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Communities of Phyllophagous Insects in Young Birch Greeneries of Northern Cities

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Abstract—Phyllophagous insect assemblages on birch trees have been studied in greeneries of the cities of Labytnangi and Salekhard and natural habitats in the environs of these cities in 2007, 2010, and 2013. The 44 recorded species were dominated by insects of the orders Lepidoptera and Hymenoptera (18 and 12 species, respectively); regarding feeding ecology and mode of life, they were dominated by open-living chewing phyllophages and miners (19 and 10 species). The urban greeneries and sparse birch forests were colonized by the same species, but the density of many species in the cities was considerably higher. The species composition of the communities changed considerably year by year. The species richness and similarity of insect assemblages at the studied sites were the highest in 2013. The basic pests of birch in the northern cities were chewing phyllophages, especially Tenthredinidae sawflies.

Keywords: northern cities, urban greeneries, birch, phyllophagous insects, species richness of assemblages, faunistic similarity, population density

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The assemblage of pests of tree and shrub foliage in cities of middle and southern Russia has been intensely studied in recent decades. The differences of this assemblage from those of natural forest biotopes and its peculiar features in different types of urban biotopes are thought to reflect parameters of the microclimate, air and soil pollution, and area and position of greeneries (Gorlenko and Pan'ko, 1972; Barannik, 1979; Belova, 1982; Stadnitskii and Grebenshchikova, 1984; Klausnitzer, 1990; Krivosheina, 1992; Belov, 2000; Tarasova et al., 2004). It is interesting to elucidate the situation in northern cities, where air temperature, humidity, velocity, and pollution are not very different from those of natural biotopes, specific urban greenery types are at early stages of formation, and the trees and shrubs are local, often transplanted directly from natural communities surrounding the city.

The cities of Labytnangi and Salekhard in the lower reaches of the Ob proved very convenient for investigating this problem. In Labytnangi, planting of various local tree species (birch, willows, alder, and larch) was started 15–20 years ago, but its intensive development in different types of urban biotopes is a recent event. In Salekhard, willow *Salix dasyclados* was abundantly growing along the streets, and planned planting of trees and shrubs, mostly birch, started only in recent years. This is the reason why birch (*Betula pubescens* ssp. *tortuosa*) was selected for studying the communities of phyllophagous insects and their temporal (interannual) and spatial variation; an additional reason was that such communities were previously actively studied in natural biotopes (Bogacheva, 1990).

MATERIAL AND METHODS

A small census of birch trees in Labytnangi (four sites) and its immediate environs (three sites) was taken on July 18–23, 2007. The second census was carried out in August 5–17, 2010, with the number of sites increased to 13, and not only in Labytnangi but also in Salekhard: two sites in the city and three in the environs (Bogacheva, 2013). A similar census was taken at the same 18 sites and an additional site in Labytnangi from July 26 to August 5, 2013. All phyllophagous insects found in the course of each census and their characteristic damage (rolled leaves, mines, eaten parts) were recorded in lower parts of the crown. A total of ten trees were examined at each site.

Similarity of species compositions recorded at two different sites (or at the same site in two different years) was estimated by Czekanowski–Sørensen index I_{CS} (Pesenko, 1982). Placement of two sites in the same statistical population was tested by Student's *t*-test.

RESULTS

Structure of phyllophagous insect communities. Over the three years of censuses, a total of 44 insect species have been recorded, representing six orders

Table 1. Species richness of phyllophagous insect assemblages on birch trees in the cities of Labytnangi and Salekhard

Site no.	2007	2010	2013
1	10	10	16
2	10	9	17
3	–	9	16
4	12	15	18
5	11	10	15
6	–	10	14
7	–	9	14
8	–	–	19
9	–	12	15
10	–	9	15
11	–	12	14
12	–	10	12
13	–	13	12
14	10	15	13
15	11	8	13
16	–	7	11
17	11	10	8
18	–	11	16
19	–	13	12
$M \pm m$	10.71 ± 0.31	10.67 ± 0.53 (10.57 ± 1.21)	14.21 ± 0.60 (14.29 ± 1.26)

In Tables 1 and 2, figures in brackets refer to seven plots sampled in 2007.

(Homoptera, 5 species; Hemiptera, 2; Coleoptera, 6; Lepidoptera, 18; Hymenoptera, 12; Diptera, 1) and 26 families. Regarding feeding ecology and mode of life, they can be divided into sucking (seven species), open-living chewing and semi-hidden-living chewing (19 and 8 species, respectively) and hidden-living miners (10 species). However, since the censuses were taken only in late summer, these data do not entirely characterize the assemblages of phyllophagous insects living on birch: spring species had already left their food plants and not all of them could be identified by damage.

The basic members of the phyllophagous insect assemblage (species occurring at least at half of the sites) were represented every year by planthoppers Delphacidae, weevil *Polydrusus ruficornis* (Bonsd.), leaf-rolling weevil *Deporaus betulae* (L.), sawflies *Hemichroa australis* (Lep.) and *Pamphilius pallipes* (Zett.), and mining sawfly *Fenusella nana* (Kl.). In some years basic species also included the aphid *Euceraphis punctipennis* (Zett.), lymantriid moth *Orgyia antiqua* L., drepanid moth *Falcaria lacertinaria* (L.), microlepidopterans *Caloptilia betulicola* (M. Hering) and *Swammerdamia caesiella* (Hbn.), mining weevil *Orchestes rusci* (Hbst.), mining lepidopterans *Stig-* 1
mella confusella (Wood) and *Phyllonorycter ulmifoliella* (Hbn.), and mining sawflies *Scolioneura betuleti* (Kl.) and *Fenusa pumila* (Leach). The occurrence frequency of the other 28 species was lower; 12 of them were represented by one or two specimens. At some sites, 7–19 phyllophagous species were found (Table 1).

Spatial differences in phyllophagous insect communities. All basic members of the phyllophagous insect assemblage are present in both studied areas, Labytnangi and Salekhard. Species recorded in only one of the two areas are scant. As a result, the phyllophagous insect assemblages of both areas, separated by approximately 20 km and the Ob River, proved fairly similar. Paired comparisons of assemblages from Labytnangi and Salekhard in 2010 ($n = 65$) give an average similarity coefficient (Czekanowski–Sørensen index) of 0.536, while the average coefficient between sites in the Salekhard area was 0.582 ($n = 10$). The values for 2013 were 0.645 ($n = 70$) and 0.646 ($n = 10$), respectively.

Sites nos. 1, 2, 3 in the city of Labytnangi are linear birch plantations along roadsides in the city center, planted a few years ago; two of them were examined also in 2007. The number of phyllophagous insect species recorded at these sites was 9–10 in 2010 and 16–17 in 2013 (Table 1). They had fairly high similarity index values both in 2010 (0.749; number of pairs compared $n = 3$) and in 2013 (0.612). This is explained by the similarity of biotopes; in addition, they are situated relatively close to each other.

Site no. 4 is a large birch plantation in the territory of the Ecological Research Station, lying somewhat apart from the town center. This plantation was repeatedly examined previously, beginning from the late 1970s (Bogacheva, 1990), when the birch trees were already mature. The number of phyllophagous insect species recorded was 15 in 2010 and 18 in 2013; the average similarity index for this site and each of the three described above was 0.630 and 0.582, respectively.

Site no. 5 is a relatively small public garden at the outskirts of the city, where trees of different species were densely planted rather long ago; these include birch, which was examined also in 2007. The number of phyllophagous insect species recorded was 10 in 2010 and 15 in 2013; the average similarity index for this site and sites no. 1–3 was 0.551 in 2010 and 0.674 in 2013.

Site no. 6 is a narrow belt of young (2 m high) birch trees planted in 2008 or 2009 near the railway station, far from the city center. The average similarity index for this site and sites no. 1–3 was 0.516 in 2010 and 0.616 in 2013. The phyllophagous insect community of this site was peculiar: this was one of the sites where the larvae of coxcomb prominent *Ptilodon capucina* (L.) and lesser swallow prominent *Pheosia gnoma* (F.) and mines of *Coleophora* sp. were found; colonies of the sawfly *Croesus septentrionalis* (L.) had their maximum abundance at this site in 2010 and 2013.

Site no. 7 is a greenery in a hospital courtyard with some birch trees, among others. It was situated near sites no. 1–3, and the average similarity index between this site and sites no. 1–3 was 0.655 in 2010 and 0.613 in 2013. This courtyard is separated from site no. 2 only by a small asphalted area and the hospital building, and the similarity index between these sites was as high as 0.778 and 0.774, respectively.

Site no. 8 is a greenery surrounded by a residential area in the city center, examined for the first time in 2013. It is situated not far from sites no. 1–3; the average similarity index between them was 0.680; the highest of the three index values was between this site and the nearest site no. 3 (0.743). This site had the highest species richness of phyllophagous insect communities, 19 species.

Sites nos. 9 and 10 are urban greenery areas in the city center of Salekhard. Birch was not planted in Salekhard until recently, and the birch trees found at these two sites are young. The numbers of phyllophagous insect species recorded on them were 12 and 9, respectively, in 2010 and 15 and 15 in 2013; the similarity index between them was 0.571 and 0.667, respectively. The abundance of leafroller moths, damage of sawfly *H. australis*, and mines of *S. betuleti* recorded at site no. 9 (public garden in a market/exhibition square) in 2010 was higher than at any other of the 18 sites; the densest colonies of weevil *D. betulae* were found at this site in 2013. Abundant colonies of sawfly *C. septentrionalis* and abundant damage of sawfly *F. pumila* (244 mined leaves) were recorded in 2010 at site no. 10 (plantation in a lawn along houses on Manchinskogo Street) in 2010.

Sites nos. 11, 12, and 13 are cemeteries: nos. 11 and 12 are an old one and a new one in Labytnangi and no. 13 is a new one in Salekhard. The greeneries of these sites are not only separated by considerable distances, but also not quite similar. At site no. 11 they include trees of several species planted long ago, tall, dense, and thus shading each other. At site no. 12 the trees are also planted, but at present remain small. At site no. 13 they include not only trees planted at graves, but also a sparse birch forest area, remaining free of graves and separated from the adjacent large forest of this type (site no. 18) only by a narrow highway and a fence; quite naturally, the phyllophagous insect communities found on birch trees in this cemetery had a high degree of similarity with the adjacent birch forest (0.750 in 2010 and 0.643 in 2013). The old cemetery in Labytnangi also had a high degree of similarity with the nearby sparse birch forest, site no. 14 (0.593 in 2010 and 0.815 in 2013), but the new cemetery differed considerably from site no. 16, taken for comparison nearby (0.353 in 2010 and 0.522 in 2013). The average similarity index between communities of the cemeteries was 0.542 in 2010 and 0.675 in 2013.

The remaining six sites are areas of sparse birch forest around Labytnangi (nos. 14–17) and Salekhard (nos. 18 and 19). They are all situated at relatively small uplands and have more or less identical vegetation (sparse birch forest with dwarf birch, northern bilberry, and Labrador tea in the second layer). The average similarity index between these sites was 0.598 ($n = 15$) in 2010 and 0.608 in 2013. However, site no. 16, a dry area with a very depleted second layer, had the smallest number of phyllophagous insect species (seven) and was least similar to the urban sites nos. 1–7: the average similarity index in 2010 was as low as 0.382 ($n = 7$), while between sites nos. 14, 15, and 17 it was 0.618, 0.566, and 0.637, respectively. In 2013 a total of 11 phyllophagous insect species were recorded at site no. 16, and the similarity of this site with urban sites of Labytnangi rose to 0.537; however, the three other sparse forest sites again had higher degrees of similarity with urban biotopes: 0.668, 0.677 and 0.590, respectively.

Thus, we have studied biotopes of three types: true urban biotopes (situated among residential areas of cities), cemeteries (situated at edges of residential areas or outside them), and natural communities of sparse birch forest in the immediate environs of cities.

Insects that colonize birch trees in cities doubtlessly originated from surrounding natural communities, as evidenced by the similarity between phyllophagous insect assemblages found in urban greeneries and in forest–tundra biotopes: in Labytnangi 0.576 in 2010 ($n = 28$) and 0.612 in 2013 ($n = 32$); in Salekhard 0.542 and 0.628, respectively ($n = 4$ in both cases). However, four of the 44 species were recorded only in natural communities and 13 were recorded only in cities. These 17 species have low density in the study area.

The average numbers of insect species in city habitats (sites nos. 1–10) and sparse birch forests around cities (sites nos. 14–19) did not differ in 2010 (10.3 and 10.7, respectively). However, the abundance of most species was the highest in urban habitats; only three species of the 34 recorded (aphid *Euceraphis punctipennis*, weevil *D. betulae*, and one sawfly species) had the greatest abundance in cemeteries; one species, weevil *P. ruficornis*, had the greatest abundance in natural habitats. In 2013 species richness was significantly higher in urban biotopes than in natural ones (15.9 and 12.2, respectively); in two of the 34 species (leafhoppers Cicadellidae and miner *Eriocrania* sp.) had the highest abundance in cemeteries; four species (true bug *Elasmostethus interstinctus* L., weevil *O. rusci*, ermine moth *S. caesiella*, and another microlepidopteran species) had the highest abundance in natural habitats. Most species were more abundant in urban than in natural habitats. For instance, sawfly *Croesus septentrionalis* was found in 2013 at six urban sites of ten (a total of 50 colonies); recently planted trees (1 m high) in the city center rather often had all trees destroyed by this species. In 2013 this species became a true pest of urban greeneries. At the same

Table 2. Similarity index for phyllophagous insect assemblages on birch trees between different years and sites

Site no.	Similarity of sites					
	with other sites			in different years		
	2007	2010	2013	2007–2010	2007–2013	2010–2013
1	0.801	0.620	0.645	0.600	0.600	0.615
2	0.657	0.585	0.622	0.526	0.444	0.308
3	–	0.586	0.560	–	–	0.400
4	0.687	0.575	0.608	0.370	0.600	0.545
5	0.770	0.477	0.724	0.476	0.615	0.320
6	–	0.472	0.633	–	–	0.417
7	–	0.559	0.608	–	–	0.174
8	–	–	0.637	–	–	–
9	–	0.467	0.600	–	–	0.444
10	–	0.499	0.611	–	–	0.583
11	–	0.516	0.683	–	–	0.462
12	–	0.529	0.565	–	–	0.364
13	–	0.602	0.658	–	–	0.480
14	0.785	0.627	0.671	0.480	0.435	0.571
15	0.667	0.569	0.675	0.421	0.500	0.476
16	–	0.422	0.532	–	–	0.444
17	0.756	0.620	0.552	0.571	0.421	0.222
18	–	0.629	0.695	–	–	0.370
19	–	0.502	0.634	–	–	0.560
$M \pm m$	0.732 ± 0.022	0.548 ± 0.015 (0.582 ± 0.018)	0.627 ± 0.013 (0.642 ± 0.022)	0.492 ± 0.029	0.516 ± 0.034	0.431 ± 0.039 (0.437 ± 0.058)

time, it was not recorded in cemeteries, and only one colony was found at all six natural forest sites.

Interannual variation in phyllophagous insect communities. The species richness of insect assemblages in 2007 and 2010 was identical, on average 10.6 species per site (Table 1); in 2013 it was higher.

Phyllophagous insect assemblages visibly differed between the three years of study; their similarity was the lowest in 2010 and the highest in 2007 (Table 2). Only about one-third of all species recorded (15 of 44) were recorded annually, usually with high levels of abundance, although sometimes also with low levels (leaf beetle *Phratora polaris* Schneid., leafroller moth *Hedya atropunctana* (Zett.)).

As noted above, in 2010 and 2013 the numbers of species recorded were 34 and 34. However, in 2013 the number of species that had unusually high abundance was considerably greater. In 2010 five common species that occurred at the sampling sites considerably more frequently than in 2013 were recorded; one of these species, lymantriid moth *O. antiqua*, was recorded in 2010 at 12 of the 18 sites (72 specimens), whereas in 2013 it was not recorded at all. In 2013 a total of 11 species that occurred considerably more frequently than in 2010 were recorded; three of them (true bug *E. interstinctus*, mining sawfly *S. betuleti*, and ermine moth *S. caesiella*) were not recorded in 2010; the first of them was also not recorded in 2007, and the moth was even the first record for the Northern Ob Region; moreover, it was found at most of the sites (15 of 19). Several other species recorded in those years were also new to the Northern Ob Region, but had low abundance: drepanid moth *Drepana falcataria* (L.), coxcomb prominent, lesser swallow prominent, and gelechiid moth *Carpatolechia proximella* (Hbn.).

Insect assemblages found at the same site in different years considerably differed in composition (Table 2). In most cases changes at particular sites were the same as in the entire study area; in other cases they differed from general trends. The assemblage of the recently created greenery (site no. 7) for some time changed more rapidly than average for all sites (Table 2). Anthropogenic changes at the sites also produced rapid transformations in phyllophagous insect assemblages; thus, the bed of the road adjacent to site no. 17 was raised, eventually causing an increase in moisture at this site and accompanied by disappearance of some phyllophagous insect species (Tables 1, 2).

DISCUSSION

Phyllophagous insect communities found on birch in the study area are composed of the same species; this is also true of the two areas separated by approximately 20 km and the Ob River (Labytnangi and Salekhard) and of all three biotope types (urban, cemetery, and sparse birch forest).

The greatest similarity is found among closely situated urban biotopes. Biotope category (streets, inner parts of residential areas, and small public gardens) plays no great role, which is not surprising considering the fact that the structure of the greeneries is not yet fully formed.

The compositions of phyllophagous insect communities differed between years. The abundance of many of them visibly changed; it was the highest in five species in 2010 and in 11 in 2013; i.e., the changes were not synchronous.

The processes of increasing species abundance take place simultaneously over large territories, including the area of this study. The most important cause of these processes is doubtlessly the rising temperature of the vegetation season. We already know that the abun-
1 dance of many phytophagous insects, including lepidopterans, reaches maximum levels in the North not during unusually warm seasons, but in the year following two such seasons in sequence (Bogacheva, 1990), even if the vegetative season of this year is cold. The season of 2010 was very cold in the Ob Region forest–tundra, in contrast to the middle and southern forest zone; as a result, the phenology of many species shifted to later dates, compared to 2007 and 2013, but it was precisely in 2010 that some species had maximum abundance. However, such species sometimes cannot complete their development during a cold vegetative season and disappear next year, as it probably happened with *O. antiqua*. In contrast, sawflies, with their perennial wintering, in cases of a favorable beginning of the vegetative season (starting early and moderately moist) can reach high levels of abundance precisely in such years, as was the case with *C. septentrionalis* in 2013. Apparently, this species had already accumulated over several years precisely in urban biotopes, since its abundance in natural biotopes remained low in that year.

Changes in population abundance encompassing large areas doubtlessly play an important role in the transformations of insect communities at each sampling site, but local factors—such as changes at the site that immediately follow the planting of the greenery—also play a role. It is probably better not to view such periods as the stage of insect community formation; at this stage the combinations of species are only accidental. Other anthropogenic factors can also cause rapid changes in phyllophagous insect communities. The most stable site in this study was no. 4, a relatively large and old area of planted birch trees; if such an area, in which insect species can exist long, is surrounded by a city, this area itself assumes the role of source for newly forming insect communities in new urban greeneries. Small isolated parts of greeneries providing conditions for successful overwintering of insect can also be rather densely populated over several years with the same phyllophagous species (sites nos. 1 and 10). In less favorable areas, assemblages are largely formed anew every year by flying adult insects.

Not only the composition of communities, but also the species richness of phyllophagous insects in urban habitats (sites nos. 1–10) and sparse birch forests surrounding the cities (site nos. 14–19) was roughly the same. However, the abundance of most species is the highest in greeneries on city streets. (The more frequent records of rare species in cities also give evidence that these species have higher levels of abundance in urban biotopes.) In cities of the temperate zone, species that prefer urban habitats also exist, but their proportions are smaller; further south phyllophagous insects that feed on trees and live in cities prefer large parks, where summer temperatures are lower and winter temperatures are higher, rather than street greeneries (Maksimova, 1967).

Many researchers who have studied urban greeneries (Belova, 1982; Stadnitskii and Grebenshchikova, 1984; Barannik, 1979; Tarasova et al., 2004) note that the principal urban insect pests are sucking insects, especially aphids and miners. This pattern is usually considered to be associated with air and food pollution, from which these two insect groups are largely protected. However, in northern cities open-living chewing phyllophagous insects are dominant: sawflies, weevils, lepidopterans, and on willows also leaf 1
beetles. Although one of the peculiar features of Labytnangi and Salekhard is precisely the lack of pollution, I am not inclined to consider the dominance of other phyllophagous insect groups in these cities to be associated with this factor. The differences in composition and role of taxonomic and ecological groups of phyllophagous insects between urban greeneries of the Subarctic and those of the southern forest zone are explained, above all, by climate parameters that determine the formation of insect communities in natural habitats. Penetration of common forest species into the southern Subarctic is facilitated by such features of their biology as rapid growth and development, short molting period, and also viviparity in some leaf beetles and ability to feed at low temperatures and perennial overwintering in sawflies (Bogacheva, 1998). Since urban greeneries in the Subarctic are formed of local tree species, such insects, colonizing Subarctic habitats, colonize also urban greeneries, often more densely than the surrounding natural biotopes (Bogacheva, 2009).

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REFERENCES

Barannik, A.P., Ecofaunistic characteristics of dendrophile insect fauna of green plantings in industrial cities of Kemerovo oblast, *Ekologiya*, 1979, no. 1, pp. 76–79.

Belov, D.A., Leaf-gnawing and mining insects in green areas of Moscow, *Extended Abstract of Cand. Sci. (Biol.) Dissertation*, Moscow: Mosk. Gos. Univ., 2000.

Belova, N.K., Species composition and structure of pest insects damaging leaves and shoots of ornamental plants in the Moscow region, *Nauch. Tr. Mock. Lesotekhn. Inst.*, Moscow, 1982, no. 147, pp. 11–16.

Bogacheva I.A. Interactions of phytophagous insects with food plants and their adaptations to life in the southern Subarctic, *Extended Abstract of Doctoral (Biol.) Dissertation*, Yekaterinburg, 1997.

Bogacheva, I.A., *Vzaimootnosheniya nasekomykh-fitofagov i rastenii v ekosistemakh Subarktiki* (Interactions of Phytophagous Insects and Plants in Subarctic Ecosystems), Sverdlovsk: Ural. Otd. Ross. Akad. Nauk, 1990.

Bogacheva, I.A., Cities as channels for expansion of "southern" phyllophagous insect species to high latitudes, *Problemy izucheniya i okhrany zhivotnogo mira na Severe: Mat-ly dokl. vserossiiskoi nauchnoi konf. s mezhdunarodnym uchastiem* (Problems in the Study and Conservation of the Fauna in the North: Proc. All-Russia Sci. Conf. with International Participation), Syktyvkar, 2009, pp. 245.

Bogacheva, I.A., Territorial distribution of phyllophagous pests of birch trees in northern cities and their surroundings, *Problemy izucheniya i okhrany zhivotnogo mira na Severe: Mat-ly dokl. vserossiiskoi nauchnoi konf. s mezhdunarodnym uchastiem* (Problems in the Study and Conservation of the Fauna in the North: Proc. II All-Russia Sci. Conf. with International Participation), Syktyvkar, 2013, pp. 18–20.

Gorlenko, S.V. and Pan'ko, N.A., *Formirovanie mikoflory i entomofauny gorodskikh zelenykh nasazhdenii* (Development of Mycoflora and Entomofauna in Urban Green Areas), Minsk: Nauka i Tekhnika, 1972.

Klausnitzer, B., *Oekologie der Großstadtfauna*, Stuttgart: Gustav Fischer, 1987. Translated under the title *Ekologiya gorodskoi fauny*, Moscow: Mir, 1990.

Krivosheina, N.P., Current views on dendrobiont insects in urban ecosystems, in *Dendrobiontnye nasekomye zelenykh nasazhdenii g. Moskvy* (Dendrobiont Insects Inhabiting Green Plantings in the City of Moscow), Moscow: Nauka, 1992, pp. 5–15.

Maksimova, Yu.P., On the study of beetles (Coleoptera) damaging trees and shrubs in the city of Kharkov, *Entomol. Obozr.*, 1967, vol. 46, no. 4, pp. 799–804.

Pesenko, Yu.A., *Printsipy i metody kolichestvennogo analiza v faunisticheskikh issledovaniyakh* (Principles and Methods of Quantitative Analysis in Faunistic Research), Moscow: Nauka, 1982.

Stadnitskii, G.V. and Grebenshchikova, V.P., Phytophagous insects in the urban environment, in *Ozelenenie, problemy fitogigieny i okhrana gorodskoi prirodnoi sredy* (Landscaping, Phytohygienic Problems, and Protection of Natural Environment in Cities), Leningrad: Zool. Inst. Akad. Nauk SSSR, 1984, pp. 60–69.

Tarasova, O.V., Kovalev, A.V., Sukhovol'skii, V.G., and Khlebopros, R.G., *Nasekomye-fillofagi zelenykh nasazhdenii gorodov: vidovoi sostav i osobennosti dinamiki chislennosti* (Phyllophagous Insects in Urban Plantations: Species Composition and Specific Features of Population Dynamics), Novosibirsk: Nauka, 2004.

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SPELL: 1. lepidopterans