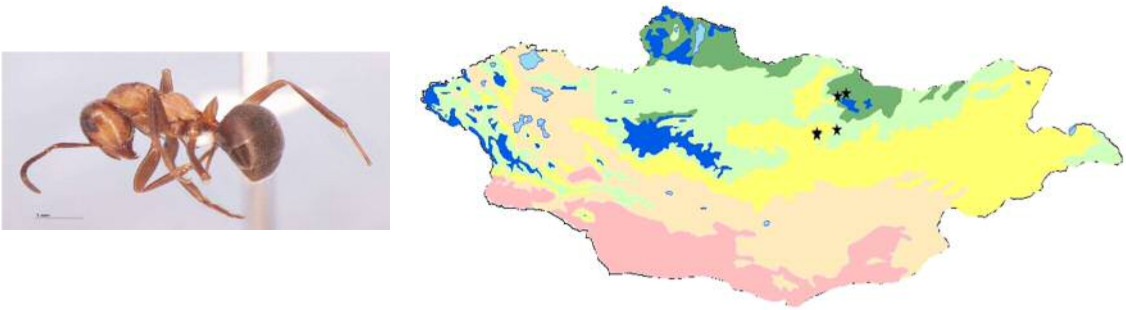

Fig. 2-15. Worker of *Formica lugubris* and collection sites.

Formica (Raptiformica) sanguinea Latreille, 1798

Formica sanguinea Latreille, 1798: 37 (type locality: France); Dlussky, 1965: 16; Pisarski, 1969b: 313; Pisarski, 1969a: 234; Dlussky and Pisarski, 1970: 89; Kupyanskaya, 1990: 191, 1995: 355; Wu and Wang, 1995: 140; Bolton 1995: 203; Kim B.-J, 1996: 185, 2003: 2; Radchenko, 2005: 163.

Worker diagnosis. Body length 5.0-7.0 mm. In full-face view posterior margin of head straight or slightly concave. Anterior clypeal margin distinctly notched medially. Eyes without hairs. Head and alitrunk with sparse short, and gaster with dense long standing hairs. Head brownish red and frons, temple, occiput blackish.

Taxonomic remarks. This species is easily distinguished from the other Mongolian *Formica* species by the anterior clypeal margin distinctly notched medially.

Material examined. Hustai nuruu (Khushuut valley), Tuv aimag, 21 VIII 2007, MG07-SKY-47 (w); Hustai nuruu, Tuv aimag, 22 VIII 2007, MG07-SKY-52 (w); same loc., 2 VII 2007, UA07-39 (w); Terelj NP (1250 m alt.), Tuv aimag, 1 VII 2003, MG03-SKY-28, -46 (w); same loc., riverside, 29 VI 2003, SKY (w); Ulaanbaatar (1350 m alt.), 9 VII 2003, SKY (w); Bogd Khaan NP (Nuht valley), 16 VII 2003, SKY (w); same loc., 17 VI 2012, UA12-18 (w); Bogd Khaan NP (Shajinkhurh valley), Tuv aimag, 21VI 2012, UA12-33 (w); Bogd Khaan

NP (ca, 1550 m alt.), Tuv aimag, 15 VIII 2004, MG04-SKY-135 (w); Bogd Khaan NP (Turgen valley), 11 VIII 2009, MG09-SKY-25 (w); Bogd Khaan NP (nr Turgen valley), Tuv aimag, 1 VIII 2009, MG09-SKY-19 (w,m); Binder sum, Khentii aimag, 27 VII 2007, S. Kawaguchi (w); nr Dadal (1050 m alt.), Khentii aimag, MG09-SKY-63 (w,m); nr Bayan-Adarga, Khentii aimag, 10 VIII 2009, MG09-SKY-90 (w).

Distribution. Europe, Russia, North Korea, Japan, Mongolia.

Bionomics. *Formica sanguinea* inhabits mainly grasslands, but is found also in open sites of forests, forest edges. It is found at altitudes between 800 and 1800 m alt. in Mongolia. It builds nests in soil, under stones, and in rotten wood. It is a facultative slave-maker. In Mongolia, workers of both *F. sanguinea* and its host *Formica (Serviformica) candida* are frequently found together in the same nest.

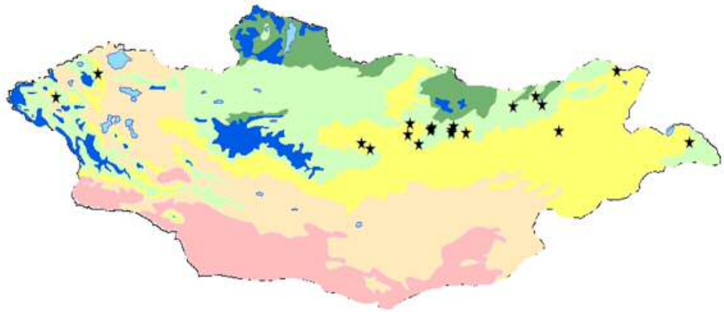

Fig. 2-16. Worker of *Formica sanguinea* and collection sites.

Formica* (*Serviformica*) *candida F. Smith, 1878

Formica candida F. Smith, 1878: 11 (type locality: China); Bolton, 1995: 192 (replacement name for *Formica picea* Nylander, 1846 that is a junior primary homonym of *Formica picea* Leach, 1825, a species of *Camponotus*); Radchenko, 2005: 161.

Formica picea Nylander: Dlussky, 1965: 31; Pisarski, 1969b: 308; Pisarski, 1969a: 233; Dlussky and Pisarski, 1970: 87; Pisarski and Krzysztofiak, 1981: 162; Kupyanskaya, 1995: 356, in key.

Formica transkaucasica Nasonov, 1889: 21 (type locality: Russia). Synonymized with *Formica picea* Nylander by Emery 1909: 195.

Worker diagnosis. Body length 4.5-6.0 mm. Body almost entirely shiny, with frontal triangle dull. In full-face view posterior margin of head convex. Anterior clypeal margin convex, not notched medially. Clypeus, frons, ventral face of head and promesonotal dorsum with long curved standing hairs. Gastral tergite 2 with very sparse pubescence, distance between appressed hairs longer than hair length. Entire body dark brown to black.

Taxonomic remarks. This species can be easily separated from the dark colored *Serviformica* species in Mongolia, namely *F. lemani* and *F. kozlovi* by the following characteristics: 1) entire body smooth and strongly shiny; 2) promesonotal dorsum with long curved standing hairs; 3) gastral tergites with very sparse pubescence, distance between appressed hairs longer than hair length.

Material examined. Khuvsgul aimag, 16 VIII 2003, UA (w,m); Hustai NP (Moltsog els), Tuv aimag, 3 VII 2003, MG03-SKY-52 (w); Hustai NP (1850 m alt.), Tuv aimag, 3 VII 2003, MG03-SKY-59 (w); same loc., 3 VII 2003, UA03-51 (w); nr Hustai NP (Argalant), 3 VII 2003, MG03-SKY-47 (w); Hustai nuruu (Tuul river valley), 21 VIII 2007, MG07-SKY-42 (w); Hustai NP, Tuv aimag, 21 VIII 2007, MG07-SKY-40 (w); Terelj NP (1250 m alt.), Tuv aimag, 29 V-1 VII 2003, MG03-SKY-25, -33, -42 (w); same loc., 29 VII 2003, UA03-36 (w); Ulaanbaatar, 10 VII 2008, MG08-SKY-02 (w); Bogd Khaan NP (1550 m alt.), Tuv aimag, 27 VI 2003, MG03-SKY-02, -08, -09 (w); Bogd Khaan NP (Khurkhree valley), Tuv aimag, 6-8 VII 2007, Tr-1 (w), Tr-2 (w), Tr-7 (fq), MG07-SKY-05 (w); Bogd Khaan NP (Nuht valley), Tuv aimag, 16 VII 2003, SKY leg. fq); same loc., 16 VII 2003, UA03-44 (w); Bogd Khaan NP (Shajinkhurh valley), Tuv aimag, 30 VII 2009, Tr-17 (w), MG09-SKY-12 (w,m); Bogd Khaan NP (Turgen valley), Tuv aimag, 13 VIII 2009, Tr-19 (w); Altanbulag, Selenge aimag, 6 IX 2003, S. Kawaguchi leg. (w); Khonin Nuga (930 m alt.), Selenge aimag, 12-13 VIII 2004, MG04-SKY-28 (w), -49 (fq), -52 (nq), -53 (w,nq), -61 (w,m), -68 (w,fq,m), -69 (w,m), -92 (w), -93 (w,m), -95 (w), -96 (w), -106 (w,m), -144 (w); same loc., 13 VIII 2004, UA04-33 (w), -35 (nq); -36 (w,nq), -39 (w,fq,m); Dadal (900 m alt.), Khentii aimag, 8 VIII 2009, SKY leg.(w); nr Dadal (950 m alt.), Khentii aimag, 9 VIII 2009, MG09-SKY-83 (w); Bereevin-hiid, Khentii aimag, 11 VIII 2009, MG09-SKY-95 (w,m); Ondorhaan, Khentii aimag, 20 VII 2008 (w); Khalkh gol sum, Dornod aimag, 24 VII 2008, SKY leg. (w); nr Numrug, Dornod aimag, 24 VII 2008, SKY leg. (w); Numrug, Dornod aimag, 25 VII 2008, MG08-SKY-66 (w); same loc., 21 VIII 2012, UA12- 84 (w); Khukh nuur (620m alt.), Dornod aimag, 26 VIII 2012, UA12-96.

Distribution. European Russia, Caucasus, Central Asian mountains, Himalayas, Tibet, Russian Far East, China, North Korea, Japan, Mongolia.

Bionomics. *Formica candida* has a very wide range of distribution, and is the commonest *Formica* in Mongolia. It is distributed from low altitudes (700-900 m) through flat steppe to high altitude mountain steppe (1800- 2400 m). Nests are built in soil, rotten wood, dead tree stumps and tree hollows, under stones and logs partly in soil. It also constructs small soil mounds. Males and winged queens are seen in middle of July in nests, and some dealated queens were collected outside the nest in late July. This species constitutes the main slaves of *Formica* (*Raptiformica*) *sanguinea* and in Eastern Mongolia (Sumber sum, Dornod aimag), a case was observed in which a colony of this species was raided by a colony of *Polyergus nigerrimus* during late afternoon.

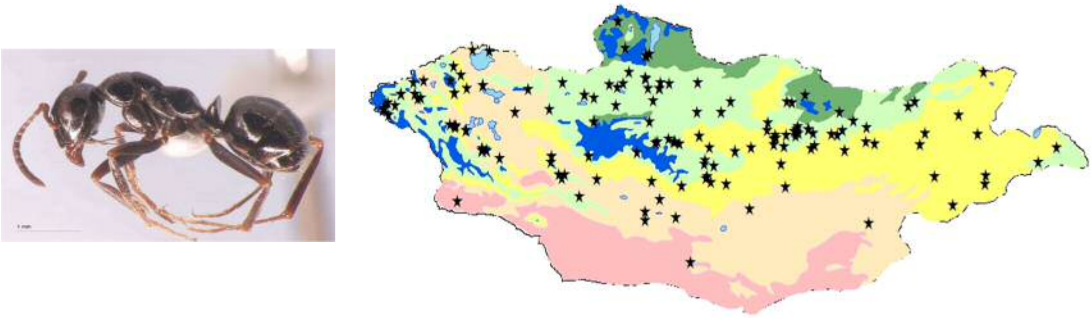

Fig. 2-17. Worker of *Formica candida* and collection sites.

Formica **(*Serviformica*)** ***kozlovi*** Dlussky, 1965

Formica kozlovi Dlussky, 1965: 32 (type locality: Mongolia); Pisarski, 1969a: 232, 1969b: 311; Pisarski and Krzysztofiak, 1981: 163.

Worker diagnosis. Body length 3.5-4.5 mm. In full-face view posterior margin of head convex or straight anterior clypeal margin convex, not notched medially. Frontal triangle dull. Whole body somewhat shining, with dense microsculpture. Ventral face of head with standing hairs. Gastral tergite 2 with sparse pubescence, distance between appressed hairs equal to hair length. Whole body dark brown.

Taxonomic remarks. This species is distinguished from *F. (Serviformica) lemani* by the following characteristics: ventral face of head with standing hairs; gastral tergite 2 with sparse pubescence, distance between appressed hairs equal to hair length. In *F. lemani* the microsculpture of the mesosoma is much denser than in *F. kozlovi*, the ventral face of head has no standing hairs, and the pronotum with short and curved standing hairs.

Material examined. Uliin Davaa (1796 m alt.), Khuvsgul aimag, 16 VIII 2003, MG03-SKY-91 (w), -94 (w,m); Terelj NP (Gorkhi, 1250 m alt.), Tuv aimag, 29 VI 2003, MG03-SKY-27 (w); same loc., 29 VI 2003, UA03-17 (w); Terelj, Tuv aimag, 8 VII 1997, M. Pfeiffer (w); Bogd Khaan NP (1550 m alt.), Tuv aimag, 27-28 VI 2003, MG03-SKY-01 (w), -04 (w), -11 (w), -13 (w); same loc., 9 VII 2003, MG03-SKY-78 (w), -82 (w,nq); same loc., 27 VI 2003, UA03-03 (w); same loc., 9 VII 2003, UA03-62 (w,nq); Bogd Khaan NP (Shajinkhurh valley), 31 VII 2009, MG09-SKY-17 (w,m); Bogd Khaan NP (Turgen valley), 13 VII 2008, MG08-SKY-14 (w), -15 (w). Goviliin ekh, Bulgan aimag, 13 VII 2009, UA09-50.

Distribution. Tibet, Mongolia.

Bionomics. This boreal species lives at altitudes from 1200 to 2000 m a.s.l. in Mongolia. It mainly inhabits coniferous and mixed forests (larch, birch and pine), but also occurs in deciduous forests. Nests are found in rotten wood, dead stumps and tree hollows, under stones and under logs partly in soil.

 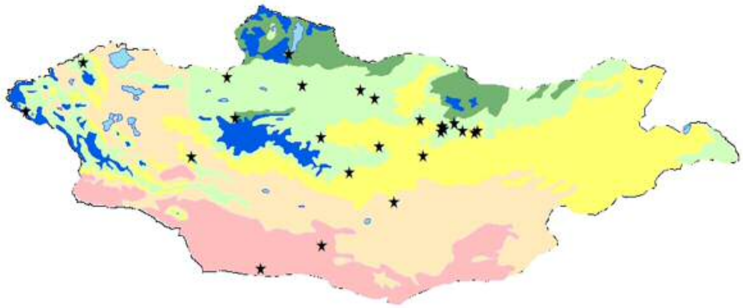

Fig. 2-18. Worker of *Formica kozlovi* and collection sites.

Formica* (*Serviformica*) *lemani Bondroit, 1917

Formica lemani Bondroit, 1917: 186 (type locality: France); Dlussky, 1965: 35; Pisarski, 1969a: 232, 1969b: 308; Pisarski and Krzysztofiak, 1981: 161; Kupyanskaya, 1995: 358; Radchenko, 2005: 189.

Worker diagnosis. Body length 5.0-6.0 mm. In full-face view posterior margin of head convex. Frontal triangle dull. Entire body somewhat shining, with dense microsculpture. Anterior clypeal margin convex, not notched medially. Ventral surface of head without standing hairs. Pronotum with short and curved standing hairs. Gastral tergite 2 with very dense pubescence, distance between appressed hairs shorter than hair length. Whole body dark brown.

Material examined. Hustai NP (1850 m alt.), Tuv aimag, 4 VII 2003, MG03-SKY-68 (w); same loc., 4 VII 2003, UA03-56 (w); Bogd Khaan NP (1550 m alt.), Tuv aimag, 28 VI 2003, MG03-SKY-20 (w); same loc., 28 VI 2003, UA03-16 (w); same loc., 9 VII 2003, MG03-SKY-75 (w); Bogd Khaan NP (Turgen valley), 13 VII 2008, MG08-SKY-09 (w); same loc., 1 VIII 2009, SKY leg. (w); same loc., 13 VII 2008, UA08-29 (w,); Unegt, Selenge aimag, 1 VIII 2009, MG09-SKY-32 (w), -33 (w), -36 (w); same loc., 1 VIII 2009, UA09-31 (w); Khonin Nuga (930 m alt.), Selenge aimag, 9-13 VIII 2004, MG04-SKY-20 (w), -24 (w), -54 (w), -66 (w), -67 (w), -98 (w), -102 (w,nq). same loc., 9 VIII 2004, UA04- 17 (w); -20 (w), -22 (w), -25 (w), -26 (w), -36 (w,nq).

Distribution. Europe, Northern Russia, South Siberia, Russian Far East, North Korea, Japan, Mongolia.

Bionomics. This common species generally lives at altitudes above 1200-1300 m in Mongolia. It mainly inhabits coniferous and mixed forests (larch, birch and pine), but also occurs in deciduous forests. Nests are found in rotten wood, dead stumps and tree hollows, and under stones and logs partly in soil.

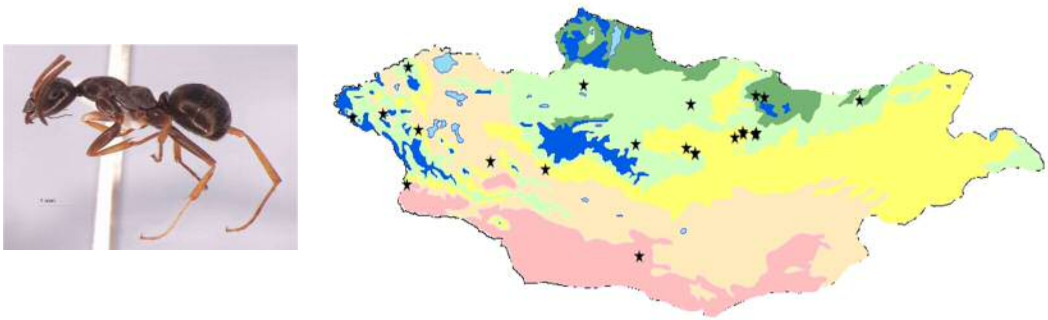

Fig. 2-19. Worker of *Formica lemani* and collection sites.

Formica (Serviformica) subpilosa Ruzsky, 1902

Formica rufibarbis subpilosa Ruzsky, 1902: 472 (type locality: Russia).

Formica subpilosa litoralis Kuznezov-Ugamsky: Pisarski, 1969b: 311; Pisarski, 1969a: 233; Dlussky and Pisarski, 1970: 88; Pisarski and Krzysztofiak, 1981: 164.

Worker diagnosis. Body length 4.6-5.2 mm. In full-face view posterior margin of head convex; anterior clypeal margin convex, not notched medially. Frontal triangle dull; clypeus with distinct median carina. Head with sparse and pronotum with dense standing hairs. Head and alitrunk red. Occiput and pronotum with brown patches.

Taxonomic remarks. This species is easily distinguished from the other bicolorous *Serviformica* (*F. uralensis*) by the following characteristics: clypeus with a distinct median carina; head with sparse and pronotum with dense standing hairs; head and alitrunk red.

Material examined. Hustai NP, Tuv aimag, 22 VIII 2007, MG07-SKY-48 (w); same loc., 22 VIII 2007, MG07-SKY-49 (w); same loc., 22 VII 2007, UA07-43 (w); same loc. (sand dune), Tuv aimag, 22 VIII 2007, MG07-SKY-47 (w); same loc. (Moltsog els), Tuv aimag, 3 VII 2003, MG03-SKY-64 (w); same loc., 3 VII 2003, UA03-58 (w); nr Binder, Khentii aimag, 10 VIII 2009, SKY leg. (w); Buir nuur, Dornod aimag, 23 VII 2008, MG08-SKY-38 (w); same loc., 23 VIII 2008, UA08-34 (w); nr Numrug, Dornod aimag, 24 VII 2008, SKY leg. (w).

Distribution. Southern part of Russian Far East, Siberia, China, Mongolia.

Bionomics. *Formica subpilosa* mostly inhabits open sites (steppe, mountain steppe), nesting in dry sandy soil. It is found at relatively low altitudes between 600 and 1500 m a.s.l. in Mongolia.

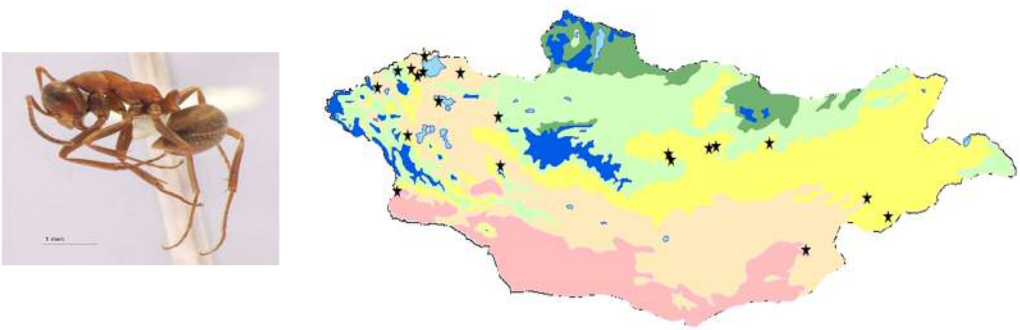

Fig. 2-20. Worker of *Formica subpilosa* and collection sites.

Formica (Serviformica) uralensis Ruzsky, 1895

Formica uralensis Ruzsky, 1895: 13 (type locality: Russia); Dlussky, 1965: 28; Dlussky and Pisarski, 1970: 88; Pisarski, 1969a: 233, 1969b: 312; Pisarski and Krzysztofiak, 1981: 164; Kupyanskaya, 1990: 189, 1995: 356; Wu and Wang, 1995: 143; Bolton, 1995: 205; Radchenko, 2005: 164.

Worker diagnosis. Body length 4.6-7.5 mm. In full-face view head as broad as long; posterior margin of head straight or slightly convex; anterior clypeal margin convex, not notched medially. Frontal triangle dull. Pronotum with few standing hairs. Alitrunk red, head and gaster completely black.

Taxonomic remarks. This species is easily distinguished from the other Mongolian *Serviformica* species by the red alitrunk, completely blackish head and gaster, and the construction of beautiful mounds made of plant material.

Material examined. Hustai NP (1850 m alt.), Tuv aimag, 3 VII 2003, MG03-SKY-50 (w), -51 (w); Hustai NP, Tuv aimag, 22 VIII 2007, MG07-SKY-51 (w); same loc., 22 VIII 2007, UA07-46 (w); nr Hustai (Algalant), Tuv aimag, 3 VII 2003, MG03-SKY-56 (w); Terelj NP (ca. 1250 m alt.), Tuv aimag, 30 VI 2003, MG03-SKY-36 (w); same loc., 30 VI 2003, UA03-51 (w); Bogd Khaan NP (Shajinkhurh valley), 31 VII 2009, MG09-SKY-15 (w,m); Bogd Khaan NP (nr Turgen valley), Tuv aimag, 1 VIII 2009, MG09-SKY-20 (w); Khonin Nuga (930 m alt.), 9 VIII 2004, MG04-SKY-47 (w); same loc., 9 VIII 2004, UA04-41 (w); nr Dadal (1050 m alt.), Khentii aimag, 8 VIII 2009, SKY leg. (w); same loc., 7-9 VIII 2009, MG09-SKY-53 (w), -78 (w); Bereevin-hiid, Khentii aimag, 11 VIII 2009, MG09-SKY-98 (w,m); same loc., 11 VIII 2009, UA09-89 (w); nr Batnorov, e of Ondorkhaan, Khentii aimag, 7 VIII 2009, MG09-SKY-45 (w); 35 km w of Chuluut Brigad, Khentii aimag, 17 VIII 1997, K. Ulykpan leg. (w); Bayan-Adarga to Binder, Khentii aimag, 10 VIII 2009, MG09-SKY-89 (w); Buir nuur, Dornod aimag, 11 VIII 1997, K. Ulykpan leg. (w); nr Khalkh gol, Dornod aimag, 25 VII 2008, MG08-SKY-68 (w); same loc., 25 VII 2008, UA08-65 (w).

Distribution. Central Europe, Amur, South Siberia, Ural, China, North Korea, Mongolia.

Bionomics. *Formica uralensis* inhabits in grasslands, meadows, open sites of forest, and forest edges. It is found at altitudes between 700 and 2200 m alt. in Mongolia. Medium-sized mounds are built with plant material. Generally numerous workers are seen on the mound surface.

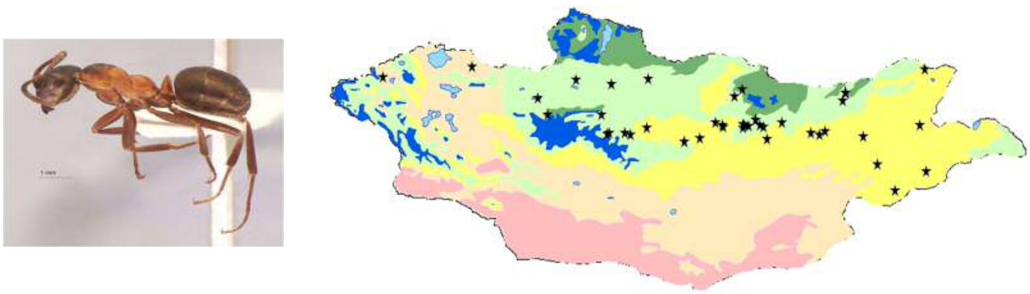

Fig. 2-21. Worker of *Formica uralensis* and collection sites.

Fig. 2-22. Mound of *Formica* (*Formica*) *aquilonia.* Bogdkkhan N.P.

Fig. 2-23. Mound of *Formica* (*Coptoformica*) sp. Bogdkkhan N.P.

Fig. 2-24. Mound of the nest of *Formica* (*Serviformica*) *uralensis*.

Fig. 2-25 . Mound surface of the same nest.

Fig. 2-26. Nest of *Formica* (*Serviformica*) *lemani* under a log.

Fig. 2-27. Workers of *Polyergus nigerrimus* marching to a nest of *Formica candida.*

Genus ***Polyergus*** Latreille, 1804

Polyergus Latreille, 1804: 179. Type species: *Formica rufescens*.

Polyergus Latreille, 1804: 179. Type species: *Formica rufescens*, Latreille, 1798: 44, by monotypy.

This genus includes five species distributed in the Holarctic. Three of them occur in the Palaearctic. One species is found in Mongolia.

Antenna 12 segmented. Antennal sockets situated very close to posterior margin of clypeus. Mandible narrow, sickle-like, tapering to pointed apex. Mesosoma in profile dorsal outline interrupted between mesonotum and propodeum. Petiole with distinct node that is scale-like or globular in shape. All the species are obligatory slave-makers. They hosts are representatives of the subgenus *Serviformica*.

Polyergus nigerrimus Marikovsky, 1963

Polyergus nigerrimus Marikovsky, 1963: 110 (type locality: Russia); Kupyanskaya, 1990: 208; Bolton, 1995: 342; Pfeiffer et al., 2003: 1935 (in list).

Worker diagnosis. Body length 4.5-5.0 mm. Head and alitrunk mat; whole gaster slightly shining. Occipital margin of head convex. Clypeus, occipital margin of head, ventral surface of head, pronotum, propodeum, petiole, all gastral tergites and sternite with long standing hairs. Whole body with dense and short pubescence.

Material examined. Sumber sum (630 m alt.), Dornod aimag, E. Mongolia, 23 VII 2003, UA & SKY (w); Solgor (47˚10'N, 106˚N04'E), 20 VII 1999, M. Pfeiffer (w).

Distribution. South Siberia, Russian Far East, Mongolia.

Bionomics. I found this species only in Eastern Mongolian steppe. It is an obligatory slave-maker. I observed a colony of this species raiding into a colony of *Formica* (*Serviformica*) *candida* in Sumber sum, Dornod aimag. Nests of both this species and *F. candida* were in soil.

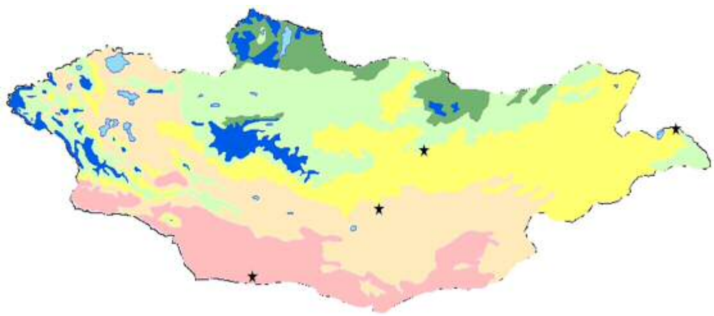

Fig. 2-28. Worker of *Polyergus nigerrimus* and collection sites.

Genus ***Proformica*** Ruzsky, 1902

Proformica Ruzsky, 1902: 13, as subgenus of *Formica*. Type species: *Formica nasuta*; Dlussky, 1969: 230 (key to species); Bolton, 1994: 43 (in key).

Worker diagnosis. Mandible triangular to elongate triangular, with 5 teeth that evenly decrease in size from apex to base so that the third tooth is larger than the fourth. Antenna with 12 segments. Antennal sockets situated very close to posterior margin of clypeus. Basal segment of maxillary palp round. Setae at base of stipes shorter than half the length of stipes. Propodeal spiracle oval to elliptical. Petiole squamiform, with lateral and dorsal crests.

Proformica is a Palaearctic genus comprising approximately 25 species, and distributed mainly in semiarid regions.

Key to species of Northcentral and Eastern Mongolia based on workers

1. Body mat; ventral surface and occipital margin of head without standing hairs.................... .... ***P. jacoti*** Wheeler
- Body shining; ventral surface and occipital margin of head with standing hairs…………… 2

2. In profile, only head, pronotum, gaster shining; gastral tergit 2 with sparse and long pubescence. ……………………………………………......…… ***P. mongolica*** Emery
- In profile, whole body shining; gastral tergit 2 with dense and short pubescence …………. ………………………………………………………………….. ***P. buddhaensis*** Ruzsky

Proformica buddhaensis Ruzsky, 1915

Proformica mongolica buddhaensis Ruzsky, 1915: 432 (type locality: China).

Proformica lefevrei Wheeler, 1929: 11 (type locality: China).

Proformica buddhaensis : Dlussky, 1969: 226; Pisarski, 1969a: 307; Pisarski and Krzysztofiak, 1981: 161.

Worker diagnosis. In large workers head in full-face view quadrat, with posterolateral corner rounded and posterior margin straight or weakly concave. Propodeum in profile dorsally convex; propodeal junction round and declivity convex that is in length equal to dorsal face of propodeum. Petiole in profile rather thin. Clypeus with distinct longitudinal striae over surface. Posterior margin of head at least with 4 standing hairs; ventral face of head with no less than 10 standing hairs. Antennal scape and tibia without standing hairs. Mesosoma with 10-12 standing hairs. Gastral tergit 2 with dense (2 times as dense as in *P. mongolica*) and short pubescence; appressed hairs a little shorter than or as long as distance between them.

Taxonomic remarks. This species is distinguished from *P. mongolica* by the following characteristics: whole body shining; antennal scape and tibia without standing hairs; gastral tergit 2 with dense (2 times as dense as in *P. mongolica*) and short pubescence.

Distribution records. Borulchiin tal ca. 100 km SE from Ulaanbaatar, 4 VII 1963 (Pisarski, 1969b); 11 km south from Zosiin davaa, Tuv aimag, 1650 m, 7 VI-15 VII 1967 (Pisarski and

Krzysztofiak, 1981); 12 km east from Bayanbaraat soum, Tuv aimag, 1380 m, 13 VII 1967 (Pisarski and Krzysztofiak, 1981); 10 km east from Tsenkhermandal soum, Khentii aimag, 1400 m, 27 VII 1965 (Pisarski, 1969b); Abzaga soum, Bulgan aimag, 1300 m, 22 VII 1966 (Pisarski, 1969b).

Distribution. North China, Mongolia.

Bionomics. *Proformica buddhaensis* generally inhabits open sites (steppe, mountain steppe, desert), nesting in dry sandy soil. It is found at relatively low altitudes between 600 and 1500 m alt. in Mongolia.

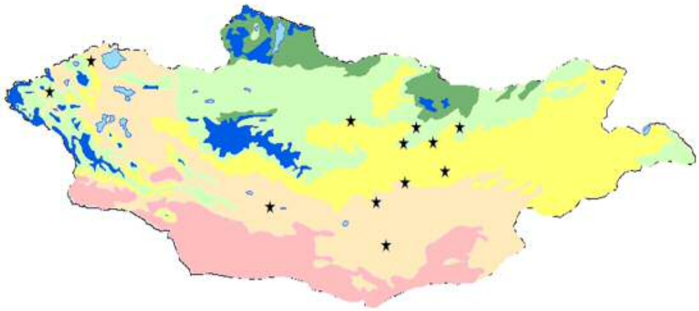

Fig. 2-29. Worker of *Proformica buddhaensis* and collection sites.

Proformica jacoti (Wheeler, 1923)

Formica jacoti Wheeler, 1923: 4 (type locality: China).

Proformica jacoti; Dlussky, 1969: 230; Bolton, 1995: 368.

Worker diagnosis. In large workers head in full-face view with posterolateral corner rounded and posterior margin convex, narrowed toward mandibular bases. Clypeus without median carina. Propodeum in profile with its junction round; dorsal face of propodeum much longer than propodeal declivity. Petiole in profile rather thick with rounded apex and parallel anterior and posterior slopes. Clypeus with distinct longitudinal striae over surface. Clypeus, occiput, mesosoma and petiole each with 2-4 standing hairs. Frons, posterior margin and ventral face of head, antennal scape, and tibia without standing hairs. Whole body with dense pubescence, not shining.

Taxonomic remarks. This species is distinguished from *P. mongolica and P. buddhaensis* by the following characteristics: whole body mat; ventral surface and posterior margin of head without standing hairs; whole body with very dense white short pubescence.

Distribution records. 11 km south from Zosiin davaa, Tuv aimag, 1650 m, 15-16 VI 1967 (Pisarski and Krzysztofiak, 1981); 12 km east from Bayanbaraat soum, Tuv aimag, 1380 m, 13 VII 1967 (Pisarski and Krzysztofiak, 1981).

Distribution. North China, Mongolia.

Bionomics. This species generally inhabits open sites (steppe, mountain steppe), nesting in dry sandy soil. It is found at relatively low altitudes between 600 and 1500 m alt. in Mongolia.

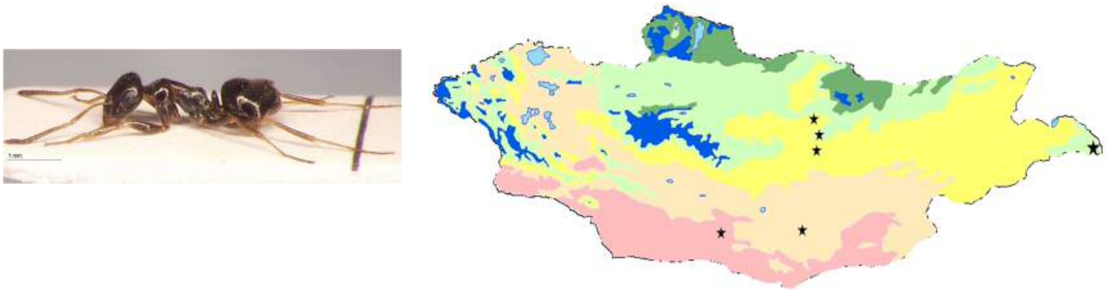

Fig. 2-30. Worker of *Proformica jacoti* and collection sites.

Proformica mongolica (Emery, 1901)

Formica nasuta subsp. *mongolica* Emery, 1901: 159 (type locality: Mongolia).

Proformica mongolica: Pisarski, 1969a: 307, 1969b: 232; Dlussky and Pisarski, 1970: 87; Pisarski and Krzysztofiak, 1981: 161; Bolton 1995: 368.

Prenolepis melanogaster : Collingwood, 1981: 29; Kim B.J. 1996 : 187 (misidentification).

Worker diagnosis. In large workers, head in full-face view quadrat, with posterolateral corner rounded and posterior margin straight or weakly concave. Propodeum in profile dorsally convex; propodeal junction round; declivity convex, its length almost equal to dorsal face of propodeum. Petiole in profile rather thin. Clypeus with distinct longitudinal striae over surface. Head and mesosoma finely microsculptured; head and pronotum somewhat shining. Gaster smooth and shining, with sparse punctation. Posterior margin and ventral face of head with standing hairs. Antennal scape and tibia usually without standing hairs, but in some large workers standing hairs present. Mesosoma dorsally with 10-12 standing hairs. Gastral tergit 2 with sparse and long pubescence. Body black or brown; in small workers mesosoma sometimes tinged with yellowish brown.

Material examined. Bogd Khaan NP, (Turgen valley) Tuv aimag, 18 IX 2009, Tr-23 (w).

Distribution. Middle Asia, Kirgistan, Kazakhstan, South Siberia, Mongolia.

Bionomics. This species generally inhabits open sites (steppe, mountain steppe), nesting in dry sandy soil. It is found at altitudes between 600 and 1800 m alt. in Mongolia.

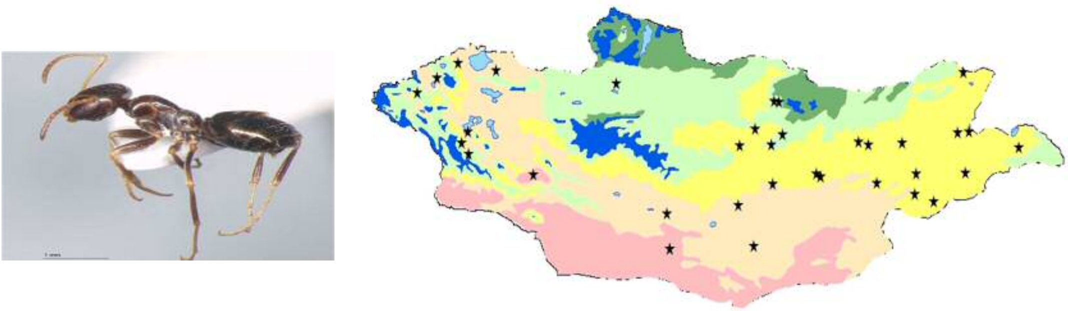

Fig. 2-31. Worker of *Proformica mongolica* and collection sites.

Genus ***Lasius*** Fabricius, 1804

Lasius Fabricius, 1804: 415. Type species: *Formica nigra*; Wilson, 1955: 11; Kupyanskaya, 1995: 361; Radchenkoi, 2005: 165.

Worker diagnosis. The smallest workers generally measuring more than 2.5 mm in total body length and the largest ca. 4.5 mm in the Mongolian species. The clypeus is broad and rounded anteriorly. Antennae are inserted behind posterior clypeal margin. The antenna is 12-segmented in the worker and queen, and 13-segmented in the male. Maxillary palp is 6-segmented, and labial palp 4-segmented. Ocelli are absent or indistinct in the worker, small but distinct in the queen and male.

The genus *Lasius* includes approximately 80 Holarctic species; more than 50 species are known from the Palaearctic region (Radchenkoi, 2005). Although 9 species have been found in Mongolia (Aibek and Yamane, 2010), the taxonomic status of some of them is not yet settled. Many *Lasius* species are very common in the temperate zone of the Holarctic region, and occur together with representatives of the genera *Myrmica* and *Formica*. They form an essential part of the Palaearctic myrmecofauna (Czechowski et. al. 2002).

Authors recorded *L.* (*Lasius*) *japonicas* Santschi, 1941 and *L.* (*Lasius*) *alienus* from Mongolia. However, I could not examine specimens of the former species, and the latter species may be *L.* (*Lasius*) *gebaueri* Seifert, 1992. Accordingly these two species were omitted in this paper. *Lasius* (*Cautolasius*) flavus was once recorded from Mongolia based on a dirty queen specimen by Holgersen (1943) but this species has never been rediscovered from Mongolia despite of intensive collections (see Aibek and Yamane, 2010).

Keys to Mongolian species of Lasius based on workers

1. Body brown, dark brown or pale brown, not shiny. In full-face view posterior margin of head convex to almost straight. Maxillary palps long, far extending beyond midlength of ventral surface of head. ……...................……………....……........…… Subgenus ***Lasius***.... 3
- Body shiny black.In full-face view head heart-shaped; itsposterior margin concave. Maxillary palp relatively short, at most reaching the midlength of the ventral surface of head. ……………... ***L.*** (***Dendrolasius***) ***fuji*** Radchenko
- Body yellow or brownish yellow. In full-face view posterior margin of head weakly concave. Maxillary palp short, not reaching midlength of ventral surface of head. ………………………………………………………………………….….……………2
2. Sides of head convex. Petiole low and thick in profile, dorsal crest seen from back round apically. Posterior portion of head and alitrunk with a few erect or suberect hairs. Long hairs on gastral tergites almost lying. Gena, scape and hind tibia without standing hairs. ……………………………………………………...... ***L.*** (***Austrolasius***) ***reginae*** Faber
- Sides of head straight or very slightly convex. Petiole high, in profile thin, tapering apicad with sharp apex; dorsal crest seen from back often emarginated medially. Posterior

portion of head and alitrunk dorsally with much more standing hairs. Long hairs on gastral tergites suberect. Whole surface of head, gena and hind tibia always with standing hairs. …………………………………...….. ***L.* (*Chthonolasius*) *distinguendus*** Emery

3. Scape without standing hairs; hind tibia at most with a few standing hairs (less than 6)…. ....…...4

- Scape and hind tibia with a many standing hairs (more than 10)…………………………... ….........................….. ***L.* (*L.*) *niger*** Linnaeus

4. Gena with a few standing hairs. Anterolateral portion of head and clypeus with denser pubescence. Posterior slope of propodeum slightly convex. Head and gaster dark brown; alitrunk lighter brown……..…………………………….….…… ***L.* (*L.*) *gebuaeri*** Seifert

- Gena usually without standing hairs. Anterolateral portion of head and clypeus with sparser pubescence. Posterior slope of propodeum almost straight. Head brown; alitrunk lighter brown with yellowish tinge. ……………………………..…. ***L.* (*L.*) *obscuratus*** Stits

Lasius* (*Austolasius*) *reginae Faber, 1967

Lasius (*Austolasius*) *reginae* Faber, 1967: 75 (type locality: Austria); Aibek and Yamane, 2010: 198.

Worker diagnosis. Body 2.8-3.2 mm long. Posterior margin of head in full-face view slightly concave. Sides of head convex. Clypeus in profile with posterior one-third rather flat and anterior two-thirds steeply sloping. Masticatory margin of mandible with nine teeth. Frons and lateral portion of head shining. Propodeal dorsum and metanotal depression continuous and rather flat; propodeal junction round; propodeal declivity slightly convex in profile. Maxillary palps very short. Petiole in anterior view with convex sides,in laterial view with both faces; in anterior view dorsal crest convex. Clypeus, frons, occipital margin of head, alitrunk, and gaster with relatively short standing hairs. Long hairs on gastral tergites almost lying. Gena and legs without standing hairs. Clypeus, head, alitrunk with sparse and gaster with dense pubescence. Head brownish yellow; alitrunk, petiole and gaster yellow; mandible reddish brown.

Specimens examined. Near Numrug ($47^0$23’656”N, $118^0$50’499”E), 812m alt., Dornod aimag, E. Mongolia, 24 VII 2008, SKY and UA (MG08-SKY-47, UAi-139-08); Numrug.

Distribution. Western Europe to Central Asia, Mongolia

Bionomics. The species inhabits dry steppe in Eastern Mongolia. A large flat mound of soil was observed in sandy habitat. Any other information is not available about the Mongolian population.

 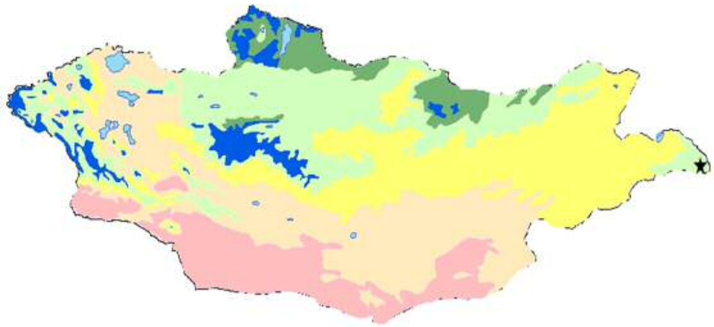

Fig. 2-32. Worker of *Lasius reginae* (after Aibek and Yamane, 2010) and collection site.

Lasius (***Chthonolasius***) ***distinguendus*** Emery, 1916

Formicina umbrata subsp. *distinguenda* Emery, 1916: 64 (type locality: Italy).

Lasius (*Chthonolasius*) *distinguendus*: Bondroit, 1918: 32; Emery, 1922: 13; Karavaiev, 1936: 214; Wilson, 1955: 151; Pisarski, 1969b: 231; 1975: 39; Collingwood, 1979: 102; Seifert, 1988: 149; 1992: 10; Czechowski et. al., 2002: 111; Japanese Ant Database Group, 2003: Radchenko, 2005: 191.

Lasius przewalskii Ruzsky: Pfeiffer et al., 2007: 4 (part, in list).

Worker diagnosis. Body 3.5-4.5 mm long. Posterior margin of head in full-face view almost straight or slightly concave. Sides of head straight or very slightly convex. Clypeus without a median carina. Lateral clypeal profile convex. Masticatory margin of mandible with seven to eight teeth. Frons and posterior portion of head weakly shining. Metanotal depression deep. In laterial view propodeal dome high, hemispheric to conic-hemispheric, and with slightly convex declivity. Petiole high, thin, and tapering apicad with sharp apex in profile; dorsal crest seen from back often emarginated medially. Petiole in anterior view with convex or straight sides, in laterial view with convex anterior and straight posterior faces. In full face view, whole surface of head with many standing hairs. Posterior portion of head and alitrunk dorsally with much more standing hairs. Long hairs on gastral tergites suberect. Hind tibia with 2-8 standing hairs. Scape with dense pubescence, and with few or many subdecumbent and suberect long hairs. Whole body yellow or reddish yellow.

Taxonomic remarks. This species is very similar to *L. przewalskii* Ruzsky. The Ruzsky's original description of *L. przewalskii* is as follows: 1) scape and tibia without standing hairs, 2) mesosoma partly with standing hairs, 3) head with sparse and short standing hairs, 4) gaster not sculptured, weakly shining, and with evanescent pubescence or without it, 5) gaster with few curved standing hairs, 6) petiole dorsal crest weakly notched. In some samples collected by me the scape and hind tibia have no standing hairs but have relatively long pubescent hairs. We did not find any other difference between *L. distinguendus* and *L. przewalskii.* Wilson (1955) synonymized *L. przewalskii* with *L. distinguendus.* We tentatively follow his view.

Specimens examined. Altanbulag, Selenge Prov., Mongolia, IV 2003, S. Kawaguchi;

Altanbulag, N. Mongolia, 5 IX 2003, S. Kawaguchi; Khandgait Jiver Mt., 1650m alt., NC. Mongolia, 07 VIII 2004, MG04-SKY-17; Turkhurh valley, 1593 m alt., Bogd Khaan N.P., NC. Mongolia, 12 VII 2008, MG08-SKY-07; same data, 122-UAi-09; Nuht valley, Bogd Khaan N.P., NC. Mongolia, 30 VIII 2009, UAi-202-09; near Numrug, N 42^0 23’ 493” E 118^0 50’ 543”, E. Mongolia, 24 VII 2008, MG08-SKY-50; same data, UAi-142-09; Numrug, Dornod aimag, E. Mongolia,25 VII 2008, MG08-SKY-57; same data, MG08-SKY-58; same data, MG08-SKY-61; same data, UAi-145-09; same data, UAi-146-09; Shajinkhurh, Bogd Khaan N.P., NC. Mongolia, 30 VII 2009, MG09-SKY-30; near Turgen valley, Bogd Khaan N.P., NC. Mongolia, 1 VIII 2009, MG09-SKY-26; Hustai N.P., 1850m alt., Tuv aimag, NC. Mongolia, 3 VII 2003, Aibek leg., 09-Hus-09; Unegt, 800-900 m alt., Selenge aimag, NC. Mongolia, 2 VIII 2009, MG09-SKY-27; near. Dadal, E. Khentii, N. Mongolia, 7 VIII 2009, MG09-SKY-51; same data, MG09-SKY-52; nr. Dadal, 940 m alt., NE. Khentii, N. Mongolia, 9 VIII 2009, MG09-SKY-75; Dadal, Khentii aimag, 1158m alt., NE. Khentii, N Mongolia, 10 VIII 2009, 49-UAi-09; same data, 50-UAi-09; same data, 58-UAi-09; Bayan-Adarga, Khentii aimag, 1158m alt., NE. Khentii, N Mongolia, 10 VIII 2009, 84-UAi-09.

Distribution. From West Europe to Russian Far East, North Korea, Japan, Mongolia.

Bionomics. The species inhabits mostly open sites (forest steppe, mountain steppe, forest edge, grassland), and is also met in different kinds of forest (larch, birch, mixed forests). Nests are built mainly in dead wood (rotten wood, fallen wood, dead standing tree, base of dead tree), under stone and partly in soil.

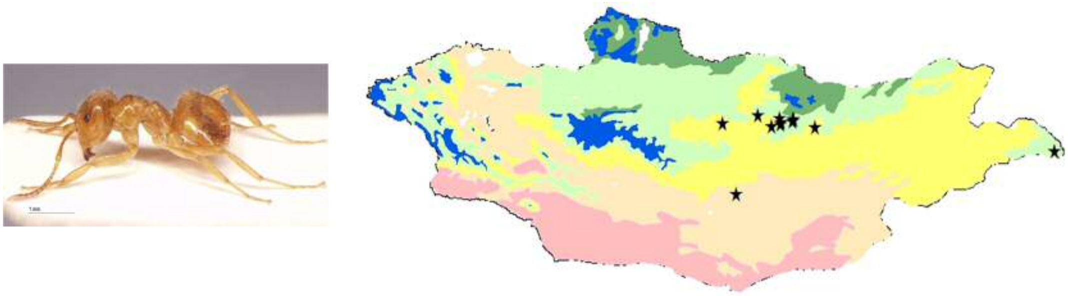

Fig. 2-33. Worker of *Lasius distinguendus* and collection sites.

Lasius **(*Dendrolasius*)** ***fuji*** Radchenko, 2005

Lasius (*Dendrolasius*) *fuji* Radchenko, 2005: 191 (type locality: North Korea).

Worker diagnosis. Body 3.5-4.5 mm long. Posterior margin of head in full-face view concave. Sides of head convex. Clypeus without median carina. Masticatory margin of mandible with eight to nine teeth. Whole body surface shining. Propodeal dome as high as mesonotum, with a round junction between dorsal and posterior faces; in profile propodeal declivity convex. Maxillary palps shorter, just reaching midlength of ventral surface of head. Petiole in anterior view with convex sides,in laterial view with convex both sides; in anterior view dorsal crest emarginated. Posterior margin of head in full-face view and in laterial view of mesonotum with a few longer standing hairs. Head corners round and without hairs. Clypeus, frons, posterior margin of head, alitrunk, coxae and gaster with relatively short standing hairs. Gena and hind tibia without standing hairs. Clypeus, head, alitrunk and gaster with sparse pubescence. Scape, femora and tibiae with dense pubescence. Head, alitrunk, and gaster shiny black or brownish black; mandible reddish brown; scape and legs blackish brown.

Specimens examined. Near Numrug, 812m alt., Dornod aimag, E. Mongolia,25 VII 2008, MG08-SKY-49; same data, UAi-140-08; Numrug, Dornod aimag, E. Mongolia,25 VII 2008, MG08-SKY-63; same data Ulz-08-144; nr. Dadal, 1050m alt., mixed forest, NE Khentii, NE. Mongolia, 8 VIII 2009, MG09-SKY-56; same data MG09-SKY-61; same data, UAi-09-E11; Dadal, Hajuu bulag, 974m alt., *Betula* forest, NE Khentii, NE. Mongolia, 8 VIII 2009, 99-UAi-09.

Distribution. North Korea, Japan, Mongolia.

Bionomics. This species inhabits at low altitude (700-900 m) forest area in Eastern Mongolia. Nests are built under base of live tree and partly in soil.

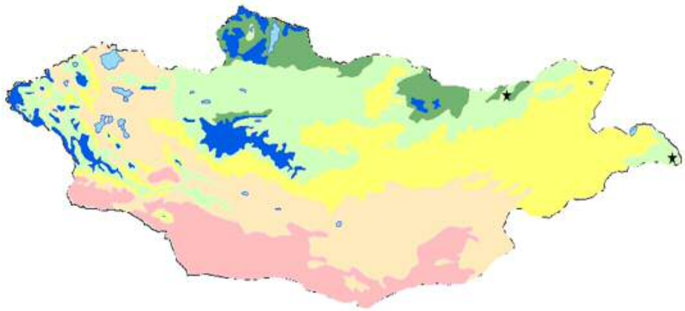

Fig. 2-34. Worker of *Lasius fuji* (after Aibek and Yamane, 2010) and collection sites.

Lasius* (*Lasius*) *gebaueri Seifert, 1992

Lasius gebaueri Seifert, 1992: 22 (type locality: Tibet); Pfeiffer et al., 2007: 4 (in list).

Worker diagnosis. Body 3.0-3.5 mm long. Posterior margin of head in full-face view, and lateral clypeal profile convex. Clypeus with distinct or blunt median carina. Masticatory margin of mandible with eight teeth. Frons and posterior portion of head weakly shining. Petiole in anterior view with straight sides, in laterial view with convex anterior face and straight or slightly concave posterior face, with rather sharp apex; dorsal crest in anterior view emarginated at middle. Declivity of propodeum slightly convex.

Posterior portion of head with standing hairs that extend to posterior margin of eye. Gena in full-face view with 2-4 setae. Clypeus, frons, ventral face of head, alitrunk and gaster with long standing hairs. Scape without standing hairs and with some long pubescence on distal third. Hind tibia with a few standing hairs (less than 6). Anterolateral portion of head, and gaster with denser and alitrunk with sparser pubescence. Head and gaster dark brown; alitrunk slightly lighter brown; mandible and scape yellowish; petiole, coxae and femora pale yellowish brown.

Taxonomic remarks. This species may have been treated as *L. alienus* (Foerster, 1850) in most of the literature on the Mongolian ants. It is also similar to *L. obscuratus* but is distinguished from the latter by the following characteristics: gena with a few standing hairs; anterolateral portion of head and clypeus with denser pubescence; posterior slope of propodeum slightly convex; head and gaster dark brown, mesosoma lighter brown.

Material examined. Bogd Khaan N.P., 1550m alt., Tuv aimag, NC. Mongolia, 27 VI 2003, MG03-SKY- 06; same loc., 15 VIII 2004, MG04-SKY- 139; same loc., Aibek leg., 12 July 09; same loc., Ulzii leg., 30 Aug 09, 101-Ulz-09; same data, 205-UAi-09; Bogd Khaan N.P., 1550m alt., Turgen valley, Tuv aimag, NC. Mongolia, 18 IX 2009, 160-Ulz-09; Terelj N.P., 1250m alt., Tuv aimag, NC. Mongolia,29 VI 2003, MG03-SKY- 29; same data, MG03-SKY-30; same data, MG03-SKY- 84; same loc., 30 VI 2003, MG03-SKY- 35; same data, MG03-SKY- 37; same loc., 29 VII 09, UAi-24-09; Hustai N.P., 1850m alt., Tuv aimag, NC. Mongolia, 3 VII 2003, MG03-SKY- 61; same data, MG03-SKY- 65; same loc., 4 VII 2003, MG03-SKY- 70; Khonin Nuga, 930m alt., Khentii Mountains, Selenge aimag, N. Mongolia, 12 VIII 2004, MG04-SKY- 79; same data, MG04-SKY- 80; same loc., 13 VIII 2004, MG04-SKY- 111; same data, MG04-SKY- 112; Khandgait Jiver Mt., 1650m alt., nr. UB. Mongolia, 07 VIII 2004, MG04-SKY-14; Ulaanbaatar, NC. Mongolia, Ulzii leg. 09 VI 2008; Nuht valley, Bogd Khaan, NC. Mongolia, 16 VII 2008, MG08-SKY-26; nr. Idermeg, riverside, Khentii aimag, E. Mongolia, 21 VII 2008, MG08-SKY-32; same data, MG08-SKY-33; Near Numrug, 812m alt., Dornod aimag, E. Mongolia,24 VII 2008, MG08-SKY-45; same data, MG08-SKY-46; same data, G.C. Sk. Yamane leg. Numrug, Dornod aimag, E. Mongolia,25 VII 2008, MG08-SKY-64; same data, UAi-137-09; same data, UAi-138-09; same data UAi-141-09; Shajinkhurh, Bogd Khaan N.P., NC. Mongolia, 30 VII 2009, MG09-SKY-13; 65 km of Ondorkhaan, Khentii aimag, N. Mongolia, 06 VIII 2009, MG09-SKY-40; near Batnorov NE of Ondorkhaan, NE. Khentii, N. Mongolia, 07 VIII 2009, MG09-SKY-44; same data, 44-UAi-09; Norovlin, Khentii aimag, 07 VIII 2009, 98-UAi-09; Dadal, 900m alt., NE. Khentii, N Mongolia, 8 VIII 2009, MG09-SKY-101; Dadal, Hajuu bulag, 900m alt., NE. Khentii, N Mongolia, 8 VIII 2009, 69-UAi-09; Dadal, Khentii aimag, 900m alt., NE. Khentii, N Mongolia, 11 VIII 2009, 90-Uzi-09

Distribution. Northeast Tibet, Mongolia.

Bionomics. The species inhabits mostly open sites (forest steppe, mountain steppe, forest edge, grassland), and is also met in different kinds of forest (larch, birch, mixed forests). Nests are built mainly under stone and partly in soil, soil mount, also in dead wood (rotten wood, fallen wood, dead standing tree, base of dead tree). A very wide range distributed from low altitude (700-900 m) flat steppe to high altitude (1300- 2000 m) mountain steppe and it is one of the commonest *Lasius* species in Mongolia.

 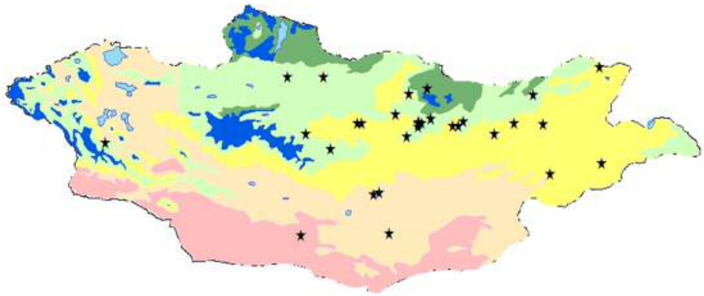

Fig. 2-35. Worker of *Lasius gebaueri* and collection sites.

Lasius (***Lasius***) ***niger*** Linnaeus, 1758

Lasius (*Lasius*) *niger* Linnaeus, 1758: 580 (type locality: Europe).

Lasius niger: Ruzsky, 1907: 23; Karavaeiv, 1912: 587; Wheeler, 1929: 10; Wilson, 1955: 78; Pisarski, 1969b: 305, Pisarsi and Krzysztofiak, 1981: 160; Collingwood, 1979: 99; Kupyanskaya, 1995: 365; Seifert, 1992: 27.

Worker diagnosis. Body 2.5-3.5 mm long. Posterior margin of head in full-face view almost straight. Clypeus with a weak median carina; lateral clypeal profile convex. Masticatory margin of mandible with eight to nine teeth. Frons and posterior portion of head weakly shining. Metanotal depression deep. In laterial view propodeal dome high, hemispheric to conic-hemispheric, and with slightly convex declivity. Petiole in anterior view with convex sides, in laterial view with convex anterior and straight posterior faces, relatively thin and sharp at apex; in anterior view dorsal crest slightly emarginated or straight. Whole surface of head with many standing hairs. Alitrunk and gaster with long standing hairs. Scape and hind tibia with many standing hairs. Anterolateral portion of head, clypeus and alitrunk with dense pubescence. Head and gaster blackish brown; alitrunk brown with yellowish tinge; mandible, clypeus, antennal scape, and trochanters of all legs yellowish-reddish brown; petiole, coxae, femora and tibiae dark brown.

Taxonomic remarks. This species is easily distinguished from the other Mongolian *Lasius* species by the whole surface of head with many standing hairs; scape and hind tibia with many standing hairs.

Material examined. Darkhan soum, Darkhan-Uul aimag, (700 m alt.) 12 IX 2010, UA10-507 (w).

Distribution. Europe, Caucasus, Baikal, Mongolia.

Bionomics. The species inhabits mostly in different kinds of meadow habitats (mountain and riverside meadow).

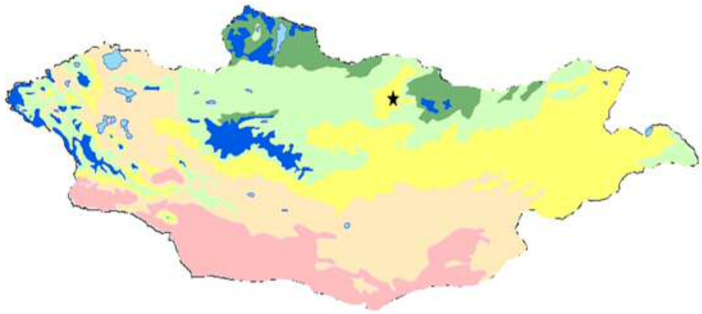

Fig. 2-36. Worker of *Lasius niger* and collection sites.

Fig. 2-37. Nest of *Lasius* (*Austrolasius*) *reginae*. Grassland near Numrug, Dornod aimag.

Fig. 2-38. Nest of *Lasius* (*Chthonolasius*) *distinguendus* under stone.

Fig. 2-39. Nest of *Lasius fuji* in dead stump.

Fig. 2-40. Habitat of *Lasius* (*Dendrolasius*) *fuji*. Grassland with a small pine forest near Numrug.

Fig. 2-41. Nest of *Lasius fuji* in dead stump.

Fig. 2-42. Nuptial flight of new queen and males of *Lasius* (*Lasius*) *gebaueri*. Bogdkhan N.P.

Subfamily **Myrmicinae**

Genus ***Harpagoxenus*** Forel, 1893

Harpagoxenus Forel, 1893. Type species: *Myrmica sublaevis* Nylander, 1849, by monotypy; Bolton, 1995: 211.

This genus includes three species, of which two are distributed in the Palaearctic region and one in the Nearctic region (Bolton, 1995). One species has been recorded in Mongolia. All the species are slave-makers, parasitizing colonies of *Leptothorax* species.

Worker diagnosis. In general appearance similar to *Leptothorax*. Antenna 11-segmented. Frontal lobe present; antennal scrobe present on side of head above eye. Masticatory margin of mandible edentate. Gaster seen from above differently shaped.

Harpagoxenus zaisanicus Pisarski, 1963

Harpagoxenus zaisanicus Pisarski, 1963: 39 (type locality: Mongolia); Pisarski, 1969a: 229, 1969b: 303; Pisarski and Krysztofiak, 1981: 158.

Worker diagnosis. Body length 3.5 mm. Head quadrate in shape. Mandible large, rectangular; masticatory margin with sharp apex. Metanotal groove shallow. Propodeal spines relatively short. Anterior and posterior faces of petiole in profile weakly concave; seen from above postpetiole 2 times as braod as petiole. Dorsa of head, mesosoma, waist and gaster with numerous standing hairs.

Bionomics. In 1962, four workers of this species was collected in a coniferous forest in Zaisan valley, Bogd Khaan National Park in a nest of *Leptothorax muscorum*. No additional records are available.

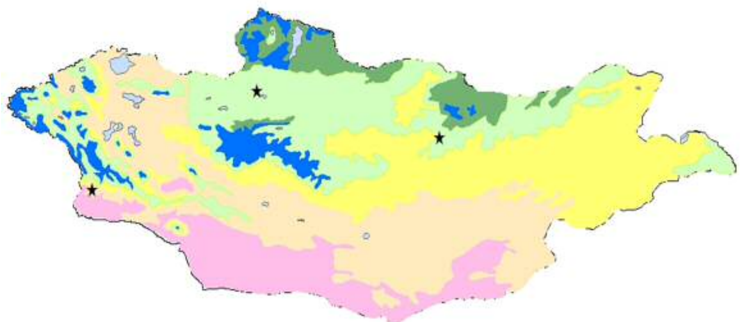

Fig. 2-43. Distribution map of *Harpagoxenus zaisanicus.*

Genus ***Lepthothorax*** Mayr, 1855

Genus *Lepthothorax* Mayr, 1855. Type species: *Formica acervorum* Fabricius, 1793, by subsequent designation of Binghan 1903; Bolton, 2003: 247, 270 (definition).

This genus is cosmopolitan (except in Australian region), and has 16 Holoarctic species (Bolton, 2003). Two species occur in Northcentral and Eastern Mongolia.

Worker diagnosis. Antenna 11-segmented. Clypeus without median carina. Frontal carina and antennal scrobe absent. Anterolateral corners of pronotum widely rounded (seen from above). Propodeal spines distinct. In the male mandible reduced, blunt, without teeth.

Key to Northcentral and Eastern Mongolian species of Leptothorax

1. Tibiae and antennal scape with numerous erect or suberect hairs. ……………….. ……………………………………………………….…………… ***L. acervorum*** Fabricius
- Tibia and antennal scape without erecthairs, only with decumbent pilosity…………... ……………………………………….……………………… ***L. muscorum*** Nylander

Lepthothorax acervorum (Fabricius, 1793)

Formica acervorum Fabricius, 1793: 358 (type locality: Denmark).

Lepthothorax acervorum: Mayr, 1855; 436; Collingwood, 1979: 70; Kupyanskaya, 1995: 348; Czechowski et. al., 2002: 41; Radchenko, 2004: 130; 2005: 135;

Lepthothorax (*Mychothorax*) *acervorum nigrescens*: Pisarski, 1969a: 228; 1969b: 297, Pisarski and Krysztofiak, 1981: 157.

Worker diagnosis. Body length 2.9-4.1 mm. Antenna 11-segmented. Propodeal spines distinct and strong. Tibiae and antennal scape with numerous erect or suberect hairs. Dorsa of head and mesosoma, and gaster dark brown; basal half of antennal flagellum, lateral face of mesosoma and tibiae and tarsi of all legs light reddish-brown (often with yellowish tinge).

Taxonomic remarks. This species is easily distinguished from *L. muscorum* by the tibiae and antennal scape with numerous erect or suberect hairs.

Material examined. Tsangaan Davaa, Arhangai aimag, 19 IX 2010, MG10-SKY-85 (w,Fq); nr Tosontsengel (240 m alt.). Zavhan aimag, 19 VII 2011, SKY (w); same loc. and date, MG11-SKY-20 (w); nr Harhorin (1700 alt.), Ovorhangai aimag, 18 IX 2010, MG10-SKY-53 (w); Uliin Davaa, Huvsgul aimag, 17 VIII 2003, MG03-SKY-98 (w,fq); Khandgait (1650 m alt.), Jiver Mts., 7 VIII 2004, MG04-SKY-15 (w); Bogd Khaan NP (1550 m alt.), Tuv aimag, 28 VI 2003, SKY leg. (w); same loc., 28 VI 2003, MG03-SKY-17 (w,fq,m); same loc., 15 VIII 2004, MG04-SKY-134 (w); same loc., 17 VIII, 2004, MG04-SKY-142 (w); same loc., 30 VIII 2009, UA09-206; Khoni Nuga (Turgen valley), Tuv aimag, 13 VII 2008, MG08-SKY-10 (w); Unegd (800-900 m alt.), Selenge aimag, 2 VIII 2009, UA leg., MG09-SKY-39 (w); Khonin Nuga (930 m alt.), Selenge aimag, 12 VIII 2004, SKY leg. (w); same loc., Selenge aimag, 13 VIII 2004, MG04-SKY-105 (w), -107 (w,fq), -108 (w), -110 (w), -115 (w,fq); Khentii Mts., Selenge aimag, 14 VIII 2004, MG04-SKY-122 (w,fq); nr Dadal (1050 m alt.), Khentii aimag, 8 VIII 2009, MG09-SKY-64 (w,fq).

Distribution. North Europe, Russia, Caucasus, Tien-Shan, North Korea, Japan, Mongolia.

Bionomics. *Leptothorax acervorum* mostly inhabits relatively open coniferous forests and forest edges in Mongolia. It also can be found in open habitats (mountain steppe). This species is found at altitudes between 1500 m and 2300 m alt. in Mongolia. Nests are built in rotten logs and stumps, in fallen branches, under the bark of trees and stones.

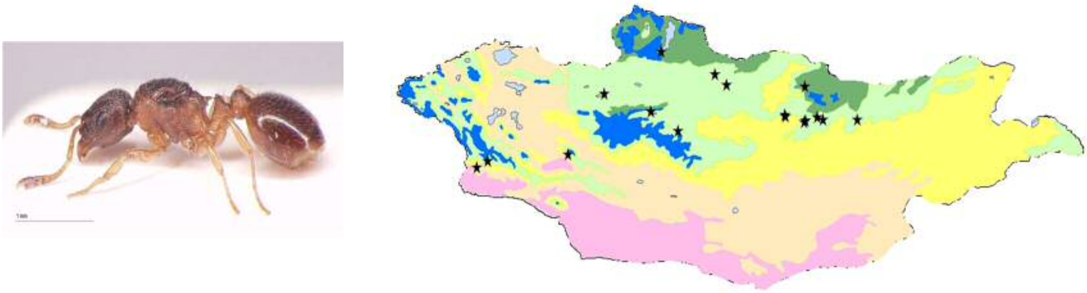

Fig. 2-44. Queen of *Leptothorax acervorum* and collection sityes.

Leptothorax muscorum (Nylander, 1846)

Myrmica muscorum Nylander, 1846: 1054. (type locality: Finland)

Leptothorax muscorum: Mayr, 1855: 167; Pisarski, 1969b: 297; Pisarski, 1969a: 9; Dlussky and Pisarski, 1970: 86; Pisarski and Krzysztofiak, 1981: 157; Radchenko, 1994a: 147, 1995b: 25.

Leptothorax muscorum muscorum: Kupyanskaya, 1990: 139, 1995: 348.

Worker diagnosis. Body length 2.7-3.4 mm. Antenna 11 segmented. Dorsum of head, alitrunk and petiole with longitudinal rugae; between rugae with small dots. Anterior and dorsal faces of petiole node (seen in profile) meet at a rounded blunt angle. Tibiae and antennal scape without standing hairs; only with decumbent pilosity.

Material examined. Chuluut, Arhangai aimag, 19 IX 2010 (w,fq); Nuuriin ekh, Khuvsgul aimag, 19 VIII 2003, UA leg., MG03-SKY-93 (W); Sumber, Khuvsgul aimag, 3 VIII 2003, UA leg. (w); Khandgait (1650 m alt.), Jiver Mts., 7 VIII 2004, MG04-SKY-12 (w,fq); Bogd Khaan NP, Tuv aimag, 28 VI 2003, MG03-SKY-10 (w,fq), -12 (w,fq); same loc., 15 VIII 2004, MG04-SKY-130 (w), -131 (w,m), -133 (w,fq); Bogd Khaan NP (Shajinkhurh), Tuv aimag, 30 VII 2009, MG09-SKY-02 (w,fq), -09 (w,m); Bogd Khaan NP. (Turhurah valley, 1598 m alt.), Tuv aimag, 12 VII 2008, Tr-9 (w); Bogd Khaan NP. (Turgen valley), Tuv aimag, 1 VIII 2009 (w); same loc. and date, UA09-44 (w).

Distribution. Southern Europe, Caucasus, Mongolia.

Bionomics. The species inhabits mostly in lighted coniferous forest and forest edge in Mongolia. It also can be found in open habitats (mountain meadows). This species occurs at altitudes between 1500 and 2200 m alt. in Mongolia. Nests are built under small stones, under bark, in rotten logs and stumps, and in fallen branches.

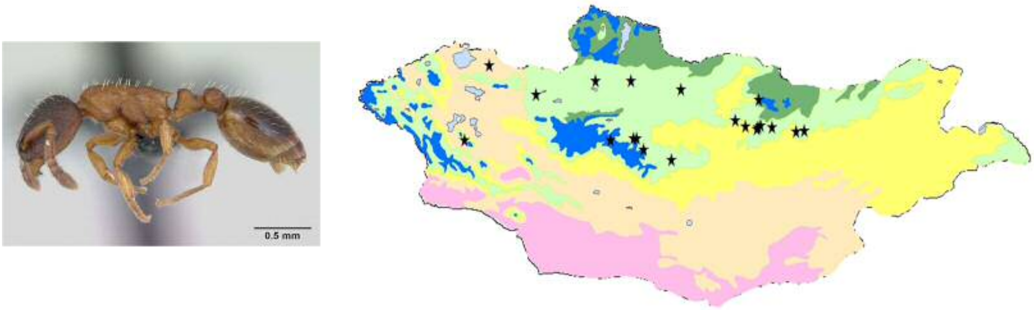

Fig. 2-45. Worker of *Leptothorax muscorum* and collection sites.

Genus ***Myrmica*** Latreille, 1804

Myrmica Latreille, 1804: 179. Type species: *Formica rubra*. Bolton 1995: 37; Radchenko and Elmes, 2010: 52.

Worker diagnosis. In most species body length measuring between 4.5-6.0 mm. Antenna 12-segmented in the worker and queen, and 13-segmented in the male. Mandible with 6-10 teeth. Maxillary palp 6-segmented, labial 4-segmented. Frontal lobe relatively well developed, covering part of antennal socket. Propodeum with a pair of spines on posterodorsal corners. In some species lateral portion of clypeus raised into a wall in front of antennal insertion as seen in *Tetramorium*. Head and mesosoma principally with longitudinal rugae that are often parallel and regular; reticulation also seen on dorsa of head and mesosoma. Body colour is generally reddish-brown, bit varying from light yellowish brown to almost black.

This is principally a Holoarctic genus, with some species in highlands of the Oriental region. *Myrmica commarginata* Ruzsky, 1905 is omitted here because this form might represent a group of abnormal individuals of more than one species (for more information, see Radchenko and Elmes, 2010). Head width was measured in full-face view just behind the eyes. Ten workers randomly chosen were used for the measurement except otherwise stated.

Complete keys to the Old World species and drawings of their important characters are available in Radchenko and Elmes (2010).

Key to the Myrmica species from Mongolia

1. Lateral portion of clypeus raised as a wall so that antennal socket is surrounded by a continuous ridge. ……….………..... ***M. transsibirica*** Radchenko (=*M. taediosa* Bolton)

− Lateral portion of clypeus low so that the bottom of antennal socket is at the same level as clypeus. …………………………………………………………………….…... 2

2. Antennal scape strongly curved near its base with a distinct angle bearing a developed carina or lobe, which separates basal shaft and main part of scape. Anterior clypeal margin convex and medially more or less notched. ………...……….. 3

− Antennal scape weakly to rather strongly curved near base, without a developed carina/lobe separating its basal shaft from main part of scape (vertical carina can be seen on basal shaft). Anterior margin usually without median notch, but sometimes notched. ……………………………………………………………………………………7

3. Propodeal spines seen from above distinctly curved inwardly. . ***M. forcipata*** Karavaiev

\- Propodeal spines seen from above almost straight. ……………………………………… 4

4. Metanotal groove usually distinct, sometimes deep. ……………………………………. 5

− Metanotal groove if any very weak; mesosoma in profile with an almost straight dorsal outline. ……………………………………………………………………………… 6

5. Carina at bend of antennal scape low, not forming a lobe. With petiole in profile, anterodorsal corner round. Mesosomal dorsum predominantly with rather regular longitudinal carinae. ………………………………………… ***M. eidmanni*** Menozzi

− Carina at bend of antennal scape developed, lobe-like. With petiole in profile, anterodorsal corner acute or right-angled. Pronotum entirely reticulate. ……………………………………………………………………………… ***M. lobicornis*** Nylander

6. Frontal lobe strongly expanded laterally with distinctly suberect lateral part. Anterior face of petiole distinctly concave. Spaces between rugae on mesosoma almost smooth and shining. Propodeal spine more strongly upward-directed. ……... ***M. koreana*** Elmes et al.

− Frontal lobe weakly expanded laterally. Anterior face of petiole in profile only weakly concave. Spaces between rugae on mesosoma subopaque. Propodeal spine more posteriorly directed, sometimes down-curved. .... ***M. pisarskii*** Radchenko

7. Propodeal spines seen from above inwardly curved. With petiole in profile anterodorsal corner more or less angulated. ………………………………………… 8

\- Propodeal spines seen from above almost straight. Petiole in profile with roundedapex; anterior face meets dorsal face without a distinct angle. ………………. 9

8. Petiole and postpetiole coarsely rugose; dorsum of petiole with 3 strong longitudinal rugae; spaces among these rugae very deep. Propodeal spine dorsally with several standing hairs. .... ***M. sulcinodis*** Nylander

− Petiole and postpetiole much weakly sculptured; dorsum of petiole without very strong longitudinal rugae. Propodeal spine dorsally with at most 1 standing hair, usually without hairs. .... ***M. angulinodis*** Ruzsky

9. Anterior margin of clypeus nearly straight or weakly emarginate medially, without distinct denticles medially. Frontal carina posteriorly not curved outward, merging with longitudinal rugae running toward posterior margin of head. ……………...... 10

− Anterior margin of clypeus often produced medially, rarely straight, usually with several denticles medially. Frontal carina posteriorly curved outward so as to merge with rugae surrounding antennal socket. ……………………………………….. 13

10. Body light brown to yellowish brown, with head and gaster slightly darker. Antennal scape only weakly and smoothly curved near base; its basal shaft without a distinct longitudinal carina. Subpetiolar process large and wide, lobe-like. …….. ……………………………………………………………… ***M. arnoldi*** Dlussky

– Body bicolorous with mesosoma and waist reddish, and head and gaster dark brown; or body more uniformly brown to dark brown without yellow tint. Basal curvature of antennal scape various, often strongly angled; basal shaft of scape with a distinct longitudinal carina. Subpetiolar process small and narrow. ………..…..…. 11

11. Mesosoma seen in profile with a very shallow metanotal groove; the groove often essentially absent. Side of mesosoma with strong and sparse rugae that are rather regular throughout. ……………………………........……….. ***M. kasczenkoi*** Ruzsky

– Mesosoma seen in profile with a distinct metanotal groove. Side of mesosoma with dense weak striation that is often irregular. …………………….……………....... 12

12. Antennal scape gently curved near base, without carina at bend. With petiole in profile node round dorsally. .... ***M. divergens*** Karavaiev

– Antennal scape strongly curved with distinct bend (almost right-angled); bend with a weak carina bordering basal shaft and main part of scape. With petiole in profile anterodorsal corner of node angled. .... ***M. kamtschatica*** Kupyansukaya

13. With petiolar node in profile dorsal outline rounded; dorsa of petiolar and post-petiolar nodes smooth or only weakly striate. .... ***M. rubra*** (Linnaeus)

– With petiolar node in profile dorsal outline nearly flat; dorsa of petiolar and post-petiolar nodes with strong longitudinal rugae. .... ***M. ruginodis*** Nylander

Myrmica angulinodis Ruzsky, 1905

Myrmica acabrinodis angulinodis Ruzsky, 1905: 689 (type locality: Russia).

Myrmica angulinodis: Pisarski, 1969a: 227; Pisarski, 1969b: 296; Dlussky and Pisarski, 1970: 86; Pisarski and Krzysztofiak, 1981: 155; Bolton, 1995: 277; Radchenko, 2005: 138; Radchenko and Elmes, 2010: 89; Yamane and Aibek, 2012: 172.

Worker diagnosis. Medium-sized species with head width 0.81−1.00 mm (mean 0.93). Frontal carina merging with a short carina extending posteriad. Anterior margin of clypeus almost straight, with a weak median emargination. Antennal scape curved rather strongly (less than right angle) near base; its basal shaft with weak longitudinal carina; carina bordering the shaft and apical main portion absent. Metanotal groove present but shallow. Propodeal spines rather strongly upward directed, seen from above curved inwardly. Petiole in profile with a rather sharp anterodorsal edge; its dorsal face and posterior slope continuous. Dorsum of head medially with longitudinal carinae, laterally and posteriorly reticulate; lateral face of head reticulate. Dorsum and side of mesosoma with coarse longitudinal rugae. Dorsa of petiole and postpetiole coarsely sculptured. Body brown to dark reddish brown, with head and gaster often darker; legs yellowish brown.

Taxonomic remarks. This species belongs to the *kasczenkoi*-complex of the *lobicornis* group. It is similar to *M. forcipata* in size and structure, but the carina at the basal bend of the scape is much more developed in the latter.

Distribution records. Arhangai aimag. Tsetserleg (UA & SKY). Bulgan aimag. Khanjargalant, 1,350 m (Pisarski and Krzysztofiak, 1981); Khutag-Undur, Namnangiin nuruu, 1,150 m (Pisarski and Krzysztofiak, 1981). Dornod aimag. Numrug (UA & SKY). Khentii aimag. Near Bayan-adarga, 1,190 m (UA & SKY); Bereevin hiid (UA & SKY); near Dadal, 1,050 m (UA & SKY). Ovorkhangai aimag. Near Harhorin, 1,700 m (UA & SKY). Selenge aimag. Khonin Nuga, 930 m (UA & SKY); Namdavaa, 1,000 m (UA & SKY); Unegt (UA & SKY). Tuv aimag. Jargalant (UA & SKY); Ulaanbaatar, Bogd khaan uul, Khurhree, 1,550 m (UA & SKY); Ulaanbaatar, Bogd khaan uul, Nuht, 1,100, 1,500 & 1,650 m (Pisarski, 1969b,b; Pisarski and Krzysztofiak, 1981; UA & SKY); Ulaanbaatar, Bogt uul, Shajinhurh (UA & SKY); Ulaanbaatar, Bogd, Turgen (UA & SKY); Ulaanbaatar, Bogd, Turhurh, 1,598 m (UA & SKY); Ulaanbaatar, Bogd khaan uul, Zaisan, 1,400 m (Pisarski, 1969a); around Ulaanbaatar city (Pisarski, 1969a); Ulaanbaatar, Bogd khaan uul (Dlussky and Pisarski 1970).

Distribution. Siberia, Far Eastern Russia, North Korea, Mongolia.

Bionomics. This species mainly inhabits birch (*Betula*) and larch (*Larix*) forests and nearby steppes, nesting in decayed wood and soil.

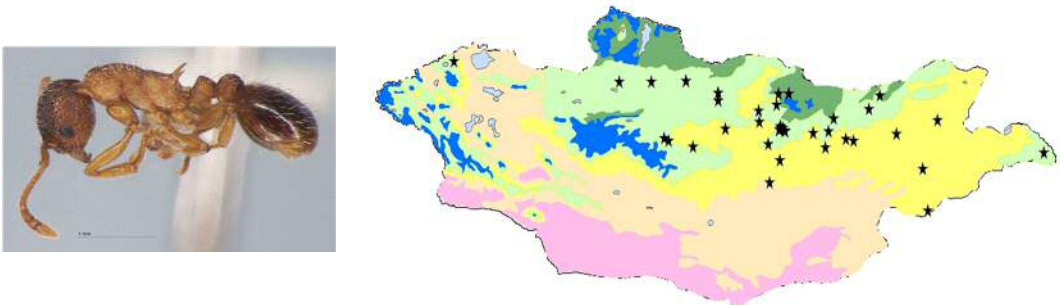

Fig. 2-46. Worker of *Myrmica angulinodis* and collection sites

Myrmica arnoldii Dlussky, 1963

Myrmica arnoldii Dlussky, 1963: 191 (type locality: Russia); Pisarski, 1969a: 227; Dlussky and Pisarski, 1970: 85; Pisarski and Krzysztofiak, 1981: 155; Radchenko, 2010: 94; Yamane and Aibek, 2012: 172.

Worker diagnosis. Smallest species in Mongolia with the head width 0.79−0.87 mm (mean 0.83). Frontal carina curved outwardly to merge with a carina surrounding antennal socket. Anterior margin of clypeus almost straight, virtually without median emargination; clypeus with carinae that are often ill developed. Antennal scape gently curved near base; the bend without carina separating the shaft from main portion of scape; basal shaft without longitudinal carina. Metanotal groove deep; mesonotum distinctly higher than propodeum. Petiolar node in profile nearly triangular with rounded summit; dorsal plate very short, continuous to posterior slope. Propodeal spines thin with sharp apex, seen from above diverging, sometimes very weakly curved inwardly. Dorsum of head with regular longitudinal rugae, but posteriorly weakly reticulate; side of head irregularly reticulate. Spaces between carinae of clypeus smooth and shiny. Dorsum of mesosoma coarsely and irregularly reticulate; side of mesosoma irregularly rugose but rugae often indistinct. Dorsa of petiole and postpetiole weakly sculptured. Entire body yellowish brown, with head and gaster often slightly darker.

Taxonomic remarks. This is the sole member of the *M. arnoldii* group.

Distribution records. Arhangai aimag. Ugii nuur (Dlussky and Pisarski, 1970). Bulgan aimag. Khutag-Undur, Namnangiin nuruu, 1,150 m (Pisarski and Krzystofiak 1981). Selenge aimag. Khonin Nuga, 930 m (SKY & UA); between Khonin Nuga & Ulaanbaatar (UA & SKY). Tuv aimag. Ulaanbaatar (Pisarski, 1969a).

Distribution. South Siberia, Mongolia.

Bionomics. Most of the nests were found in birch/larch forests (often forest gaps) from rotting twigs, rotting wood and soil, and from under logs.

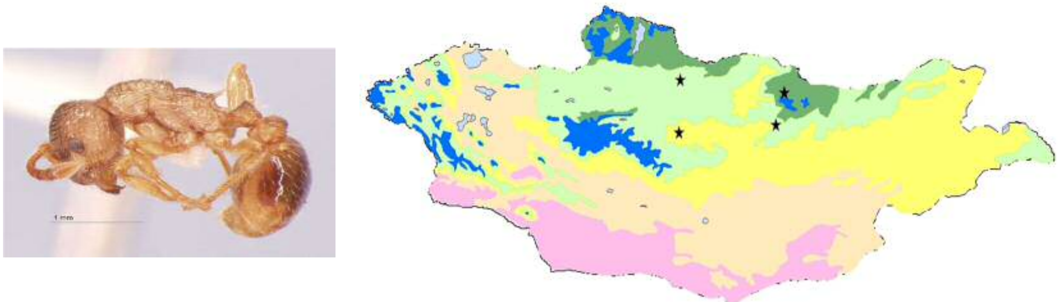

Fig. 2-47. Worker of *Myrmica arnoldi* and collection sites.

Myrmica divergens Karavaiev, 1931

Myrmica bergi var. *divergens* Karavaiev, 1931: 105 (type locality: Russia).

Myrmica bergi divergens: Pisarski, 1969a: 227; Dlussky and Pisarski, 1970: 85.

Myrmica divergens: Radchenko and Elmes, 2010: 121; Yamane and Aibek, 2012: 174.

Worker diagnosis. Relatively large species with head width 0.94−1.10 mm (mean 1.02). Frontal carina merging a carina extending toward occipital margin. Anterior margin of clypeus straight, with a median emargination that is weak or rather distinct; clypeus with strong longitudinal carinae. Scape strongly but roundly bending near base; weak carina present along basal shaft; no carina present separating the shaft and apical main portion. Metanotal groove distinct, in profile often U- shaped. Propodeal spine directed posteriad, in profile broadened at base, seen from above parallel. Petiolar node in profile with roundly angled anterodorsal corner; dorsal face and posterior slope continuous. Dorsum of head closely and regularly rugose medially, but weakly reticulate posteriorly and laterally; side and venter of head reticulate. Side of mesosoma densely rugose; mesosoma dorsally with sinuated longitudinal rugae, with pronotum anteriorly reticulate. Dorsum of petiole minutely punctate; dorsum of postpetiole with longitudinal carinae in addition to minute punctation.

Bicolorous, with head and gaster dark brown to blackish brown, and mesosoma, antennae and legs brown to reddish brown.

Taxonomic remarks. This species belongs to the *bergi*-complex of the *scabrinodis* group.

Distribution records. Arhangai aimag. Tsagaan Davaa (UA & SKY). Hovd aimag. 47˚02'565N 92˚58'242E (UA & SKY). Selenge aimag. Khentii Mts., Galsan bulag (UA & SKY). Tuv aimag. Terelj, 1,250 m (UA & SKY); Ulaanbaatar, Bogd khaan uul (Dlussky and Pisarski, 1970); Ulaanbaatar, Bogd khaan uul, Zaisan, 1,400 m (Pisarski, 1969a); Ulaanbaatar, Tsognii ovoo, 1,700−1,900 m (Pisarski and Krzysztofiak, 1981); Ulaanbaatar, Gorkhi (Pisarski, 1969a). Tuv aimag. Tuul Basin (UA & SKY).

Distribution. South and East Siberia (to the west until Altai Mts.), Mongolia.

Bionomics. Among the four colonies collected, three were found in meadows or at riverside from under stones. The remaining one was dug from under a thick tree root near ground surface in a *Betula* forest (isolated forest in a desert area of Western Mongolia).

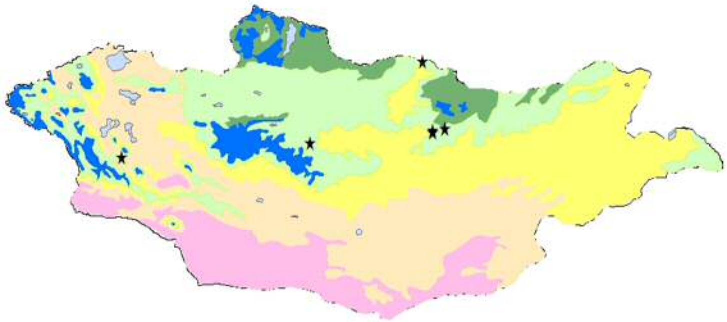

Fig. 2-48. Worker of *Myrmica divergens* and collection sites.

Myrmica eidmanni Menozzi, 1930

Myrmica eidemani Menozzi, 1930: 331 (type locality, Buryatia, Russia); Radchenko, 2005: 139, 2010: 127; Radchenko and Elmes, 2010: 127; Yamane and Aibek, 2012: 174.

Myrmica scabrinodis eidmanni: Bolton, 1995: 278.

Myrmica jessensis Forel: Bolton, 1995: 279 (part).

Worker diagnosis. Relatively large species with head width 0.94−1.08 mm (mean 1.10). Frontal carina merging with a carina(e) extending posteriad. Antennal scape strongly bent (right-angled) near base; a carina present that separates basal shaft and apical main part, continuing as a carina along whole length of basal shaft. Anterior margin of clypeus straight or weakly convex, with a median emargination. Metanotal groove shallow but recognizable. Propodeal spines relatively long, only slightly shorter than apical segment of antenna, seen from above weakly diverging. Petiolar node in profile round at apex. Dorsum of head rather finely rugose in median portion, posteriorly and laterally reticulate; side and venter reticulate. Lateral face of mesosoma moderately rugose (pronotal side anteriorly reticulate); dorsum of mesosoma coarsely and irregularly reticulate. Dorsa of petiole and postpetiole minutely and densely punctate, provided with a few indistinct carinae. Mesosoma and waist orange brown, with darker dorsum; legs and antenna deep yellow to yellowish brown; head and gaster reddish brown to dark reddish brown.

Taxonomic remarks. This species belongs to the *lobicornis*-complex of the *lobicornis* group. The species is similar to *M. divergens* in body sculpture, but easily distinguished from the latter by the carinate bend of the antennal base.

Distribution records. Selenge aimag. Galsan bulag (UA & SKY); near Eruu River, Khonin Nuga (Pfeiffer et al., 2007); Khonin Nuga, 930 m (UA & SKY).

Distribution. South Siberia, Far East Russia, North Korea, Mongolia.

Bionomics. Two nests were collected in Khonin Nuga, Selenge aimag. One was found from surface soil on roadside, and the other from under a stone in the grassland.

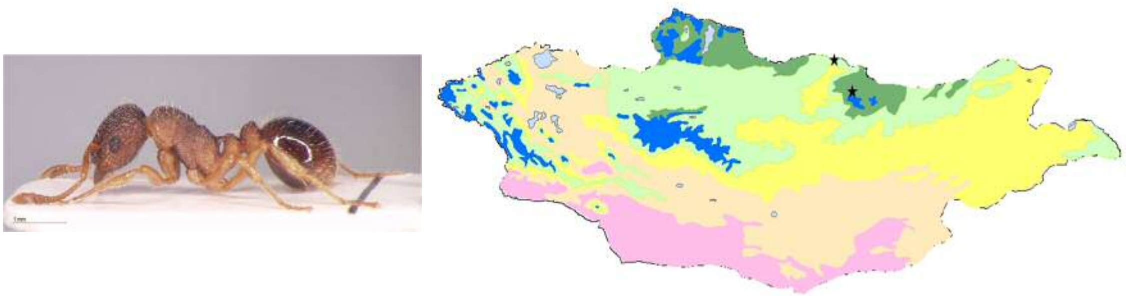

Fig. 2-49. Worker of *Myrmica eidmanni* and colelction sites.

Myrmica forcipata Karavaiev, 1931

Myrmica forcipata Karavaiev, 1931: 105 (type locality: Russia); Pisarski, 1969a: 228; Pisarski, 1969b: 296; Pisarski and Krzysztofiak, 1981: 156; Radchenko and Elmes, 2010: 134; Yamane and Aibek, 2012: 175.

Worker diagnosis. Relatively small species with head width 0.71−0.92 mm (mean 0.84); size variation considerable. Anterior margin of clypeus straight, shallowly and widely emarginated in middle; striation on disc not strong. Frontal carina merging with a ruga(e) that extends posteriad. Antennal scape strongly curved (right-angled) near base; carina separating basal shaft and apical main part distinct; the shaft with developed dorsal carina along its whole length. Metanotal groove present but shallow. Propodeal spines thick, strongly upward directed, seen from above strongly curved inwardly. Petiole in profile with angled anterodorsal corner. Dorsum of head extensively rugose; reticulation restricted to narrow area near occipital margin and to lateral area; side and venter of head irregularly rugose to reticulate. Side of mesosoma coarsely rugose; dorsum of mesosoma with coarse sinuate rugae, with a few cross meshes. Dorsa of petiole and postpetiole minutely and densely punctate, with a few longitudinal carinae. Mesosoma and waist yellowish brown to pale reddish brown; legs and antenna deep yellow to yellowish brown; head and gaster dark brown to dark reddish brown.

Taxonomic remarks. *M. forcipata* belongs to the *lobicornis*-complex of the *lobicornis* group. Itis very similar to *M. angulinodis* in body size, body sculpture and angled petiolar node, but is distinguished from the latter by the developed carinae at the apex and upper margin of the shaft of the antennal scape. *M. angulinodis* inhabits predominantly in forests, while *M. forcipata* prefers more opened areas.

Distribution records. Bulgan aimag. Khishig-Undur, 1,390 m (Pisarski and Krzysztofiak, 1981); Khutag-Undur, Namnangiin nuruu, 1,150 m (Pisarski and Krzysztofiak, 1981); Khanjargalant, 1,350 m (Pisarski and Krzysztofiak, 1981). Khentii aimag. Near Batnorov, NE of Ondorkhaan (UA & SKY); 65 km E of Ondorkhaan (UA & SKY). Khuvsgul aimag. Tosontsengel, 1,450 m (Pisarski and Krzysztofiak, 1981). Selenge aimag. Khonin Nuga, 930 m (UA & SKY). Tuv aimag. Batsumber (Pisarski, 1969a); Bayantsogt, 1,600 m (Pisarski 1969b); Lun, 1,200 m (Pisarski and Krzysztofiak, 1981); Ulaanbaatar, Bogd khaan uul, Khurhree, 1,550 m (UA & SKY); Ulaanbaatar, Bogd khaan uul, Nuht, 1,500−1,800 m (Pisarski, 1969b); same loc., 1,880−2,000 m (Pisarski, 1969b); Ulaanbaatar, Bogd khaan uul, Zaisan (Pisarski, 1969a); Ulaanbaatar, Bogd khaan (UA & SKY); Ulaanbaatar, Tsognii ovoo, 1,500−1,700 m (Pisarski and Krzysztofiak, 1981).

Distribution. South Siberia, Far East Russia, Mongolia.

Bionomics. Nests were found in varying habitats, e.g., *Betula* bush, roadside in grassland, riverside meadow, from decayed wood or soil.

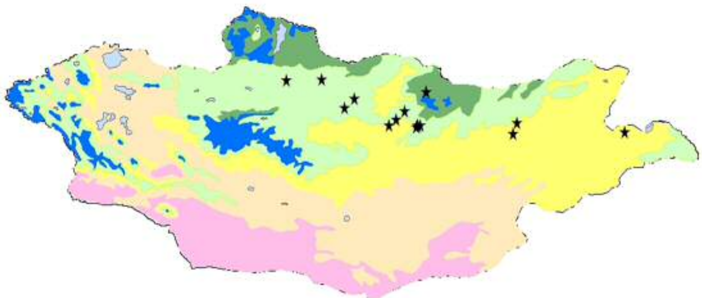

Fig. 2-50. Worker of *Myrmica forcipata* and collection sites.

Myrmica kamtschatica Kupyanskaya, 1986

Myrmica kamtschatica Kupyanskaya, 1986: 88 (type locality: Russia); Bolton, 1995: 280; Radchenko, 2005: 141; Pfeiffer et al., 2007: 5 (in list); Radchenko and Elmes, 2010: 161; Yamane and Aibek, 2012: 176.

Worker diagnosis. Material of this species from Mongolia is not available. The following description is based on three paratype specimens from Kamchatka kindly donated by Dr. Kupyanskaya to the SKY Collection. Medium- sized species with head width 0.94−0.98 mm (mean 0.96) (3 workers from Russia). Antennal scape rather strongly bent near base; the bend less than 90˚, without a developed carina separating shaft and remaining distal part; the shaft with a carina along its upper margin. Clypeus with its anterior margin weakly emarginated medially. Metanotal groove shallow but distinct; propodeal spines seen from above weakly diverging, not distinctly curved inwardly. Petiole short with its dorsal face not clearly separated from posterior slope; postpetiole larger than petiole, globular, shorter than high, in profile its dorsal outline roundly convex, without flat apical portion. Dorsum of head extensively reticulate; only its central portion longitudinally rugose. Clypeus with longitudinal rugae; mandible strongly striate. Dorsum of mesosoma coarsely and irregularly rugoso-reticulate; lateral face of pronotum coarsely rugose; mesopleuron, metapleuron and lateral face of propodeum with weaker rugae. Lateral faces of petiole and postpetiole rather coarsely and irregularly sculptured; mediodorsal portion of postpetiole finely punctate. Body brown to light reddish brown, with head and gaster slightly darker, and mandibles, antennae and legs paler.

Taxonomic remarks. This species, belonging to the *kasczenkoi* complex of the *lobicornis* group, is similar to *M. angulinodis*, but separable from the latter by the more rounded anterodorsal corner of petiole and diverging propodeal spines.

Distribution records. Khonin Nuga (970 m), Near Sharlan River, Selenge aimag (Pfeiffer et al., 2007).

Distribution. Siberia, Far East Russia, Mongolia.

Bionomics. No information is available in Mongolia. This species has a relatively strong resistance against cold climates and can live even in tundra habitats with permafrost (Berman et al., 2010).

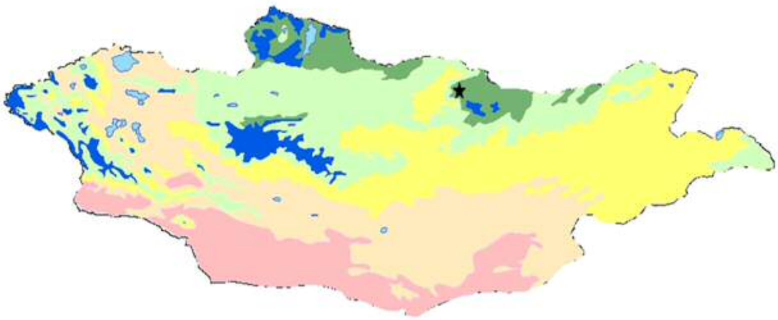

Fig. 2-51. Collection site of *Myrmica kamtschatica.*

Myrmica kasczenkoi Ruzsky, 1905

Myrmica sucabrinodis kasczenkoi Ruzsky, 1905: 702 (type locality: Russia).

Myrmica kasczenkoi: Pisarski, 1969a: 2262; Pisarski, 1969b: 296; Dlussky and Pisarski, 1970: 85; Pisarski and Krzysztofiak, 1981: 156; Radchenko and Elmes, 2010: 166; Yamane and Aibek, 2012: 176.

Worker diagnosis. Medium-sized species with head width 0.90–0.96 mm (mean 0.94). Anterior margin of clypeus straight with a weak median emargination; rugae on clypeus coarse and regular. Frontal carina merging with a ruga extending posteriad. Antennal scape rather strongly but smoothly curved near base, with a faint carina along the upper rim of shaft, but without carina between shaft and apical main part of scape. Metanotal groove very weak or absent. Propodeal spines at most as long as, often shorter than, apical antennal segment, slightly down- curved, and seen from above straight and diverging. Petiolar node with anterior slope concave; in profile dorsal and posterior faces forming a single arch; anterodorsal corner of petiole round, but sometimes weakly angled; subpetiolar process lobe-like. Dorsum of head coarsely rugose; rugae regular and parallel; posterior and lateral portions reticulate. Side of mesosoma with coarse regular rugae; on dorsum of mesosoma coarse rugae often sinuated. Tergal portion of petiole and postpetiole rugose in addition to minute punctuation. Mesosoma, legs and antennae brown to reddish brown; head sometimes with same colour near posterior margin.

Taxonomic remarks. This species belongs to the *kasczenkoi*-complex of the *lobicornis* group.

Distribution records. Arhangai aimag. Ikhtamir, 2,150 m (Pisarski, 1969b). Bayankhongor aimag. Egiin davaa, 2,300 m (Pisarski, 1969b). Bayan-Ulgii aimag. Near Tsengel, 1,900 m (UA & SKY). Bulgan aimag. Khanjargalant, 1,350 m (Pisarski and Krzysztofiak 1981). Dundgovi aimag. Delgerkhangai, Choot bulag,1,480 m (Pisarski and Krzysztofiak, 1981); Govi-Altai aimag. Sharga, Khuvsgul tunamal nuur (Pisarski and Krzysztofiak, 1981). Khentii aimag. Murun, 1,200 m (Pisarski, 1969b). Khuvsgul aimag. Burenkhaan, 1,650 m (Pisarski and Krzysztofiak, 1981); Murun, 1,740−1,900 m (Pisarski and Krzysztofiak, 1981); Tosontsengel, 1,480 m (Pisarski and Krzysztofiak 1981). Tuv aimag. Bayandelger, 1,400 m (Pisarski, 1969b); Bayantsogt, 1,600 m (Pisarski, 1969b); Hustai, Khushuut (UA & SKY); Lun, 1,180 m (Pisarski, 1969b); Terelj, 1,250 m (UA & SKY); Ulaanbaatar, Kherlen buudal (Pisarski, 1969a); Ulaanbaatar, Bogd khaan uul, Khurhree, 1,550 m (UA & SKY); Ulaanbaatar, Bogd khaan uul, Nuht, 1,800 m (Pisarski, 1969b); Ulaanbaatar, Bogd, Shajinhurh (UA & SKY); Ulaanbaatar, Bogd, Turgen (UA & SKY); Ulaanbaatar, Bogd, Turhurh, 1,598 m (UA & SKY); Ulaanbaatar, Songino (Pisarski, 1969a); Ulaanbaatar, Tuul hundii (Dlussky and Pisarski, 1970); Ulaanbaatar, Zosiin davaa, 1,650 m (Pisarski and Krzysztofiak, 1981). UVS aimag. Uureg nuur, 1,500 m (Pisarski and Krzysztofiak, 1981). Zavkhan aimag. Telmen nuur, 1,827 m (UA & SKY).

Distribution. Far East Russia, Mongolia.

Bionomics. This species inhabits disturbed steppe and open bare ground, and nests in soil.


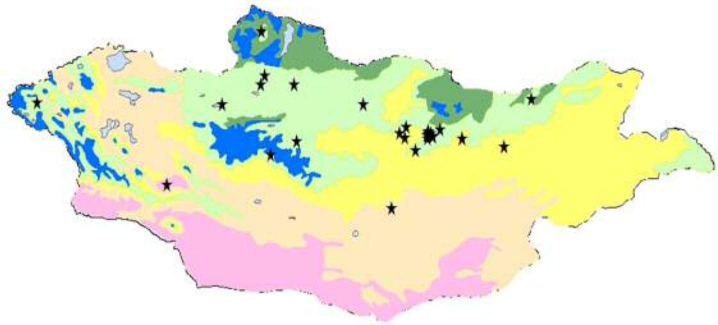

Fig. 2-52. Worker of *Myrmica kasczenkoi* and collection sites.

Myrmica koreana Elmes et al., 2001

Myrmica koreana Elmes, Radchenko and Kim, 2001: 108 (type locality: Korean Peninsula); Radchenko, 2005: 141; Radchenko and Elmes, 2010: 169; Pfeiffer et al., 2007: 5 (in list); Yamane and Aibek, 2012: 177.

Worker diagnosis. Medium-sized species with head width 0.90−0.96 mm (mean 0.93) (3 specimens measured). Anterior margin of clypeus not convex, with a wide and shallow median emargination;. Frontal carina merging with rugae extending posteriad; frontal lobe exceptionally large; its broadest portion slightly less than twice as broad as narrowest portion. Antennal scape strongly curved (angle>90°) near base, with a large round lobe at bend and a wide fringe of lamella along basal shaft. Propodeal spines seen in profile long and sharp, seen from above almost parallel. Petiolar node long, seen from above much longer than broad; anterior face of petiole comprising narrow pedicel-like anterior part and steep posterior part; with petiole in profile anterodorsal corner more or less angled; dorsal face short, followed by gently sloping posterior face; subpetiolar process very small forming a small anterior angle. On the dorsum of head rugae confined to a small area behind frontal triangle; other areas extensively reticulate. Striae on clypeal disc fine and widely spaced. Lateral face of mesosoma coarsely rugose; rugosity on dorsum of mesosoma similarly coarse but less regular. Dorsa of petiole and postpetiole rather coarsely sculptured. Mesosoma, waist, mandibles, antennae and legs yellowish brown to brown; head and gaster reddish brown to dark reddish brown.

Taxonomic remarks. This species belongs to the *schencki* group. It is similar to *M. kasczenkoi* in the sculpture of the mesosoma, but is easily separable from all the other Mongolian congeners by the very large frontal lobe, long petiole and vestigial subpetiolar process.

Distribution records. Dornod aimag. Menengiyn tal, 627 m (UA & SKY). Tuv aimag. Zorgol (Pfeiffer *et al.*, 2007). Dornogovi aimag. Delgerekh (Pfeiffer *et al.*, 2007).

Distribution. Korean Peninsula, Mongolia,.

Bionomics. We collected only foragers in a well-preserved steppe. Radchenko and Elmes (2011) mentioned that this species inhabits mainly in steppes and steppe-like habitats, both on planes and mountains up to 1,700 m alt. Nests are constructed in soil.


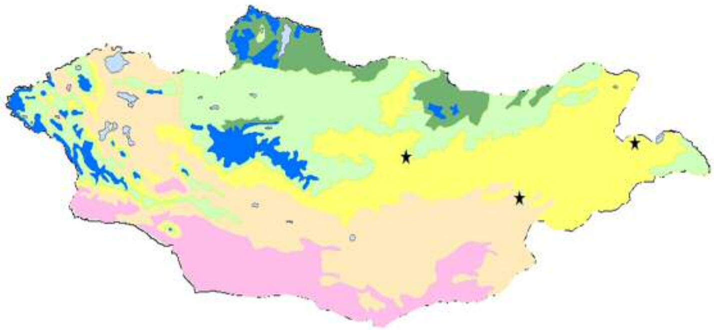

Fig. 2-53. Photo of *Myrmica koreana* and collection sites.

Myrmica lobicornis Nylander, 1846

Myrmica lobicornis Nylander, 1846: 932 (type locality: Finland); Radchenko and Elmes, 2010: 185; Yamane and Aibek, 2012: 178.

Worker diagnosis. I do not have any specimen of this species (see remarks).

Taxonomic remarks. *Myrmica lobicornis* belongs to the *lobicornis*-complex of the *lobicornis* group. This species is said to show an extreme variation in morphology (Radchenko and Elmes, 2010), but can be distinguished from the other Mongolian congeners by the following set of characteristics: antennal scape strongly bent near base; lobe encircling the bend generally very large; basal shaft of scape without well-developed fringe of lamella; with petiole in profile anterodorsal corner of petiolar node acute or right angled.

Distribution records. Dornod aimag. Choibalsan, Tamsagbulag, 600 m (Pisarski and Krzysztofiak, 1981). Dundgovi aimag. Delgerkhangai uul, 1,650−1,700 m (Pisarski and Krzysztofiak, 1981). Khentii aimag. Undurkhaan, 1,000 m. Sukhbaatar aimag. Baruun-Urt, 1,050 m (Pisarski and Krzysztofiak, 1981).

Distribution. Central and Northern Europe, Siberia, Mongolia.

Bionomics. In Mongolia nothing is known of it biology.

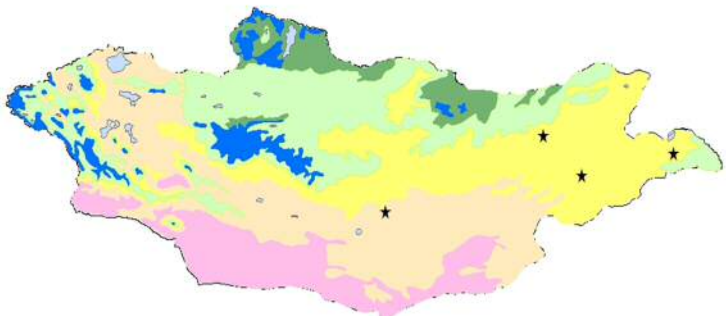

Fig. 2-54. Worker of *Myrmica lobicornis* and collection sites.

Myrmica pisarskii Radchenko, 1994

Myrmica pisarski Radchenko, 1994b: 208 (type locality: Transbaikalia); Radchenko and Elmes, 2010: 216; Yamane and Aibek, 2012: 179.

Myrmica saposhnikovi Ruzsky: Pisarski, 1969b: 206; Pisarski and Krzysztofiak, 1981: 156.

Myrmica saposhnikovi saposhnikovi: Pisarski, 1969a: 228.

Myrmica saposhnikovi baikalensis Karavaiev: Pisarski, 1969a: 228.

Worker diagnosis. Mesosoma, waist, legs, mandibles and antennae yellowish brown to pale reddish brown; head and gaster dark reddish brown. Relatively small species with head width 0.79–0.90 mm (mean 0.83). Small area behind frontal triangle longitudinally rugose; other parts of dorsum of head reticulate. Anterior margin of clypeus not convex, with a broad and shallow median emargination; rugae on clypeal disc coarse. Frontal carina merging with a carina(e) that extends posteriad. Side of mesosoma with relatively regular and coarse rugosity; rugae on dorsum of mesosoma sinuated. Metanotal groove inconspicuous or absent. Propodeal spines thin and sharp, seen from above weakly diverging and slightly curved inwardly. Petiole in profile with anterior slope nearly straight; pedicel and node not differentiated; anterodorsal corner bluntly angled; subpetiolar process a small process projecting anteroventrad; petiole and postpetiole (particularly their sides) rather coarsely rugose.

Taxonomic remarks. This species belongs to the *lobicornis*-complex of the *lobicornis* group.

Distribution records. Arhangai aimag. Tsenkher, Urdtamir gol, 1,620 m (Pisarski, 1969b). Bulgan aimag. Bayan-Nuur, 1,000 m; Khutag-Undur, Namnangiin nuruu, 1,150 m (Pisarski and Krzysztofiak, 1981); near Rashaant, 1,420 m (UA & SKY). Dundgovi aimag. Delgertsogt, 1,480 m (Pisarski and Krzysztofiak, 1981). Khentii aimag. Dadal, 900 m (UA & SKY); Delgerkhaan, 1,250 m (Pisarski, 1969b); Jargaltkhaan, Chandagan tal, 1,300 m (Pisarski, 1969b); Murun, 1,200 m (Pisarski, 1969b); Tsenkhermandal, 1,400 m (Pisarski, 1969b). Khuvsgul aimag. Burenkhaan, 1,650 m (Pisarski and Krzysztofiak, 1981); Hanh, Tarag (UA & SKY); Tosontsengel, 1,480 m (Pisarski and Krzysztofiak, 1981). Sukhbaatar aimag. Baruun-Urt, 1,050 m (Pisarski, 1969b); Khongor, Ongon els, 900 m (Pisarski, 1969b); Tumentsogt, 1,000 m (Pisarski 1969b). Tuv aimag. Bayanbaraat, 1,380 m (Pisarski and Krzysztofiak, 1981); Bayandelger, Kherlen buudal, 1,400 m (Pisarski, 1969b); Bayantsogt, 1,600 m (Pisarski 1969b); Ulaanbaatar, Bogd khaan uul, Khurhree, 1,550 m (UA & SKY); Ulaanbaatar, Bogd khaan uul, Shajinhurh (UA & SKY); Ulaanbaatar, Bogd, Turhurh, 1,598 m (UA & SKY); Ulaanbaatar, Bogd khaan uul, Zaisan, 1,400 m (Pisarski 1969b); Ulaanbaatar, Bogd, Zosiin Davaa, 1,650 m (Pisarski and Krzysztofiak, 1981); Ulaanbaatar, City area (UA & SKY). Zavkhan aimag. Tosontsengel to Hyargas nuur (UA & SKY).

Distribution. South Siberia, Mongolia.

Bionomics. This species is mainly collected in disturbed steppes in high densities, and nests in soil.


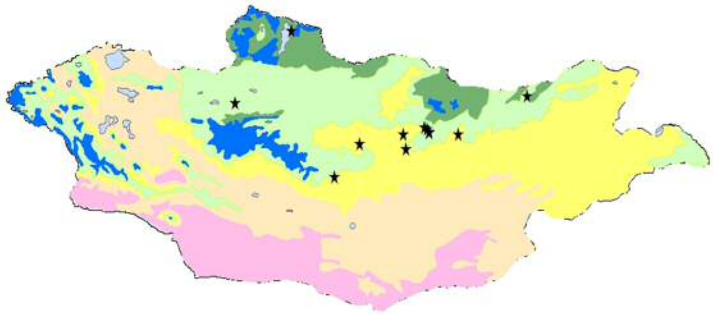

Fig. 2-55. Worker of *Myrmica pisarskii* and collection sites.

Myrmica rubra (Linnaeus, 1758)

Formica rubra Linnaeus, 1758: 580 (type locality: Europe); Bolton, 1995: 282; Radchenko and Elmes, 2010: 228; Yamane and Aibek, 2012: 180.

Worker diagnosis (based on specimens from Finland). Medium-sized species with head width 0.87−0.98 mm (mean 0.94) (5 Finish specimens measured). Anterior margin of clypeus nearly straight to weakly convex, without median emargination; disc of clypeus with weak carinae that terminate as small denticles on anterior margin of clypeus. Frontal triangle smooth and shiny. Frontal carina generally curved outwardly to merge with a carina(e) that surrounds antennal socket. Antennal scape gently curved without distinct angle near base; vertical carina on basal shaft, if any, vestigial. Metanotal groove distinct. Propodeal spines variable in length, often longer than apical segment of antenna. With petiole in profile node with round apex; anterior face concave. Dorsum of head weakly rugose; lateral face of head (and often posterior portion of head) somewhat reticulate. Clypeus smooth and shiny. Lateral face of mesosoma rugose; dorsum of mesosoma with coarse and irregular reticulation. Tergal portion of petiole and postpetiole entirely finely and superficially sculptured, with a few weak, longitudinal carinae. Body deep yellow through yellowish brown to brown; dorsum of head and gaster often darker; legs and antennae more yellowish.

Distribution records. Not available, but see Radchenko and Elmes (2010, Map 94).

Distribution. Europe, Siberia, Mongolia.

Bionomics. No information is available of the biology of this species in Mongolia. In Europe this species inhabits a variety of habitat types from grassland to forest, generally preferring wet soil. It nests in soil, under or in decayed wood.

Myrmica ruginodis Nylander, 1846

Myrmica ruginodis Nylander, 1846: 929 (type locality: Finland); Bolton, 1995: 282; Radchenko and Elmes, 2010: 235; Yamane and Aibek, 2012: 181.

Worker diagnosis. Specimens from Mongolia are not available. The following description is based on Korean and Japanese specimens. Relatively large species with head width 0.98−1.04 mm (mean 1.01) (5 South Korean specimens measured). Anterior margin of clypeus distinctly produced medially where several small denticles are present, with more than 10 longitudinal carinae. Dorsum of head rugose, but reticulate posteriorly and laterally to variable extent; side and venter of head often with fine sculpture only. Clypeus smooth and shiny. Body yellowish brown to brown; dorsa of head, mesosoma and waist, and gaster often darker; legs and antennae more yellowish.
Taxonomic remarks. This species belongs to the *rubra* group.
Distribution records. Not available, but see Radchenko and Elmes (2010, Map 95).
Distribution. Major part of norther Eurasia including Siberia, Far East Russia, Northeastern China, Korean Peninsula, Japan, Mongolia.
Bionomics. This species inhabits forests and forest edges, but without information in Mongolia.

Myrmica sulcinodis Nylander, 1846

Myrmica sulcinodis Nylander, 1846: 934 (Type locality: Finland); Pisarski, 1969a: 227; Pisarski, 1969b: 296; Radchenko and Elmes, 2010: 293; Yamane and Aibek, 2012:181.
Worker diagnosis. Largest species in Mongolia with head width 1.08−1.17 mm (mean 1.13). Anterior margin of clypeus weakly convex, without median emargination; Frontal triangle also sculptured. Frontal carina merging with a carina that extends posteriad, but often also connected with carinae surrounding antennal socket. Antennal scape rather strongly bent (angle>9˚0) near base; carina separating basal shaft and apical main part absent; carina along basal shaft weak. Propodeal spines stout and long, much longer than apical segment of antenna, rather strongly upward directed, and seen from above distinctly curved inwardly. With petiole in profile anterior slope concave, and anterodorsal corner distinctly angled; subpetiolar process triangular. Dorsum of head very coarsely sculptured; area between frontal carinae up to the half length of head longitudinally rugose; other parts of head reticulate. Disc of clypeus with coarse rugae. Entire mesosoma with very coarse rugae; posterior face of propodeum extensively sculptured.; tergal parts of petiole with several strong longitudinal carinae, interspaces being very deep; postpetiole also coarsely rugose with deep interspaces. Conspicuously bicolorous; mesosoma reddish brown; waist slightly darker; legs extensively and antennae except for apical segments dark brown; head and gaster blackish brown.
Taxonomic remarks. This species belongs to the *sulcinodis*-complex of the *lobicornis* group. This is a very distinctive species with very coarse rugae over surface of mesosoma and waist.
Distribution records. Khentii aimag. Tsenkhermandal, 1,400 m (Pisarski, 1969b). Selenge

aimag. Namdavaa, 1,000 m (UA & SKY). Tuv aimag. Hustai, Ehen-Us (UA & SKY); Ulaanbaatar (Pisarski, 1969a); Ulaanbaatar, Bogd khaan uul, Nuht, 1,500−1,800 m (Pisarski, 1969b).

Distribution. Northern Europe throug Siberia, Far East Russia, Mongolia.

Bionomics. The colonies were collected in forested or wet areas near the river.

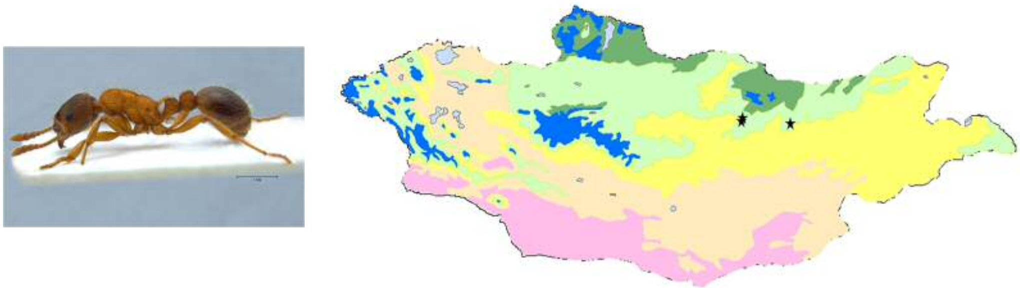

Fig. 2-56. Worker of *Myrmica sulcinodis* and collection sites.

Myrmica transsibirica Radchenko, 1994

Myrmica transsibirica Radchenko, 1994: 212 (type locality: Russia); Bolton, 1995: 284; Yamane and Aibek, 2013: 182.

Myrmica taediosa Bolton 1995: 284; Yamane, 2008: 29.

Myrmica sp. 6: Japanese Ant Database group, 2003: 170 (part).

Worker diagnosis. Material from Mongolia is not available. The following description is based on specimens from southern Primorye, Russia. Relatively small to medium-sized species with head width 0.85−0.96 mm (mean 0.92) (5 specimens from Russian Primorye and South Korea measured). Clypeus with anterior margin very weakly emarginated medially; lateral margin of clypeus raised as a wall surrounding antennal socket. Antennal scape strongly bent near base; the bend less than 90; carina separating basal shaft and remaining distal part absent; carina along upper margin of the shaft developed. Metanotal groove shallow but distinct; propodeal spines sharp at apex, weakly diverging posteriad. Petiole in profile round dorsally, but median 'flat' section separable from posterior slope; postpetiole much larger than petiole. Head extensively reticulate; median portion of dorsum of head with rather regular longitudinal rugae; clypeus sparsely rugose. Entire mesosoma more or less regularly and longitudinally rugose; on promesonotum rugae waved. Sculpture on petiole and postpetiole weak. Body light brown to brown; gaster and head darker; mandibles, antennae and legs paler, but legs only slightly lighter than mesosoma.

Taxonomic remarks. This species belongs to the *excelsa*-complex of the *lobicornis* group, and has been referred to as *M. taediosa* Bolton. *M. transsibirica* is very similar to *M. excelsa* Kupyanskaya with a more easterly distribution. However, it is easily separated from the latter by the entirely smooth gastral tergite 1, which is superficially coriaceous over the surface in the latter (Yamane, 2008).

Distribution records. Not available for Mongolia, but see Radchenko and Elmes (2010, Map 125).
Distribution. South Siberia, Far East Russia, Northeast China, Korean Peninsula, Japan, Mongolia.
Bionomics. No information is available in Mongolia.

Genus ***Temnothorax*** Mayr, 1861

Temnothorax Mayr, 1861: 68. Type species: *Myrmica recedens* Nylander, 1856: 94, by monotypy; Bolton 2003: 252 (revived from synonymy), 270 (definition); Radchenko, 2004: 120.

Leptothorax: Bolton, 1982: 319 (part), 1995a: 33 (part).

Worker diagnosis. Relatively small species, measuring 3 mm or less in total length. Frontal carina and antennal scrobe absent. Clypeus with median carina. Antenna 11- or 12-segmented. Antennal socket anteriorly not margined with such wall. In profile mesosoma with more or less flat dorsal outline. Postpetiole not massive, seen from above at most 1.2 times as broad as petiole. In profile petiole roughly triangular, with rounded dorsal margin. Dorsa of head and mesosoma with standing hairs; mid- and hind tibiae with simple spurs.

Key to species of Temnothorax from Northcentral and Northeastern Mongolian

1. In profile propodeal spine very long, almost as long as length of propodeal dorsum, down-curved; in profile petiolar node massive, broad, with slightly concave anterior slope, short anterior peduncle, and slightly rounded apex. ………….…….. ***T. nassonovi*** Ruzsky
- In profile, propodeal spine much shorter, less than half length of propodeal dorsum, not down-curved. …………………………………………………….………………………… 2
2. In profile petiolar node with straight anterior face and without anterior peduncle, with narrowly rounded apex; gastral tegite 1 unicolorous…...………..... ***T. mongolicus*** Pisarski
- In profile petiolar node with distinct concave anterior face and anterior peduncle, with broadly rounded apex; gastral tergite 1 with pale basal spot. ....… ***T. kaszabi*** Pisarski

Temnothorax kaszabi (Pisarski, 1969)

Leptothorax kaszabi Pisarski, 1969b: 301. (type locality: Mongolia); Pisarski and Krysztofiak, 1981: 158; Radchenkoi, 1994: 157, 1995: 19; Bolton, 1995: 240.

Leptothorax tuberum sachalinensis: Kupyanskaya, 1990: 142, 1995: 348.

Temnothorax kaszabi: Bolton, 2003: 271; Radchenkoi, 2004: 124.

Worker diagnosis. Body length 2.5-2.8 mm. Antenna 12-segmented. Antennal scape short, not clearly reaching occipital margin. Propodeal spine short. In profile petiolar node relatively short, with distinctly concave anterior face, and broadly rounded and slightly convex dorsal plate. Dorsa of head densely punctuate, with fine longitudinal striation. Gaster brown, distinctly darker than mesosoma; tergite 1 with pale spot at base.

Taxonomic remarks. This species is distinguished from *T. mongolicus* and *T. nassonovi* by the following characteristics: 1) in profile petiolar node with distinctly concave anterior face and broadly rounded apex; 2) dorsum of head densely punctate, with fine longitudinal striation; 3) petiole with distinct anterior peduncle; 4) gastral tergite 1 with pale spot at base.

Material examined. No specimens are available.

Distribution. Southeastern Altai, Tuva, Southern Yakuta, Russian Far East, North Korea, Mongolia.

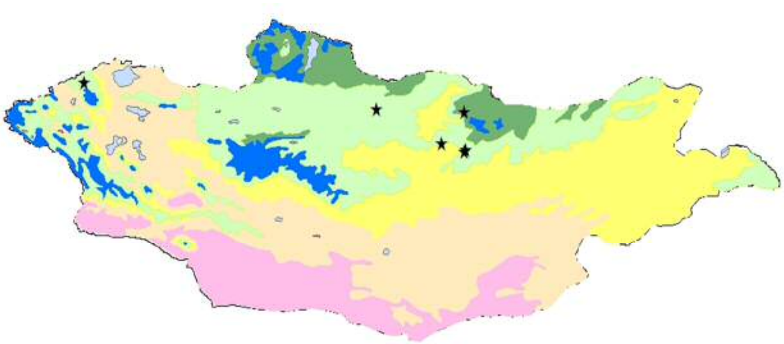

Fig. 2-57. Collection sites of *Temnothorax kaszabi.*

Bionomics. It inhabits mainly steppes, dry meadows and in Mongolia. Nests are built in soil.

Temnothorax mongolicus (Pisarski, 1969)

Leptothorax serviculus mongolicus Pisarski, 1969: 299. (type locality: Mongolia); Dlussky and Pisarski, 1970: 86; Pisarski and Krysztofiak, 1981: 158.

Leptothorax mongolicus: Radchenko, 1994: 156; Bolton, 1995: 241.

Leptothorax serviculus: Kupyanskaya: 1990: 140, 1995: 348.

Temnothorax mongolicus: Bolton, 2003: 271, Radchenko, 2004: 194.

Worker. Body length 2.6-2.8 mm. Antenna 12-segmented. Antennal scape short, in profile not clearly reaching posterior margin of head. In profile petiolar node subtriangular, with very slightly concave or almost straight anterior face and very narrowly rounded dorsally. Propodeum with short, sharp denticles (spines). Propodeal denticles 3 times less than length of dorsal face of propodeum. Mesosoma and waist ochreous-yellow to brownish-yellow; dorsum of head brownish, distinctly darker than alitrunk; gaster entirely brown. Gastral tergite 1 without pale spot at base.

Taxonomic remarks. This species can be separated from *T. nassonovi* by the following characteristics: propodeal spines short sharp denticles; in profile petiolar node subtriangular; mesosoma and waist ochreous-yellow to brownish-yellow, dorsum of head brownish, distinctly darker than mesosoma; gaster entirely brown.

Material examined. Menengiyn tal (627 m alt.), Dornod aimag, 22 VII 2008, SKY leg. (w).
Distribution. Chita and Amur regions of Russia, North Korea, Mongolia
Bionomics. *Temnothorax mongolicus* inhabits mainly steppes and dry meadows, and nests are built in soil (Radchenko, 2005).

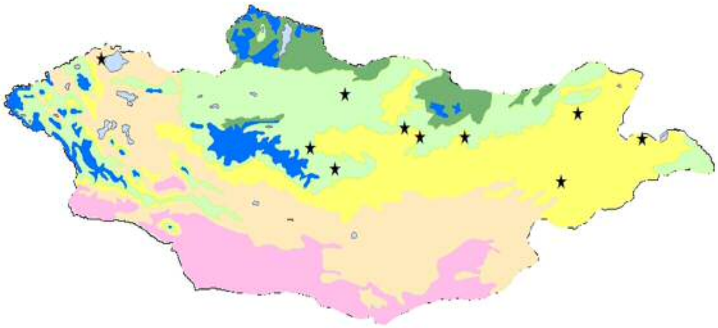

Fig. 2-58. Worker of *Temnothorax mongolicus* and collection sites.

Temnothorax nassonovi (Ruzsky, 1895)

Leptothorax nassonovi Ruzsky, 1895: 26 (type locality: Russia); Kupyanskaya 1990: 143, 1995: 348; Radchenko, 1994: 155; Bolton, 1995: 240.

Temnothorax nassonovi: Bolton, 2003: 271, Radchenko, 2004: 194.

Leptothorax nassonovi fissovi: Pisarski, 1969b; 302, Pisarski, 1969a; 229; Pisarski and Krysztofiak, 1981: 158.

Worker. Body length 2.1-3.3 mm. Antenna 12-segmented. Propodeum with long, sharp spines that is equal to length of dorsal face of propodeum. In profile petiole with short anterior peduncle, petiolar node massive, broad, with slightly rounded apex. Dorsum of head finely striated or at most finely rugulose and densely punctuate. Mesosoma yellow to brownish-yellow, dorsa of head and gaster brown.

Material examined. Algalant, nr Hustai NP, Tuv aimag, 3 VII 2003, MG03-SKY-57 (w); Bogd mountain, Tuv aimag, 20 VI 2005, UA leg. (w); Bogd Khaan NP (Turhurah valley, 1598 m alt.), 12 VII 2008, UA leg., Tr-9 (w); Bogd Khaan NP (Khurkhree valley), 7 VII 2007, Tr-1 (w,fq); same loc. and date, UA leg., Tr-9 (w); same loc., 6 VII 2007, MG07-SKY-04 (w,fq,m).
Distribution. Tien-Shan, North Korea, Mongolia
Bionomics. *Temnothorax nassonovi* inhabits steppe and forest steppe habitats in Mongolia. Nets are built in soil.

 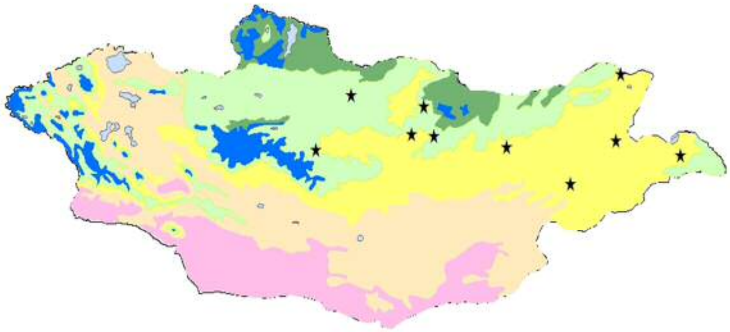

Fig. 2-59. Photo of *Temnothorax nassonovi* and distribution map.

Genus ***Tetramorium*** Mayr, 1855

Tetramorium Mayr 1855: 423. Type species: *Formica caespitum* Linnaeus, 1758: 581, by subsequent designation of Girard 1879: 1016.

Tetramorium belongs to the most specious ant genera, containing more than 400 species, mainly in the tropics and subtropics. Approximately 60 species occur in the Palaearctic region, mostly in the southern parts of the region. One or two species occur Northcentral and Northeastern Mongolia.

Worker diagnosis for the Mongolian species**..** Body measuring 3 mm or less in total length. Antenna 12-segmented. Antennal socket margined anteriorly with sharp-edged wall of posterolateral margin of clypeus. In profile petiole rectangular, with more or less flat dorsal portion; postpetiole not massive, seen from above at most 1.2 times as broad as petiole. Dorsa of head and mesosoma with standing hairs.

Tetramorium cf. ***tsushimae*** Emery, 1925

Tetramorium tsushimae Emery, 1925: 187. (type locality: Japan), Bolton, 1995: 415; Japanese Ant Database Group, 2003: 136.

Tetramorium jacoti: Radchenko, 1992: 45.

Tetramorium caespitum: Dlussky and Pisarski, 1970: 86; Kupyanskaya 1990: 151, 1995: 350.

Worker diagnosis. Body length 2.5-3.0 mm. Monomorphic. Head shape roughly subrectangular. Mandibles triangular. Antenna 12-segmented. Antennal scapes not conspicuously short; easily extended beyond eye level; do not extend beyond posterior margin of head. Antennal scrobe present. In profile petiole rectangular, with more or less flat dorsal portion; antennal socket margined anteriorly with sharp-edged wall of posterolateral margin of clypeus. Petiole with a square-shaped node; pedunculate; lacking large subpetiolar process postpetiole attached to lower surface of gaster. Dorsa of head and mesosoma with standing hairs.

Taxonomic remarks. In Mongolia there are several species related to *T. tsushimae*, of which some should be native to Mongolia (Pfeiffer, 2007). From the area surveyed in this study there are colony series with workers variable in size and sculpture. A complete revision is needed for the Mongolian species.

Material examined. Meningiin tal, (627 m alt.), Dornod aimag, 22 VII 2008, MG08-SKY-37 (w); nr Numrug (812 m alt.), Dornod aimag, 24 VII 2008, MG08-SKY-48 (w).

Distribution. Korea, Japan, introduced in many places in the world, Mongolia.

Bionomics. The species inhabits mostly dry steppe and desert habitats, and frequently in urban areas in Mongolia. This species was found in the steppe of Eastern Mongolia (Meningiin tal and Numrug) from two colonies. It is distributed at relatively low altitudes between 600- 1000 m. Nests are built in soil.

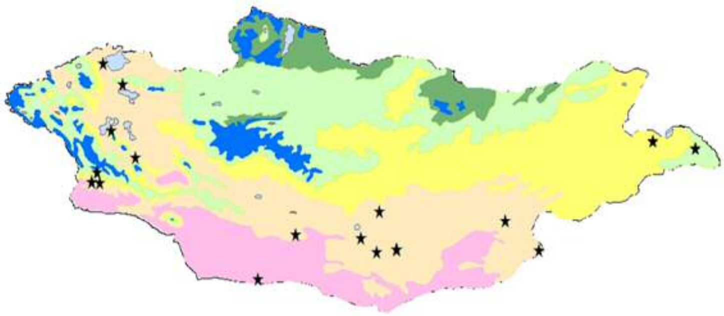

Fig. 2-60. Worker of *Tetramorium* cf. *tsushimae* and collection sites.

Part 3. Ant communities in different habitat types in NC Mongolia

3.1. Introduction

Ants have numerous advantages over vertebrates and other arthropods in studies of landscape disturbance and species diversity (Graham et al. 2004). They are extremely abundant, have relatively high species richness, include many specialist species at higher trophic levels, are responsive to changing environmental conditions (Nash et at. 2001). They occur throughout the world, are easily collected, are taxonomically relatively well known, and constitute an important fraction of animal biomass in terrestrial ecosystems (Fittkau and Klinge 1973; Lynch et al. 1988; Hölldobler and Wilson 1990). At the regional and local scale, ant species richness is sensitive to plant cover and diversity (Morrison 1998), soil type (Peck et al. 1998), disturbance regime (Kaspari 1996; Feener and Schupp 1998).

Ant communities have a number of attributes that may make them particularly useful as indicators of ecosystem change. The structure and composition of ant communities are influenced by competition, natural enemies, resource availability, habitat change, and disturbance (Wilson 1971; Hölldobler and Wilson 1990; Bestelmeyer and Wiens 1996, 2001; Andersen 1997; Kaspari and Majer 2000). Habitat degradation and biological invasions are the two greatest threats to global biodiversity. The maintenance of species diversity in modified and natural habitats is the central focus of conservation biology (Luis et al., 2010).

A number of studies have examined the effects of different habitat disturbances on ant communities, including changes after the fire (Andersen and McKaige 1987; Andersen, 1991), mining (Majer 1984, 1985; Majer and Nichols 1998; King et al. 1998), forest clear cutting (Jennings et al. 1986; Whitford and Gentry 1981), soil vegetation changes resulting from over grazing and drought (Wisdom and Whitford 1981, James et al. 1999), biodiversity and conservation research (Alonso and Agosti 2000; Schults and McGlynn 2000; Dauber and Wolter 2005; Lenoir 2008), livestock grazing effects (Seymour and Dean 1999; Nash et at. 2001, 2004; Luis et al. 2010; Bestelmeyer and Wiens 2001). Ant assemblages can be quantified on scale of abundance or nest density (Bestelmeyr et al. 2000; Schlick-Steinner et al. 2006; Sagata et al. 2010).

Livestock grazing is one of the most extensive forms of land use. Approximately 26% of the earth's land surface (Carlos and Steinfeld 1996), 70% of land in the 11 western United States, 67% of land in the Kazakhstan and 82% (129,294 mill. a) of land in Mongolia are used primarily for grazing (Neely 2009). More than 70% of land in Mongolia has been degraded by overgrazing, mining, climate changing, and desertification.

Many studies have reported that intensive grazing affects habitat structure facilitating the dominance of some competitive species, but with scare consequences on the organization of assemblages of ants (Orians 1986; Deyrup et al. 2000; Hoffmann and Andersen 2003; Graham 2004).

I examined the effects of livestock grazing on species composition, structure and nesting density in ant communities in six different habitat types in the Bogdkhan Mountain region, Northcentral Mongolia. It is postulated that the ant species richness would decline as a function of rangeland worsening, and that the abundance of some species or functional groups would consistently respond positively or negatively to the change in rangeland condition.

Ant communities in disturbed habitats have lower species diversity and greater numbers of dolichoderines in Australia (Andersen 1997; King et al. 1998; Majer and Nichols 1998). Do ant communities in Northcentral Mongolia show a similar response to disturbance?

3.2. Materials and Methods

Study area

The Bogdkhan Mountains are located in Northcentral Mongolia, constituting the southern part of the Khentii Mountain Range, which lies between forest steppe and steppe, and also forms the southern border of larch forest. This mountain range is regarded as typical of northern regions of Mongolia characterized by the cold winter, cool summer and sharp continental climatic features. In this area are found four vegetation subzones, i.e., alpine taiga, alpine forest, forest steppe and arid steppe. Also some mountain riversides have generated patch meadows. The annual mean air temperature ranges from -2.5˚C to -3.1˚C, and precipitation 200-300 mm at the meteorological station in Ulaanbaatar. More than 80% of precipitation falls between May and September. In the coldest month, January, the mean air temperature is -19˚C to -24˚C, and in the warmest month, July, it is +14.5˚C to +16.8˚C. The territory of Bogdkhan Mountains covers 41.6 thousand ha and average elevation is 1,580 m above the sea level. The present survey was carried out in the valleys of Hurhree, Shajinhurh, Turhurh, Huht and Turgen in and around the Bogdkhan Mountains.

Sampling methods

In total, 23 transects were established in three types of vegetation and in natural and grazed conditions: natural steppe [NS] (n = 3), grazed steppe [GS] (n = 7), natural [NFS] and grazed forest steppe [GFS] (n = 3 for each), natural meadow [NM] (n = 3), and grazed meadow [GM] (n = 4), from June to September in 2007, 2008 and 2009 (in total 6 habitat types). Each transect (belt) was 2 m x 50 m, and was divided into 25 quadrates (2 x 2 m), totalling to 575 quadrates. I sampled ants with three types of bait (powdered cheese, honey, sesame seed) with the help of Seiki Yamane and some of my students. Baits of the three kinds were randomly placed directly on the soil in each quadrat (in total 75 baits per transect). For honey baits we used square pieces of cotton (2 x 5 cm) soaked with 40% of honey.

Fig. 3-1. Transect in natural forest steppe.

Fig. 3-2. Transect in disturbed meadow.

Fig. 3-3. Transect in heavily disturbed steppe near Ulaanbaatar.

Fig. 3-4. *Formica* (*Coptoformica*) *manchu* workers attracted to a sugar bait.

Fig. 3-5. *Formica* (*Serviformica*) *candida* and *Myrmica kasczenkoi* workers attracted to a sugar bait. No aggressive encounters were observed.

This is a technique similar to those used to measure ant richness and activity in a variety of habitats and locations (e.g. Andersen and Patel 1994; Perfecto and Vandermeer 2002; Ratchford et. al. 2005). We started to check the baits approximately 20 min. after placing them, recorded the ants present at baits, and collected some individuals of each species for later identification. Also we recorded ants not attracted to the baits but found within quadrates. Ant nests were located and counted within quadrates. Ants sampled were indentified to species with keys in Radchenko (2005), Radchenko and Elmes (2010), Kupyanskaya (1995), and other literature.

Data analysis

The ant species richness was estimated for each transect using Chao 2 index in the software package EstimateS (Colwell 2006). Comparisons of the number of species and the number of nests among different habitat types were conducted with StatView 5.0.1 (1992-1998, SAS Institute Inc.) and also used two way ANOVA (JMP 5.0 1992-1998, SAS Institute Inc.). The number (proportion) of quadrates with ants of each species and the number of nests per transect (100 m^2) were used to evaluate the frequency of each species. These results were compared between the vegetation types and between the natural and grazed conditions.

3.3. Comparison of species composition among different habitat types

Twenty one species of ant were recorded in the study sites (Table 3-1). Five of them occurred in all the vegetation types, i.e., forest steppe, steppe and meadow: *Camponotus saxatilis, Formica candida, Formica manchu, Myrmica kasczenkoi,* and *Myrmica pisarskii*. However, only two, *Formica candida* and *Myrmica kasczenkoi*, were found in all six habitat types. Nine species were found only in one habitat type. *Formica pisarskii, Lasius distinguendus* and *Temnothorax nassanowi* in natural steppe, *Formica uralensis* and *Proformica kaszabi* in disturbed steppe, *Formica kozlovi* in natural forest steppe, *Formica sanguinea* and *Formica lemani* in disturbed forest steppe, *Formica exsecta* in disturbed meadow. The most species rich genera were *Formica* with 8 species (38.1%) and *Myrmica* with 4 species (19.0%) when all the habitat types are combined. Overall, we collected 19 species (90.5%) from forest steppe, 18 species (85.7%) from steppe, and 12 species (57.1%) from meadow.

Based on occurrence data, the most common species were *Formica candida, Myrmica kasczenkoi and Myrmica pisarskii*.

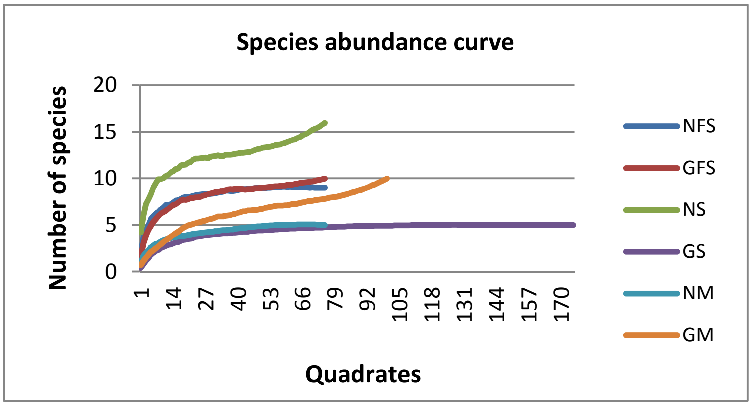

Fig. 3-6. Ant species abundance curves in all habitat types.

Species richness estimates calculated by EstimateS for all habitat types ranged from 5 to 16. The analysis showed that species accumulation curves are almost saturated for most of the habitat types. Only in the natural steppe [NS] and grazed meadow [GM] the number of species is still rising. According to the species estimator Chao 2, we found 70 to 100% of the estimated numbers have been already sampled (Fig. 3-6).

Table 3-1. Frequency of occurrence of ant species in three different vegetation types.

№	Name of species	Forest steppe		Steppe		Meadow		Total
		natural	Grazed	natural	grazed	natural	grazed	-
1	*Camponotus sachalinensis*	9	28	1	0	0	0	38
2	*Camponotus saxatilis*	0	3	5	0	2	1	11
3	*Coptoformica exsecta*	0	0	0	0	0	1	1
4	*Formica candida*	156	16	52	410	351	140	1125
5	*Formica exsecta*	0	0	0	0	0	3	3
6	*Formica kozlovi*	2	0	0	0	0	0	2
7	*Formica lemani*	0	26	0	0	0	0	26
8	*Formica manchu*	38	0	0	3	4	0	45
9	*Formica pisarskii*	0	0	7	0	0	0	7
10	*Formica sanguinea*	0	1	0	0	0	0	1
11	*Formica uralensis*	0	0	0	2	0	0	2
12	*Lasius gebaueri*	0	1	59	0	0	0	60
13	*Lasius przewalskii*	0	0	20	0	0	0	20
14	*Lepthotorax acervorum*	2	0	1	0	0	0	3
15	*Myrmica angulinodis*	7	4	20	0	0	0	31
16	*Myrmica forcipata*	0	0	3	0	0	6	9
17	*Myrmica kasczenkoi*	9	4	18	25	14	5	75
18	*Myrmica pisarskii*	19	1	29	0	14	1	64
19	*Proformica kaszabi*	0	0	0	13	0	0	13
20	*Temnothorax muscorum*	1	6	4	0	0	0	11
21	*Temnothorax nassanowi*	0	0	4	0	0	0	4
	Total occurrences	243	90	223	453	385	157	1551
	Total species richness	9	10	13	5	5	6	48

Natural habitats generally had larger numbers of species, and grazed steppe had the smallest number (total: 5 species; mean: 1.5 species) among all six habitat types that is remarkably smaller than natural steppe (total: 13 species; mean: 6.6). The mean numbers of species in the remaining 4 habitats were similar, varying between 3-5 species.

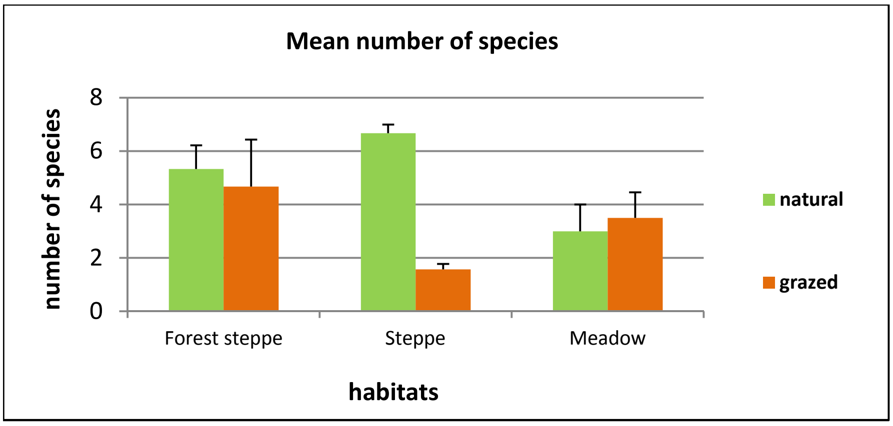

Fig. 3-7. Mean number of ant species for each vegetation and habitat type. Error bar line indicates ±1 standard error.

Table 3-2. Factors affecting the number of species.

Source	DF	Sum of Squares	F Ratio	Prob > F
Vegetation	2	9.81394	1.9529	0.1724
Condition	1	16.039737	6.3837	**0.0217**
Vegetation*condition	2	33.491359	6.6647	**0.0073**
Error	17	42.71429		

The number of ant species in each habitat depends on the grazing condition (F=6.3837, P=0.0217), and interaction between grazing condition and vegetation (F=6.6647, P=0.0073).

Table 3-3. Factors affecting the occurrence of species.

Source	DF	Sum of Squares	F Ratio	Prob > F
Vegetation	2	2562.145	0.4207	0.6632
Condition	1	13567.408	4.4556	**0.0499**
Vegetation*condition	2	5486.113	0.9008	0.4248
Error	17	51765.512		

Ant species occurrence in all habitat types depends only on habitat conditions (F= 4.4556, P= 0.0499).

3.4. Comparison of dominant species among different habitat types

Abundance was measured by the number of quadrates (frequency) in which individual(s) of each species was sampled or observed for each habitat type (Table 3-1). Generally *Formica candida* was the dominant species in all habitats with grazing by livestock animals. But ant occurrence and nest density studies show this species was more dominant in grazed steppe and natural meadow habitats. *Myrmica kasczenkoi* was subdominant, next to *F. candida*, in the grazed steppe and natural meadow. In natural forest steppe, *F. manchu* was dominant, followed by *M. pisarskii*. Also *M. pisarskii* was a dominant species in all natural habitats. *Lasius gebaueri* and *L. distinguendus* were dominant in the natural steppe habitat. *M. kasczenkoi* and *M. forcipata* were subdominant in the grazed meadow habitat.

3.5. Nesting biology of genera and species

Formica candida and *Myrmica kasczenkoi* mainly dig nests in the soil under stones and livestock dung in all habitat types, but *F. candida* often constructs small soil mounds. *Camponotus sachalinensis, F. sanguinea and F. lemani* nests are built in the soil, under stone and logs partly in the soil in the grazed forest steppe. *F. uralensis* builts medium-sized mounds with plant material and *F. exsecta* constructs mounds with tiny plant material. *Proformica mongolica* nests in the soil in the grazed steppe. and *Myrmica forcipa* nests are built in the soil in the grazed meadow. *Lepthotorax acervorum* nests in soil in the natural forest steppe. *Lasius gebaueri, L. distinguendus* and *Temnothorax nassonovi* nests are built in soil and under stone in the natural steppe. *T. muscorum* nests in soil in the grazed and natural forest steppe.

3.6. Nest density

In total, I counted 1173 ant nests in 23 transects (Table 2). The largest number of nests (957, or 81.5 %) belonged to *Formica candida*, followed by *Myrmica kasczenkoi* (46 nests, 3.9%). The lowest number of nests (1, or 0.08 %) belonged to *Formica exsecta*, *Formica sanguinea* and *Leptothorax acervorum*, followed by *Formica uralensis* and *Myrmica forcipata* (2, or 0.15 %).

Table 3-4. Total number of nests per habitat type.

№	Name of species	NFS	GFS	NS	GS	NM	GM	Total
1	*Camponotus sachalinensis*	0	12	0	0	0	0	12
2	*Camponotus saxatilis*	0	2	2	0	0	0	4
3	*Formica candida*	104	12	33	384	326	98	957
4	*Formica exsecta*	0	0	0	0	0	1	1
5	*Formica lemani*	0	4	0	0	0	0	4
6	*Formica manchu*	12	0	0	3	1	0	16
7	*Formica sanguinea*	0	1	0	0	0	0	1
8	*Formica uralensis*	0	0	0	2	0	0	2
9	*Lasius gebaueri*	0	1	37	0	0	0	38
10	*Lasius distinguendus*	0	0	18	0	0	0	18
11	*Leptothorax acervorum*	1	0	0	0	0	0	1
12	*Myrmica angulinodis*	2	2	13	0	0	0	17
13	*Myrmica forcipata*	0	0	0	0	0	2	2
14	*Myrmica kasczenkoi*	5	4	7	15	12	3	46
15	*Myrmica pisarskii*	9	0	12	0	11	0	32
16	*Proformica mongolica*	0	0	0	13	0	0	13
17	*Temnothorax muscorum*	1	6	0	0	0	0	7
18	*Temnothorax nassonovi*	0	0	2	0	0	0	2
	Total number of nests	134	44	124	417	350	104	1173
	Density of nest (nest/m^2)	0.45	0.15	0.41	0.59	1.17	0.26	

Among the six habitats, the lowest density of nests was in the grazed forest steppe (0.15 nests/m^2) and the highest in the natural meadow (1.17 nests/m^2). The natural (0.41 nests/m^2) and grazed (0.59 nest/m^2) steppes had similar nest densities (but differed in the number of species, see Table 1). Statistically, there was no difference in the nest density between all vegetation and habitat types (F= 6.68; P= 0.5237).

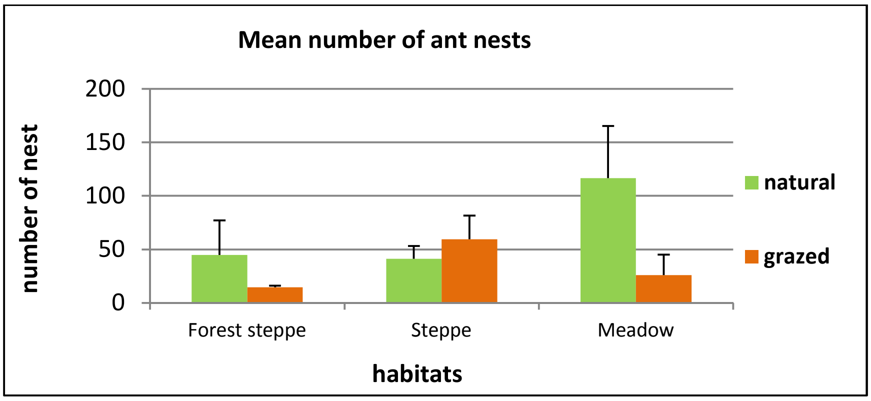

Fig. 3-8. Mean numbers of nests for each habitat type. Error bar line indicates ±1 standard error.

The highest mean number of ant nests (116.6) was in the natural meadow and the lowest (15) was in the grazed forest steppe habitats. The mean numbers of ant nests in natural (59.5) and grazed steppes (41.3) were almost similar. But in the natural (44.6) and grazed forest steppe (14.6) the mean numbers of nests were relatively different.

Table 3-5. Factors affecting the number of nests.

Source	DF	Sum of Squares	F Ratio	Prob > F
Vegetation	2	5566.04	1.0222	0.3809
Condition	1	6077.9	2.2325	0.1535
Vegetation*condition	2	11194.481	2.0559	0.1586
Error	17	46282.381		

On the other hand the number of nests does not depend on vegetation (F=1.0222, P=0.3809), grazing conditions (F=2.2325, P=1.1535), and also their interactions not affected the number of nests (F=2.0559, P=0.1586). The slice test for meadow habitat only shows that ant nest number depends on the habitat condition (F= 5.1762, P= 0.03613) (see table 3-6.). But number of ant nests in other habitats does not depend on condition and vegetation types.

Table 3-6. Number of nests in the meadow habitats.

Sum of Squares	14092.19
Numerator DF	**1**
Denominator DF	**17**
F Ratio	5.176208
Prob > F	**0.036134**

3.7. Foraging distance in different species

The foraging distances were observed for 16 species in the six habitats are shown in Table 3-7.

Table 3-7. Foraging distance between baits and nests (cm)

№	Name of species	Number of samples	Mean	Standard deviation	Range
1	*Camponotus sachalinensis*	4	33.2	37.9	7 - 89
2	*Camponotus saxatilis*	2	1465	49.4	1430-1500
3	*Formica candida*	391	52.4	54.7	3 - 637
4	*Formica exsecta*	23	222.7	184.8	10 - 682
5	*Formica lemani*	3	327	224.9	118 - 565
7	*Formica manchu*	9	99	48.8	37 - 169
8	*Lasius gebaueri*	30	36.1	29	2 - 115
9	*Lasius distinguendus*	16	42.5	49.2	2 - 180
10	*Leptothorax acervorum*	2	74.5	48.7	40 – 109
11	*Myrmica angulinodis*	13	79.5	59.7	10 – 234
12	*Myrmica forcipata*	4	28	27	3 – 65
13	*Myrmica kasczenkoi*	22	68.3	41.5	3 – 160
14	*Myrmica pisarskii*	29	52.5	33.4	7 – 132
15	*Proformica mongolica*	11	72.7	53.2	5 – 170
16	*Temnothorax nassonovi*	2	12.5	10.6	5 – 20

Camponotus saxatilis, *Formica exsecta and F. candida*, all belonging to the subfamily Formicinae, were observed having the longest foraging distances, while *Myrmica forcipata, Temnothorax nassonovi* and *Leptothorax acervorum*, all belonging to the subfamily Myrmicinae, had the shortest foraging distances. The foraging distance has a direct relation to the ant body size.

3.8. Species interaction

Formica candida and *M. pisarskii* were nesting closely, with distances from 13 to 137 cm. No apparent aggressiveness was observed between them. *F. sanguinea* and *L. acervorum* have close interaction. They were nesting in close proximity (15cm) in the grazed habitats. *C. sachalinensis* and *L. acervorum* have very good relationship in the grazed meadow. They were nesting in close distance (15) in the grazed habitats. *Lasius gebaueri* is very aggressive species thus other species keep the nests in a distance of more than 1 m from them. Unwillingness to coexist and aggression of *Lasius gebaueri* to share the same honey bait with other species was evidenced by the deadly attack to *F. candida* and carrying the victim to its nest. *F. candida, F. manchu* and *M. pisarskii* coexist in the natural forest habitat. C. sachalinensis and F. candida coexist in the grazed forest habitat. *L. gebaueri, L. distinguendus, F. candida, M. angulinodis* and *M. pisarskii* coexist in the natural steppe habitat.

Table 3-8. Distance between nests of the same species

№	Name of species	Number of samples	Mean	Standard deviation	Range
1	*C. sachalinensis - C. sachalinensis*	4	109.2	70.3	42 -189
2	*F. exsecta - F. exsecta*	6	152.8	32.5	96 -180
3	*F. candida - F. candida*	2266	101.1	48.6	5 – 256
4	*L. gebaueri - L. gebaueri*	14	114	71	42- 290
5	*L. distinguindes - L. distinguendus*	19	88.3	40.6	23 – 142
6	*M. angulinodis - M. angulinodis*	4	76.7	23	56 -106
7	*M. forcipata - M. forcipata*	2	18	-	18
8	*M. kasczenkoi - M. kasczenkoi*	7	147	63	38 -224
9	*M. pisarskii - M. pisarskii*	13	153	52	57 -210
10	*P. mongolica - P. mongolica*	4	165	28	129- 198
11	*T. nassanovi - T. nassonovi*	1	-	-	64

Table 3- 9. Distance between nests of different species.

№	Name of species	Number of samples	Mean	Standard deviation	Range
1	*C. sachalinensis - M. angulinodis*	2	100	53	62 -174
2	*C. sachalinensis - L. acervorum*	1	-	-	15
3	*F. exsecta - M. kasczenkoi*	2	192	25.4	174 – 210
4	*F. exsecta - M. pisarskii*	3	85	81	70 -174
5	*F. exsecta - F. candida*	10	125	50	30 – 185
7	*F. candida - L. gebaueri*	12	96	27	83 -135
8	*F. candida - L. distinguendus*	1	-	-	85
9	*F. candida - L. acervorum*	1	-	-	133
10	*F. candida - M. angulinodis*	20	113	51.1	20 -212
11	*F. candida - M. forcipata*	8	78.1	45	19 – 145
12	*F. candida - M. kasczenkoi*	86	80	30.1	57 – 123
13	*F. candida - M. pisarskii*	31	80.2	34.6	13 – 137
14	*F. sanguinea - L. acervorum*	1	-	-	15
15	*L. gebaueri - M. angulinodis*	1	-	-	134
16	*L. gebaueri - T. nassonovi*	4	97	23	110 – 116
17	*M. forcipata - M. angulinodis*	6	75.3	50.3	15 – 138
18	*M. pisarskii - L. acervorum*	1	-	-	89

Formica candida and *L. distinguendus* nested closely to conspecific nests, while nests of *F. exsecta* and *P. mongolica* were located apart from their conspecific nests (see Table 3-9). *F. candida - M. pisarskii and F. candida - M. forcipata* were nesting closely and *L. gebaueri - T. nassonovi and F. exsecta - M. kasczenkoi* were nesting far from each other (Table 3-10). Anyway different species nested within single quadrats. In total, 94 quadrats were nested by different species and the mean number of species was 0.12 per quadrat.

3.9. Discussion

This study demonstrates the effect of livestock grazing on the ant species composition, community structure and nesting density in six different habitat types in Northcentral Mongolia. In terms of the frequency of occurrence *Formica candida* was the dominant species in all habitats. *Myrmica kasczenkoi* was also abundant next to *F. candida*. These two species are supposed to have a broader range of adaptability than other ant species, and will survive considerable habitat change.

Ant community in the disturbed steppe has remarkably low species diversity compared to that of the natural steppe. This result is consistent with those of Anderson (1997a), King et al. (1998), Majer and Nichols (1998) that ant communities in disturbed habitats have lower species diversity. This suggests that ants can be considered to be a bioindicator in disturbed steppe of the Northcentral Mongolia.

It is interesting that in terms of nest density there was no significant statistical difference between the above two steppe habitats. The nest density is relatively high in the disturbed steppe even if species diversity is poor. Although at present it is difficult to estimate the biomass of ants in each habitat type, it can be mentioned that even if the habitat condition deteriorates ants continue to retain a substantial biomass.

Ant communities in the other habitats of the Northcentral Mongolia do not have observable difference in response to the disturbance. Contrary to the general expectation, the observed nest densities in the natural forest steppe and natural steppe were no very high. This may be true, but the detection of nests in natural condition is not so easy because of dense vegetation cover. We should have better methodology to estimate the biomass of ants in such habitats.

It is also observed that the most of the ant species coexist well except the only aggressive species *Lasius gebaueri* that does not allow other species to construct their nests within its vicinity. We do not know at present the resource partitioning among the species concerned since the food preference of each species is not precisely documented. At least some larger species seemed to tolerate smaller species at baits. Direct observations on species interaction are needed in the field to reveal the mechanism of the coexistence of particular species.

Part 4. Diversity and biogeography of ants in Mongolia

4.1. Introduction

Ants are one of the most attractive groups of insects as all species live in societies with various forms of caste. They have colonised almost every landmass of the world, and represent a high proportion of the biomass and diversity on the earth. Ants thrive in most ecosystems, and may comprise 15-25% of the terrestrial animal biomass (Hölldobler & Wilson 1990). They constitute an important part of the edaphic mesofauna that enriches the soil, disperses seeds, tends homopterans, and controls other insects (Wilson 1971; Fittkau & Klinge 1973). More than 12,000 species of Formicidae are known in the world, the majority of them inhabiting tropical or subtropical zones (Bolton 1995; Bolton 2003, 2010). Most species of ants are carnivorous, although some are scavengers, herbivores or omnivores (Brown 2000). In their varied capacities, ants frequently exert strong effects on ecological communities (Hölldobler & Wilson 1990).

The Formicidae are well-suited to the ecosystems and biogeographic study approaches, not only because of the social character of the group, but also because of the ability to disperse aerially (Comín del Río & Espadaler 1984). Their success has been attributed to their social organisation and their ability to modify habitats, tap resources and defend themselves (Carroll & Janzen 1973, Hansen & Klotz 2005).

Ants are common, almost ubiquitous insects in Mongolia, and they can be found in all ecosystems and main terrestrial habitats. However, the ant fauna of Mongolia is still incompletely known. Mocsáry & Szépligeti (1901) and Ruzsky (1903, 1915) published the pioneer works on the Mongolian ants, based on material from the southern Gobi and northern forested areas. However, the exact locality of some historical records from southern and northern Mongolia is unclear, because these places are now in China or Russia, and difficult to access. For instance, Holgersen (1943) recorded *Myrmica rubra* (Linnaeus, 1758) from the place named as Sajan, Sistikem, but Wetterer & Radchenko (2011) revealed that the actual name of this place is Systyg Khem of the Sayan Mountains (in Siberia), which is located in the Russian Republic of Tuva. Another example is Stitz (1934), who reported five species, namely *Formica clara* Forel, 1886, *F. picea* Nylander, 1846, *Lasius alienus* (Foerster, 1850), *Tapinoma geei* Wheeler, 1927 and *T. orthocephalum*, Stitz, 1934 from south and southwestern Mongolia, without giving exact names of the collection localities. Two of the above-mentioned species, *T. geei* and *L. alienus* have not yet been confirmed in Mongolia. It is possible that the collection sites are located in Inner Mongolia, China.

Actual research on ants in Mongolia is considered to have commenced in the mid 1960s with Dlussky (Dlussky 1965). Later, Pisarski (1969a, b), Dlussky & Pisarski (1970), Pisarski & Krzysztofiak (1981), and Radchenko (1994a) published extensive works and recorded more than 50 species for the country. However, this number required some amending to reflect the taxonomic status and actual occurrence of some species in Mongolia. Therefore, Radchenko (1994a, b, 1995, 1997, 2005), and Seifert (2000, 2002, 2004) provided additional information on the ants of Mongolia, and were concerned with the taxonomic resolution of the species. Pfeiffer et al. (2003) completed the first comprehensive study on ant communities in Mongolia examining the distribution patterns of ants along an ecological gradient from steppe to desert, assessing the impact of climatic parameters and the influence of vegetation on community structure and species diversity of ants. Later, Aibek et al. (2006) reported 17 species from Mt. Bogdkhan in north-central Mongolia along with information on nesting habits of each species. They reviewed the ant species list recorded in this mountain area, and made comments on status and earlier records of some of those species.

Finally, summarising the literature sources as well as their unpublished records, a checklist of ants in Mongolia was published by Pfeiffer et al. (2007), which reported 68 species from 17 genera, with new records of six species. They excluded several species from the checklist due to improbable occurrence or incorrect identification. Subsequently, Yamane & Aibek (2007) published a short note on ants of Mongolia that comprised all species also included in Pfeiffer et al. (2007).

Later studies focused on certain systematic groups, rather than on documentation of overall faunal diversity. Thus, Aibek & Yamane (2009) reviewed the genus *Camponotus* in Mongolia, and recorded five species along with a new finding of two species, *C. aterrimus* Emery, 1895 and *C.* (*Tanaemyrmex*) *tashcumiri* Tarbinsky, 1976. Subsequently, these authors studied the subgenera *Austrolasius* and *Dendrolasius* of the genus *Lasius* in Mongolia (Aibek & Yamane 2010), and reported nine species of *Lasius*, two of which, namely *L.* (*Austrolasius*) *reginae* Faber, 1967 and *L.* (*Dendrolasius*) *fuji* Radchenko, 2005 were new records to the Mongolian fauna. *Lasius obscuratus* Stitz, 1930, which had been excluded from the Mongolian fauna by Pfeiffer et al. (2007), thus neglecting the possible occurrence of this species in Mongolia, was again recorded by Aibek & Yamane (2010), who included this species in their list. However, the nominal subgenus *Lasius* has not been seriously revised, leaving many problems.

More recently, Yamane & Aibek (2012) studied the distributional patterns of 14 species of the genus *Myrmica* in Mongolia, and provided an identification key for all those species. They omitted *Myrmica commarginata* Ruzsky, 1905 from the species list, but newly added *M. lobicornis* Nylander, 1846.

A significant study for present-day myrmecologists would be the assessment of biodiversity, community composition, biogeography, and other basic investigations of the ecology of a regional ant biota. Such a study would grant researchers a background from which to begin further more detailed studies. The research presented here examines the ant fauna of Mongolia in a biogeographical and ecological context. For the moment I simply attempt to combine what is already known with our unpublished data in order to contribute to a better understanding of the diversity and biogeography of ants in Mongolia. Hopefully, this work will also help to conserve the interesting ant fauna of Mongolia.

4.2. Materials and methods

Study area

Mongolia stretches across central and north-east Asia, and occupies several vegetation zones where the Siberian taiga forest meets the Central Asian steppe and desert. The north-south axis measures more than 1,200 km at its maximum, and the widest east-west distance reaches about 2,370 km. Mongolia is an upland country, with an average elevation of 1,580 m (range of elevation: 535-4390 m), and about 85% of its area elevated over 1,000 m alt. (Murzaev 1952).

Mongolia has an extreme continental climate, and temperature fluctuates greatly, both daily and annually. The lowest temperatures are recorded in January, with monthly averages under -15°C and minimum temperatures as low as -30°C. July is the warmest month, with mean temperatures 15°C in the mountains and 25°C in the southern semi-desert and deserts. The highest precipitation values do not exceed 600 mm in the northern mountains, whereas southern desert areas receive roughly 50 mm of precipitation. From the north to the south of the country, mean annual precipitation decreases steadily, which is a decisive factor for the distribution of vegetation formations. From north to south it not only gets drier, but warmer as well. From the west to the east some areas show comparatively low precipitation because they are on the lee side of mountain chains. Such a rain shadow effect is most pronounced in the depressions of larger lakes in western Mongolia, but it is recognisable in central and eastern Mongolia (Hilbig 1995). This complex set of parameters, together with the large area of the country, creates a large variety of habitats and has a distinct influence on the biodiversity of the region.

Temperature and vegetation follow a similar pattern of altitudinal zonation, and generally speaking, the north to south distribution of vegetation zones corresponds well with the precipitation pattern. Thus, Mongolia has several vegetation zones and vertical belts, i.e. from north to south we meet: alpine meadow (alpine vegetation with upper limit of closed turf), mountain taiga-forest, forest-steppe, steppe, desert-steppe (semi-desert), and desert (Yunatov 1950; Murzaev 1952).

Based upon vegetation, floral composition, topographic and climatic characteristics, Mongolia divides into 16 phytogeographical regions (Yunatov 1950; Murzaev 1952; Grubov 1955, 1982; Fig. 4-1). Two of these regions are mountain taiga forests (1. Khuvsgul, 2. Khentii), three are forest-steppes (3. Khangai, 4. Mongolian Dauria, 5. Great Khyangan), four are steppes (6. Khovd, 7. Mongolian Altai, 8. Middle Khalkh, 9. Eastern Mongolia), four are semi-deserts (10. Depression of Great Lakes, 11. Valley of Lakes, 12. Eastern Gobi, 13. Gobi Altai), and three are deserts regions (14. Dzungarian Gobi, 15. Trans-Altai Gobi, 16. Alashan Gobi).

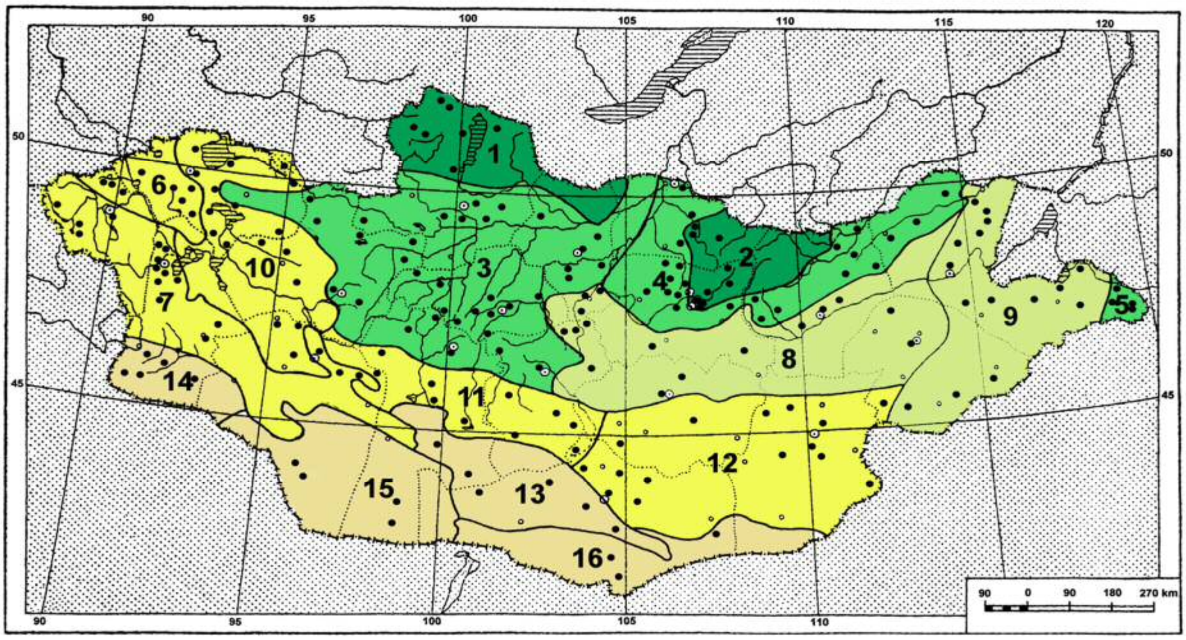

Fig. 4-1. Phytogeographical regions of Mongolia (modified after Yunatov 1950).
Refer to “Study area” subsection for numbering of these regions.

Data collection

The material studied has been obtained from my collections as well as from samples provided by other zoologists and students, derived from different regions of Mongolia. My collections came from 202 sites covering 993 samples, which involved more than 10,500 specimens. Sampled sites were covered the main habitats in all phytogeographical regions of Mongolia though the number of samples in each region was different because of their area size, habitat types and remoteness (see Fig. 4-1). Ant collections are currently deposited in the Department of Ecology, National University of Mongolia, Ulaanbaatar, Mongolia.

In addition, I collected all previously available information on ant species in Mongolia, including revisions of species groups (Mocsáry & Szépligeti 1901; Ruzsky 1903, 1915; Dlussky 1965; Pisarski 1969a, b; Dlussky & Pisarski 1970; Pisarski & Krzysztofiak 1981; Radchenko 1994a,b, 1995; Seifert 2000, 2002, 2004; Pfeiffer et al. 2003; Radchenko 2005; Aibek et al. 2006; Pfeiffer et al. 2007; Yamane & Aibek 2007; Aibek & Yamane 2009, 2010; Seifert & Schultz 2009; Yamane & Aibek 2012), as well as species lists from the internet (e.g. http://www.antbase.org; http://www.antbase.net; http://www.antcat.org; http://antwiki.org). In the present paper, the species list by Pfeiffer et al. (2007) is updated with some modifications. Generic and species names of ants are listed in alphabetical order.

The relative area size of the phytogeographical regions of Mongolia is taken from Ulziikhutag (1989). Plant species richness was estimated based on the number of vascular plant species recorded within each phytogeographical region (Gubanov 1996; Ariuntsetseg & Boldgiv 2009).

Biogeographical analysis of ant species found in Mongolia is based on data in the published literature which provides information on geographical ranges (Seifert 1992, 2000; Bolton 1995; Kupyanskaya 1995; Collingwood 1997; Czechowski et al. 2002; Bolton 2003; Imai et al. 2003; Radchenko 2005; Aibek & Yamane 2009, 2010; Radchenko & Elmes 2010; Guénard & Dunn 2012). Division of biogeographical regions is based on that applied by Bielawski (1984), Nikolajev & Puntsagdulam (1984), Bayartogtokh (2010), Bayartogtokh et al. (2012).

Data analysis

We assessed the similarity of the ant species in Mongolia and other surrounding regions using the Sørenson-Dice's qualitative Index (C_s; see Jackson et al. 1989). If $C_s = 0$, the faunas are completely different from each other, if $C_s = 1$, the faunas are completely similar. Cluster analysis was performed using Euclidian distance measure and the complete linkage clustering algorithm with the software BioDiversity Professional (McAleece et al. 1997).

The occurrences of ants in different altitudes and phytogeographical regions were arranged in presence/absence tables. Multiple regression analysis was used to examine relationships of ant diversity versus plant diversity and area size.

The differences in the numbers of plant and ant species and in the percentage of cover areas between the various phytogeographical regions, as well as differences of ant species numbers along various elevational gradients were tested using a one-way analysis of variance (ANOVA). We used Pearson's product-moment correlations to examine the relationships between species richness of ants versus area size, and plant diversity versus ant diversity. All statistical analyses were performed with software Statistica 5.0 for Windows (StatSoft Inc.). For all statistical tests, we considered results significant when $p < 0.05$.

4.3. Diversity of the ants in Mongolia

Based on my investigations, the ant fauna of Mongolia comprises 71 species belonging to 17 genera in three subfamilies. A list of ant species and their occurrences in various phytogeographical regions of Mongolia is given in Appendix 1. With regard to our species list, the discrepancy with the data from Pfeiffer et al. (2007) who listed 68 species for this country arises because six species (*Camponotus atterrimus* Emery, 1895, *C. tashcumiri* Tarbinsky, 1976, *Formica orangea* Seifert et Schultz, 2009, *Lasius reginae* Faber, 1967, *L.*

fuji Radchenko, 2005 and *Myrmica lobicornis* Nylander, 1846) have recently been added to the fauna of Mongolia (Aibek & Yamane 2009; Seifert & Schultz 2009; Aibek & Yamane 2010; Yamane & Aibek 2012). On the other hand, I omitted *Lasius flavus* (Fabricius, 1782) and *Myrmica rubra* (Linnaeus, 1758) as these do not occur in Mongolia (Aibek & Yamane 2010; Wetterer & Radchenko 2011). I removed also *Temnothorax serviculus* (Ruzsky, 1902) from the fauna list because its former subspecies, *T. mongolicus* exists in Mongolia (Pisarski 1969b), and is now an independent species (the nominal subspecies does not occur in Mongolia). *Camponotus japonicus* Mayr, 1866 was also removed from the list because its former subspecies, *C. aterrimus* Emery, 1895 is now considered an independent species, while the nominal subspecies *C. japonicus* does not occur in Mongolia (Aibek & Yamane 2009). Kupyanskaya (2012) listed *Formica japonica* as distributed in Mongolia, but its occurrence in this country has not been confirmed. So, I omit this species from the list.

Yamane & Aibek (2012) considered the occurrence of *Myrmica ruginodis* Nylander, 1846 in Mongolia improbable as this species was not discovered during the recent extensive explorations throughout the country. However, I include this species in the checklist based on Radchenko & Elmes (2010), who provided a distribution map, in which the geographical range of *M. ruginodis* covered northern Mongolia.

The largest number of Mongolian species belongs in the subfamily Formicinae (39 spp.), followed by Myrmicinae (29 spp.); these two subfamilies comprising more than 95 percent of the total ant species. A third subfamily, the Dolichoderinae, is poorly represented in Mongolia with only three species (Appendix 1).

The most species rich and commonly encountered genera are *Formica* (19 spp.), *Myrmica* (14 spp.), *Lasius* (7 spp.), *Camponotus* (5 spp.) and *Proformica* (5 spp.). The other genera involve less than five species. *Temnothorax* and *Tetramorium* are both represented by four species, and *Leptothorax*, *Messor* and *Tapinoma* by two species only. Seven genera are represented by a single species, namely: *Cardiocondyla*, *Cataglyphis*, *Crematogaster*, *Dolichoderus*, *Harpagoxenus*, *Plagiolepis* and *Polyergus*. Thus, only a few ant genera are species rich, whereas the majority comprise fewer species, with the mean number per genus 4.2, and the median only 2.0.

I compared the diversity of ants in Mongolia with that of the surrounding countries or regions, and found that both generic and species diversity of ants in Mongolia is relatively lower than in most of neighbouring regions (Fig. 4-2). Only the regions of northern China show much lower diversity of ants, but this is most probably due to insufficient investigation of those areas (see Discussion for references and species lists).

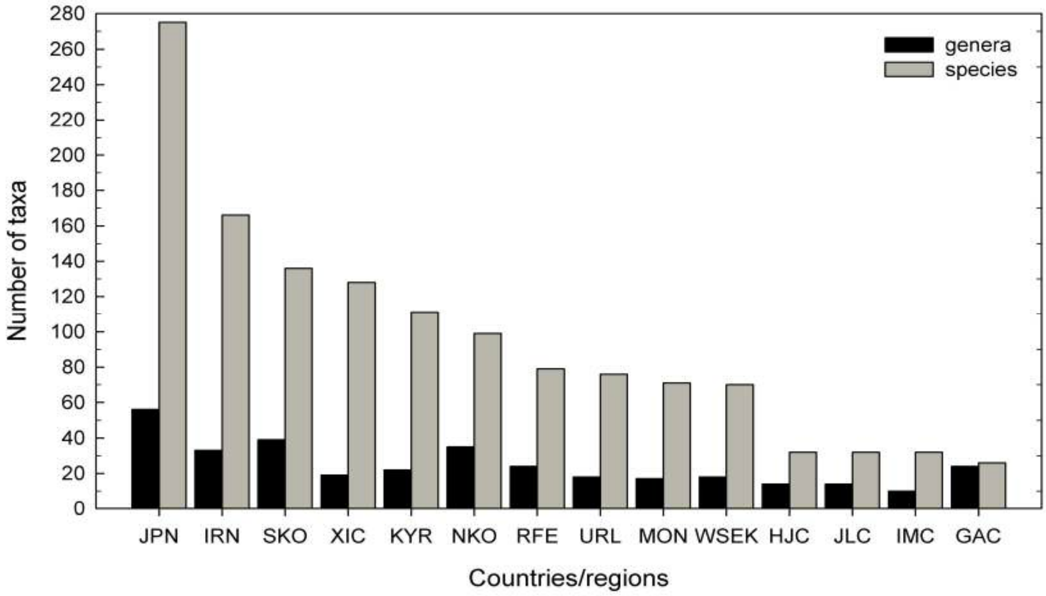

Fig. 4-2. Relationship of generic and species diversity of ants in Mongolia and its surrounding regions. Abbreviations: JPN – Japan; IRN – Iran; SKO – South Korea; XIC – Xinjiang, China; KYR – Kyrgyzstan; NKO – North Korea; RFE – Russian Far East; URL – Ural region of Russia; MON – Mongolia; WSEK – Western Siberia and eastern Kazakhstan; IMC – Inner Mongolia, China; HJC – Heilongjiang, China; JLC – Jilin, China; GAC – Gansu, China.

The ant fauna of Mongolia shares relatively few species with those of the surrounding regions as balanced with the total number of species in compared regions or countries; hence the estimated faunal similarity was very low. The Russian Far East and Gansu Province of China show the closest similarity with the Mongolian ant fauna. Japan and Iran have the lowest faunal similarity with ants of Mongolia (Table 4-1).

Table 4-1. Faunal similarity of the Mongolian ant fauna with those of the surrounding regions. Total number of species, number of overlapping species, and Sorenson's Index of similarity (C_s) values.

	KYR	URL	WSEK	IRN	RFE	XIC	IMC	HJC	GAC	JLC	SKO	NKO	JPN
Number species in each country/region	111	76	70	166	79	128	26	32	26	32	136	99	275
Number of common species with Mongolia	26	24	20	11	25	26	12	12	16	11	20	27	9
Similarity with Mongolian ant fauna (C_s)	0.22	0.25	0.22	0.08	0.25	0.21	0.20	0.19	0.25	0.18	0.16	0.24	0.05

Refer to Fig. 4-2. for abbreviations of the names of the countries/regions. Only native species are considered, exotic species are excluded.

4.4. Distribution of ants in phytogeographical regions of Mongolia

The number of ant species in the 16 phytogeographical regions ranged from 3 to 39 with a mean of 19. Each of these regions had a peculiar composition of ants, but there were several species dominating in most regions. Thirty-nine species were found in the Khentii mountain-taiga region, 38 species in the Mongolian Dauria forest-steppe region, 30 species in the Khangai forest-steppe region, 28 species in the Middle Khalkh steppe region, 25 species in Mongolian Altai mountain-steppe, 24 species in Depression of Great Lakes desert-steppe regions, and 20 species in the Eastern Gobi desert-steppe region. The species richness of ants in other phytogeographical regions varied between 3 and 18 (see Appendix 1).

One species, *Formica candida* was common to 12 phytogeographical regions, and another species, *Proformica mongolica*, inhabited 11 out of 16 regions which provide a variety of habitats. Three species, *Cataglyphis aenescens*, *F. kozlovi* and *Tetramorium tsushimae* were found in ten regions. *Formica lemani* was recorded from nine regions, and two other species, *F. clarissima* and *F. pisarskii* were distributed in eight regions. The other 63 species were confined to seven regions or less. From our data it was apparent that 13 species are rather rare in Mongolia, their distribution being restricted to a single phytogeographical region (see Appendix 1). A large number of species were restrictedly distributed in only two or three regions (12 and 9 spp., respectively).

Differences between the faunal compositions of ants in various phytogeographical regions are of great interest. Regions were grouped into four main clusters (Fig. 4-3), and the dissimilarity of the regions reflects their different geographical position and discrepant ecological conditions. Most of these clusters involve the regions that are geographically adjacent to one another, and reflect the main landscape pattern of Mongolia. For instance, the boreal forest group includes the Khentii, Khangai and Mongolian Dauria regions. The dry steppe group includes Middle Khalkh, Eastern Mongolia and Mongolian Altai regions. The semi-desert group involves Gobi-Altai, Eastern Gobi, Depression of Great Lajes and Khovd regions. The Gobi desert group encompasses Trans-Altai Gobi, Eastern Gobi, Dzungarian Gobi, Valley of Lakes and Alashan Gobi regions. The main surprising pattern here is a relatively low dissimilarity observed between two distantly isolated and ecologically different regions, such as Khuvsgul mountain taiga region and Khovd mountain-steppe region. We consider that this is because only few and wide ranging species (7 spp.) were found in Khuvsgul region. It should be noted here that because of different sampling effort, diversity of ants in some regions, such as Khuvsgul, Great Khyangan, Valley of Lakes, Dzungarian Gobi, Alashan Gobi etc. might be not fully explored yet. Overall, the ant faunas in various regions are relatively different from one another, and this fact confirms the well-established classification of the phytogeographical regions in Mongolia.

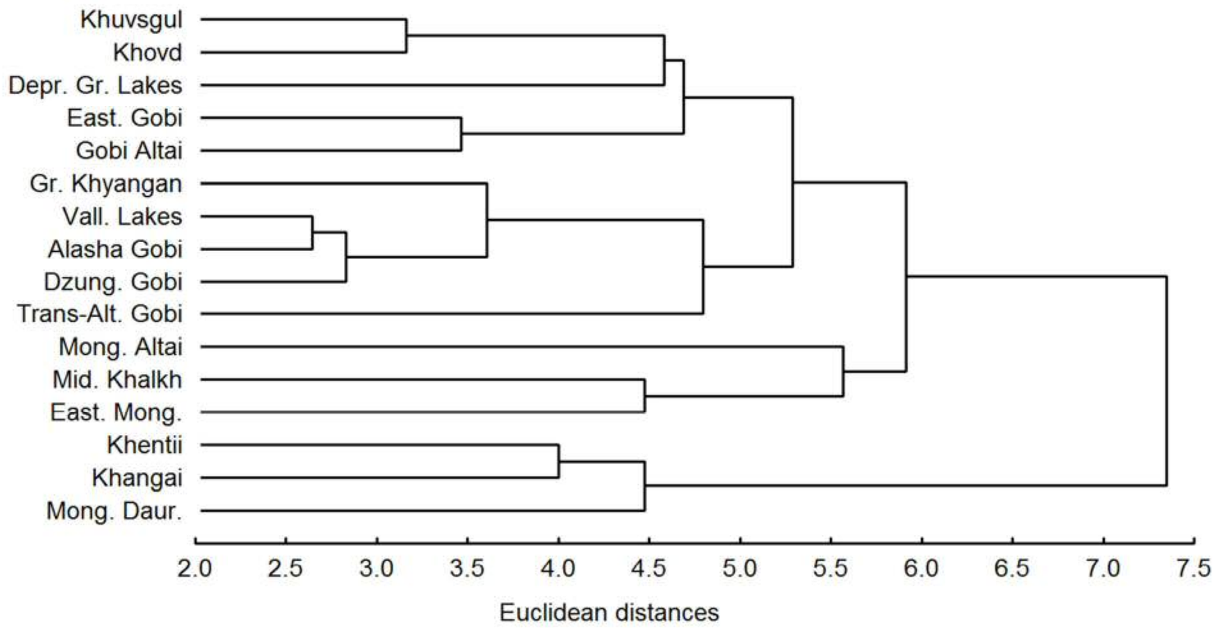

Fig. 4-3. A dendrogram depicting the faunal dissimilarity of ants among the phytogeographical regions of Mongolia.

Species – area relations

Regarding the geographical distribution of ant species in various phytogeographical regions of Mongolia, we found a mismatch between the regions' area size and the respective number of ant species. The highest number of species (39 of a total 71 spp.) was recorded in Khentii mountain-taiga region, though the total area of this region is roughly equal to only 3.05% of the territory of Mongolia. Thirty-eight species were found from the Mongolian Dauria forest-steppe region that covers only 6.62% of the country. Thirty species were recorded in Khangai forest-steppe region, which comprises 17.59% of the entire area of the country. Species richness of ants and total land area of regions were not correlated (Pearson's correlation, n = 16, $r = 0.42$, $p = 0.101$, n.s., Fig. 4-4).

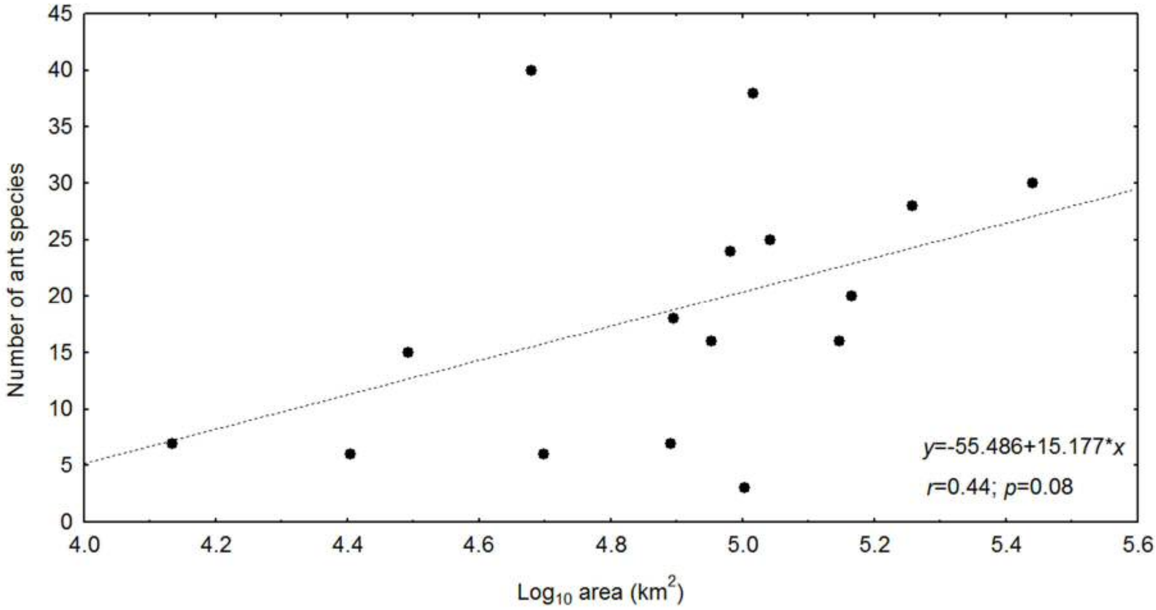

Fig. 4-4. Non-significant relationship between area size and ant diversity for various biogeographical regions of Mongolia. A regression line was fit to visualise the hypothesised interdependence.

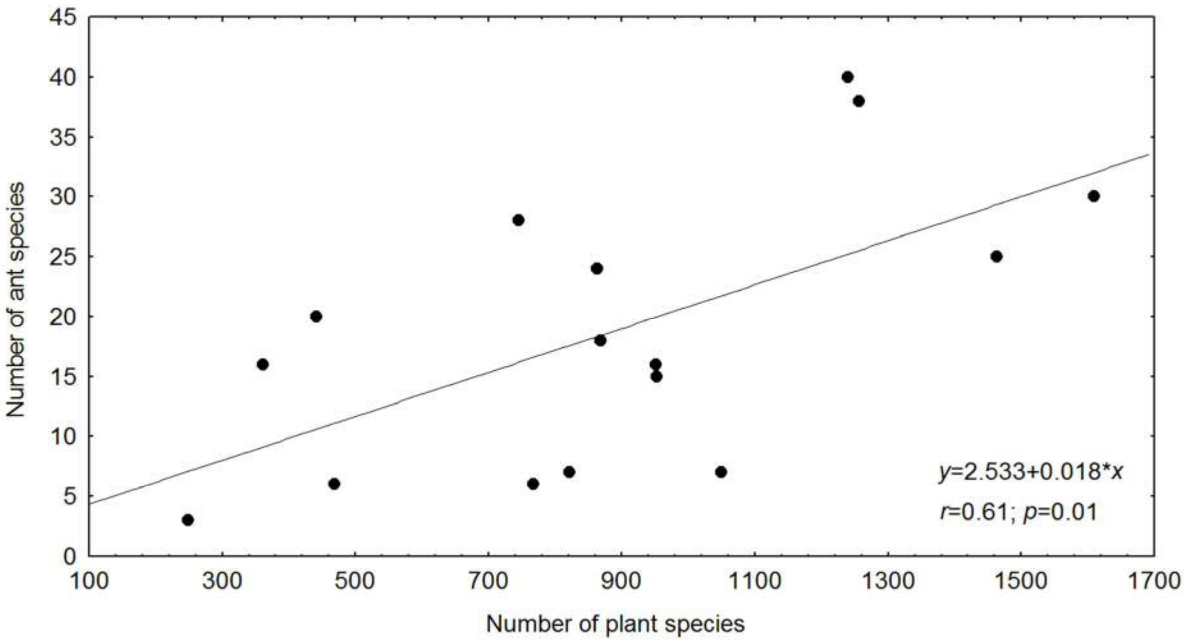

Fig. 4-5. Relationship between plant and ant diversities in various biogeographical regions of Mongolia. A regression line was fit to visualise the connection between both variables.

Since area size and plant diversity were not correlated for the phytogeographical regions (Pearson's correlation, n = 16, r = 0.31, p = 0.24), we plotted them separately against ant species richness. Within the study region as a whole, plant diversity in different phytogeographical regions varied significantly (ANOVA, df = 1, F = 21.16, p = 0.0004). Diversities of ants and vascular plants within phytogeographical regions showed a significant positive correlation (Pearson's correlation, n= 16, $r = 0.61$, $p = 0.01$) (Fig. 4-5).

4.5. Altitudinal pattern of diversity

My calculation of the altitudinal distribution of ant species was based upon collection data from 307 different elevational points. There was no distinct distribution pattern of ant species along altitudinal gradients as most of the species were recorded in a wide range of elevations (Fig. 4-6). The width of altitudinal intervals was very large for most of the ant species, hence the number of species in various altitudes did not differ significantly (ANOVA: $df = 1$, $F = 1.64$, $p = 0.24$). Only four species, *Myrmica commarginata*, *Proformica coriacea*, *Tapinoma orthocephalum* and *T. sinense* were restricted to lower altitudes, between 600 and 800 m alt.. Several other species (*Formica exsecta*, *Lasius niger*, *Myrmica lobicornis*, *Polyergus nigerrimus*, *Proformica kaszabi*, *Tetramorium armatum*, *T. concaviceps*, *T. inerme*) were reported at elevations of 600-1600 m alt.. Twelve species (*Formica candida*, *F. cunicularia*, *F. kozlovi*, *F. lemani*, *F. manchu*, *F. pisarskii*, *F. uralensis*, *Leptothorax acervorum*, *L. muscorum*, *Myrmica divergens*, *M. eidmanni*, *M. kasczenkoi*) were present at the widest range of elevations between 600 and 2400 m alt.. Species richness was greatest between 1000-2000 m alt., as 27 species were recorded in this mid-elevational gradient, whereas 22 species occurred at 800-1800 m alt.. Thus, I found a peak of species richness between 800 and 2000 m alt..

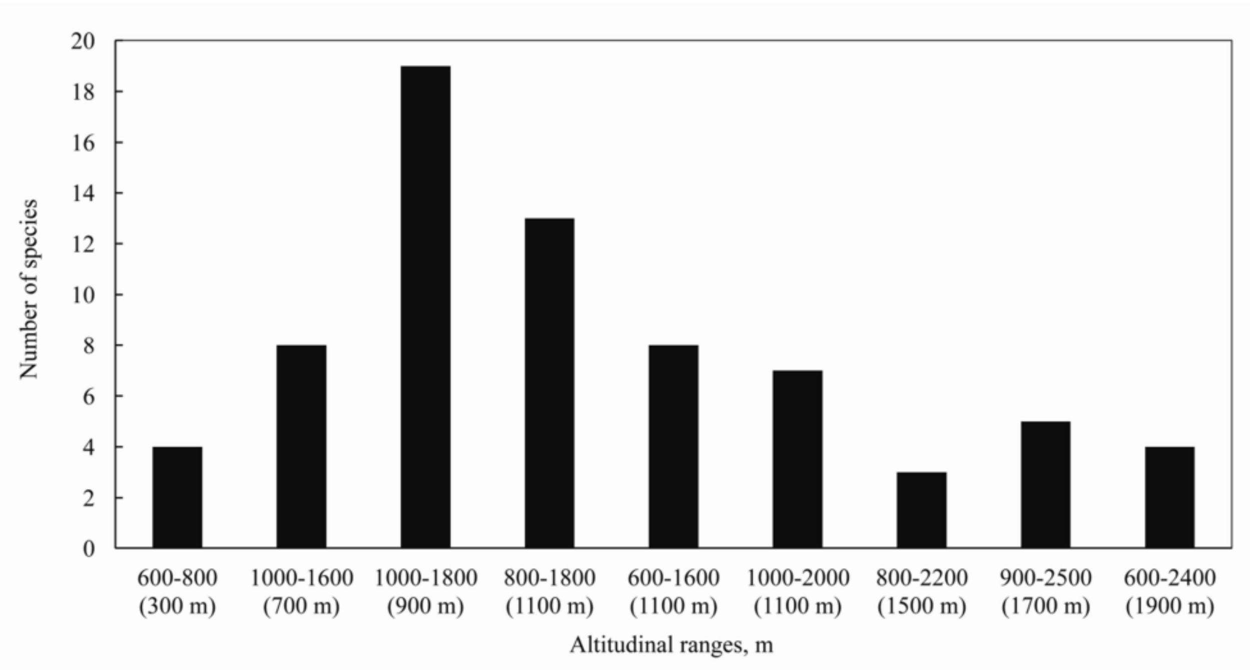

Fig. 4-6. Altitudinal distribution of ants in Mongolia, categorised upon a range of elevational gradients, with a minimum range of 300 m and a maximum of 1900 m (altitudinal ranges are given in parentheses).

4.6. Geographical distribution of species

The biogeographic distributions of all known species of ants in Mongolia were compiled , and the species were divided into groups based upon their dispersal areas. Table 4-2 shows the biogeographical composition of the ant fauna of Mongolia. Species with a wide geographical distribution comprise a large proportion of the ant fauna of Mongolia. Three species, *Leptothorax acevorum*, *L. muscorum* and *Tetramorium tsushimae* are widely distributed throughout the Holarctic Region. The quantitatively most important biogeographical elements are Transpalaeartcic (24 spp., 33.8%), Central Asian (15 spp., 21.1%), Eastern Palaearctic (13 spp., 18.3%) and East Asian species (10 spp., 14.1%). A few species, *Myrmica arnoldii*, *M. commarginata*, *M. pisarskii* and *Polyergus nigerrimus* are restricted to Siberia and Mongolia (4 spp., 5.6%). *Formica pressilabris* is the only representative of Europe-Siberian species (1 sp., 1.4%). There is only a single species, *Harpagoxenus zaisanicus* that appears to be endemic to Mongolia. This species was described by Pisarski (1963) from Mongolia, and has not been found outside the country (Bolton 2010). The absence of Oriental or Afrotropical faunal components in Mongolia is notable.

Table 4-2. Biogeographical composition of ants in Mongolia.

Species name	Species number	Geographical range
Leptothorax acervorum, *L. muscorum*, *Tetramorium tsushimae*	3	Holarctic
Cataglyphis aenescens, *Crematogaster subdentata*, *Formica aquilonia*, *F. candida*, *F. clara*, *F. cunicularia*, *F. exsecta*, *F. forsslundi*, *F. lemani*, *F. lugubris*, *F. pisarskii*, *F. pratensis*, *F. sanguinea*, *F. truncorum*, *F. uralensis*, *Lasius distinguendus*, *L. gebaueri*, *L. niger*, *L. reginae*, *Myrmica divergens*, *M. lobicornis*, *M. ruginodis*, *M. sulcinodis*, *Temnothorax nassonovi*	24	Transpalaearctic
Camponotus aterrimus, *Formica kozlovi*, *F. manchu*, *F. obscuratus*, *Myrmica angulinodis*, *M. eidmanni*, *M. koreana*, *M. transsibirica*, *Plagiolepis manczshurica*, *Proformica buddhaensis*, *P. jacoti*, *Temnothorax kaszabi*, *T. mongolicus*	13	Eastern Palaearctic
Camponotus tashcumiri, *C. turkestanus*, *Cardiocondyla koshewnikovi*, *Formica clarissima*, *F. orangea*, *F. subpilosa*, *Lasius przewalskii*, *Messor excursionis*, *Proformica coriacea*, *P. kaszabi*, *Tapinoma orthocephalum*, *Temnothorax melleus*, *Tetramorium armatum*, *T. concaviceps*, *T. inerme*	15	Central Asian and Iran-Turanian
Formica pressilabris	1	Europe-Siberian
Myrmica arnoldii, *M. commarginata*, *M. pisarskii*, *Polyergus nigerrimus*	4	Siberia-Mongolian
Camponotus sachalinensis, *C. saxatilis*, *Dolichoderus sibiricus*, *Lasius fuji*, *Messor aciculatus*, *Myrmica forcipata*, *M. kamtschatica*, *M. kasczenkoi*, *Proformica mongolica*, *Tapinoma sinense*	10	East Asian
Harpagoxenus zaisanicus	1	Mongolian endemics

4.7. Discussion

Diversity

Mongolia has representatives of about 7.4% of the known world ant genera and 0.52% of the currently described species (Bolton, 2010) – a relatively impoverished fauna compared to most of the surrounding regions. Thus, Tarbinsky (1989) found 103 species belonging to 23 genera from Tien-Shan and Alai mountains in Central Asia (Kyrgyzstan); Schultz et al. (2006) and Borowiec et al. (2009) recorded 111 species (22 genera) from Kyrgyzstan; Gridina (2003) recorded 76 species from 18 genera in the Ural region of Russia; Reznikova (2003) revealed 70 species (18 genera) along a transect from taiga-forest to desert in western Siberia and eastern Kazakhstan. Another Asian country, Iran, which has a similar land area to Mongolia, supports a much higher diversity of ants according to Paknia et al. (2008, 2010), Radchenko & Paknia (2010), Firouzi et al. (2011), Ghahari & Collingwood (2011), Mohammadi et al. (2012), and Nezhad et al. (2012), who altogether listed 166 species (33 genera) from this country. Kupyanskaya (1995) reported 79 species (24 genera) in the Russian Far East. Concerning northern China, Guénard & Dunn (2012) reported 128 species (19 genera) from Xinjiang, 26 species (10 genera) from Inner Mongolia, 26 species (24 genera) from Gansu, 32 species (10 genera) from Heilongjiang, and 32 species (14 genera) from Jilin provinces. Three other East Asian countries, more distantly located from Mongolia, also have a much higher diversity of ants: Kim & Park (2003) reported 136 species (39 genera) from South Korea; Radchenko (2005) found 99 species (35 genera) in North Korea, and Japanese Ant database Group (2003) listed 275 species (56 genera) from Japan.

This might reflect the intensity of the investigations carried out in different countries or regions. It should be noted that, with the exception of Japan, the ant faunas of most of the nearby regions (especially in northern China) have not been fully explored, and the number of species known from those regions may increase significantly when remote or unexplored areas have been surveyed and all available material has been examined (see Guénard & Dunn 2012). Nevertheless, current information is considered to be adequate to gain an understanding of the major faunal patterns in these regions (see Kim & Park 2003; Radchenko 2005; Paknia et al. 2008; Guénard & Dunn 2012).

On the other hand, the extremely harsh and fluctuating climates, as well as arid or very dry conditions in most areas of Mongolia make the country unfavourable for the habitation of species that commonly occur in areas with humid, sub-continental mild climates. This pattern of climatic and environmental conditions in Mongolia might be considered as the main basis for the relatively poor composition of the ant fauna as compared to the surrounding regions or countries regardless of land area. In general, ant species diversity declines with latitude and altitude elsewhere (Kusnezov 1957; Cushman et al. 1993; Dunn et al. 2009a, b; Guénard & Dunn 2012), and this effect may, in some cases, explain the relatively low diversity of ants in Mongolia as the country lies in northern latitudes possessing a cold climate.

Concerning the faunal composition of ants in Mongolia, two major subfamilies, Formicinae and Myrmicinae, comprise more than 95% of total recorded species, while another subfamily, Dolichoderinae is represented by only three species. The Formicinae and Myrmicinae are the largest ant subfamilies in the world and the dominant groups in most terrestrial habitats. The prevalence of these subfamilies has been reported to increase with increasing aridity (Marsh 1986, Lindsey & Skinner 2001). In contrast, Australian and North American semi-arid areas are characterised by a more even spread of species across subfamilies such as the Dolichoderinae and Ponerinae (Briese & Macauley 1977; Whitford et al. 1978; Andersen 1986). This may reflect the different evolutionary histories of the ant faunas of the arid areas in these places.

Almost half of the recorded species in the Mongolian ant fauna belong to the genera *Formica* and *Myrmica*. Five other genera contain four or more species in Mongolia: *Camponotus* (5 spp.), *Lasius* (7 spp.), *Proformica* (5 spp.), *Temnothorax* (4 spp.) and *Tetramorium* (4 spp.). Together, the seven most diverse genera constitute nearly 81% of the ant species known from Mongolia, while other genera, such as *Cardiocondyla*, *Cataglyphis*, *Crematogaster*, *Dolichoderus*, *Harpagoxenus*, *Leptothorax*, *Messor*, *Plagiolepis*, *Polyergus* and *Tapinoma* comprise much smaller proportions of the fauna. Similar faunistic patterns are found in other arid Asian regions, e.g. eastern Kazakhstan and western Siberia (Reznikova 2003), the Ural region of Russia (Gridina 2003), Kyrgyzstan (Tarbinsky 1989; Schultz et al. 2006) and northern China (Guénard & Dunn 2012).

I suppose that the main faunal composition of ants of Mongolia is already revealed, but some cryptic species likely remain undiscovered because previous collecting has been mostly limited to nest collections, pitfall traps and rarely baited traps. Extraction of ants from sifted leaf litter using Winkler traps has proved to be very productive when conducting systematic inventories of ants (Fisher 1999; Longino et al. 2002).

Distribution in phytogeographical regions

Based on the similarity analysis of the ant faunas of various phytogeographical regions, three main groups can be distinguished. The "forest-steppe" group encompasses the Khentii, Mongolian Dauria, Khangai, Middle Khalkh, Eastern Mongolia and Great Khyangan regions. The "steppe-semidesert" group includes the Khovd, Depression of Great Lakes, Mongolian Altai, Valley of Lakes, Eastern Gobi, Gobi Altai and Trans-Altai Gobi regions. The "desert" group consists of the Alashan Gobi and Dzungarian Gobi regions. Surprisingly, the Khuvsgul taiga forest region was fell within "steppe-semidesert" group, but we consider that it is because of the very low ant diversity discovered in Khuvsgul region as only seven species were recorded there. As we noted above that due to unequal sampling intensities and its completeness in various phytogeographical regions of Mongolia, the actual diversity of ants may increase, when remote or unexplored areas have been surveyed.

It is notable that the most common species (e.g. *Cataglyphis aenescens*, *Formica aquilonia*, *F. candida*, *F. kozlovi*, *F. lemani*, *F. pisarskii*, *Proformica mongolica*) tended to be widely distributed across various phytogeographical regions, but in contrast, the rare species (*Dolichoderus sibiricus*, *F. obscuratus*, *F. pressilabris*, *Lasius reginae*, *Messor excursionis*, *Myrmica commarginata*, *M. jessensis*, *M. kamtschatica*, *M. ruginodis*, *M. transsibirica*, *Tapinoma orthocephalum*, *T. sinense*, *T. melleus*, *Tetramorium concaviceps*) were highly restricted in their distribution, generally occurring only in one region.

Pfeiffer et al. (2003) noted the considerable changes of ant communities along the environmental gradient from steppe to desert, and found that the steppe was dominated by cold-resistant species; semi-desert supported mainly opportunistic species, whereas desert involved mostly hot climate specialists. However, these authors, and also Morton & Davidson (1988) and Medel (1995) did not find a correlation between precipitation and diversity of ants.

Generally, the diversity of local ant communities is primarily influenced by climatic conditions (e.g. temperature regimes, precipitation), landform, nest sites, microhabitat patterns (e.g. vegetation cover, soil type, moisture, texture), and food resource availability (Koen 1988; Andersen 1993, 2000; Bestelmeyer & Wiens 2001; Fergnani et al. 2008). In Mongolia however, due to the high habitat heterogeneity, species diversity of ants in various phytogeographical regions may differ as a consequence of small microclimatic factors that can determine whether a species is present or absent within a location (Pfeiffer et al. 2003), thus small scale patterns of habitat are most important for ant life in Mongolia especially in arid regions. Li et al. (2011) revealed that in arid ecosystems of Central Asia, the species richness and abundance (nest density) of ants are closely associated with silt content, soil organic matter, nitrogen and soil moisture, as well as topsoil temperature. Similarly, in humid subtropical and dry tropical areas, habitat strongly influences the composition and community structure of ants (Lindsey & Skinner 2001; Calcaterra et al. 2010).

Relation between plant and ant diversities

Positive correlation between plant diversity and diversity of ants is frequently reported (Andersen 1997; Paknia & Pfeiffer 2012), and this was in accordance with our results on the relationship between the diversities of ants and vascular plants in various phytogeographical regions of Mongolia. Other investigations showed that habitats with more complex vegetation structure and higher primary productivity support more diverse and dense ant assemblages (Andersen 1997; Kaspari et al. 2000; Sarty et al. 2006; Paknia & Pfeiffer 2012). Moreover, in arid habitats of central and southern Mongolia, Pfeiffer et al. (2003) revealed a high correlation between ant and plant communities. These authors also indicated that the ant diversity pattern could be a result of the productivity of resources that are consequences of soil texture, small-scale topography and other mosaic-like local environmental variations.

Elevational distribution

I suggest that a relatively high uncertainty of elevational distribution for the majority of ant species is due to local mosaic-like topographic relief, as the vast majority of the country contains mountainous landscapes (about 85% of its area elevated over 1000 m alt.), except the plain grasslands in eastern Mongolia. Nevertheless, the observed patterns conform to the mid-elevational rise in species richness recorded in temperate (Sanders et al. 2003; Glaser 2006), subtropical (Bharti et al. 2013) and tropical regions (Fisher 2004). At similar altitudes, the northern Palaearctic, Europe-Siberian and Boreomontane species show a mid-elevational peak between 900 and 1800 m alt. in the Eastern Alps (Glaser 2006).

The mid-elevational peak in ant diversity is attributed to the more open and dry litter habitat conditions and prey resource availability at mid-elevations. Based on their research in tropical montane forests, Brühl et al. (1999) and Sabu et al. (2008) observed that ant abundance is higher in more open and drier conditions as moist and humid habitat conditions limits ants' foraging ability and reduce the time availability for foraging on the litter floor.

The absence of ant species at elevations above 2500 m alt. might be due to low temperature and strong winds, both of which would not permit their distributions at high altitudes in Mongolia. As ants are thermophiles (Hölldobler & Wilson 1990), which react negatively to low mean annual temperatures, the cold climate seems to be a major factor working against the diversification of certain ant genera in Mongolia (Pfeiffer et al. 2003). Sanders et al. (2003) revealed that generally, species of the subfamilies Dolichoderinae and Myrmicinae are more common at lower elevations than at higher elevations, while species of Formicinae are more common at high elevations. However, I did not observe such a pattern in altitudinal ant distributions in Mongolia.

It is worth noting that this is the first report on the elevational distribution of ants in Mongolia, and the indistinct pattern of ant distribution in various elevation steps might also be caused by varying investigation intensities in different regions of the country. This emphasises the importance of intensive biogeographic research to get more realistic elevational distribution maps.

Biogeography

The biogeographic composition of ants in Mongolia declares it as one of the representative parts of the Palaearctic ant fauna as there are neither Oriental nor Afrotropical species. The majority of ant species in Mongolia seem to be widespread in the whole Palaearctic region, with the addition of a few Holarctic elements. Thus, species which are distributed in the whole area, or the eastern part of the Palaearctic as well as in Holarctic regions, comprise more than half of the total species (56%).

The other specific character of the Mongolian ant fauna is the presence of strong western, northern and eastern components. Nearly one fifth (21%) of Mongolian species are distributed in various regions or countries in the Eastern Palaearctic region, such as Siberia, Russian Far East, north-eastern China, Korean Peninsula and Japan. The remaining species (22%) seem to be distributed in the arid regions of Central Asia. Although the number of species shared with surrounding regions was relatively small, the whole ant fauna of Mongolia does not differ significantly from that of the neighbouring regions, and the majority of species occurring in Mongolia, probably originated in neighbouring areas to the west, north and east.

Part 5. Conclusion

The most parts of Mongolian forest, forest steppe and steppe areas are present in Northcentral and Northeastern Mongolia, and give relatively good conditions for many insect species of the entire Mongolia except for species that are well adapted to desert and semi-desert conditions. From this area I have recognized 44 species of ant belonging to 12 genera in 3 subfamilies. Most of Nortcentral and Northeastern Mongolian ant species belong in the subfamily Formicinae (25 spp.), and Myrmicinae (18 spp.). Only one species, *Dolichoderus sibiricus* belongs to the subfamily Dolichoderinae (1 spp.). Sixty-two percent of the total ant species of Mongolia (71 spp.) occur in this area. This means that not a few species are confined to other types of habitat like desert and semi-desert located in southern part of the country. One species of *Crematogaster* and two species of *Tapinoma* are among them. Since *Crematogaster* ants are most thriving in tropical regions (Hosoishi and Ogata 2009), the presence of one species of this genus in Govi desert might be explained by the warmer climate rather than the dry climate. For *Tapinoma* a similar reasoning can be possible, but some species of this genus occur in very disturbed conditions so that the two Mongolian species may be adapted also to dry conditions.

The species rich and commonly encountered genera are *Formica* (12 spp.), *Myrmica* (11 spp.), *Lasius* (5 spp.), *Camponotus* (3 spp.), *Proformica* (3 spp.), *Temnothorax* (3 spp.), and *Leptothorax* (2 spp.). Five genera are represented by a single species, namely: *Cataglyphis*, *Dolichoderus*, *Harpagoxenus*, *Polyergus* and *Tetramorium*. Among the species four are new to the Mongolian ant fauna, and two of them (genus *Lasius*) belong to two subgenera that have not been recorded from any part of the country. The locality for the principally European species *Lasius* (*Austrolasius*) *reginae* (see Seifert, 2007), namely Numrug located close to easternmost part of Mongolia, represents the eastern limit of the range of this species. On the other hand, *L.* (*Dendrolasius*) *fuji* ranges from Japan through Korean Peninsula to Northeastern Mongolia, marking the western limit of its range.

This study demonstrates that the effect of livestock grazing on the ant species composition, community structure and nesting density was rather limited in three different vegetation types in Northcentral Mongolia. In terms of the frequency of occurrence *Formica candida* was a very dominant species in all habitats (note that this species is the most common species in the entire northern part of the country). *Myrmica kasczenkoi* was also abundant next to *F. candida*. These two species are supposed to have a broader range of adaptability than other ant species, and could survive in considerable habitat change.

Ant community in the disturbed steppe has a remarkably low species diversity compared to that of the natural steppe. However, in forest steppes and meadows, the species diversity was not different between natural and grazed conditions. This suggests that the diversity of ants is considered to be dependent on the habitat condition, especially in steppe vegetation.

It is interesting that in terms of nest density there was no significant statistical difference between the above two steppe habitats. The nest density is even slightly higher in the disturbed steppe even if species diversity is poor. It is higher in the natural condition than in the grazed condition in the two other types of vegetation, i.e., forest steppe and meadow. Although at present it is difficult to estimate the biomass of ants in each habitat type, it can be mentioned that even if the habitat condition deteriorates ants continue to retain a substantial biomass.

The ant species richness in Northcentral Mongolia does not necessarily have observable differences in response to the disturbance. However, grazed habitats tended to be occupied by common widespread species that are adapted to disturbed areas. Retaining natural conditions may be important in conserving the native set of ant species that had been principal members of Northcentral and Northeastern Mongolia.

Contrary to the general expectation, the observed nest densities in the natural forest steppe and natural steppe were not very high compared to natural meadow. But it should be mentioned that the detection of nests in natural condition in the first two vegetation types is not so easy because of dense vegetation cover. A better methodology should be employed to estimate the biomass of ants in such habitats.

Most of the ant species coexisted well in close vicinities except for *Lasius gebaueri* that was aggressive and did not allow other species to construct their nests within its vicinity. At present the resource partitioning among the species concerned is not known since the food preference of each species has not been precisely documented. At least some larger species seemed to tolerate smaller species at baits. Direct observations on species interaction are needed in the field to reveal the mechanism of the coexistence of particular species.

The absence of ant species at elevations above 2500 m alt. might be due to low temperature and strong winds, both of which would not permit their distributions at high altitudes in Mongolia. As ants are thermophiles (Hölldobler & Wilson 1990), which react negatively to low mean annual temperatures, the cold climate seems to be a major factor working against the thriving of certain ant genera in Mongolia. More forested areas are found in northern parts of Mongolia, whereas these areas have very cold climates. On the other hand warmer southern parts are mostly deserts and semi-deserts. All this has limited the number of ant species in Mongolia.

According to similarity analyses of the ant faunas of various phytogeographical regions in Mongolia, three main groups can be distinguished. The “forest-steppe” group encompasses the Khentii, Mongolian Dauria, Khangai, Middle Khalkh, Eastern Mongolia and Great Khyangan regions. The “steppe-semidesert” group includes the Khovd, Depression of Great Lakes, Mongolian Altai, Valley of Lakes, Eastern Gobi, Gobi Altai and Trans-Altai Gobi regions. The “desert” group consists of the Alashan Gobi and Dzungarian Gobi regions.

The ant fauna of the whole Mongolia shares a relatively few species with those of the surrounding regions as balanced with the total number of species in compared regions or countries; hence the estimated faunal similarity was very low. The Russian Far East and Gansu Province of China show the highest similarity with the Mongolian ant fauna. Japan and Iran have the lowest faunal similarity with ants of Mongolia. But forested areas in eastern Mongolia should be more intensively surveyed because they may have more species that are found in Inner Mongolia through Korean Peninsula to Japan.

We excluded the exotic species *Monomorium pharaonis* (Linnaeus, 1758) from the species list of Mongolian ants. This species is distributed nearly all over the warmer parts of the world, mainly through human activities. In Mongolia it has been found only in a human settlement in northcentral part, and not in natural habitats.

Concerning the faunal composition of ants in the whole Mongolia, two major subfamilies, Formicinae and Myrmicinae, comprise more than 95% of total recorded species, while another subfamily, Dolichoderinae is represented by only three species. Almost half of the recorded species in Mongolia belong to the genera *Formica* and *Myrmica*. Five other genera contain four or more species: *Camponotus* (5 spp.), *Lasius* (7 spp.), *Proformica* (5 spp.), *Temnothorax* (4 spp.) and *Tetramorium* (4 spp.). Together, the seven most diverse genera constitute nearly 81% of the ant species known from Mongolia, while other genera, such as *Cardiocondyla*, *Cataglyphis*, *Crematogaster*, *Dolichoderus*, *Harpagoxenus*, *Leptothorax*, *Messor*, *Plagiolepis*, *Polyergus* and *Tapinoma* represent much smaller proportions of the fauna. Ponerinae are completely missing (only one winged queen of *Ponera* was collected in a restaurant in Ulaanbaatar). The tendency is completely the same as in northcentral and northeastern parts of the country, and similar patterns are found in other arid Asian regions, e.g. eastern Kazakhstan and western Siberia.

The seven ant species found in Mongolia are listed as threatened species in the Red List of the International Union for Conservation of Nature. Thus, *Harpagoxenus zaisanicus*, *Lasius reginae* and *Polyergus nigerrimus* are categorised as Vulnerable species, whereas *Formica aquilonia*, *F. lugubris*, *F. pratensis* and *F. uralensis* are treated as Near-threatened species (IUCN 2012). In order to conserve Mongolia's biodiversity, reducing the pressure by heavy grazing may be most important. Objective estimates of populations of the above-mentioned species will provide useful data to more precise measures of conservation.

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Appendix 1. Ant species and their distributions in different phytogeographical regions of Mongolia.

No	Species name	KHU	KHE	KHA	MD	GKH	KHO	MA	MKH	EM	DGL	VL	EG	GA	DZG	TAG	AG
1	*Camponotusaterrimus* Emery, 1895	1	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0
2	*C. sachalinensis*Forel, 1904	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0
3	*C. saxatilis*Ruzsky, 1895	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
4	*C. tashcumiri*Tarbinsky, 1976	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
5	*C. turkestanus* André, 1982	0	0	0	1	0	0	1	0	0	1	0	1	1	1	1	0
6	*Cardiocondylakoshewnikovi*Ruzsky, 1902	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0
7	*Cataglyphisaenescens* (Nylander, 1849)	1	0	1	0	0	1	1	1	0	1	1	1	1	0	1	0
8	*Crematogastersubdentata*Mayr, 1877	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
9	*Dolichoderussibiricus*Emery, 1889	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
10	*Formica aquilonia* Yarrow, 1955	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
11	*F. candida* Smith, 1878	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0
12	*F. clara*Forel, 1886	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0
13	*F. clarissima* Emery, 1925	0	1	1	1	1	0	0	1	0	1	0	1	1	0	0	0
14	*F. cunicularia*Latreille, 1798	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0
15	*F. exsecta*Nylander, 1846	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
16	*F. forsslundi*Lohmander, 1949	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0
17	*F. kozlovi*Dlussky, 1965	1	1	1	1	0	1	0	1	0	1	0	1	1	0	1	0
18	*F. lemani*Bondroit, 1917	0	1	1	1	0	1	1	0	0	1	1	0	1	1	0	0
19	*F. lugubris*Zetterstedt, 1838	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
20	*F. manchu* Wheeler, 1929	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0
21	*F. orangea*Seifert & Schultz, 2009	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
22	*F. pisarskii*Dlussky, 1964	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0
23	*F. pratensis*Retzius, 1783	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
24	*F. pressilabris*Nylander, 1846	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
25	*F. sanguinea*Latrielle, 1798	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0
26	*F. subpilosa*Ruzsky, 1902	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0
27	*F. truncorum*Fabricus, 1804	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0
28	*F. uralensis*Ruzskyurale, 1895	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0
29	*Harpagoxenuszaisanicus*Pisarski, 1963	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0
30	*Lasiusdistinguendus* (Emery, 1916)	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

31	*L. fuji*Radchenko, 2005	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
32	*L. gebaueri* Seifert, 1992	0	1	1	1	0	0	0	1	0	0	0	1	1	0	0	0
33	*L. niger* (Linnaeus, 1758)	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0
34	*L. obscuratus*Motschulsky, 1866	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
35	*L. przewalskii*Ruzsky, 1915	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
36	*L. reginae* Faber, 1967	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
37	*Lepthothoraxacervorum* (Fabricius, 1793)	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
38	*L. muscorum* (Nylander, 1846)	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0
39	*Messoraciculatus* (Smith, 1874)	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
40	*M. excursionis*Ruzsky, 1905	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
41	*Myrmicaangulinodis*Ruzsky, 1905	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
42	*M. arnoldii*Dlussky, 1963	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
43	*M. commarginata*Ruzsky, 1905	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
44	*M. divergens*Karavaiev, 1931	0	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0
45	*M. eidmanni*Menozzi, 1930	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0
46	*M. forcipata*Karavaiev, 1931	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0
47	*M. kamtschatica*Kupyanskaya, 1986	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	*M. kasczenkoi*Ruzsky, 1905	0	1	1	1	0	1	0	1	0	1	0	1	0	0	0	0
49	*M. koreana*Elmes, Radchenko et Kim, 2001	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0
50	*M. lobicornis*Nylander, 1846	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
51	*M. pisarskii*Radchenko, 1994	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0
52	*M. ruginodis*Nylander, 1846	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	*M. sulcinodis*Nylander, 1846	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
54	*M. transsibirica*Radchenko, 1994	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	*Plagiolepismanczshurica*Ruzsky, 1905	0	0	0	1	0	0	0	1	0	0	0	1	1	0	1	0
56	*Polyergusnigerrimus*Marikovsky, 1963	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
57	*Proformicabuddhaensis*Ruzsky, 1915	0	1	1	1	0	1	0	1	0	1	0	1	0	0	0	0
58	*P. coriacea*Kuznetsov-Ugamsky, 1927	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
59	*P. jacoti* (Wheeler, 1923)	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0
60	*P. kaszabi*Dlussky, 1969	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0
61	*P. mongolica* Emery, 1901	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0
62	*Tapinomaorthocephalum*Stitz, 1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
63	*T. sinense* Emery, 1925	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

64	*Temnothoraxkaszabi* (Pisarski, 1969)	0	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0
65	*T. melleus* (Forel, 1904)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
66	*T. mongolicus* (Pisarski, 1969)	0	1	1	1	0	0	0	1	1	1	0	1	0	0	0	0
67	*T. nassonovi* (Ruzsky, 1895)	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0
68	*Tetramoriumarmatum*Santschi, 1927	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
69	*T. concaviceps*Bursakov, 1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
70	*T. inerme*Mayr, 1877	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
71	*T. tsushimae* Emery, 1925	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1

Refer to “Study area” subsectionfor abbreviations of the names of phytogeographical regions.