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Family of Ground Beetles (Coleoptera, Carabidae) in the Arctic Fauna: Communication 1

Yu. I. Chernov, K. V. Makarov, and P. K. Eremin

Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, 117071 Russia
Moscow Pedagogical State University, Moscow, 129278 Russia

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Abstract—Ground beetles are a group of insects most successfully occupying tundra landscapes. Their share in the fauna of Coleoptera is much higher in tundra, than in other natural zones. In Eurasia, about 90 carabid species have been recorded from tundra and about 170 from the tundra and forest-tundra combined. The potential carabid fauna of the whole Arctic in the broadest limits is estimated to comprise 240–300 species, which constitutes 0.6–0.8% of the total number of species in this family. The number of proper arctic species cannot be precisely determined as yet, but it is in any case no less than 35. The list of arctic, and tending to Eurasian Arctic, ground beetles includes 67 species. The northern limit of the family distribution almost coincides with the latitude 76° N. Ground beetles are absent from polar deserts. The number of species in local faunas within the tundra zone is closely correlated with the average July temperature. The spectrum of life forms is characterized by the absence of specialized types, small number of geobionts, and relatively high share of epigeobionts. Typical carnivorous and some polyphagous species capable of phytophagy appeared to be most successful in tundra conditions. Specific features of the latitudinal (zonal) and meridional (sectoral) distribution of carabids in the tundra zone are discussed.

The decrease in the diversity of the fauna at high latitudes varies widely between taxa. Some of them retain considerable species diversity and demonstrate clear evidence of biological progress in arctic landscapes. An example of such a group is the family Carabidae. The increase in their role in tundra communities correlates well with the rising share of carnivores in the fauna from equator to poles (Chernov, 1992). A high share of predacious insects, carabids among them, was recorded as a characteristic feature of the arctic insect fauna as early as in 1938 by Kuznetsov (1938). Undoubtedly, studying the structure of taxa forming the core of the arctic fauna and reflecting, in their distribution, the global trends of the biota is of special interest. This paper is a continuation of a series of publications by the Laboratory of Synecology, Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, analyzing the taxonomic composition of different groups in the arctic insect fauna (Lantsov and Chernov, 1987; Chernov *et al.*, 1993; Chernov, 1995a; Khruleva and Korotyaev, 1999; etc.). This paper is based on the available publications, mainly concerning the Eurasian sector of the Arctic, field research of the authors, and examination of collections deposited at the Zoological Institute, Russian Academy of Sciences, and Zoological Museum, Moscow State University, and those supplied by T.R. Andreeva (Yamal Peninsula), A.B. Babenko (Taimyr and other regions), V.I. Bulavintsev (Novosibirsk Islands, Severnaya Zemlya), E.M. Veselova (Yamal Peninsula), K.Yu. Es'kov (Taimyr, Putorana Plateau), R.I. Zlotin (Chukotka Peninsula), Yu.I. Korobeinikov (Yamal), V.I. Lantsov (Taimyr), O.L. Makarova (shore of Lake Taimyr, Putorana Plateau, upper Nizhnyaya Agapa River), O.A. Khruleva (Wrangel Island, Taimyr), and A.I. Tsybul'skii (Ust'-Lenskii Nature Reserve). Some important data on the distribution of arctic carabids were supplied by D.E. Lomakin (Tyumen'), R.Yu. Dudko (Novosibirsk), and A.E. Brinev (Moscow).

The field research by Yu.I. Chernov has been performed since 1957 in different regions of the tundra zone from the Yugorskii Peninsula and Bol'shezemel'skaya Tundra to Gulf of Anabar, mainly in Taimyr: Dikson Town and to the south of it, in the basins of the Ragozinka and Efremovka Rivers; in the lower sections of the Uboinaya and Lenivaya Rivers; on the shore of Marii Pronchishchevoi Bay; in the basin of Syradasai; near Tareya Village (lower Pyasina River), Kresty (upper Pyasina), and also in the American sector of the Arctic (Alaska, Devon and Ellesmere Islands). The faunistic data obtained in these studies have been published in part (Chernov, 1964, 1966, 1973, 1978a, etc.).

P.K. Eremin performed field observations from 1988 till 1993 in the Kanin Peninsula, basins of the Oma and Pechora Rivers, Yugorskii Peninsula (Kartaikha, Amderma, Ust'-Kara), S Yamal (basin of the Shchuch'ya River, Salekhard), Taimyr (Lake Taimyr, Logata, Novorybnoe, Khatanga), and in the lower Kolyma. This material was partly included in taxonomic publications (Eremin, 1990, 1998, etc.).

The authors are based in providing the species characteristics, calculating the ratios between faunal components, and correlating these with elements of the environment on this very extensive material, which cannot be cited entirely in a journal paper. The main faunistic material, including an annotated list of arctic Carabidae, will be published in subsequent papers.

The scheme of zonal and subzonal subdivision of the Arctic, used in the paper, has been repeatedly described in previous publications (Chernov, 1978a, 1985; Chernov and Matveyeva, 1979, 1997).

Share of Carabids in the Arctic Insect Fauna

Judging from the approximate calculations based on "Opredelitel' nasekomykh..." (1965), the obligatory and facultative predators constitute about a quarter of the total number of species of Coleoptera in the temperate zone. The share of carabids among them is about 36%. In total, the family Carabidae comprises almost 10% of species in the order. In the arctic fauna, zoophages (in a broad sense) constitute more than half of the coleopteran fauna, most of them being carabids.

Danks (1981) recorded 185 beetle species from arctic America, with about 125 predators included and 85 carabids among these. Khruleva (1987) found 53 beetle species in Wrangel Island, with 30 predators and conventional predators included and 17 carabid species among them. The ratios in local faunas are no less indicative. Near mouth of Tareya, a tributary of the Pyasina River (subzone of typical tundra), 30 beetle species occur, including about 15 carabids (Chernov, 1978a). Farther northwards, in the lower Uboinaya River (arctic tundra), 9 beetle species have been recorded, with 4 carabids among them. In the northernmost parts of the tundra zone, Coleoptera are usually represented mainly by Carabidae, together with a few species of Dytiscidae, Staphylinidae, sometimes Chrysomelidae, Curculionidae, Catopidae, etc. On the whole, carabids constitute more than a third of the beetle species in the tundra zone. Their share is even higher among the arctic species proper of this order.

In the Arctic, the Carabidae surpass other beetle families in the integrated characteristics of biological progress, such as taxonomic and ecological diversity, cenotic importance, colonization of biotopes, and lansdcape-zonal distribution (Chernov, 1978a). Of particular role is the presence of the examples of very extensive adaptive radiation of superspecies taxa in the tundra conditions (see below) within the family. Most of the beetles inhabiting zonal communities of flat interfluves are carabids (Chernov, 1966, 1978a). Only Staphylinidae can to some extent compete with Carabidae in colonization of flat interfluves in the tundra zone.

High adaptive abilities of the Carabidae in the Arctic are especially pronounced as compared with those of the largest beetle families, Chrysomelidae and Curculionidae, representing in the arctic fauna the main part of phytophagous and the most advanced groups of Coleoptera. In high-latitude landscapes, the family Carabidae is represented by a number of species about 3 times that of these two families combined. Danks (1981) recorded from arctic America 13 species of Chrysomelidae, 14 species of Curculionidae, and 85 species of Carabidae. A total of about 40 species of Chrysomelidae have been recorded from the Arctic. Only 4 of them are undoubtedly arctic, and no more than 9 can be included in the arctic complex taken in a very broad sense (Chernov *et al.*, 1993). The number of typical arctic species of carabids cannot be determined precisely as yet, but in any case it is no less than 35 (see Communication 2).

Clearly, these ratios strongly vary between different sectors of the Arctic, depending on historical, landscape, climatic, and cenotic factors. So, the chrysomelid and curculionid species diversity in NE Asia, including Wrangel Island, much exceed that in other regions of the Arctic and, in total, is comparable with the taxonomic diversity of carabids (see, e.g., Khruleva, 1987; Khruleva and Korotyaev, 1999). This is most likely correlated with the wide distribution in this sector of the so-called tundra-steppe communities characterized by increased diversity of phytophages.

It is well known that the order Coleoptera is the largest in the class Insecta, constituting about 40% of the world insect fauna. In the arctic insect fauna, its share decreases to 13%, and precedence is taken by the Diptera constituting about 50% of insect species (Chernov, 1995a, 1995b). At the same time, when the diversity and role in biocenoses of the tundra zone are compared at the level of insect families, it appears that

Table 1. Number of species recorded from northern landscapes of Eurasia and America (after Lindroth, 1966, 1968, 1992; Danks, 1981; Kryzhanovskij, 1983; Kryzhanovskij *et al.*, 1995; the authors' material)

Genus	Eurasia			America
	tundra zone and forest-tundra	tundra zone	subzone of arctic tundra	tundra zone and forest-tundra
Carabus	16	7	1	4
Cychrus	1	0	0	0
Nebria	3	2	0	4
Pelophila	1	1	1	1
Notiophilus	6	4	1	2
Blethisa	2	1	0	1
Diacheila	2	2	2	1
Elaphrus	5	3	0	2
Loricera	1	0	0	1
Dyschirius	6	2	0	1
Miscodera	1	0	0	0
Trechus (Epaphius)	1	0	0	0
Bembidion	35	18	1	20
Patrobus	2	1	0	1
Poecilus	3	2	0	1
Pterostichus	44	34	9	29
Agonum	11	4	0	3
Calathus	1	0	0	0
Amara	13	5	2	5
Curtonotus	5	4	2	5
Trichocellus	2	1	0	1
Cymindis	4	0	0	1
Total number of species	165	91	19	83

carabids rank with Tenthredinidae (Hymenoptera), Noctuidae (Lepidoptera), and Tipulidae (Diptera), which are examples of the most successful colonization of the Arctic. Undoubtedly, analysis of the taxonomic structure, adaptive traits, and ranges of such groups largely contributes to clarifying the ways of colonization of tundra by insects.

Number of Species and the Distribution Limits

More than 90 carabid species of 16 genera have been recorded from the territory of the Eurasian tundra zone (Table 1). About 170 species have been recorded from the Eurasian Arctic in broader sense, i.e., in arctic and subarctic landscapes including forest-tundra; this is evidently below the actual number. In all probability, this number should be increased to no less than 200. Data on various groups of insects testify that every species widespread in the taiga belt can occur in forest-tundra. Taking into account the small width of this transitional, ecotone landscape and its varying latitudinal position (in Eurasia the shift in zonal boundaries reaches 4°), any species of its fauna can be considered a potential inhabitant of southern variants of the tundra landscapes.

According to our interpretation of Danks's (1981) data, 65 carabid species have been recorded from the American sector of the tundra zone, and, when combined with the forest-tundra territories, about 85 species, which constitutes about 10% of the arctoboreal-forest belt fauna of America (see Danks, 1979). The broader taxonomic diversity of the Palaearctic arctic fauna is attributable to a greater landscape variety and

Table 2. Number of carabid species in local faunas of the Taimyr Peninsula (the authors' material)

Locality	Zonal position	Average July temperature, °C	Carabini	Elaphrini	Bembidiini	Pterostichini	Zabrini	Total number of species
Marii Pronchishchevoi Bay	Northern belt of arctic tundra	4.0	0	0	0	2	1	3
Uboinaya River, lower section	Middle belt of arctic tundra	4.5	0	0	0	2	1	3
Dikson Town	Southern belt of arctic tundra	5.0	0	0	1	5	1	9*
Northern shore of Lake Taimyr	Boundary between typical and arctic tundra	7.0	0	0	1	5	2	8
Ragozinka River	Boundary between typical and arctic tundra	7.5	1	1	2	4	1	11*
Tareya Village	Northern belt of typical tundra	8.5	1	2	2	8	2	16*
Lake Logata	Northern belt of typical tundra	9.5	1	1	1	7	2	13
Novorybnoe Village	Southern tundra	10.5	1	3	2	7	2	15
Nizhnyaya Agapa River, upper section	Southern tundra	11.0	1	1	2	8	2	21
Lukunskaya River	Southern tundra	11.5	1	4	7	19	6	43
Khatanga Village	Forest-tundra	12.5	4	6	8	19	10	59

* Based on data of long-standing collecting.

vast continental territory. Faunogenetic reasons must not be ruled out, either.

Based on our own and published data and also on collections, we estimate the circumpolar carabid fauna of the tundra zone (without forest-tundra) to comprise about 160 species, which constitutes about 0.4–0.6% (depending on an estimation of the total species number) of the world fauna. The total diversity of the arctic carabid fauna in the broadest sense, i.e., with all records from forest-tundra regions and those from southern parts of the tundra zone included, may be estimated at 240–300 species, which constitutes 0.6–0.8% of the world fauna of the family.

In continental regions of Eurasia, the number of carabid species sharply decreases from forest-tundra to the subzone of arctic tundra (Table 2). Local forest-tundra faunas usually comprise more than 60 species. Clearly, the regional faunas are more diverse. For example, a thorough collecting by T.R. Andreeva and E.M. Veselova in the middle course of Shchuch'ya River in the Yamal Peninsula revealed 85 species, with 103 species found over the entire S Yamal, including tundra, forest-tundra, and, partly, northern-taiga areas (Andreeva and Eremin, 1991).

In the subzone of southern tundra, each local fauna comprises about 30–50 species; for the subzone of typical tundra, most characteristic figures are 10–20 species. In the subzone of arctic tundra in Taimyr, we found only 10 carabid species, with 3–4 species in each particular locality. At the same time, the diversity and composition of regional and local faunas may strongly vary within each subzone (see below).

Carabids usually do not penetrate into the zone of polar deserts. They have not been recorded from Franz Josef Land, Severnaya Zemlya (Bulavintsev and Babenko, 1983), and flat interfluve areas of Cape Chelyuskin (Chernov *et al.*, 1979). In the American sector of the Arctic, carabids have not been found in N Ellesmere Island (Oliver, 1963; our observations), Bathurst Islands (Danks, 1980), and Ellef Ringnes Island (McAlpine, 1965) with landscapes of polar-desert type. Thus, as regards the penetration into the highest-latitude landscapes, carabids are inferior to many groups of Diptera, Lepidoptera, and Hymenoptera, and also to the two families of Coleoptera (Staphylinidae and Dytiscidae) represented by 1–3 species in the listed islands. Even few specimens of Chrysomelidae (*Chrysolina subsulcata* Mnnh.) have been found in Severnaya Zemlya (Chernov *et al.*, 1993; collected by V.I. Bulavintsev and O.L. Makarova).