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Circumpolar diversity of spiders: implications for research, conservation and management

Yuri M. Marusik[1)] & Seppo Koponen[2)]

[1)] *Institute for Biological Problems of the North, Russian Academy of Sciences, Portovaya Str. 18, Magadan 685000, Russia*
[2)] *Zoological Museum, Centre for Biodiversity, University of Turku, FIN-20014 Turku, Finland*

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The number of spider species found in faunas north of 60°N varies from 250 (Polar Urals) to 620 (Finland). Faunal lists allow for comparison of the most interesting and important areas of species diversity. Only two areas, divided by the Beringian Strait, namely northeast Siberia and northwest North America have marked proportions of endemic spider taxa. There are still some areas in Eurasia which can be regarded as unstudied "white spots". Investigations are especially required in west Siberia, northwest Yakutia and in northern parts of the Verkhoyanski and Cherski Mountain ranges. High levels of endemism, together with rather high species diversities in NE Siberia (550 spider species) and NW Nearctic (about 500 species) in spite of inadequate levels of investigation show a high necessity of further studies and conservation, at least in NE Siberia.

Introduction

Spiders (Arachnida: Araneae) comprise one of the largest orders of animals, preceded only by the insect orders Coleoptera, Hymenoptera, Lepidoptera, Diptera and "Hemiptera." Almost 40 000 spider species are known so far (Platnick 1999). Spiders have a worldwide distribution, missing (as living organisms) only in the Antarctic. Spiders are one of the best objects to study and monitor species diversity in terrestrial ecosystems, especially at high latitudes, because of their (1) abundance in all types of biotopes, (2) high (or highest) species diversity among northern meso- and macroarthropods, (3) easy collecting methods, and (4) easy identification (for specialists).

Before the 1970s only the spider faunas of Sweden, Finland and Greenland had been more or less well-studied in northern areas. The last two decades have been marked by a considerable increase of taxonomic and faunistic publications

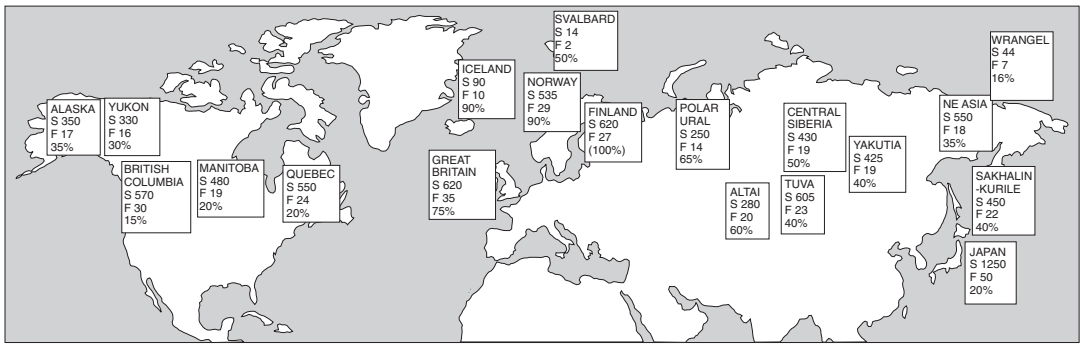

Fig. 1. Diversity of certain well-known spider faunas (S: number of spider species, F: number of families) and faunal similarity (as a percentage of jointly occurring species) between the local fauna in question and Finland.

dealing with arctic, subarctic and boreal spiders both in Eurasia and North America. The previously almost unknown faunas of the Urals, Krasnoyarsk Province, Yakutia, NE Siberia, Tuva, Yukon Territory, British Columbia, Manitoba, and Quebec have become rather well-known due to several catalogues, revisions and checklists (cf. Koponen 1996). The accumulation of knowledge on some spider faunas has been great. For example, the species number known in Yakutia has increased from 120 to 425, in NE Siberia from 36 to 550, and in Tuva from 4 to 605 species in the last twenty years. More than 300 spider species new to science have been described from the arctic and boreal zones of Asia during the last 15 years (cf. Mikhailov 1997, 1998, 1999).

Despite the markedly high level of taxonomic knowledge in the northern Holarctic, new taxa will probably be found at least in the families Linyphiidae and Lycosidae, and especially in the Beringian area. In this paper, we try to present the available knowledge of northern spider faunas and, based on that, discuss the need for research and conservation in the boreal and subarctic zones.

Analysis of mega-areas

Well-studied areas

Well-studied faunas in different parts of the northern Holarctic region are shown in Fig. 1. The Fennoscandian countries, Finland and Norway, and the British Isles are more or less well studied. Less, but still rather well studied are the faunas of Iceland, Yakutia, Magadan, the Sakhalin area, Alaska, Yukon, British Columbia, Manitoba and Quebec. Species number varies in the faunas north of 60°N, when islands are excluded, from 250 (Polar Urals) and 330 (Yukon) to 620 (Finland). The number of known families also varies considerably, being only 10 in Iceland but as high as 29 in Norway. The number of species found largely depends on the duration and intensity of study in each area, especially on the number and qualification of collectors.

We consider as well-studied a larger area where either local or foreign specialists have worked actively for some years. The spider fauna of Finland has been studied more or less actively for 150 years, while the second largest fauna of NE Siberia (NE Asia in Fig. 1) has been investigated for 15 years only. This difference in the diversity of spiders (620 vs. 550 species) is probably real, and caused by glaciation history (see below), not by insufficient study in NE Siberia. On the basis of presently known species numbers, in any larger area lying between 60°N and 70°N there seem to live up to 650 spider species.

Species richness of many invertebrate groups is enormously high in northern (northwestern) Europe. By simply extrapolating from the estimated proportions of British or Finnish insects in the expected worldwide insect fauna (*see* Hammond 1992, Platnick 1999), the number of spider species of the world can be estimated to reach 230 000–250 000. This figure is, however, too high, and more precise calculations show that the

possible worldwide number of spiders is closer to 80 000 (Platnick 1999). The great species diversity of spiders in NW Europe may be explained by the glaciation history. Contrary to NE Siberia and NE Nearctic, NW Europe was covered by ice (Flint 1971, Pielou 1991), and has been colonized relatively recently by species moving both from the south and east, and occupying vacant niches. This proposed enriching effect of the glaciation contrasts with many previous studies (e.g. Mönkkönen & Viro 1997) but for spiders, as a group of generalist predators, it may be true.

The similarities of northern faunas are shown in Fig. 1, based mainly on the data by Koponen (1993, 1996), Dondale *et al.* (1997), Koponen *et al.* (1998), Marusik *et al.* (2000) and Nabuo Tsurusaki (pers. comm.). The faunal similarity (as percentage of jointly-occurring species) between Finland (a well-studied area) and chosen circumpolar faunas varies from 90% in Northern Europe to 60% (Altai Mts) or less in Siberia, and to 15%–20% in boreal Canada. For comparison, the faunal similarity between Finland and Japan (a species and family rich area) is 20%. Faunal similarity of closely located Beringian areas, NE Siberia and NW America is only 40%; the proportion of jointly-occurring species varying between 36% and 70% in different spider families (Y. M. Marusik unpubl. data).

Extrapolating from the level of similarity between the above-discussed northern areas, the total number of spider species north of 60°N latitude could be about 1 400–1 500 species. However, when considering the faunal similarity and total species number, problems concerning the identity of many species in the huge circumpolar area must be borne in mind. For example, of the 33 species of spiders found in the low arctic Belcher Islands, Hudson Bay, the real identity of as many as eight of them (one fourth) is problematic (Koponen 1992).

Poorly studied areas

There are still some practically unstudied areas in the northern Holarctic that could be called "white spots", and which therefore require faunistic investigations. These include (Fig. 2): (1) west Siberia (from Ob to Yenisei), (2) Northwest Yakutia (from Kotui to Olenyok), (3) northern parts of the Verkhoyanski and Cherski Mountain ranges, (4) the northern part of Khabarovsk province and South Yakutia, (5) Koryakiya, and (6) western and northern Alaska.

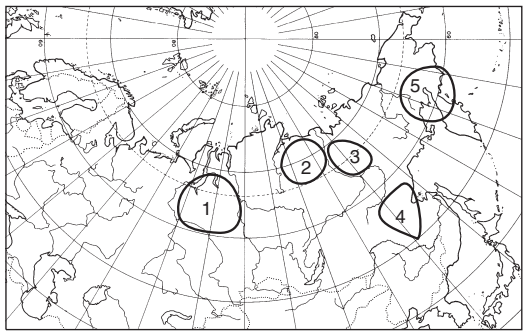

Fig. 2. Unstudied areas in northern Asia: — 1: West Siberia, — 2: Northwest Yakutia, — 3: northern Verkhoyanski and Cherski Mts, — 4: northern Khabarovsk province and South Yakutia, — 5: Koryakiya.

A very interesting area for study is the upstream area of the Indigirka River in eastern Siberia (within area 3 in Fig. 2). It is an exceptionally warm area within the boreal zone, with a thermal sum that corresponds to that of the south Siberian steppes. Here high temperature, rather northern position and existence of permafrost allow to coexist, within a few meters, a mosaic of very warm (ground temperature up to 65 °C) and very cold (less than 10 °C) microbiotopes (Alfimov 1998).

Specificity (endemism)

The percentage of endemic spider species in larger areas north of 55°N does not generally exceed 1%. The two exceptions are the areas divided by the Beringian Strait, namely NE Siberia and NW North America, which both have a higher proportion of endemic taxa (around 8%), belonging to several spider families. NE Siberia has the globally highest species diversity of Linyphiidae (as well as of several smaller taxa), the dominant spider family in northern areas (e.g. Koponen 1996). Thus it is rich both in species number and in endemics.

The high level of endemism, rather high

known (and potential) species diversity in NE Siberia (550) and NW Nearctic (500), and the inadequate level of investigation, show a high necessity for further studies and for the founding of a network of protected areas, at least in NE Siberia. These two areas will certainly contain many still undescribed and non-collected species.

Species richness in local faunas

There are rather few well-studied areas at the northern latitudes; however, some good examples can be found (Table 1). This kind of local species richness can be used as basic comparative data for nature protection, e.g. in selection of possible nature reserves.

In the arctic zone, the Wrangel Island has patches of southern tundra, and this hilly area with rather high temperatures harbours a high number (44) of spider species. In the boreal zone, the maximum diversity has been found at the southern border (Tvärminne; 425 species). In central parts of the boreal zone there are up to 350 species, and near the forest border in the north only about 150 species (Table 1). The areas of the studied localities are some hundreds of square kilometers. Two local faunas studied at comparable intensities, those of Tvärminne (Finland) and Aborigen (Kolyma River) host especially high species richness. In Aborigen not only the species number is high, but it also has the highest numbers of linyphiid spider species and endemics (Marusik 1988).

Conservation

While there is no need to protect certain individual species of spiders in the northern regions, there is a need to protect certain habitats (or diversity of biotopes; cf. Primack 1993). The situation is different in the south, for instance in the Mediterranean area and central Asia where some species may be threatened by commercial collecting due to their venoms (cf. Tarabaev 1993), or in the tropics where spiders are collected for pet animal business.

Generally, there is no reason to include small-sized invertebrates in the Red Data Books, because even experts cannot identify species without killing them. On the other hand, due to legislation, including a spider species in a Red Data Book may be a good legal step to protect its specific habitat.

It is most practical to concentrate on the protection of small selected areas (*see* e.g., Franklin 1993), as large regions can normally not be protected. The strategy for conservation of invertebrates must differ from that applied to larger animals, and have its own specific regulations and management practices. For example, it may be possible and useful to protect small sites outside Nature Parks and other reserves. In general, it is the "exotic" or rare biotopes that need protection, such as warm xerothermic sites in the north and mire areas, with "northern" environmental characteristics, in the south. Sometimes also human activity has an enriching effect on the environment and fauna, for example by forming open, dry and warm habitats in the north for

Table 1. Species number in local faunas between 60° and 82°N

Local fauna	Latitude	Number of species	Reference
Hazen Camp, Ellesmere Island	82°N	13	Leech (1966)
Isfjord, Svalbard	78°N	14	Koponen (1996)
Wrangel Island	72°N	44	Marusik *et al.* (1992)
Kevo, Finland	70°N	165	Koponen (1984)
Kuusamo, Finland	66°N	240	Koponen & Viramo (1998)
South Yamal, Russia	66°N	160	Esyunin & Efimik (1996)
Aborigen, Upper Kolyma	62°N	340	Marusik (1988)
Tvärminne, Finland	60°N	425	Palmgren (1972)

southern species. Introduction of new alien species is naturally not in our mind.

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