Ecological and geographical features of the true bugs (Heteroptera) fauna of the Japanese elm communities in the lower reaches of the Selenga River

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Abstract. Japanese elm (Ulmus japonica Rehder) grows in the Baikal Region in the lower reaches of the Selenga River and forms refugia of nemoral biota where many rare and relict species of plants, fungi, bryophytes, lichens and invertebrate animals are found. Refugia of nemoral biota represent an important object to study environmental conditions of the Baikal Region in the past geologic epochs, as they are slightly changing ecosystems. Comprehensive research of elm communities, including qualitative and quantitative studies of insects, is required to fully understand functioning of these refugia and develop measures for their protection. The study summarizes data on 29 true bug species of 24 genera and 10 families, which inhabit closely in the Japanese elm communities. Polyphytophagous species prevalent in the investigated fauna, mixotrophic species also make significant contribution. Carnivores and species with more specific nutritional adaptation are significantly less numerous. As for distribution pattern, species with Trans-Eurasian and Trans-Palaearctic ranges prevail, individual species have Siberian-Far-Eastern and European-Siberian ranges. Species diversity of true bugs is significantly lower in the depths of dense elm forests than at the edges of the communities, especially in place of contact with open habitats. Some Heteroptera species which are typical of the genus Ulmus and live on a different species (U. pumila) in the Baikal Siberia, are not found on the Japanese elm, which confirms distinctness of these communities.

1. Introduction

A relict species of the Baikal Region of Siberia, Japanese elm (Ulmus japonica Rehder), grows in the Republic of Buryatia in the lower reaches of the Selenga River. Ulmus japonica is a nemoral flora species, its forests had been widely spread in Siberia in climatic optima periods [1]. Japanese elm forests are inhibited by rare and relict species of organisms, the entirety of which confirms the refugial role of these communities and the importance of Japanese elm as an edificatory species. Refugia of nemoral biota in Siberia are of particular interest, since in the modern era European nemoral forests range extends to the south of Western Siberia, and East Palaearctic forests extend to the west not further than Eastern Transbaikalia [2]. Refugia of nemoral biota play an important role in studying formation history of natural communities not only in Baikal Siberia, but also throughout the whole Northern Asia, since they represent slightly changing ecosystems and reflect environmental features of the past geologic epochs.

Elm groves are located in close proximity to human settlements, highways and railways, which leads to a decline in areas of refugia, some of which are currently occupied by haylands, pastures and
fallow lands. Fires often occur there due to careless human activities. Comprehensive study of these refugia is also required to develop measures for their protection.

In the lower reaches of the Selenga River Japanese elm forms small forests of not more than 25 hectares which may be far away from each other. Locations of these communities are very distant from the main range of the species which is in the south of the Russian Far East, eastern aimaks of Mongolia, southeastern provinces of China, Japan, and the Korean Peninsula [3, 4].

The climate of the Baikal Region is mainly extreme continental with long cold winter, brief hot summer, and small amount of precipitate. The climate in the study territory is slightly milder due to the proximity water body of Baikal and topographic features. The average temperature in July is +18°C, the average temperature in January is -24°C. Average annual precipitation is about 400 to 500 mm [5].

As in most other terrestrial ecosystems, insects are an integral part in the Japanese elm communities of the Selenga River. Scientific knowledge of insect population of the territory is far from being complete, however, a number of rare, Red List, and relict species have been already identified there [6-8]. Among insects with incomplete metamorphosis, the order Heteroptera (considered by some foreign authors as a suborder of the order Hemiptera is one of the richest in the number of species and numerically. True bugs inhabit a variety of ecotopes, have different types and broad range of nutritional adaptation, and therefore are an important part of most terrestrial and some aquatic ecosystems [9].

2. Materials and methods

The studies took place in the years from 2013 to 2019 in Kabansky and Pribaykalsky districts of the Republic of Buryatia, Russian Federation, in the vicinity of the following settlements: Kabansk, Bryansk, Beregovaya, Nikolsk, Mostovka, Yugovo, Talovka, Ilyinka, Tataurovo.

True bugs were collected and studied using generally accepted methods directly in the communities of U. japonica right from the trees, as well as from herbaceous and shrub vegetation under elm canopy and from leaf litter [10, 11]. Inhabitants of herbaceous layer, crowns of trees and shrubs were swept with an entomological net. True bugs inhabiting the surface of the soil and forest floor were collected using entomological sieve or manually during examination of leaf litter.

Accurate identification of true bugs specimens at the species level is possible only for imago (adult insect), while different species of true bugs have different life cycles, imaginal phase of some species is relatively short. Therefore, collecting had been performed for several years during all the three summer months to cover the faunistic composition fully. The material was identified using specialized literature [12], species identity of some specimens was established using the entomological collection of the Zoological Institute, Russian Academy of Sciences, Saint Petersburg. The taxa names and data on species distribution are provided in accordance with the Catalogue of the Heteroptera of Asian part of Russia [9]. The material is kept at the V.B. Sochava Institute of Geography SB RAS, Irkutsk, Russia.

3. Results and discussion

Japanese elm forests are confined to the upper floodplain of the Selenga River not flooded during high water. The trees need proximity of ground water, but suffer even from temporary flooding of the root-inhabited level [1]. Basically, elm forms mesophilic communities, where bird cherry (Padus avium Mill.) is often a codominant in the tree layer. The shrub layer of elm groves is composed in various combinations of Malus baccata (L.) Borkh., Rhamnus davurica Pall., Rosa acicularis Lindl., R. davurica, Swida alba (L.), etc. In the herbaceous layer, plants with predominantly East Asian or Manchuro-Daurian type of distribution are common: Festuca extremiorientalis Ohwi, Filipendula palmata (Pall.) Maxim., Thalictrum baicalense Turcz. ex Ledeb., etc. In vicinity of the villages Nikolsk and Bryansk of the Kabansk district, Japanese elm forms xeromesophytic thinned communities which include pine (Pinus sylvestris L.).
29 true bug species of 24 genera and 10 families are collected in the study territory in the communities of U. japonica. Among them, 13 species are collected directly from elm. Shield bug (Pentatomidae) Pentatoma rufipes (Linnaeus, 1758) was one the most typical inhabitants of the trees crown. Despite the fact that this species is a phytivorous polyphage with wide type of distribution, in the studied area it preferred Japanese elm to other deciduous trees. Three species of phytivorous polyphages of the family Acanthosomatidae were found both in the crowns of elms and in the crowns of birches (Betula platyphylla Sukaczev, B. pendula Roth) and bird trees belonging to the communities or growing nearby. The milkweed bug Kleidocerys resedae resedae (Panzer, 1797) also inhabit birches and elms. Two species of flat bugs (Aradidae) feeding on fungal hyphae were found on elm trunks: Aradus hieroglyphicus J. Sahlberg, 1878 and A. lugubris Fallén, 1807. Three species of plant bugs (Miridae), which are predominantly carnivorous mixotrophs, are confined to Japanese elm and are not found or rare on other plants of the area: Pilophorus confusus (Kirschbaum, 1856), P. mongolicus Kerzhner, 1984, Psallus ulmi Kerzhner et Josifov, 1966. Two predator species are identified on elm: flower bug (Anthocoridae) Anthocoris nemorum (Linnaeus, 1761) and plant bug Deraeocoris olivaceus (Fabricius, 1777).

Two species of true bugs are identified in the shrub layer on brier: plant bug Excentricus planicornis (Herrich-Schaeffer, 1836) and lace bug (Tingidae) Physatocheila smreczynskii China, 1952. In addition, a zoophytophage Pilophorus confuses is found both on apple tree and on elm.

The herbaceous layer is inhabited primarily by phytivorous polyphages and broad oligophages. These species usually inhabit meadows adjacent to forests, but also come under tree canopy. The most typical representatives are plant bugs Adelphocoris lineolatus (Goeze, 1778), A. quadripunctatus (Fabricius, 1794), representative of the family Lygaeidae Rhyparochromus pini (Linnaeus, 1758), scentless plant bugs (Rhopalidae) Stictopleurus crassicornis (Linnaeus, 1758), S. punctatonervosus (Goeze, 1778), widely distributed polyphagous shield bug Dolycoris baccarum (Linnaeus, 1758). Moreover, predatory damsel bug Nabis flavomarginatus Scholtz, 1847, as well as three zoophytophages – plant bugs Phytocoris novickyi Fieber, 1870 and Globiceps flavomaculatus (Fabricius, 1794), Berytidae Berytinus elavipes (Fabricius, 1775) – are regularly found under elm canopy.

Some milkweed bugs (Lygaeidae), such as Panaor us adspersus (Mulsant et Rey, 1852), and species of the genera Drymus and Plinthisus inhabit not very shaded communities under the elm forest canopy in leaf litter and on the surface of the soil. These species are polyphagous and feed mainly on seeds of various plants.

7 variants of geographical distribution (ranges) of insects was identified in the fauna under study. The most numerous is the Trans-Eurasian type, it includes 12 of 29 species (41.4%). Fewer species of true bugs (8 species, 27.6%) have the Transpalaearctic distribution type. Three species (10.3%) have the Holarctic and the Siberian-Far-Eastern ranges, respectively. One species (3.4%) is found from Kazakhstan to the south of the Far East, another species is spread in the Eastern Siberia and Mongolia, and one species has the Eastern Palaearctic type of range.

Among trophic groups, phytivorous polyphages are presented by the greatest number of species (16 species, 55.2%). The group representatives inhabit all layers of the considered communities. 6 mixotrophic species (20.7%) inhabit mainly the elm crowns: these are species of the genus Pilophorus and Psallus. Zoophytophages from the families Miridae and Berytidae are found under the canopy of elms. 4 predatory species (13.8%) are identified, two of them inhabit the elm crowns: Anthocoris nemorum and Deraeocoris olivaceus. Broad oligophagous phytophages are represented only by two species (7%): Adelphocoris lineolatus feeds on legumes, Physatocheila smreczynskii feeds on Rosales. One species (3.4%) is trophically associated with brier in elm communities: narrow oligophage Excentricus planicornis.

Analysis of distribution types and trophic connections reveals that the fauna is comprised basically of the species widely spread in the Palaearctic, which are phytivorous polyphages. The Eastern Palaearctic species, Aradus hieroglyphicus, is not strictly allocated to the Japanese elm either trophically or topically. The plant bug Pilophorus mongolicus distributed in Eastern Siberia and
Mongolia is more closely related to the trees of the genus *Ulms*, but it was not found on Japanese elm in large numbers [6]; this zoophytophagous bug is more typical for another species of the genus, *U. pumila*. An interesting species is *Psallus ulmi* collected from elms at the Selenga River in great numbers and having the Siberian-Far-Eastern type of range [8]. Despite the fact that it is also a predominantly carnivorous zoophytophage, it is allocated to the species of the genus *Ulms* and, therefore, is known in Buryatia both with *U. japonica* and *U. pumila* [12].

Speciees with the European Siberian and Western-Central Palaearctic ranges are not found in the fauna under study, but there are species with the East Palaearctic and Siberian-Far-Eastern ranges. The modern Heteroptera fauna is quite likely to have been formed from local Siberian and eastern species, which is also true for species with a wide distribution.

Phytivorous bugs in the studied communities are primarily polyphagous; less often broad olygophagous with Trans-Eurasian and Transpalaearctic types of range are found. Even though there are no species obligatory trophically associated to Japanese elm among the identified phytophages, two of them (*Acanthosoma haemorrhoidalis angulatum, Pentatoma rufipes*) prefer to feed specifically on *U. japonica*, while *P. rufipes* was not found on surrounding trees and shrubs.

It should be noted that faunistic diversity and the number of true bug specimens decreases deeper in dense communities of Japanese elm. Some species, for example *Adelphocoris lineolatus, A. quadrirupunctatus, Phytoecoris nowickyi, Physatocheila smreczynskii, Stictopleurus crassicornis*, etc., are not found in the densest part of the forests. Common species, such as *Deraecocoris olivaceus, Pentatoma rufipes*, are found in single specimens. Distribution of true bug, as well as of many other insect groups, under dense forest canopy is influenced by the absence of some forage plants that are found at the edges of communities, but not in their depths. Moreover, sunlight intensity is of great importance for insect distribution [13]. There is no such pattern in xeromesophytic communities due to their low density.

Another feature is the absence of some true bugs typical for the genus *Ulms* on Japanese elm in refugia of the Selenga River. Just 70 km to the south in the vicinity of Tarbagatay village, species, such as plant bug *Ulmica baikalica* (Kulik, 1965) and milkweed bug *Arocatus rufipes* Stål, 1872, are regulary found on *U. pumila*. 100 km further to the south in the vicinity of Okino-Klyuchi and Bichura villages, plant bug *Ulmocyllus virens* Seidenstücker, 1964 and shield bug *Pentatoma metallifera* (Motschulsky, 1860) are common. It can be suggested that these species are more xerophilous, like *U. pumila* itself, as compared to *U. japonica*, and natural conditions at the Selenga are not suitable for them, however shield bug *P. metallifera* is also common on *U. japonica* in the main part of its range in the east of the Zabaykalsky Kray, where communities structure is generally similar to that at the Selenga. Probably, natural conditions here in the geological past were such that specific Far Eastern fauna and fauna trophically associated with the genus *Ulms* could not survive them, however Japanese elm has survived by now and even serve as an edificatory species.

4. Conclusion

Thus, true bugs fauna of Japanese elm in the lower reaches of the Selenga River is formed mainly by Siberian, as well as by eastern and widely distributed species. In general, the number of true bug species inhabiting *U. japonica* is not large (13 species), almost half of them (6 species) are predominantly carnivorous zoophytophages, while only four of the phytophage species prefer this tree as a feeding plant. Relict and Far Eastern true bug species are not found here yet. Most of the studied species have broad distribution types: Trans-Eurasian and Transpalaearctic. Ranges of all identified species cover the Far East, China, Korea, or Japan, except for *Pilophorus mongolicus*, the main range of which extends to the south, but not to the east.

Zoophytophage *Psallus ulmi* collected in large amounts and not found on surrounding vegetation appeared to be the most characteristic of the Japanese elm communities at the Selenga River. This species is common in the Eastern Siberia, in the south of the Far East, in China, on the Korean Peninsula. Elm crowns are also widely inhabited by phytivorous broad polyphage *Pentatoma rufipes*. Many true bug species typical for the genus *Ulms*, which are common to the south and/or east on *U.
pumila, are not found in refugia of the Selenga River on Japanese elm. It can be assumed that modern conditions of natural environment at the Selenga are not favorable for survival of more thermophilic entomofauna, which confirms the significance of these communities as refugia of nemoral biota with Japanese elm as an edificator species at the extreme western border of its existence.

Similar studies in the Far East of the Russian Federation, in the north of China, as well as in Mongolia, where Japanese elm is also likely to form refugia, are required for better understanding of the formation and functioning processes of Japanese elm refugia in the Baikal Region of Siberia.

Acknowledgements
The reported study was funded by RFBR according to the research project No. 18-05-00557 A and carried out using the framework of basic research project No. AAAA-A17-117041910172-4.

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