Distribution records of aphids (Hemiptera: Phylloxeroidea, Aphidoidea) associated with main forest-forming trees in Northern Europe

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We report records of 25 species of aphids collected from four species of woody plants (*Pinus sylvestris*, *Picea abies*, *Betula pubescens* and *B. pendula*) at 50 study sites in Northern Europe, located from 59° to 70° N and from 10° to 60° E. Critical evaluation of earlier publications demonstrated that in spite of the obvious limitations of our survey, the obtained information substantially contributed to the knowledge of the distribution of aphids in North European Russia, including Murmansk oblast (103 species recorded to date), Republic of Karelia (58 species), Arkhangelsk oblast (37 species), Vologda oblast (17 species) and Republic of Komi (29 species). We confirm the occurrence of *Cinara nigritergi* in Southern Karelia; *Pineus cembrae*, *Cinara pilosa* and *Monaphis antennata* are for the first time recorded in Norway.

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1. Introduction

Species distributions and, consequently, spatial representations of biodiversity can only be assessed by analyzing the totality of species records. The georeferenced records (those that include map coordinates or allow accurate estimation of coordinates on the basis of verbal information) are vital for identifying and explaining distributional changes (Parmesan *et al.* 1999, Thomas 2005).

While entomologists in Finland and many other North European countries have collected and analyzed faunistic records of insects – often at very fine scales, up to 10 × 10 km grid – for decades (e.g., Albrecht 2012), no comparable data (with rare exceptions) exist for the northern parts of the European Russia. This especially concerns aphids, which are rarely sampled by non-specialists and identification of which requires highly qualified taxonomic expertise. The only revision of aphids that covers North European Russia (Shaposhnikov 1967) is outdated and provides distributional data with very low spatial resolution. We are not aware of any published or web-based dot maps showing records of aphid species in Russia. Even the distribution ranges of pest aphids (e.g., maps in Afonin *et al.* 2008) are to a larger extent extrapolated rather than based on actual records.

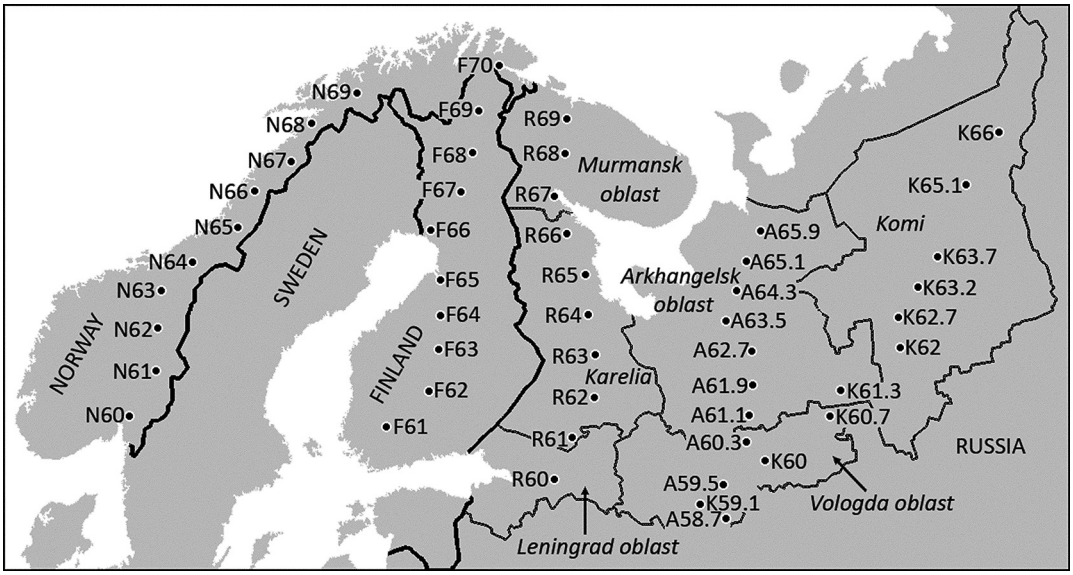

Fig. 1. Distribution of study sites in Northern Europe.

In the course of an ecological project addressing the levels of background herbivory on forest-forming woody plants, the team led by M. Kozlov in 2008–2011 collected herbivorous insects from four tree species (Scots pine, *Pinus sylvestris* L.; Norway spruce, *Picea abies* (L.) Karst.; downy birch, *Betula pubescens* Ehrh.; white birch, *B. pendula* Roth.) at 50 sites in Northern Europe, located from 59° to 70° N and from 10° to 60° E (Fig. 1). All aphids found in these samples were identified by A. Stekolshchikov.

Although this sampling scheme, which includes only few species of host plants, poorly suits the goals of a faunistic inventory, the scarcity of data on the diversity of aphids in the northern parts of the European Russia justifies publication of the obtained records.

In addition, we briefly review publications by the Russian scientists (which are hard to access for researchers outside Russia) that contain faunistic information on aphids of Murmansk oblast, Republic of Karelia, Arkhangelsk oblast, Vologda oblast and Republic of Komi, and discuss the completeness of the faunistic information obtained in the course of our surveys. Data on aphid abundance will be published elsewhere.

2. Material and methods

Sampling was conducted along five latitudinal gradients (Fig. 1: N, in Norway; F, mostly within Finland; R, between St. Petersburg and Murmansk; A, between Vologda and Arkhangelsk; K, between Vologda and Inta). The sampling sites were located in forests typical for each geographical region. Care was taken to select representative sites where all four species of forest-forming trees (mentioned above) grow naturally. In some situations this was impossible, and therefore in 13 of 50 sampling sites we collected samples from three species and in two localities from only two species of trees (Table 1). In most study sites the sampled area did not exceed 2,000 m^2. Samples from each site were collected twice per year (N gradient: 29.VI.–2.VII and 27.–30.VIII.2011; F gradient: 25.–26.VI and 2.–4.IX.2008; R gradient: 23.–29.VII and 21.–25.VIII.2008, 24.–29.VI and 24.–28.VIII.2009, 22.–27.VI and 29.VII.–2.VIII.2010, 12.–16.VI and 10.–14.VIII.2011; A gradient: 16.–18.VI and 7.–9.VIII.2010; K gradient: 18.–20.VI and 1.–3.IX.2009).

Mature trees (generally aged 20 or more years) with lower branches that can be reached from the ground (i.e., within 2 m height) were selected on a "first found, first sampled" basis. At each site samples were collected from five trees

Table 1. Geographical coordinates of sampling sites and numbers of aphid species collected from each host plant species at each site.

Study site	Country[1]	Region or provenance[2]	Coordinates		Numbers of aphid species[3]			
			Latitude, N	Longitude, E	sp	pi	db	wb
N60	NOR	AK	59° 47' 34"	10° 45' 35"	1	2	2	0
N61	NOR	HE	61° 04' 40"	11° 20' 46"	0	0	4	2
N62	NOR	HE	62° 04' 19"	10° 42' 40"	1	1	2	–
N63	NOR	ST	62° 59' 28"	10° 15' 50"	0	2	2	3
N64	NOR	NT	63° 54' 15"	11° 26' 25"	1	2	2	–
N65	NOR	NT	65° 04' 19"	13° 18' 15"	1	1	1	–
N66	NOR	Ns	66° 02' 56"	13° 36' 32"	0	3	1	–
N67	NOR	Ns	66° 59' 44"	15° 20' 22"	2	0	2	–
N68	NOR	Nn	68° 02' 26"	15° 58' 32"	0	2	0	–
N69	NOR	TR	68° 59' 30"	18° 30' 51"	0	0	0	–
F61	FIN	Ta	61° 00' 27"	23° 30' 42"	3	3	4	3
F62	FIN	Ta	62° 00' 06"	25° 31' 30"	1	2	5	6
F63	FIN	Tb	63° 03' 14"	25° 49' 33"	1	1	5	5
F64	FIN	Om	63° 53' 48"	25° 47' 52"	0	2	2	4
F65	FIN	Oba	64° 45' 47"	25° 34' 09"	1	2	4	–
F66	FIN	Obb	65° 58' 32"	24° 39' 49"	2	1	2	3
F67	FIN	Obb	66° 58' 49"	26° 19' 32"	0	0	2	1
F68	FIN	Lkor	67° 58' 35"	26° 50' 53"	1	1	1	1
F69	FIN	Li	69° 00' 41"	27° 00' 39"	–	0	1	2
F70	NOR	F	70° 04' 41"	27° 59' 22"	0	0	–	–
R60	RUS	Le	59° 58' 26"	32° 11' 46"	4	3	4	6
R61	RUS	Ka	61° 00' 03"	33° 03' 41"	3	5	4	6
R62	RUS	Ka	61° 58' 51"	34° 14' 27"	2	3	7	5
R63	RUS	Ka	63° 00' 07"	34° 22' 55"	0	4	6	3
R64	RUS	Ka	64° 01' 44"	34° 04' 11"	1	1	2	3
R65	RUS	Ka	65° 01' 25"	34° 00' 40"	2	2	4	3
R66	RUS	Ka	66° 01' 57"	32° 59' 13"	1	4	4	2
R67	RUS	Mu	66° 56' 04"	32° 12' 24"	1	2	2	4
R68	RUS	Mu	68° 01' 05"	32° 57' 07"	5	3	4	3
R69	RUS	Mu	68° 52' 34"	33° 07' 42"	2	3	2	–
A58.7	RUS	Vo	58° 40' 55"	40° 18' 35"	0	–	1	1
A59.5	RUS	Vo	59° 32' 17"	40° 25' 20"	0	1	1	1
A60.3	RUS	Vo	60° 29' 04"	41° 48' 50"	1	2	3	3
A61.1	RUS	Ar	61° 08' 22"	42° 11' 40"	0	2	4	1
A61.9	RUS	Ar	61° 51' 49"	42° 38' 01"	1	0	1	4
A62.7	RUS	Ar	62° 41' 52"	42° 53' 35"	1	2	3	2
A63.5	RUS	Ar	63° 30' 59"	41° 42' 55"	0	2	3	4
A64.3	RUS	Ar	64° 13' 25"	42° 37' 44"	0	2	1	1
A65.1	RUS	Ar	64° 54' 21"	43° 31' 03"	1	2	1	2
A65.9	RUS	Ar	65° 34' 27"	44° 37' 35"	0	1	2	–
K59.1	RUS	Vo	59° 07' 31"	39° 11' 26"	0	3	0	2
K60	RUS	Vo	59° 57' 11"	42° 37' 07"	1	0	3	3
K60.7	RUS	Vo	60° 43' 13"	46° 14' 51"	2	2	1	1
K61.3	RUS	Ar	61° 16' 35"	47° 04' 04"	0	1	2	3
K62	RUS	Km	61° 55' 37"	50° 40' 47"	1	2	3	3
K62.7	RUS	Km	62° 38' 42"	51° 03' 52"	2	2	5	4
K63.2	RUS	Km	63° 11' 32"	52° 38' 30"	0	2	2	2
K63.7	RUS	Km	63° 44' 14"	54° 12' 43"	1	4	0	2
K65.1	RUS	Km	65° 08' 33"	57° 16' 22"	1	2	2	–
K66	RUS	Km	66° 00' 16"	60° 20' 14"	0	–	6	–

1 FIN, Finland; NOR, Norway; RUS, Russia.
2 Regions of Russia: Ar, Arkhangelsk oblast; Ka, Republic of Kareila; Km, Republic of Komi; Le, Leningrad oblast; Mu, Murmansk oblast; Vo, Vologda oblast. Abbreviations of provenances of Finland and Norway after Heie (1995).
3 Host plants: sp, *Picea abies*; pi, *Pinus sylvestris*; db, *Betula pubescens*; wb, *B. pendula*.

of each species at each sampling date. The sampled trees were not tagged, and therefore early and late summer samples were generally collected from different trees. One branch (that can be accessed without disturbing the insects feeding on it) of about 50 cm in length (with approximately 80 leaves in birches, or 500 needle pairs in Scots pine, or 4,000 needles in spruce) was selected on a tree. One of two collectors placed a mesh bag attached to a ring (60 cm diameter) under the selected branch and the second collector cut the branch in such a way that it fell down into the bag together with insects that dropped from the branch when disturbed. The bag was immediately closed, labeled, and transported to the laboratory where all invertebrates were thoroughly collected and preserved in alcohol.

Total of 12,636 aphids were found in 995 samples; 1,995 samples did not contain aphids. The number of aphid individuals in a sample varied from 1 to 2,189 (with the median value of 3); 751 samples contained adults (apterous or alatae viviparous females, or males, or oviparous females). All adults and some nymphs (e.g., those of *Monaphis antennata*) were identified to the species. All specimens (including 1,488 slides prepared using Faure-Berlese mounting fluid) are deposited in the Zoological Institute of the Russian Academy of Sciences (St. Petersburg).

3. List of species

The list below contains information on the study site(s) where the species was recorded, and on the plant species from which it was sampled. Aphid nomenclature follows Remaudière & Remaudière (1997) with subsequent additions (Eastop & Blackman 2005, Holman 2009, Blackman & Eastop 2011). Each site code consists of the letter indicating one of the five gradients (Fig. 1) and the approximate latitude (°N). For exact co-ordinates of the study sites, plants sampled and number of aphid species found at each site, consult Table 1.

The study sites in the list are preceded by the abbreviated information on the geographical region (Ar, Arkhangelsk oblast; FIN, Finland; Ka, Republic of Karelia; Km, Republic of Komi; Le, Leningrad oblast; Mu, Murmansk oblast; NOR, Norway; RUS, Russia; Vo, Vologda oblast); an asterisk (*) denotes that the species had not been recorded from this region earlier. A dash indicates that the species was also found in all sites located between those connected by a dash. Information on host plant(s) is shown in parentheses: pi, *Pinus sylvestris*; sp, *Picea abies*; db, *Betula pubescens*; wb, *B. pendula*. Information placed at the end of the line refers to all records, otherwise host plants are indicated for each individual record.

3.1. Phylloxeroidea

3.1.1. Adelgidae

Adelges laricis Vallot. **RUS. Mu**: R67–R69 (sp).
Aphrastasia pectinatae (Cholodkovsky). **RUS. Mu***: R68 (sp).
Pineus cembrae (Cholodkovsky). **NOR***. N67. **RUS. Ar***: A61.9 (sp).

3.2. Aphidoidea

3.2.1. Lachnidae

Cinara costata (Zettersted). **FIN.** F61. **RUS. Le**: R60; **Ka***: R61, R64, R65; **Mu***: R68 (sp).
Cinara nigritergi Mamontova. **RUS. Ka***: R61, R63 (pi).
Cinara piceicola (Cholodkovsky). **NOR.** N62. **FIN.** F61. **RUS. Le**: R60; **Ka***: R62; **Ar***: A65.1; **Km***: K62, K65.1 (sp).
Cinara pilicornis (Hartig). **NOR.** N60, N64, N65, N67. **FIN.** F61, F63, F65, F66. **RUS. Le**: R60; **Ka***: R61, R62, R66; **Mu**: R68; **Vo***: K60, K60.7, A60.3; **Ar***: A62.7; **Km***: K62.7, K63.7 (sp).
Cinara pilosa (Zettersted). **NOR***. N66. **RUS. Ka***: R61, R62, R66 (pi).
Cinara pinea (Mordvilko). **NOR.** N60, N62–N64, N66, N68. **FIN.** F61, F62, F65. **RUS. Le**: R60; **Ka***: R61, R65, R66; **Mu**: R67–R69; **Vo***: K59.1; **Ar***: A62.7, A63.5; **Km**: K63.7, K65.1 (pi).
Cinara pini (Linnaeus). **NOR.** N68. **FIN.** F64. **RUS. Le**: R60; **Ka***: R63; **Ar***: A64.3; **Km***: K62, K63.7 (pi).
Cinara pruinosa (Hartig). **FIN.** F66 (sp).

Eulachnus agilis (Kaltenbach). **FIN.** F61. **RUS. Ka**: R61–R63, R66; **Mu**: R68, R69; **Vo***: K59.1, K60.7, A60.3; **Ar***: A61.1, A65.1, A65.9; **Km***: K62–K65.1 (pi).

Schizolachnus pineti (Fabricius). **NOR.** N60, N63–N66. **FIN.** F61–F66, F68. **RUS. Le**: R60; **Ka**: R61– R66; **Mu**: R67–R69; **Vo***: K59.1, K60.7, A59.5, A60.3; **Ar***: K61.3, A61.1, A62.7–A65.1; **Km***: K62.7–K63.7 (pi).

3.2.2. Hormaphididae

Hamamelistes betulinus (Horvath). **RUS. Ka**: R62 (db), R64–R65 (wb), R66 (db); **Mu**: R69 (db); **Vo***: K60 (db); **Ar***: A61.9 (wb).

3.2.3. Drepanosiphidae

Betulaphis quadrituberculata (Kaltenbach). **NOR.** N61 (db), N64–N65 (db), N67 (db). **FIN.** F61 (db), F63 (db), F64 (wb), F66–F67 (db), F69 (db). **RUS. Le**: R60 (wb); **Ka***: R61–R63 (wb, db); **Mu**: R67 (wb), R68 (db); **Vo***: K60 (wb), K60.7 (db); **Ar***: K61.3 (wb, db), A61.1 (db), A61.9 (wb); **Km***: K62 (db), K62.7 (wb, db), K63.7 (wb), K65.1–K66 (db).

Calaphis flava (Mordvilko). **NOR.** N60–N61 (db), N63–N64 (db). **FIN.** F61–F63 (wb, db), F64–F66 (db), F69 (wb). **RUS. Le**: R60 (db); **Ka***: R61 (wb, db), R62–R63 (db), R65 (db); **Mu**: R68 (db); **Vo***: K60 (db), A58.7–A60.3 (db); **Ar***: A61.1 (db), A62.7 (db), A63.5 (wb, db), A64.3 (db); **Km**: K62 (wb), K62.7 (wb, db).

Calaphis betulicola (Kaltenbach). **FIN.** F62 (wb).

Callipterinella calliptera (Hartig). **FIN.** F61 (db), F66 (wb). **RUS. Le**: R60 (wb); **Vo***: K60 (db); **Ar***: A63.5 (wb), A65.9 (db); **Km***: K62–K62.7 (db), K63.2 (wb, db).

Callipterinella tuberculata (von Heyden). **FIN.** F62. **RUS. Le**: R60; **Ka**: R61–R62; **Mu**: R67; **Vo***: A60.3; **Km***: K63.7 (wb).

Clethrobius comes (Walker). **FIN.** F67 (wb). **RUS. Ka***: R62 (wb, db); **Mu**: R68 (wb); **Vo***: A60.3 (db); **Ar***: K61.3 (wb).

Euceraphis betulae (Koch). **NOR.** N61 (wb, db), N63 (wb). **FIN**. F61 (wb), F62–F63 (wb, db), F64 (wb), F66 (wb), F68 (wb). **RUS. Le**: R60 (wb, db); **Ka***: R61–R62 (wb), R63–R66 (wb, db); **Mu**: R67–R68 (wb, db); **Vo***: K59.1–K60.7 (wb), A58.7–A60.3 (wb); **Ar**: K61.3 (wb, db), A61.1 (wb, db), A61.9 (wb), A62.7–A63.5 (wb, db), A64.3 (wb), A65.1 (wb, db); **Km***: K62–K63.2 (wb).

Euceraphis punctipennis (Zettersted). **NOR**. N61–N63 (db), N66 (db), F70 (db). **FIN**. F61–F62 (wb, db), F63 (wb), F64 (wb, db), F65 (db), F66 (wb). **RUS. Le**: R60 (wb, db); **Ka**: R61–R66 (wb, db); **Mu**: R67–R68 (wb, db), R69 (db); **Vo***: K59.1 (wb), A60.3 (wb, db); **Ar***: A61.1 (db), A61.9–A63.5 (wb, db), A65.1 (wb), A65.9 (db); **Km**: K62 (wb), K62.7 (db), K65.1 (db).

Monaphis antennata (Kaltenbach). **NOR***. N60 (db). **FIN**. F62–F63 (wb, db), F65 (db). **RUS. Le**: R60 (db); **Ka***: R61 (wb, db), R62–R63 (db), R65–R66 (db); **Km***: K62–K63.2 (db).

Symydobius oblongus (von Heyden). **NOR**. N61 (wb), N62 (db), N67 (db). **FIN**. F62 (db), F63 (wb, db), F64 (wb), F65 (db), F67–F68 (db), F69 (wb). **RUS. Le**: R60 (wb); **Ka**: R62–R63 (db); **Vo***: K60 (wb); **Km***: K62.7 (wb).

3.2.4. Aphididae

Elatobium abietinum (Walker). **FIN**. F62, F68. **RUS. Le**: R60; **Ka***: R61, R65; **Mu**: R68–R69; **Vo***: K60.7; **Km***: K62.7 (sp).

4. Discussion

4.1. Completeness of faunistic inventory

A comparison of the catalogue by Holman (2009) with the list of species recorded from Finland (Albrecht 2012) demonstrated that 45 aphid species can be found in Finland on the tree species investigated by us. During our survey of 2008 we recorded 18 species, i.e. 40% of the potential fauna. On the basis of this comparison we conclude that for the sampled regions of Russia our inventory revealed between one-quarter and one-half of aphid fauna associated with the investigated tree species.

Table 2. Summary of publications reporting faunistic information on aphids for North European Russia.

Region	Reference	Study type	Data quality		No. of species
			Identifications	Localities*	
Murmansk oblast	Nesterchuk 1930	Applied	Questionable	Exact	1
	Mordvilko 1935	Faunistic	OK	Approximate	13
	Znamenskaya & Zanadvorova 1934	Applied	Questionable	Exact	1
	Fridolin 1935	Faunistic	OK	Exact	1
	Fridolin 1936	Ecological	Questionable	Exact	16
	Znamenskaya 1941, 1962	Applied	OK	Exact	8
	Znamenskaya 1961	Applied	OK	Not reported	3
	Novitskaya 1962	Applied	OK	Exact	9
	Shaposhnikov 1967	Revisionary	OK	Approximate	35
	Vershinina 1972, 1975, 1981	Applied	Questionable	Not reported	12
	Rupais 1985	Faunistic	OK	Exact	1
	Heie 1986, 1992, 1994, 1995	Faunistic	OK	Not reported	24
	Vershinina & Rak 1993	Applied	Questionable	Not reported	4
	Buga 1999	Faunistic	OK	Exact	18
	Rak *et al.* 2001	Applied	Questionable	Exact	4
	Mitina & Kuznetsova 2006	Faunistic	Questionable	Exact	1
	Stekolshchikov & Buga 2006	Morphological	OK	Exact	1
	Rak & Litvinova 2010	Applied	Questionable	Exact	5
	Stekolshchikov 2012	Faunistic	OK	Exact	68
Republic of Karelia	Shaposhnikov 1972	Applied	OK	Not reported	1
	Heie 1980, 1982, 1986, 1992, 1994, 1995	Faunistic	OK	Not reported	31
	Stekolshchikov *et al*. 1998	Ecological	OK	Exact	1
	Kutenkova 1991	Ecological	Questionable	Exact	3
	Kutenkova 2011	Faunistic	Questionable	Exact	15
	Stekolshchikov 2011	Faunistic	OK	Exact	1
Arkhangelsk oblast	Ezhov 2008, Burak & Ezhov 2009, 2010	Applied	Questionable	Approximate	10
	Burak 2010, Ezhov & Burak 2010	Applied	Questionable	Exact	18
	Starkovskiy & Zorin 2010	Applied	Questionable	Not reported	2
Vologda oblast	Starkovskiy & Zorin 2010	Applied	Questionable	Not reported	2
	Vasilieva & Stepanova 2011	Applied	Questionable	Exact	1
Republic of Komi	Sedykh 1974	Faunistic	Questionable	Approximate	4
	Yurkina 2000a, 2001	Ecological	Questionable	Not reported	7
	Yurkina 2000b	Ecological	Questionable	Not reported	3
	Yurkina 2003	Ecological	Questionable	Not reported	1
	Yurkina 2007	Ecological	Questionable	Not reported	13
	Yurkina & Strekalova 2011	Ecological	Questionable	Not reported	16
	Mingaleva & Pestov 2011	Applied	OK	Approximate	1

* Exact: position of the sampling site can be attributed to 10 × 10 km area; approximate: can be attributed to 50 × 50 km area.

4.2. Present faunistic knowledge of aphids of North European Russia

An analysis of publications which contain information on aphids collected from the administrative regions covered by our surveys (except for Leningrad oblast) demonstrated that most of the authors did not provide exact locality data, and that the reliability of species identification is generally low (Table2). The identifications by some researchers (Mitina & Kuznetsova 2006, Burak & Ezhov 2009, 2011, Ezhov & Burak 2010, Mingaleva & Pestov 2011) are based on a combination of the host plant identity and external appearance of the aphids, and no voucher specimens have been preserved. Although even under

these circumstances there is a probability of correct identification, this practice is likely to end up with false records and should therefore be discontinued.

Compared to Finland and Norway, with 477 (Albrecht 2012) and 344 species of aphids recorded to date (Nieto Nafria *et al.* 2011), aphid fauna of North European Russia is poorly known. The total numbers of aphid species recorded from the regions covered by our survey are as follows (in parentheses: proportion of new records relative to the number of previously known species): Murmansk oblast 103 (+2%), Republic of Karelia 58 (+32%), Arkhangelsk oblast 37 (+61%, including *Cavariella pastinacae* (L.) occasionally sampled from birch at A61.9), Vologda oblast 17 (+467%), Republic of Komi 29 (+53%). Thus, our survey, in spite of its obvious incompleteness, substantially increased the knowledge of the distribution of aphids in northern taiga and subarctic forests of European Russia. Moreover, we found three species that have not yet been reported from Norway (*Pineus cembrae*, *Cinara pilosa* and *Monaphis antennata*).

Most recorded species are common throughout their distribution ranges, thus finding them in the study regions was more or less predictable. However, the discovery of *Cinara nigritergi* (for diagnostic features consult Stekolshchikov 2011) in Southern Karelia (site R63) was somewhat astonishing. Noteworthy, when the mentioned paper was already in print, additional specimens were identified in samples from another locality (R61), confirming the occurrence of this species in Karelia. Recently, *C. nigritergi* was also discovered in Finland (A. Albrecht, pers. comm.). It seems likely that this species is relatively common but overlooked in many parts of its distribution range.

Thus, even incomplete surveys conducted for the reasons other than faunistic research contributed substantially to the knowledge of aphids of Northern Europe, especially of the Russian parts of it. The discovery of one species new for the region (*C. nigritergi*) and addition of three species to the well-known fauna of Norway hint that selection of sampling sites driven by reasons other than "entomologist's internal algorithm" (intuition) may occasionally yield interesting faunistic information.

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