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Aphid fauna of arctic region of Eurasia

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Abstract: About 500 aphid species inhabit the arctic zone in Northern hemisphere. Current level of knowledge of aphid species composition is too different for certain arctic and subarctic regions. Due to numerous expeditions to the arctic region of Eurasia during the last years our knowledge of species composition of aphid fauna and its genesis has been deepened significantly. The aphid fauna of Chukotka is more similar to the fauna of North America than to that of Siberia and Europe. From the West to the East proportion of monoecious species is increased but species richness is decreased. Monophagous species are the most numerous among arctic aphids. In conditions when plant hosts are rare some aphids inhabit plants atypical for them, that can lead to genesis of new species.

Key words: severe climatic conditions, taxonomic structure, zoogeography structure, life cycles, host plant.

Introduction

The arctic territories are characterized by severe climatic conditions: low temperatures, short vegetation period (large duration of the winter period and short summer period with the long daylight phase), high humidity, strong winds (particularly on islands), etc. In spite of these extreme environmental conditions, poor floristic diversity and low taxonomic diversity of their host plants, about 500 aphid species inhabit arctic and subarctic zones in the Northern hemisphere. Until recently, level of knowledge on aphid fauna composition was too different for certain arctic and subarctic regions. The more intensively explored areas were arctic territories of North America (USA: Alaska; Canada: Yukon Territory, Northwest Territories, Nunavut) and the largest islands in the Atlantic Ocean (Greenland, Iceland). In Eurasia detailed researches on aphid fauna have been fulfilled for Fennoscandia and Kola Peninsula whereas aphid fauna of other territories was poorly known (Stekolshchikov & Buga 2009).

Results

Over the past 9 years, due to the numerous expeditions, new data on the aphids of the Arctic and Subarctic Palaearctic have been obtained (Stekolshchikov & Kozlov 2012, Stekolshchikov & Khruleva 2014, 2015, Stekolshchikov 2017, Stekolshchikov & Buga 2018). The aphid fauna is studied not only in the North West region of European Russia (Kola

Peninsula), but also in the North East region (Nenets Autonomous Region), as well as the aphid fauna of Taimyr, Chukotka and Wrangel Island.

There are significant climatic differences between the next four regions:

1. The North of Scandinavian and Kola Peninsula are washed by the warm North Atlantic Stream (the North-Eastern continuation of the Gulf Stream), which makes its climate milder than the climate of other Arctic regions of Eurasia. As a result, the plain (non-Alpine) tundra occupies only about 20% territory, forest tundra and the Northern taiga occupy the rest.

2. Nenets Autonomous Okrug is located on the Arctic coast. Its climate is formed mainly under the influence of Arctic and Atlantic air masses. The climate becomes more severe from the West to the East of the region and deeper into the continent. The northern taiga zone occupies only 8% of the territory, while the tundra occupies three quarters.

3. The Taimyr Peninsula is located in the arctic and subarctic zones, that determines the extreme severity of the local climate. The Northern taiga is completely absent here, and the forest tundra occupies only a small part of the territory. However, the tree vegetation on the Taimyr extends as far to the north as nowhere else on the Globe, to almost 73 °N (North latitude).

4. The climate of the Chukotka Peninsula is very severe due to the cold Kurile Stream. Its impact determines that the Peninsula is completely covered with tundra. The Northern limit of forest distribution in the region is displaced 10 degrees to the South, then at similar latitudes in Siberia outside Chukotka. Small coniferous forests are found very rarely in river valleys only. The high mountain (Alpine) tundra and stony semideserts and deserts occupy about a half of the territory of the Peninsula, the vegetation covers no more than a third of their area. The climate of Wrangel Island, located to the North of the Peninsula, is even more severe, with a significant influence of cyclonic activity. The frost-free period on the island usually does not exceed 20–25 days.

At present, after the studies, a total of 233 Aphidomorpha species are known from the Arctic and Subarctic regions of Eurasia.

Discussion

The taxonomic composition of aphid fauna varied among the examined regions (**Table 1**, **Fig. 1**). Species richness is decreasing from the West to the East, following taxonomic diversity of host plants, namely woody plants.

With the latter closely related aphids from such families as Adelgidae, Eriosomatidae, Lachnidae, Mindaridae and Hormaphididae (aphid taxonomic classification follows Shaposhnikov (1964) with some minimal changes). As a result, in Chukotka and Wrangel Island only Drepanosiphidae and Aphididae (s.str.) have been registered. It seems interesting that, despite the presence of shrubby willows in the territory of Chukotka, there were no species of Chaitophoridae family.

The similarity between the fauna of distant areas is low (**Table 2**). It is naturally that the fauna of the nearby territories is more similar. Nevertheless, the aphid fauna of Chukotka differs significantly from the aphid fauna of the European regions, but also Taimyr. In the aphid fauna of European territories and of the north of Central Siberia most species have a geographic distribution limited to the Palaearctic, herewith the proportion of Palearctic species increases from the West to the East, while Holarctic and non-Arctic species decrease (**Fig. 2**). A larger proportion of these species in the west of the Northern Europe may be explained by some connections of the European and North American fauna through the large

Table 1. Number of species and taxonomic structure of aphid fauna of different Arctic regions of Eurasia.

Families	Arctic and subarctic zones of Eurasia	Lapland	Nenets Autonomus Region	Taymyr	Chukotka and Wrangel Island
Adelgidae	9 (3.9%)	9 (4.7%)	1 (1.7%)	1 (2.05%)	0
Eriosomatidae	8 (3.4%)	8 (4.1%)	2 (3.3%)	1 (2.05%)	0
Lachnidae	16 (6.9%)	15 (7.7%)	3 (5.0%)	3 (6.1%)	0
Mindaridae	1 (0.4%)	1 (0.5%)	0	0	0
Hormaphididae	1 (0.4%)	1 (0.5%)	0	0	0
Drepanosiphidae	21 (9.0%)	17 (8.8%)	6 (10.0%)	7 (14.3%)	3 (14.3%)
Chaitophoridae	10 (4.3%)	10 (5.2%)	0	3 (6.1%)	0
Aphididae	167 (71.7%)	133 (68.5%)	48 (80.0%)	34 (69.4%)	18 (85.7%)
Aphidomorpha generally	**233 (100%)**	**194 (100%)**	**60 (100%)**	**49 (100%)**	**21 (100%)**

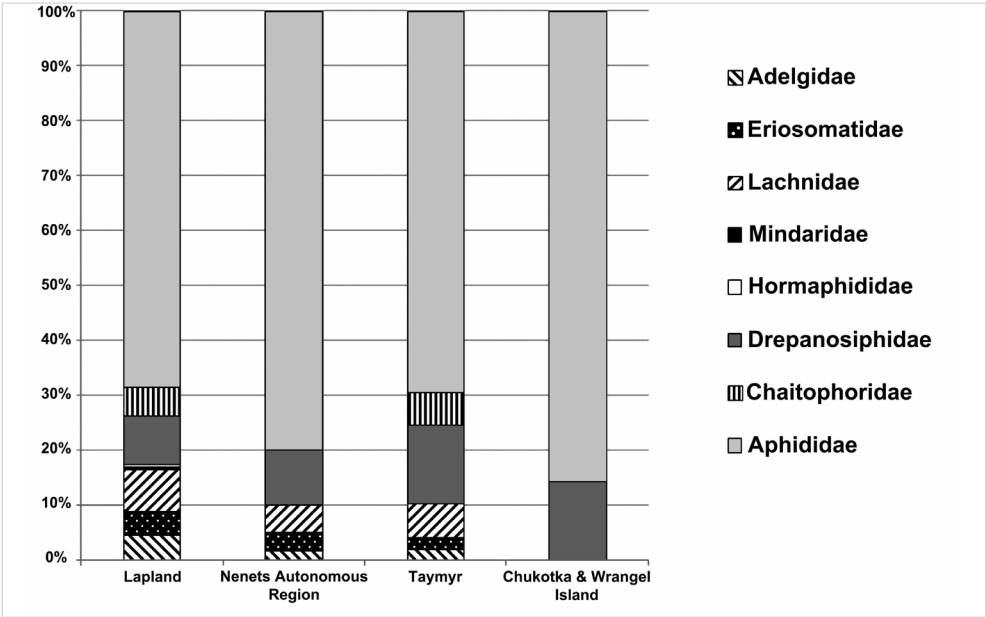

Fig. 1. The taxonomic structure of aphid fauna of the Arctic regions of Eurasia Regions.

islands of the Atlantic Ocean. Another situation is in the North of Far East of Eurasia. About a half of the aphid fauna of Chukotka and Wrangel Island consists of species with distribution on the American continent. This allows us to suppose that in the genesis of the aphid fauna of the North of Eurasia, the occupation of the European and Siberian North was conditioned by the expansion from the West to the East. At the same time, Chukotka and the adjacent territories were either colonized by aphid species from the North American continent or the center of aphid speciation was located here, and the similarity of the fauna of Chukotka and

Table 2. Jaccard similarity index for aphid fauna of the Arctic and Subarctic regions of Eurasia.

	Kola Peninsula	Nenets Autonomous Region	Taimyr	Chukotka & Wrangel Island
Kola Peninsula	1.00			
Nenets Autonomous Region	0.24	1.00		
Taimyr	0.15	0.21	1.00	
Chukotka & Wrangel Island	0.04	0.08	0.04	1.00

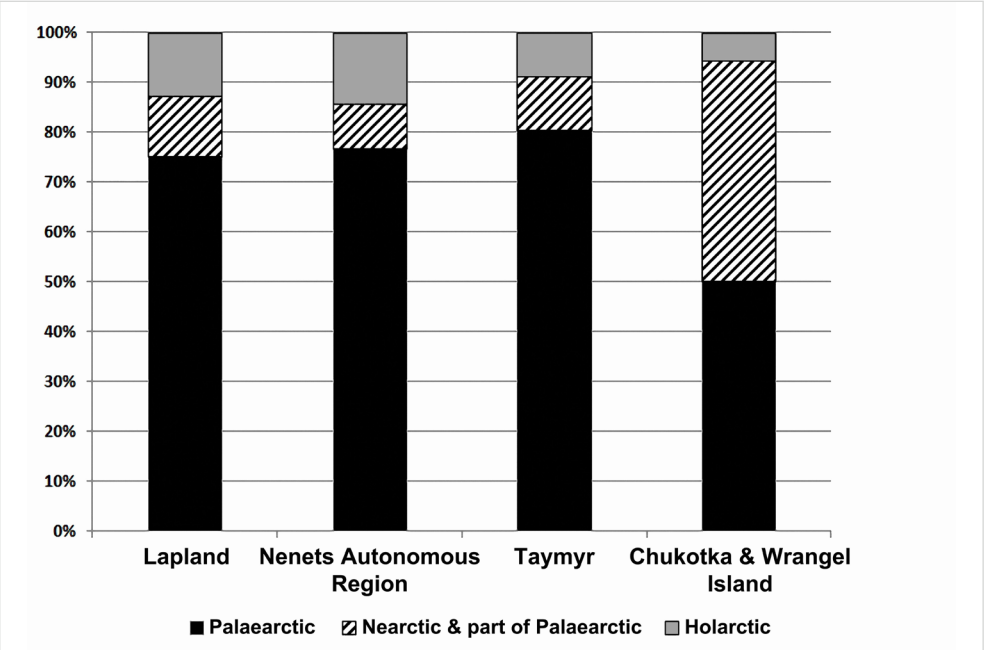

Fig. 2. The zoogeographical structure of aphid fauna of the Arctic regions of Eurasia.

North America is determined by their expansion into the North American continent.

The Arctic and Subarctic regions are characterized by a large number of species inhabiting semishrubs, mainly from the order Ericales. In Lapland (Scandinavian and Russian) the majority of species inhabit wood plants throughout or during part of the life circle (**Table 3**). This proportion decreases from the West to the East and in Chukotka the species richness of herbobionts is three times larger than the richness of dendrobionts, dioecious species are absent completely. Undoubtedly, this correlates with a significant decrease in the species richness of woody plants in the Eastern Arctic regions of Eurasia, as well as a short summer, for which aphids do not have time to make migration and remigration.

The species richness of monoecious species is higher everywhere than that of dioecious (**Fig. 3**). In Taimyr, Chukotka and Wrangel Island anholocyclic aphid species haven't been registered, apparently because of the severe climate. It is necessary to keep in mind that in

Table 3. Number of species in aphid fauna of Arctic regions of Eurasia connected with different type of host plants and having different type of life cycles.

Primary host plants	Secondary host plants	Lapland	Nenets Autonomous Region	Taimyr	Chukotka & Wrangel Island
Woody plants		53	11	16	5
Semishrub		16	7	2	0
Herbaceous plants		83	30	22	14
Woody plants	Woody plants	8	0	2	0
Woody plants	Herbaceous plants	29	11	6	1
Semishrub	Herbaceous plants	1	0	0	0
Woody plants & herbaceous plants		1	1	0	0
Unknown		1	0	1	1

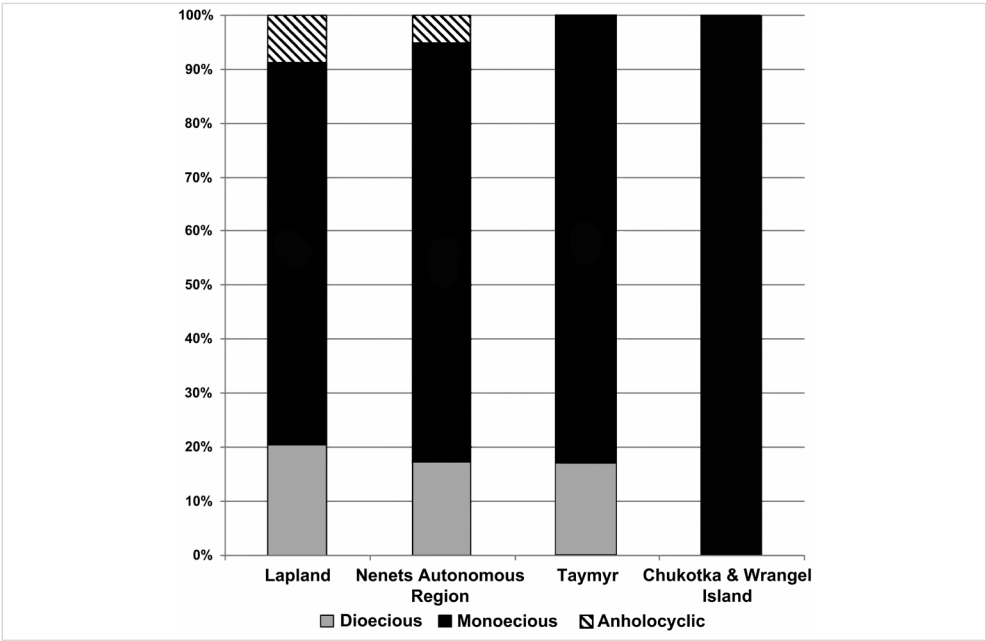

Fig. 3. The proportion of species having different types of life cycles in aphid fauna of the Arctic regions of Eurasia.

Lapland a significant part of anholocyclic species is found only indoor and is not able to overwinter outdoor.

Monophagous species consist about two third of the total number of aphid species (**Fig. 4**), possibly due to the greater benefit of deeper adaptation to the host plant in severe conditions. But the largest proportion of polyphagous species is in the aphid fauna of Chukotka, where the flora is poor and the number of specimens of each vascular plants species is extremely low. Polyphagy may be considered as an adaptation to low taxonomic richness of host plants in tundra.

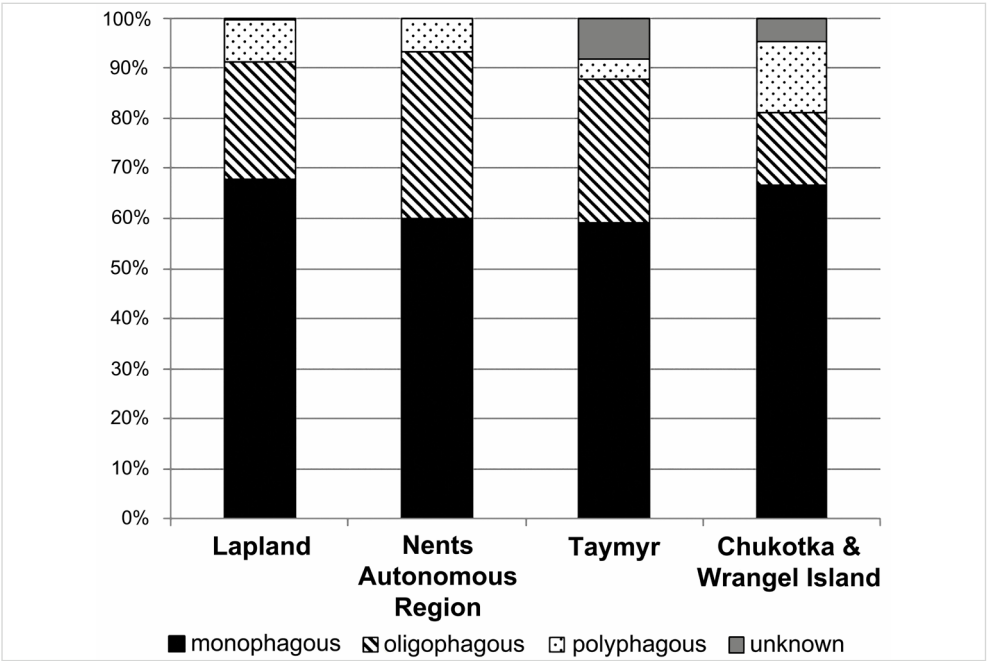

Fig. 4. The proportion of species having different range of host plant in aphid fauna of the Arctic regions of Eurasia.

Despite the considerable specificity of the climatic conditions of these areas, the proportion of endemic species is relatively small (7.62% of the total number of species). This can be explained by the fact that aphids are very strongly associated with their host plants, adaptation to which is more important for them than adaptation to other environmental factors. As a result, endemic species of aphids could be formed on endemic plants, but the Arctic flora is relatively young and does not have a wide range of endemic species (Tolmachev & Yurcev 1970). At the same time, the aphids formed within the Arctic areas on plants which are not endemic and could easily spread to more southerly areas with a milder climate. Possibly this is true for *Nasonovia* (*Kakimia*) *dzhetisuensis* Kadyrbekov, 1995. Currently the species is known only from two territories: the first is the Northern Tien Shan and the Dzhungar Alatau and the second is Nenets Autonomous Okrug. The shortened life cycle of this species makes it possible to assume its Northern origin and subsequent distribution to the South, although the formation of this species in the high-altitude regions of Central Asia is also possible, with the subsequent extension to the North in a territory with similar high mountain conditions.

A similar situation is observed with *Macrosiphum chukotense* Stekoshchikov et Khruleva, 2015. This species was described from Chukotka. It is morphologically very similar to *Macrosiphum euphorbiae* (Thomas, 1878), and differs from *M. euphorbiae* mainly in its life cycle: *M. chukotense* is a monoecious species, while *M. euphorbiae* primarily is a heteroecious holocyclic with a sexual phase on *Rosa*, although currently in majority geographic areas of the Globe it is mainly or entirely anholocyclic on secondary hosts. The groups of individuals close in morphology to *M. chukotense* were found in all overviewed Arctic territories. In Europe, the groups of individuals morphologically similar

to *M. chukotense* were registered much to the South of the subarctic zone, but their precise identification is significantly complicated by the presence in Europe of the anholocyclic form of *M. euphorbiae*. So, further research is needed to understand real distribution and taxonomic status of the both species.

There is a group of closely related species belonging to the genus *Aphis* L., the current distribution of which is limited by the Arctic zone only. Among them *Aphis aquilonalis* Stekolshchikov et Khruleva, 2015, *Aphis beringiensis* Stekolshchikov et Khruleva, 2015 and *Aphis khrulevae* Stekolshchikov et Buga, 2018. All three species differ not only from all other species of the genus *Aphis*, but also from the majority of the species of the tribe Aphidini in an almost complete absence of marginal tubercules on all segments of the body, including pronotum, I and VII abdominal tergites, i.e. those that are typical for the genus *Aphis* and the entire subtribe. *Aphis atuberculata* Hille Ris Lambers, 1955, described from Iceland and having very small and often completely reduced marginal tubercules adjoins to them. Presumably, this group is endemic for the Arctic region and has more or less circumpolar distribution.

A number of species in the North expand or change their host plant specialization. So, in the North *Amphorophora rubi* (Kaltenbach, 1843) feeds on *Rubus chamaemorus* L. while in Continental Europe on *Rubus caesius* L. and *Rubus fruticosus* L. Monoecious and holocyclic species *Acyrthosiphon knechteli* (Börner, 1950) is widely distributed from Belgium to Western Siberia and no researcher has found it on species of any plant genera other than *Vaccinium*. In contrast, the individuals are morphologically almost indistinguishable from *Acyrthosiphon knechteli*, that found in Nenets Autonomus Region on plant species belonging to 6 families and 8 genera. They form large colonies on the plants of two families both far from Ericaceae and from each other. Aphids were able to give birth to oviparous females on one of them. It is possible that such changes in host plant specialization can lead or have already led to the formation of morphologically indistinguishable or very close to the original sibling species.

The number of alien species depends on the specificity of plant growing and climatic conditions. Thus, the relatively warm climate of the Kola Peninsula allows plant growing and landscaping of settlements. There are active road and rail transport links with more southern territories. Population density is relatively high. The aphid fauna of the region contains a number of alien species (13% of the total species richness).

Communication with the rest 3 regions of Russia is possible only by air or by water transport. Population density is low. Plant growing is impossible due to severe climate. As a result, alien species of aphids are not registered here.

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