Ann. Zool. Fennici 57: 115–128 ISSN 0003-455X (print), ISSN 1797-2450 (online)
Helsinki 23 April 2020 © Finnish Zoological and Botanical Publishing Board

Stinging wasps, ants and bees (Hymenoptera : Aculeata) of the Nenets Autonomous Okrug, northern Russia

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Received 18 Feb. 2020, final version received 19 April 2020, accepted 2 Mar. 2020

Paukkunen, J. & Kozlov, M. V. 2020: Stinging wasps, ants and bees (Hymenoptera : Aculeata) of the Nenets Autonomous Okrug, northern Russia. — *Ann. Zool. Fennici* 57: 115–128.

Among Aculeata, only bumblebees (*Bombus* spp.) have long been popular targets of entomological research in the Russian Arctic, whereas the information on wasps, ants and solitary bees from this region is scarce. Sampling in the surroundings of Nary-an-Mar in the years 2013, 2015 and 2019 yielded 39 species of Aculeata, among which 27 species are for the first time reported from the Nenets Autonomous Okrug (NAO). Noteworthy findings include *Gorytes neglectus*, *Lasioglossum boreale*, *Mimumesa littoralis*, *Odynerus alpinus* and *Osmia maritima*. Combined with published information, our data increased the fauna of aculeate Hymenoptera of NAO to 61 species. We also list and discuss erroneous or doubtful records of additional 11 species. Collection localities are provided for each species. Based on comparisons with northern Finland and the Murmansk Oblast in Russia we estimate that about 60 additional aculeate species could still be found in NAO.

Introduction

Although studying invertebrates of the Arctic has become increasingly popular, particularly due to rapid climatic changes in polar regions (Coulson *et al.* 2014), still many Arctic and Subarctic areas remain poorly studied in terms of their insect fauna, and the Nenets Authonomous Okrug (hereafter NAO) is one of them. However, during the past few years, faunistic lists were published for some groups of insects found in the area (Stekolshchikov 2017, Kozlov *et al*. 2019).

While climate change is a serious threat to many Arctic specialists, it may also cause major changes in the distribution and abundance of other boreal species with more general ecological requirements. For example, Davydov and Mikhailova (2011) reported an increase in social wasps on Vaygach (site 39 in Fig. 1 and Appendix) resulting from climate warming. Since aculeates are important pollinators and predators of other insects, changes in their populations can profoundly affect Arctic ecosystems more widely. Thus, more research is needed to assess the current state of aculeates in NAO and other poorly studied Arctic regions.

Aculeates (Aculeata) comprise a monophyletic group of Hymenoptera, which includes stinging wasps, ants and bees. Within this group, bumblebees (*Bombus* spp.), which are among the most important pollinators in the tundra biome, have long been popular targets of entomological

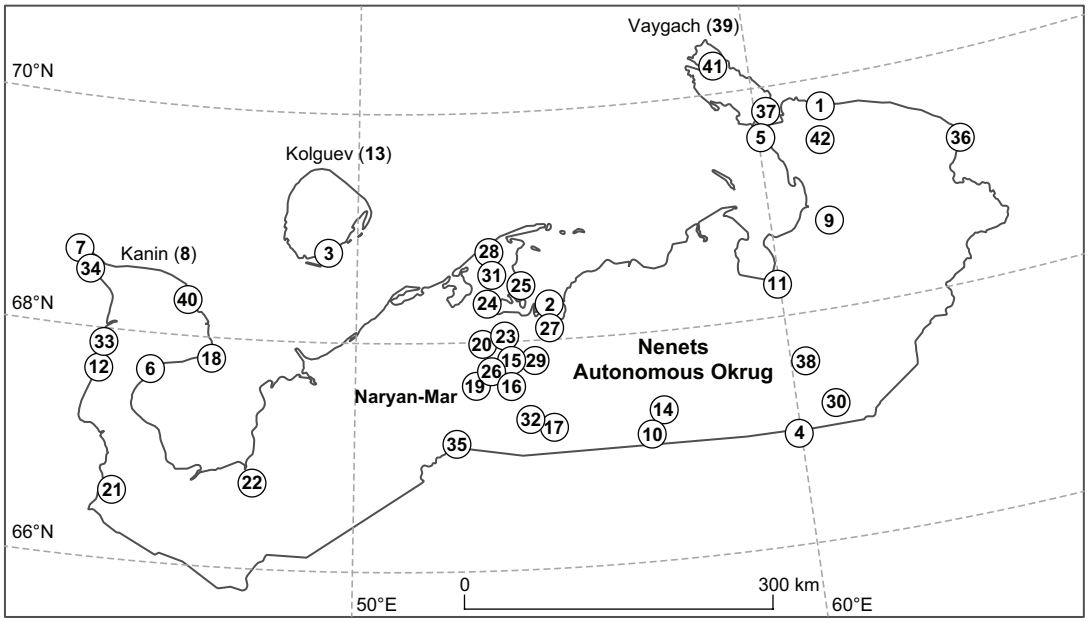

Fig. 1. Collection sites of aculeate Hymenoptera in the Nenents Autonomous Okrug. 1. Amderma (village), 2. Bolvansky Nos (peninsula), 3. Bugrino (village), 4. Foma-Yu (river), 5. Greben' (cape), 6. Gubistaya (river), 7. Kanin Nos (village), 8. Kanin (peninsula), 9. Karatayka (village), 10. Kharyaginsky (village), 11. Khaypudyrskaya Guba (bay), 12. Kiya (village), 13. Kolguev (island), 14. Kolva (river), 15. Krasnoe (village), 16. Kuya (river), 17. Malchigeity (lake), 18. Mikulkin Nos (cape), 19. Naryan-Mar (town), 20. Nelmin Nos (village), 21. Nes (village), 22. Nizhnaya Pesha (village), 23. Pechora site 1 (landmark), 24. Pechora site 2 (landmark), 25. Pechora site 3 (landmark), 26. Pechora site 4 (landmark), 27. Pechora site 5 (landmark), 28. Pechora site 6 (landmark), 29. Pechora site 7 (landmark), 30. Pymvashor (river), 31. Russky Zavorot (peninsula), 32. Shapkina (river), 33. Shoyna (village), 34. Tarkhanovo (abandoned village), 35. Toshviska (village), 36. Ust-Kara (village), 37. Varnek (village), 38. Vatyarty (lake), 39. Vaygach (island), 40. Vostochnaya Kambalnitsa (village), 41. Yangoto (lake), 42. Yugorsky (peninsula).

research in the Arctic (Chernov 1966, Martinet *et al.* 2015, 2019, Potapov *et al.* 2014, 2017, 2019, Potapov & Kolosova 2019a, Williams *et al.* 2019). In NAO, *Bombus balteatus* Dahlbom was the first species of Aculeata ever reported based on specimens collected from Vaygach in 1875 (Holmgren 1883). Two other *Bombus* species were collected from Kanin (site 8 in Fig. 1 and Appendix) by Poppius (1908), and recent works increased the number of bumblebees recorded from NAO to 21 species (Rasmont & Iserbyt 2010–2014, Potapov *et al.* 2014, 2017, Kolosova *et al.* 2016). At the same time, information on other Aculeata occurring in NAO has been limited to four solitary bee species, two ant species and seven wasp species, one of which is probably misidentified (Sintenis 1904, Osychnjuk & Kozhevnikova 1984, Ross 2000, Zryanin 2017).

Here, we report findings of species of Aculeata from the surroundings of Naryan-Mar, and critically revise all earlier records from NAO, providing the first checklist of an ecologically important group of insects from a poorly studied Arctic region.

Material and methods

Study area

The area of NAO (Fig. 1) area is approximately 177 000 km^2, with a human population of only 44 000. Three quarters of the total population lives in the town of Naryan-Mar and in a nearby Iskateley village. NAO is located in three vegetation zones: tundra (77% of the territory), forest-tundra (15%) and northern taiga forests (8%). The summer in Naryan-Mar is short, and the average temperature of July in 2010–2018 varied from 9.0 to 18.8 °C, while the mean annual tempera-

ture was –1.6 °C. A larger part of NAO belongs to the Russian border security zone, hence visiting the restricted area requires a special permit.

Field work

The specimens studied were collected between 2 and 12 July 2013 by M. V. Kozlov and V. Zverev near Naryan-Mar and from a site 10 km SEE of Naryan-Mar, between 18 July and 1 August 2015 by A. Stekolshchikov near Naryan-Mar, and between 7 and 9 June 2019 by M. V. Kozlov in Naryan-Mar.

The insects were collected by netting in the following habitats: (1) erect dwarf-shrub tundra with a dense cover of *Betula nana* (up to 80 cm tall) and several species of willows, including *Salix lanata*; (2) low-shrub tundra with a sparse cover of *B. nana* (20–30 cm tall), dwarf shrubs (*Vaccinium uliginosum*, *V. vitis-idaea*, *Arctous alpina*) and lichens (*Cladonia* spp.); (3) sedge wetlands, which include swampy areas covered by *Sphagum* mosses, sedges (*Eriophorum angustifolium*, *E. vaginatum*, *Carex paupercula*) and *Comarum palustre*, with small spots of open water, and drier areas covered by *Andromeda polifolia*, *Rubus chamaemorus* and *B. nana*; (4) downy birch (*B. pubescens*) woodland on sandy soils, sometimes with larch (*Larix sibirica*), with spots of lichens scattered among sparse filed layer vegetation consisting of *Empetrum hermaphroditum*, *Arenaria* sp., *Tanacetum bipinnatum*, *Allium schoenoprasum* var. *sibiricum* and *Campanula* sp.; (5) forest islands formed by Norway spruce (*Picea abies*), larch and downy birch, with dense understory consisting of *Juniperus sibirica*, *Lonicera pallasii*, *Rosa* sp., *Ribes rubrum* and diverse herbaceous vegetation, including *Chamenerion angustifolium*, *Veratrum lobelianum*, *Solidago virgaurea*, *Geranium sylvaticum*, *Trollius europaea*, *Rubus arcticus*, *Thalictrum minus*, *Aquilegia* sp., *Trifolium pratense*, *T. bipinnatum*, *A. schoenoprasum* var. *sibiricum*, *Clematis sibirica*, *V. uliginosum*, *V. vitis-idaea*, *Polygonum viviparum*, *Galium boreale*, *Equisetum arvense*, *Valeriana* sp. and *Linnaea borealis*; (6) relatively narrow, 10–50 m wide, meadows that extended along riverbanks and were covered primarily by *C. angustifolium*, *V. lobelianum*, *T. vulgaris*, *P. viviparum*, *Achillea millifolium*, *Filipendula ulmaria*, *Veronica* sp., *Alchemilla* sp. and *Galium boreale*. For photos of the sampling sites, consult Kozlov *et al*. (2019).

Other material

We examined materials collected in NAO by B. Poppius (deposited in MZH) and carefully searched all published data on aculeates from NAO, including papers written in Finnish and Russian. All published records were examined for reliability of identifications by the first author taking into account the distribution data and the probability of confusion between different species. The published data are from 42 localities scattered across NAO (Fig. 1 and Appendix). If several publications reported the same species from the same locality, only the oldest reference is provided in the species accounts below. The records for each species are listed in a chronological order.

Species identification

The aculeates were identified by the first author and deposited in the Finnish Museum of Natural History, University of Helsinki (MZH). The DNA barcode sequences (standard 658 base pair segments of the mitochondrial *COI* gene) of two specimens, belonging to *Bombus cryptarum* (Fabricius) and *Odynerus alpinus* von Schulthess, were produced by the Canadian Centre for DNA barcoding (CCDB). The sequences were deposited in the BOLD systems database (www.boldsystems.org; dataset https://www.doi.org/10.5883/DS-NENETS) and GenBank (www.ncbi.nlm.nih.gov/genbank, accession numbers MN942376 and MN942377).

The nomenclature of bees follows Kuhlmann *et al.* (2015), while that of other groups follow Fauna Europaea (Mitroiu 2013). For apoid wasps (or digger wasps), however, we adopted the newly revised family classification of Sann *et al.* (2018). The families and species within the families are listed in alphabetical order. Species reported for the first time from NAO are marked with an asterisk (*). Noteworthy species are

provided with brief remarks on their distribution and status.

Species recorded from NAO

Family Andrenidae

**Andrena barbilabris* (Kirby, 1802)

Material examined: Naryan-Mar, 6 July 2013, 1♀, leg. Zverev & Kozlov, 7–9 June 2019, 1♂, leg. Kozlov.

Andrena clarkella (Kirby, 1802)

Pechora site 7 (Ross 2000).

Andrena haemorrhoa (Fabricius, 1781)

Toshviska (Osychnjuk & Kozhevnikova 1984).

Andrena lapponica Zetterstedt, 1838

Pechora site 7 (Ross 2000).

Material examined: Naryan-Mar, 8 July 2013, 1♀, leg. Zverev & Kozlov; Kuya, 10 July 2013, 1♀, leg. Zverev & Kozlov.

Family Apidae

Bombus balteatus Dahlbom, 1832

Greben' (Holmgren 1883, as *B. nivalis* Dahlbom); Kanin (Poppius 1908, as *B. kirbyellus* var. *pyrrhopygus* Friese); Kanin Nos, Kharyaginsky, Karatayka (Panfilov 1984); Pechora sites 1–7 (Ross 2000); Amderma, Kolguev, Naryan-Mar (Rasmont & Iserbyt 2010–2014); Bugrino, Nes, Pymvashor, Shoyna (Potapov *et al.* 2014); Yugorsky (Potapov *et al.* 2017).

Material examined: Kiya, 1 July 1903, 2♀♀, leg. Poppius (on flowers of *Salix lanata*); Tarkhanovo, 12 July 1903, 1♀, leg. Poppius (on flowers of *Oxytropis sordida*); Vostochnaya Kambal'nitsa, 19 July 1903, 1♀, leg. Poppius (on flowers of *Pedicularis lapponica* and *Vaccinium vitis-idaea*); Kanin, 21 June–11 August 1903, 1♀, leg. Poppius.

Bombus bohemicus Seidl, 1837

Naryan-Mar, Pechora site 4 (Ross 2000); Kanin (Rasmont & Iserbyt 2010–2014); Nes (Potapov *et al.* 2014).

Bombus cingulatus Wahlberg, 1855

Amderma, Pymvashor (Potapov *et al.* 2014); Yugorsky (Potapov *et al.* 2017).

Material examined: Naryan-Mar, 6 July 2013, 1☿, leg. Zverev & Kozlov, 18 July 2015, 1☿ + 1♂, leg. Stekolshchikov, 25 July 2015, 1☿, leg. Stekolshchikov.

Bombus consobrinus Dahlbom, 1832

Pechora site 1 (Ross 2000); Kanin, Naryan-Mar (Rasmont & Iserbyt 2010–2014); Nes (Potapov *et al.* 2014).

Bombus cryptarum (Fabricius, 1775)

Gubistaya, Nelmin Nos, Krasnoe (Panfilov 1981, as *B. lucorum* (Linnaeus)); Naryan-Mar, Pechora sites 1–3, 4 and 7 (Ross 2000, as *B. cryptarum* and *B. lucorum*); Kharyaginsky (Filippov 2008, as *B. lucorum*); Amderma, Kanin, Nes (Rasmont & Iserbyt 2010–2014, as *B. lucorum*); Shoyna (Potapov *et al.* 2014, as *B. lucorum*); Pymvashor (Kolosova *et al.* 2016, as *B. cryptarum*); Yugorsky (Potapov *et al.* 2017, as *B. cryptarum pallidocinctus* Bertsch).

Material examined: Naryan-Mar, 7 July 2013, 1☿, (specimen http://id.luomus.fi/GP.92296, GenBank accession number: MN942376), 9 July 2013, 1☿, leg. Zverev & Kozlov, 7–9 June 2019, 2♀♀, leg. Kozlov.

Remarks: *Bombus cryptarum* is difficult or even impossible to distinguish morphologically from *B. lucorum*, and therefore DNA barcoding should be used for reliable identification. So far, all DNA barcoded specimens from NAO have belonged to *B. cryptarum* (Kolosova *et al.* 2016, Potapov & Kolosova 2016, this study). Based on DNA barcoded material from other regions of northern Europe, we assume that *B. lucorum* does not occur in NAO. Apparently, it has a more southerly distribution in Russia, and possibly does not even reach the Arkhangelsk Oblast (e.g. Kolosova *et al.* 2016, Potapov & Kolosova 2016; G. Potapov pers. comm.).

Bombus distinguendus Morawitz, 1869

Kanin (Sintenis 1904); Naryan-Mar (Rasmont & Iserbyt 2010–2014); Nes (Potapov *et al.* 2014).

Bombus flavidus Eversmann, 1852

Naryan-Mar, Pechora sites 1, 2, 4 and 7 (Ross 2000); Kanin (Rasmont & Iserbyt 2010–2014); Amderma, Nes, Pymvashor (Potapov *et al.* 2014); Vaygach, Yugorsky (Potapov *et al.* 2017).

Bombus hortorum (Linnaeus, 1761)

Pechora sites 1, 2 and 7 (Ross 2000); Kanin (Rasmont & Iserbyt 2010–2014); Nes, Pymvashor (Potapov *et al.* 2014).

Bombus hyperboreus Schönherr, 1809

Amderma, Bugrino, Karatayka, Varnek (Chernov 1966); Kanin, Kolguev, Naryan-Mar, Vaygach (Rasmont & Iserbyt 2010–2014); Yangoto lake (Potapov *et al.* 2014); Yugorsky (Potapov *et al.* 2017).

Bombus hypnorum (Linnaeus, 1758)

Kanin (Sintenis 1904); Nes, Malchigeity lake, Vatyarty lake (Panfilov 1984); Naryan-Mar (Rasmont & Iserbyt 2010–2014); Amderma, Pymvashor (Potapov *et al.* 2014); Yugorsky (Potapov *et al.* 2017).

Material examined: Naryan-Mar, 7–9 June 2019, 1♀, leg. Kozlov.

Bombus jonellus (Kirby, 1802)

Yugorsky (Chernov 1966); Gubistaya, Nes, Foma-Yu (Panfilov 1982); Kharyaginsky (Filippov 2008); Naryan-Mar, Pechora sites 1, 2 and 7 (Ross 2000); Amderma, Kanin, Kolguev (Rasmont & Iserbyt 2010–2014); Bugrino, Pymvashor, Shoyna (Potapov *et al.* 2014).

Material examined: Naryan-Mar, 9 July 2013, 1♂, leg. Zverev & Kozlov; Kuya, 10 July 2013, 1☿, leg. Zverev & Kozlov.

Bombus lapponicus (Fabricius, 1793)

Kanin (Sintenis 1904); Amderma, Karatayka, Russky Zavorot, Ust-Kara, Varnek (Chernov 1966); Pechora sites 1–7 (Ross 2000); Kharyaginsky (Filippov 2008); Kolguev, Naryan-Mar, Vaygach (Rasmont & Iserbyt 2010–2014); Bugrino, Nes, Pymvashor, Yangoto lake (Potapov *et al.* 2014); Yugorsky (Potapov *et al.* 2017).

Material examined: Tarkhanovo, 12 July 1903, 1♀ ("var. *glacialis*"), leg. Poppius (on flowers of *Oxytropis sordida*); Vostochnaya Kambal'nitsa, 19 July 1903, 1♀, leg. Poppius (on flowers of *Pedicularis lapponica* and *Vaccinium vitis-idaea*); Mikulkin Nos, 3 August 1903, 1♀, leg. Poppius (on bushes); Kanin, 21 June–11 August 1903, 5♀♀, leg. Poppius; Naryan-Mar, 8–9 July 2013, 2♂♂, leg. Zverev & Kozlov.

Remarks: Two specimens collected from Kanin in 1903 have black hairs on the tip of the metasoma (Fig. 2) and were identified by Poppius (1908) as *B. lapponicus* var. *glacialis* Friese. According to Poppius (1908), these black-tipped individuals are rare on Kanin as compared with the typical red-tipped individuals. The status of *glacialis* has been controversial, as some authors have considered it as a synonym or subspecies of *B. lapponicus* (e.g. Kupianskaya 1995, Williams 2019), while others raised it to the species rank (e.g. Rasmont & Iserbyt 2010–2014). Recently, Potapov *et al.* (2018) published results of a morphological and molecular study, which supported the status of *glacialis* as a distinct species. The morphological characters of the two specimens identified as *glacialis* by Poppius were also studied by G. Potapov, but they were identified as abnormally colored individuals of *B. lapponicus* (G. Potapov pers comm.). Currently, reliable records of *B. glacialis* are only known from Novaya Zemlya, although it has also been reported from Kolguev and Wrangel Islands (Potapov *et al.* 2018, 2019).

Fig. 2. A queen of *Bombus lapponicus* "var. *glacialis* Friese" collected from Tarkhanovo on Kanin, by B. Poppius on 12 July 1903 (coll. MZH). Photo by Pekka Malinen.

Bombus muscorum (Linnaeus, 1758)

Kolva, Shapkina (Kolesnichenko 2006).

Bombus norvegicus (Sparre-Schneider, 1918)

Kharyaginsky (Filippov 2008); Amderma, Kanin, Kolguev, Naryan-Mar (Rasmont & Iserbyt 2010–2014); Bugrino (Potapov *et al.* 2014).

Bombus pascuorum (Scopoli, 1763)

Naryan-Mar (Ross 2000); Kharyaginsky (Filippov 2008); Kanin, Karatayka (Rasmont & Iserbyt 2010–2014); Nes,

Shoyna (Potapov *et al.* 2014); Pymvashor (Kolosova *et al.* 2016).

Material examined: Naryan-Mar, 6 July 2013, leg. Zverev & Kozlov, 30 July 2015, 1♂, leg. Stekolshchikov; Kuya, 10 July 2013, 1♀ + 1☿, leg. Zverev & Kozlov.

Bombus pratorum (Linnaeus, 1761)

Kanin Pns (Sintenis 1904); Nes, Nizhnaya Pesha, Bolvansky Nos, Vatyarty lake (Panfilov 1981); Naryan-Mar (Rasmont & Iserbyt 2010–2014); Pechora sites 1, 2, 4 and 7 (Ross 2000); Pymvashor (Potapov *et al.* 2014).

Material examined: Kuya, 10 July 2013, 2☿☿, leg. Zverev & Kozlov; Naryan-Mar, 6♂♂, 18 July–1 August 2015, leg. Stekolshchikov.

Bombus pyrrhopygus Friese, 1902

Yugorsky (Chernov 1966, as *B. arcticus* Kirby); Kharyaginsky (Filippov 2008, as *B. polaris* Curtis); Amderma, Kanin, Kolguev, Naryan-Mar, Vaygach (Rasmont & Iserbyt 2010–2014); Bugrino (Potapov *et al.* 2014, as *B. polaris* Curtis); Yugorsky (Potapov *et al.* 2017).

Remarks: The specimen reported by Poppius (1908) from Kanin as *B. kirbyellus* var. *pyrrhopygus* Friese (deposited in MZH) is an aberrant specimen of *B. balteatus* with reddish (instead of usually whitish) hairs on tergites 4–6. *Bombus polaris* is the Nearctic sibling species of *B. pyrrhopygus* (Williams *et al.* 2015).

Bombus schrencki Morawitz, 1881

Kharyaginsky (Filippov 2008); Kanin (Rasmont & Iserbyt 2010–2014); Pymvashor (Potapov *et al.* 2014).

Bombus sichelii Radoszkowski, 1859

Kanin (Rasmont & Iserbyt 2010–2014); Nes (Potapov *et al.* 2014).

Bombus sporadicus Nylander, 1848

Kharyaginsky (Filippov 2008); Kanin, Naryan-Mar (Rasmont & Iserbyt 2010–2014); Nes (Potapov *et al.* 2014); Yugorsky (Potapov *et al.* 2017).

Material examined: Naryan-Mar, 19 July 2015, 1☿, leg. Stekolshchikov.

Bombus sylvestris (Lepeletier, 1832)

Kanin, Naryan-Mar (Rasmont & Iserbyt 2010–2014); Pymvashor (Potapov *et al.* 2014).

Bombus veteranus (Fabricius, 1793)

Kanin, Naryan-Mar (Rasmont & Iserbyt 2010–2014); Nes (Potapov *et al.* 2014).

Nomada sp.

Pechora site 7 (Ross 2000).

Remarks: *Nomada leucophthalma* (Kirby) and *N. panzeri* Lepeletier are the most likely species to occur in NAO (e.g. Paukkunen & Kozlov 2015). Their hosts species are *Andrena clarkella* and *A. lapponica*, respectively.

Family Bembicidae

**Alysson ratzeburgi* Dahlbom, 1843

Material examined: Naryan-Mar, 6 July 2013, 1♂, leg. Zverev & Kozlov.

**Gorytes neglectus* Handlirsch, 1895

Material examined: Naryan-Mar, 6 July 2013, 1♂, leg. Zverev & Kozlov.

Remarks: A rare northern species classified as near threatened in Finland (Paukkunen *et al.* 2019).

Family Chrysididae

**Elampus panzeri* (Fabricius, 1804)

Material examined: Naryan-Mar, 12 July 2013, 1♀, leg. Zverev & Kozlov.

Family Colletidae

**Colletes impunctatus* Nylander, 1852

Material examined: Naryan-Mar, 3–6 July 2013, 4♂♂, leg. Zverev & Kozlov.

Family Crabronidae

**Crabro lapponicus* Zetterstedt, 1838

Material examined: Kuya, 5 July 2013, 1♂, 10 July 2013, 1♀, leg. Zverev & Kozlov.

**Crabro maeklini* Morawitz, 1866

Material examined: Naryan-Mar, 6–11 July 2013, 1♂ + 2♀♀, leg. Zverev & Kozlov, 24 July 2015, 1♀, leg. Stekolshchikov.

Remarks: A rare northern species, which is classified as near threatened in Finland (Paukkunen *et al.* 2019), Sweden (ArtDatabanken 2015) and Norway (Ødegaard *et al.* 2015).

**Crossocerus wesmaeli* (Vander Linden, 1829)

Material examined: Naryan-Mar, 6–8 July 2013, 5♂♂, leg. Zverev & Kozlov.

Family Formicidae

**Formica gagatoides* Ruzsky, 1904

Material examined: Naryan-Mar, 4 July 2013, 1☿, leg. Zverev & Kozlov; 21–27 July 2015, 3☿☿, leg. Stekolshchikov.

**Formica lemani* Bondroit, 1917

Material examined: Naryan-Mar, 4 July 2013, 2☿☿, leg. Zverev & Kozlov; 29 July 2015, 2☿☿, leg. Stekolshchikov, 7–9 June 2019, 4☿☿, leg. Kozlov.

Leptothorax acervorum (Fabricius, 1793)

Khaypudyrskaya Bay (Zryanin 2017).

Material examined: Naryan-Mar, 18 July 2015, 1☿, leg. Stekolshchikov.

Leptothorax cf. *kutteri* Buschinger, 1966

Khaypudyrskaya Bay (Zryanin 2017).

**Myrmica sulcinodis* Nylander, 1846

Material examined: Naryan-Mar, 20–29 July 2015, 1♀ + 5☿☿ + 1♂, leg. Stekolshchikov, 7–9 June 2019, 4☿☿, leg. Kozlov.

Family Halictidae

**Halictus rubicundus* (Christ, 1791)

Material examined: Naryan-Mar, 7–9 June 2019, 3♀♀, leg. Kozlov.

**Lasioglossum boreale* Svensson, Ebmer & Sakagami, 1977

Material examined: Naryan-Mar, 20 July 2013, 4♀♀, leg. Stekolshchikov, 7–9 June 2019, 1♀, leg. Kozlov.

Remarks: A deficiently known Holarctic boreal species that has been reported from the northern regions of Sweden, Norway, Japan and Canada (Svensson *et al.* 1977). The species is classified as vulnerable in Norway (Ødegaard *et al.* 2015). One of the specimens collected in NAO was DNA unsuccessfully barcoded (specimen http://id.luomus.fi/GP.98462).

**Lasioglossum fratellum* (Pérez, 1903)

Material examined: Naryan-Mar, 3–6 July 2013, 2♀♀, leg. Zverev & Kozlov.

**Sphecodes hyalinatus* von Hagens, 1882

Material examined: Naryan-Mar, 20 July 2013, 1♂, leg. Stekolshchikov.

Family Megachilidae

**Osmia maritima* Friese, 1885

Material examined: Naryan-Mar, 3 July 2013, 1♀, leg. Zverev & Kozlov.

Remarks: The closest known populations of this rare species are on the White Sea shore in the Murmansk Oblast (Paukkunen & Kozlov 2015) and in southern Sweden and Norway, where the species is classified as endangered (ArtDatabanken 2015, Ødegaard *et al.* 2015). The distribution area in Europe reaches the coastal regions of Denmark, Germany, the Netherlands and Poland; outside Europe, the species is known from Mongolia, eastern Siberia, Russian Far East, Alaska and Canada's Northwest Territories (Rightmyer *et al.* 2010, Müller 2011, Antropov *et al.* 2017).

Family Mutillidae

Mutilla europaea Linnaeus, 1758

Pechora site 7 (Ross 2000).

Material examined: Shoyna, willow-grass tundra, 30 July 2003, 1♀, leg. Filippov.

Family Pompilidae

**Arachnospila anceps* (Wesmael, 1851)

Material examined: Naryan-Mar, 6 July 2013, 1♀, leg. Zverev & Kozlov.

**Arachnospila fumipennis* (Zetterstedt, 1838)

Material examined: Naryan-Mar, 3 July 2013, 1♂, leg. Zverev & Kozlov.

**Evagetes sahlbergi* (Morawitz, 1893)

Material examined: Naryan-Mar, 3 July 2013, 1♂, leg. Zverev & Kozlov.

Family Psenidae

**Mimesa equestris* (Fabricius, 1804)

Material examined: Naryan-Mar, 27 July 2015, 1♂, leg. Stekolshchikov.

**Mimumesa littoralis* (Bondroit, 1934)

Material examined: Naryan-Mar, 4–6 July 2013, 2♂♂, leg. Zverev & Kozlov.

Remarks: A rare species classified as near threatened in Finland (Paukkunen *et al.* 2019) and Sweden (ArtDatabanken 2015).

Family Vespidae

**Ancistrocerus antilope* (Panzer, 1798)

Material examined: Naryan-Mar, 25 July 2015, 1♀, leg. Zverev & Kozlov.

**Ancistrocerus scoticus* (Curtis, 1826)

Material examined: Naryan-Mar, 3 July 2015, 1♀, leg. Stekolshchikov.

**Ancistrocerus trifasciatus* (Müller, 1776)

Material examined: Naryan-Mar, 3–8 July 2013, 1♀ + 1♂, leg. Zverev & Kozlov; Kuya, 10 July 2013, 1♀, leg. Zverev & Kozlov.

**Dolichovespula adulterina* (Buysson, 1905)

Material examined: Naryan-Mar, 20–29 July 2015, 1♀ + 3♂♂, leg. Stekolshchikov.

Dolichovespula norwegica (Fabricius, 1781)

Kanin (Sintenis 1904); Naryan-Mar, Pechora sites 1–4 and 7 (Ross 2000); Kolguev (G. Potapov pers. comm.).

Material examined: Naryan-Mar, 8 July 2013, 1♀, leg. Zverev & Kozlov; 26 July 2015, 1☿, leg. Stekolshchikov.

Dolichovespula saxonica (Fabricius, 1793)

Pechora site 1 (Ross 2000).

**Odynerus alpinus* von Schulthess, 1897

Material examined: Naryan-Mar, 20 July 2015, 1♀, leg. Stekolshchikov (specimen http://id.luomus.fi/GP.98461, GenBank accession number: MN942377).

Remarks: This rare species is for the first time discovered in northern Europe. Its range includes alpine areas of central Europe and Belarus (Gusenleitner 2013), Caucasus, Siberia and Russian Far East (Antropov *et al.* 2017). It resembles closely *O. spinipes* (Linnaeus, 1758), but the light markings of its body are very pale yellow (Schmid-Egger 2002; Fig. 3). The species identification was confirmed by DNA barcoding.

**Symmorphus allobrogus* (Saussure, 1856)

Material examined: Naryan-Mar, 6 July 2013, 1♂, leg. Zverev & Kozlov.

Vespula austriaca (Panzer, 1799)

Pechora site 3 (Ross 2000).

Material examined: Naryan-Mar, 1 August 2015, 1♀, leg. Stekolshchikov.

Vespula rufa (Linnaeus, 1758)

Kanin (Sintenis 1904).

Vespula vulgaris (Linnaeus, 1758)

Pechora site 3 (Ross 2000).

Fig. 3. Female of *Odynerus alpinus* von Schulthess collected from Naryan-Mar by A. Stekolshchikov on 20 July 2015 (coll. MZH). Photo by Pekka Malinen.

Erroneous and doubtful records

Bombus fragrans Pallas, 1771

Kanin (Sintenis 1904).

We believe that this record is based on erroneous identification, since this rare species is restricted to southeastern parts of Europe (Rasmont & Iserbyt 2010–2014).

Bombus glacialis Friese, 1902

Kanin (Poppius 1908, as *B. lapponicus* var. *glacialis* Friese); Kolguev (Pittioni 1943, Rasmont & Iserbyt 2010, Potapov *et al.* 2018, 2019).

The specimens from Kanin have been identified as abnormal individuals of *B. lapponicus* (G. Potapov pers. comm.; *see B. lapponicus* above [Fig. 2]), and the records from Kolguev have been regarded as highly questionable (Potapov *et al*. 2019). Currently, reliable records of *B. glacialis* are known only from Novaya Zemlya (Potapov *et al*. 2018, 2019).

Bombus lapidarius Linnaeus, 1758

Kanin (Sintenis 1904).

This species was recorded only a few times to the north of the Arctic Circle in Europe (Martinet *et al.* 2015) and can be easily confused with other northern species (e.g. *B. pyrrhopygus*). The record is probably based on a misidentified specimen.

Bombus lucorum (Linnaeus, 1761)

We attribute all records of this species from NAO to *Bombus cryptarum*. For details, *see* remarks to the latter species above.

Bombus mendax Gerstaecker, 1869

Kanin (Sintenis 1904)

We believe that this record is based on erroneous identification, since the species is restricted to the Alps and Pyrenees in Europe (Rasmont & Iserbyt 2010–2014).

Bombus quadricolor (Lepeletier, 1832)

Kanin (Sintenis 1904).

Although occurrence of this species in NAO is possible, the species is easily confused with e.g. *B. flavidus* and *B. sylvestris*, and therefore this record requires confirmation.

Bombus saltuarius (Skorikov, 1931)

Karatayka (Rasmont & Iserbyt 2010–2014).

There are no reliably identified specimens from the surrounding areas, and the status of this

species in North European Russia requires further investigation (Potapov & Kolosova 2016).

Bombus subterraneus (Linnaeus, 1758)

Kanin (Sintenis 1904).

The record is most likely based on misidentification, as the northern limit of the species lies in the Vologda Region in the East European Plain (Potapov & Kolosova 2016).

Bombus vestalis (Geoffroy, 1785)

Kanin (Sintenis 1904).

The record is probably erroneous, since the closest confirmed observations are from Latvia and southern Sweden (Rasmont & Iserbyt 2010–2014).

Megachile nigriventris Schranck, 1870

Kanin (Sintenis 1904).

Although this species could occur in NAO, we consider the record unreliable due to the relative difficulty in identification of the species combined with many misidentifications by the author.

Vespula germanica (Fabricius, 1793)

Kanin (Sintenis 1904).

The record is unreliable, because the northernmost confirmed records in Europe are from southern Finland and Russian Karelia, and the species is relatively easy to confuse with other social wasps, such as *V. vulgaris* (Linnaeus).

Discussion

Of the 61 species of aculeate Hymenoptera that have been found from NAO, 27 are reported here as new to the area. As many as 22 species and 36% of all the known aculeates of the area are bumblebees. The high proportion of bumblebees is explained by a sampling bias towards large-sized and easily detected taxa. In other Arctic regions of northern Europe, the recorded number of bumblebee species and the proportion of bumblebees are 21 and 16.9%, respectively, in the Murmansk Ooblast (Paukkunen & Kozlov 2015, Potapov *et al.* 2018a), and 22 and 17.3%, respectively, in northern Finland (biogeographical provinces *Le*, *Li*, *Lkoc* and *Lkor*; Söderman & Vikberg 2003). If we assume that the percentage of bumblebees in NAO is the same as in the Murmansk Oblast and northern Finland, then the aculeate fauna of NAO should include 120–130 species. This estimate is close to the total number of aculeate Hymenoptera species recorded from the Murmansk Oblast (124 species) and from the four northernmost biogeographical provinces of Finland (127 species) (Paukkunen & Kozlov 2015, Potapov *et al.* 2018a, Söderman & Vikberg 2003). In addition, 34 of 61 (56%) species were collected from a single locality, which also suggests that many more species are still likely to be found from NAO.

The aculeates of the areas surrounding NAO of are poorly known, and published records generally concern regions located at lower latitudes than NAO. Dolgin and Filippov (2012) listed 36 bumblebee species from the Komi Republic, while Levchenko and Tomkovich (2014) reported a total of 31 bumblebee and solitary bee species from the Khanty-Mansi Autonomous Okrug. Potapov and Kolosova (2016) listed 34 species of bumblebees from the mainland part of the Arkhangelsk Region, and reported 14 species of megachilid solitary bees from the same area (Potapov & Kolosova 2019b). Knowledge on other aculeate groups in the surrounding areas is even scarcer, but Baghirov (2019) reported six species of Pompilidae, and Baghirov and Nesterovich (2019) five species of Sphecidae (*sensu stricto*) from the from Yamalo-Nenets Autonomous Okrug, which is located South-East of NAO. At the same time, no aculeates are known from Svalbard or Franz Josef Land, and only three bumblebee species were reported from Novaya Zemlya (Coulson *et al.* 2014). This highlights the importance of our data, which represent the northernmost records of many aculeate species in eastern Europe.

All species recorded in our study have a Palaearctic or Holarctic distribution and were previously known from Europe. A recently

published survey of the Lepidoptera of NAO showed that a relatively large proportion of the lepidopteran fauna was composed by Beringian species, which have their main range in the eastern part of Russia and Alaska (Kozlov *et al*. 2019). In contrast, we failed to identify any true Beringian species among aculeates. The fauna of northern Siberia (Tyumen oblast, Krasnoyarsk krai, Yakutia Republic) and northern Russian Far East (Chukotka Autonomous Area, Kamchatka krai, Magadan oblast) includes approximately 80 aculeate species which are not known from Europe (Antropov *et al.* 2017). Further faunistic studies in northern Eurasia and Alaska are needed to conclude whether factors that have shaped distribution of Arctic insects may have differently affected the two major orders, Lepidoptera and Hymenoptera.

Acknowledgements

Sampling in Naryan-Mar was made possible due to financial support from the Otto Malm Foundation and Percy Sladen Memorial Fund. We are grateful to V. Zverev, A. Stekolshchikov and B. Filippov for donating their samples to MZH, and to G. Potapov for providing valuable unpublished information. We also thank S. Lommi for preparing the map and P. Malinen for taking the pictures of *Bombus lapponicus* and *Odynerus alpinus*.

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Appendix. Localities (numbers as in Fig. 1) from which or near to which aculeates were collected in NAO along with species numbers studied by the authors and in published records. Error radius is the radius of a circle which includes the whole (or most of) the locality.

Locality (type)	Coordinates (wgs84)	Error radius (km)	Species number	
			studied by the authors	published records
1. Amderma (village)	69°45´°N, 61°40´°E	5	0	10
2. Bolvansky Nos (peninsula)	68°17´°N, 54°30´°E	25	0	1
3. Bugrino (village)	68°46´°N, 49°18´°E	10	0	6
4. Foma-Yu (river)	66°58´°N, 59°57´°E	25	0	1
5. Greben' (cape)	69°40´°N, 59°59´°E	5	0	1
6. Gubistaya (river)	67°41´°N, 45°17´°E	25	0	2
7. Kanin Nos (village)	68°40´°N, 43°20´°E	25	0	1
8. Kanin (peninsula)	67°45´°N, 44°50´°E	100	2	22
9. Karatayka (village)	68°45´°N, 61°24´°E	10	0	4
10. Kharyaginsky (village)	67°09´°N, 56°43´°E	10	0	9
11. Khaypudyrskaya Guba (bay)	68°16´°N, 59°57´°E	3	0	2
12. Kiya (village)	67°39´°N, 44°05´°E	5	1	0
13. Kolguev (island)	69°01´°N, 46°22´°E	50	0	8
14. Kolva (river)	67°13´°N, 56°47´°E	25	0	1
15. Krasnoe (village)	67°50´°N, 53°36´°E	25	0	1
16. Kuya (river)	67°38´°N, 53°16´°E	3	6	0
17. Malchigeity (lake)	67°13´°N, 54°24´°E	25	0	1
18. Mikulkin Nos (cape)	67°49´°N, 46°40´°E	5	1	0
19. Naryan-Mar (town)	67°38´°N, 53°00´°E	5	37	18
20. Nelmin Nos (village)	67°59´°N, 52°57´°E	25	0	1
21. Nes (village)	66°36´°N, 44°40´°E	10	0	15
22. Nizhnaya Pesha (village)	66°45´°N, 47°45´°E	25	0	1
23. Pechora site 1 (landmark)	68°03´°N, 53°28´°E	10	0	9
24. Pechora site 2 (landmark)	68°20´°N, 53°05´°E	10	0	6
25. Pechora site 3 (landmark)	68°29´°N, 53°54´°E	10	0	2
26. Pechora site 4 (landmark)	67°42´°N, 53°07´°E	10	0	7
27. Pechora site 5 (landmark)	68°08´°N, 54°20´°E	10	0	2
28. Pechora site 6 (landmark)	68°47´°N, 53°10´°E	10	0	2
29. Pechora site 7 (landmark)	67°48´°N, 54°01´°E	10	0	9
30. Pymvashor (river)	67°11´°N, 60°52´°E	10	0	12
31. Russky Zavorot (peninsula)	68°35´°N, 53°13´°E	25	0	1
32. Shapkina (river)	67°16´°N, 54°06´°E	25	0	1
33. Shoyna (village)	67°52´°N, 44°09´°E	10	1	4
34. Tarkhanovo (abandoned village)	68°30´°N, 43°38´°E	5	2	0
35. Toshviska (village)	67°07´°N, 52°18´°E	5	0	1
36. Ust-Kara (village)	69°14´°N, 64°55´°E	10	0	1
37. Varnek (village)	69°42´°N, 60°03´°E	5	0	2
38. Vatyarty (lake)	67°35´°N, 60°20´°E	25	0	2
39. Vaygach (island)	70°00´°N, 59°30´°E	50	0	4
40. Vostochnaya Kambalnitsa (village)	68°18´°N, 46°00´°E	5	2	0
41. Yangoto (lake)	70°14´°N, 59°07´°E	5	0	2
42. Yugorsky (peninsula)	69°28´°N, 61°31´°E	50	0	10