Ecological impact of biotic factors on the natural ecosystem during agricultural cultivation of *Lonicera caerulea* in Central Russia

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Abstract. The aim of the study is to search for the influence of biotic factors in the agrocenosis with edible honeysuckle (*Lonicera caerulea* L.) on the state of forest woody plants in natural phytocenosis. A nursery of the N.V. Tsitsin Main Botanical Garden of the Russian Academy of Sciences (Moscow) and natural biocenoses, including coniferous and deciduous trees, was a place of research in the regions of Central Russia in the period of 2005-2020. More than 50 phytophages and phytopathogens on edible honeysuckle plants in the monitoring process were noted. Complex biotic relationships with numerous trophic connections are formed between the agrocenosis and the natural ecological system was revealed. The polyphages *Lepidosaphes ulmi* L., *Parthenolecanium corni* Bouche, *Chionaspis salicis* L., *Phenacoccus aceris* Bouche, and *Tetranychus urticae* Koch are especially active in this system, creating environmental problems of various levels. It is noted that nonspecific phytopathogens are dangerous for artificial and natural cenoses, especially *Neonectria ditissima* (Tul. & C. Tul.) Samuels & Rossman, *Nectria cinnabarina* (Tode) Fr., *Phellinus conchatus* (Pers.) Quèl., and *Fumago vagans* Pers. that formed food chains with weakened plants. The rules of plant care and protection are necessary to follow to preserve natural populations and obtain a good harvest in berry nurseries.

1. Introduction

Ecological issues and the study of environmental conservation problems in regions with a large scale of agricultural cultivation are relevant at the present time [1]. Assessment of factors affecting the life support of biota during anthropogenic introduction into natural biosystems is formulated among the important tasks of geological ecology [2].

The area occupied by berry bushes has been rapidly increasing in recent years in Russia. The blue honeysuckle culture (*Lonicera caerulea* L., Caprifoliaceae) is very popular. Its edible berries are full of biologically active substances, vitamins and sugars. The berries of this culture are good for human health, ripen earlier than garden strawberries do and are in demand in horticulture [3, 4]. There are nurseries where sweet-berry honeysuckle is cultivated in every region of Central Russia. Usually they are located near large cities, there are several in the Moscow region (Figure 1).

Long-term monitoring of the phytosanitary state of fruit crops, including edible honeysuckle, in Moscow, in the N.V. Tsitsin Main Botanical Garden of the Russian Academy of Sciences showed that the number of phytophages and phytopathogens increases every year [5, 6]. This has been noted in the agricultural nurseries of the Kirov and Tambov regions [7, 8]. The state of natural phytocenoses in the...
regions of Central Russia depends on biotic factors [9] identified in the process of cultivation of plants in nearby nurseries.

Figure 1. Map of Central Russia with the regions, where *Lonicera caerulea* is cultivated: Moscow (Sovkhoz Lenina, Yakshroma, Domodedovo, Krasnaya Pakhra, etc.), Smolensk (Rudnyansky, Podarok), Tver (Lagunovo etc.), Yaroslavl (Pereslav-Zalessky, Lazarevskoye), Kostroma (Russian collection), Ivanovo (Shuya, Zelenyy Sad), Vladimir (Kirzhach, Kurkinykh), Ryazan (Mikhailovsky, Lasino), Tula (Kutepovo, Vitsa etc.), Kaluga (Esichev, Mishkovo), Bryansk (Vygonichsky etc.), Oryol (Zhilino), Kursk (Besedino), Belgorod (Shebekino, Tomarovskoy), Tambov (Michurinsk, etc.) and Voronezh (Rossoshansky, Babyakovskoy, etc.).

Since agricultural nurseries are artificially created associations of plants, they are characterized by broken and short trophic links, the absence of a natural system of self-regulation. A large number of plants of the same species in the agroecosystem contribute to the development of pathogenic microflora and harmful ethnomofauna. The disadvantage of artificial agrocenosis is the regular increase in the population of phytophages and phytopathogens, which not only harm the harvest of fruit and berry crops, but also worsen the ecological state of natural phytocenoses.

The purpose of this study was to find the relationship between the identified phytophages and phytopathogens in the *Lonicera caerulea* agricultural crop and their influence on the state of individual tree species of mixed forests in natural phytocenoses of Central Russia.

2. Materials and Methods
Annual monitoring, including analysis of *Lonicera coerulea* plants for symptoms of the presence of phytopathogens and damage by phytophages was carried out in an agricultural nursery of the N.V.
Tsitsin Main Botanical Garden of the Russian Academy of Sciences (Moscow) in the period of 2005-2020. In addition, during this period, we got acquainted with the phytosanitary state of blue honeysuckle in nurseries of the cities of Pereslavl-Zalessky (Yaroslavl region), Orel, Belgorod, Michurinsk (Tambov region), etc. Natural biocenoses, including coniferous and deciduous trees, were examined in the city of Moscow (protected area Ostankino), in Yaroslavl, Kostroma, Tambov and Tula regions. The Latin names of plants are given according to the taxonomic database The Plant List [10].

Identification of Fungi was carried out by standard methods, given according to Index Fungorum [11]. The species composition of Arthropoda is determined by damages, larvae and adults, given in accordance with Fauna Europaea [12]. Digital microscope Keyence –VHX1000 E (Japan) was used for identification and micro-measurements of organisms of the entomofauna (Acariformes, Coccoidea, Aphididae).

3. Results and Discussion

The interaction of an agrocenosis with a natural ecosystem has both positive and negative effects. There is a saturation with biotic factors in the food chains of artificial agrocenosis due to neighboring natural cenoses, the reserves of a diversity of useful entomofauna. Many pathogenic phytophages can change the food supply from natural to cultural ecosystems, and vice versa.

Gnawing (27 species) and sucking (16 species) phytophages prevail on the edible honeysuckle agricultural crop to our population monitoring. Monophages are especially harmful: Hayhurstia tataricum Aizenb. (= Semiaphis tataricae Aiz.), Semiaphis lonicerina Shap., Aceria xylostei Can., Rhyncaphytoptus lonicerae Kuang & Zhao, transmitting viral diseases. They are of little danger for natural ecosystems, because the life support capabilities of these specialized phytophages are limited by Lonicera caerulea plants in the agrocenosis. An exception may be single connections with natural forest communities if there is a related species there, for example, Lonicera xylosteum L.

Dioecious aphids Rhopalosiphominus lonicerae Sieb. (= Rhopalomuzus lonicerae Sieb.) and Prociphilus xylostei Deg. for its food base in the agro-nursery, it first uses blue honeysuckle plants, then winged insects migrate to natural phytocenoses on Picea abies (L.) H. Karst., as well as on gramineous plants (Poaceae). When such a biotic factor appears, an ecological regression occurs at several coenotic levels. In the food chain, cultivated plantings, forest-forming conifers, as well as field grasses associated with the development cycles of useful entomofauna and arthropods of the class Arachnida are involved and suppressed.

Polyphages that have trophic connections with a wide range of plants pose a special threat in agroecoses in the case of mass development of phytophages. Depletion of the food supply in agrocenosis is one of the conditions for the migration of a certain polyphage to the natural biocenosis. Migration is able to shift the equilibrium system of natural coenosis to an unfavorable situation, in which the natural mechanisms of regulation, though, useful entomofauna (predators and parasitoids), birds and entomopathogens cease to cope.

It was noted that the maximum danger to the natural ecosystem is represented by species from the families Coccoidea and Tetranychidae (Tetranychus urticae Koch) [4] according to observations of the agricultural culture of Lonicera caerulea. Polyphages Lepidosaphes ulmi L., Parthenolecanium corni Bouche., Chionaspis salcis L. and Phenacoccus aceris Sign. that are capable to spread over considerable distances with the participation of wind, birds, winged insects and humans [6]. Phytophages have multiple trophic relationships with woody species typical of the mixed forests of Central Russia, as shown in Figure 2. These plants can experience strong environmental pressure from damaging phytophages migrating from agriculture.

In addition, the food chains «agrocenosis - natural ecosystem» may include phytophages from the gnawing complex characteristic of the edible honeysuckle agriculture. We observed among the polyphages that damage in the leaves of forest trees Larentia autumnata Bkh., Exape congelatella Cl., Orthosta gothica L., O. stabilis Schiff., O. incerta Hdn., and Eupoecilia ambiguelia Hübner. These phytophages create fragmentary ecological problems for trees: Quercus robur L., Fraxinus excelsior
L., *Ulmus glabra* Huds., *Populus nigra* L. and *Betula pendula* Roth. Larvae of *Archips variegana* Den. et Schiff. and *Tortix rosana* L. are more often included in trophic chains with *Sorbus aucuparia* L., *Rosa acicularis* Lindl., *R. canina* L., etc. Root damage in young trees was observed during active reproduction in the agrocnosis of *Melolontha melolontha* L. During the transition from the agro-nursery to the forest communities of individuals of *Zeuzera pyrina* L. there is a violation of the wood of the trunks, the transport of nutrients in *Fraxinus excelsior* and *Ulmus glabra* is weakened. Adverse, possibly catastrophic, disturbances in the life of the forest ecosystem can occur when viruses, phytoplasmas and nematodes are transmitted by polyphages *Pentatoma rufipes* L., *Dolicoris baccarum* L., *Mesocerus marginatus* L. and *Nephrotoma crocata* L. They damage edible honeysuckle, as well as *Tilia cordata* Mill., *Betula pubescens* Ehrh., *Quercus robur*, and young trees of *Pinus sylvestris* L.

Among nonspecific phytopathogens, *Neonectria ditissima* (Tul. & C. Tul.) Samuels & Rossman (= *Nectria galligena* Bres.) and *Nectria cinnabarina* (Tode) Fr. are known, which can be transmitted by spores on *Lonicera caerulea* and natural woody plants [13]: *Tilia* spp., *Alnus* spp., *Betula* spp., *Fraxinus* spp., *Populus* spp., *Salix* spp. and others. Pathogenic micromycetes cause necrosis of wood in trees that are weakened, as a result of such stressful factors as drought and the development of other pathogenic organisms. It was found in Canada that a peak ejection rate of *Neonectria ditissima* ascospores and conidia on *Betula alleghaniensis* Britt. depends on environmental conditions: precipitation, humidity and air temperature [14]. In addition, it was found on edible honeysuckle that aging plants are susceptible to the fungi *Phellinus conchatus* (Pers.) Quél., whose hyphae cause wood rot, and fruit bodies appear on the trunk, developing sporulation [6]. Possible death can be for the entire plant. This phytopathogen, under favorable conditions (for example, at high humidity), can use as a host plant native trees: *Populus nigra*, *P. tremula* L., *Betula pendula* and others, if they were damaged in the winter or have mechanical damage.
Although there are many genera of dark-colored fungi known in tropical and subtropical climates that cause sooty moulds [15], the main cause of sooty mould is the saprotrophic fungus *Fumago vagans* Pers. in Russia. In the agro-nursery, it often appears in conditions where the blue honeysuckle bushes are located close to each other and the leaves have a lack of light. This saprophyte develops on the sugary secretions of aphids on conifers of *Picea abies*, *Pinus sylvestris* [5] and leaves of *Tilia, Ulmus, Betula, Salix, Scopulus, Sorbus, Crataegus, Euonymus* [16], affected and weakened by sucking phytophages, such as aphid *Prociphilus xylostei*.

4. Conclusion

The study revealed a complex system of biotic relationships that establish the relationship between artificial agrocenosis and natural biocenosis. At the same time, the role of producers is equally assigned to both the agriculture of *Lonicera caerulea* and certain types of forest phytocenosis, for example, *Quercus robur*, *Sorbus aucuparia*, etc.

It is noted that polyphages (especially *Lepidosaphes ulmi, Parthenolecanium corni, Chionaspis salicis, Phenacoccus aceris* and *Tetranychus urticae*) can form multiple trophic networks in the food chain «agrocenosis - natural ecosystem».

Since non-specific phytopathogens, especially *Neonectria ditissima* and *Nectria cinnabarina*, often appear in agrocenosis on sick and aging plants, it is important to periodically update plants in an artificially created agro-nurseries, and limit the development of a population of sucking insects that contribute to the defeat of saprotroph *Fumago vagans*.

When using agro-nurseries with *Lonicera caerulea*, it is necessary to carry out plant care and protection measures that prevent the migration of harmful entomofauna and phytopathogens from the agrocenosis to the surrounding natural ecosystem in order to preserve its populations.

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