Ecological composition of communities of herpetobiont insects of the Botanical Garden of Volgograd Pedagogical University

Tatyana Tokareva*

Volgograd State Socio-Pedagogical University, Volgograd, Russia

Abstract: The species diversity of the herpetobiont complex in the biocenosis of the botanical garden is considered, the percentage of ground insects by the method of nutrition in the artificial ecosystem is analyzed, measures to attract beneficial insects to the territory of the botanical garden are proposed. The purpose of the work: to study a group of coleoptera insects from the herpetobiont complex on the territory of the botanical garden. The method of Barber pitfall traps was used to study coleoptera herpetobionts. The collected insects were recorded and stored for further processing and determination in the laboratory conditions. The entomocomplex of herpetobionts of the botanical garden consists of 15 species from 5 families. The most numerous are the Carabidae, the dominant species are Calathus ambiguus and Cicindela campestris). The subdominant species is Harpalus rufipes, the usual species are Calathus distinguendus, Silpha obscura, Poecilus versicolor. Rare species are Dorcus parallelipipedus, Crypticus quisquilius, Cymindis miliaris. The monotony and species poverty of the Botanical Garden ecosystem is determined by a special complex system of agrotechnical measures, the use of chemicals to exterminate insect pests, and the intensity of anthropogenic pressure. All this leads to instability and variability of the ecosystem. These findings confirm the thesis that overdomination is characteristic of unstable communities with disturbed equilibrium. As a result, there is an increase in insect pests of plants. The study of ground insects by the mode of nutrition revealed 4 groups: zoophages, phytophages, mixophages, necrophages. Zoophages, in particular various species of Carabidae, are the most widespread (66.7%). This is due to the abundance of small invertebrates, the nature of vegetation, the level of humidity in the botanical garden. In order to increase the diversity of the species composition of beneficial insects, it is necessary to create favorable living conditions for them: to increase the food base, to create shelters. The creation of a food reserve is solved by planting mixborders.

1 Introduction

Currently, the composition of fauna in urbanized biocenoses attracts scientific attention due to its adaptability to recreational loads and technogenic pressure. The factors of existence

* Corresponding author: forest61@bk.ru

of urbanized biocenoses affect the composition, structure and number of their population. A special group of invertebrates – herpetobionts - react most actively to changes in the environment [1].

The relevance of studying herpetobiont insects is dictated by the role they play in urban biocenoses, often participating in biological methods of pest control. This group of insects is poorly studied, especially there is little information about herpetocomplexes in specialized urban green areas, such as the botanical garden.

The purpose of the work: to study the condition of a group of coleoptera insects from the herpetobiont complex on the territory of the botanical garden.

Tasks: To study the species composition of herpetobiont insects in the botanical garden, to analyze the species diversity of the entomocomplex of the botanical garden, to develop measures to attract beneficial insects to the botanical garden.

The research was carried out on the territory of Volgograd in the Botanical Garden of the VSPU during 2016-2022. The Botanical Garden is an educational and scientific laboratory of the university, where the morphological and decorative characteristics of plants are studied and the most promising species and varieties are selected to form an assortment used in urban landscaping. The Botanical Garden creates conditions conducive to the preservation of rare and endangered plants of the local flora. Native species grow on the territory of the Botanical Garden, as well as introduced plants from different geographical zones. These factors dictate the faunal diversity, including the composition and structure of the entomocomplex. Monitoring the condition of different groups of organisms allows to preserve the faunal uniqueness of the Botanical Garden.

The Botanical Garden of the VSPU is located in the center of the city of Volgograd on the territory of the university courtyard on 1 hectare of land. There is a highway in the immediate vicinity of it. There are 1,430 species, varieties and forms of vascular plants growing in the Botanical Garden. Among them are woody plants (350 species, varieties and forms); perennial herbaceous plants, including local flora (796 species and varieties); annual plants (104 species and varieties); greenhouse plants (180 species, varieties and forms).

The Botanical Garden contains various types of junipers, spiraea, daylilies, irises. Several expositions are highlighted here: Shadow Garden, Japanese Garden, Aquatic and Near-aquatic Plants. Coniferous and deciduous trees grow in the Japanese Garden, such as: Japanese larch (*Larix japonica* A.Murray), Manchurian aralia (*Aralia mandshúrica* Rupr. et Maxim.), maidenhair tree (*Ginkgo biloba* L.), red cedar (*Thuja plicata* DONN ex D.DON), white cedar (*Thuja occidentalis* L.), common juniper (*Juniperus communis* L.) [2] . Decorative shrubs are also present here: white dogwood (*Cornus alba* L.), Japanese kerria (*Kerria japonica* DC), Thunberg's barberry (*Berberis thunbergii* DC.) [3], common yew (*Taxus baccata* L.), junipers: horizontal (*J. horizontalis* MOENCH), savine *(J. sabina* L.), shore (*Juniperus conferta* PARL).

In the reservoir of the lower terrace, aquatic and near-aquatic plants grow: pink water lilies of Laydeker (*Nymphaea x laydekeri*) *'Laydekeri Lilacea'),* frog's-bit (*Hydrocharis morsus-ranae* L.), floating moss (*Salvinia natans* (L.) ALL.), batter dock (*Potamogeton natans* L), duckweed (*Lemna* L.), rush (*Juncus* L), sedges (*Carex* L.), reeds (*Scirpus* L.) and cattails (*Typha* L.). Ostrich fern (*Matteuccia struthiopteris* L. Tod), marsh iris (*Iris pseudacorus* L.), Siberian iris (*Iris sibirica* L.), horsetail species (*Equisetum* L.) grow along the shoreline of the reservoir. Various types of thyme (*Thymus* L.), houseleek (*Sempervivum* L.), golden tuft (*Sedum acre* L.), moss pink (*Phlox subulata* L), ground-covering plants are collected on elevated, well-lit rockeries.

The composition of the plantings of the Botanical Garden and its ecological state forms the species composition and the number of insects and plays an important role in the formation of agrobiocenosis. We have studied a group of herpetobiont insects that play an important role in the formation of the ecosystem of the Botanical Garden.

2 Materials and methods

The most common method of Barber pitfall traps was used to study coleoptera herpetobionts. The collected herpetobionts were fixed and stored for further processing [4]. The collected entomological material was determined in the laboratory conditions according to the entomological collections of the VSPU [5].

A dominance scale was used to characterize the participation of a particular species in the population. The following abundance classes were identified: over 5% – dominant species, 2-5% – subdominant, 1-2% – common, less than 1% — rare [6].

For a comprehensive analysis of the collected material, the following indicators were determined for the characteristics of entomocomplexes: the percentage of species, the percentage of occurrence, the abundance coefficient. These indicators give grounds to judge the fauna of biotopes with sufficient accuracy. The abundance coefficient is of particular importance. This criterion is one of the most essential for practical purposes, as well as for the study of the structure and further ways of formation of fauna.

3 Results and discussion

The faunal diversity and structure of the group of ground insects of the botanical garden has some qualitative and quantitative features. The species richness of herpetobiont insects in the biocenosis of the Botanical Garden of the VSPU is presented in Table 1.

Table 1. The species composition of insects of the Botanical Garden of the VSPU.

No.	Type name	Quantity, pcs	Mode of nutrition
	1	**2**	**3**
	Family Carabidae — Ground Beetles		
1	*Broscus semistriatus* (Dejean, 1828)	4	Zoophage
2	*Calathus ambiguus* (Payk. 1790)	189	Zoophage
3	*Calathus distinguendus* (Chaudoir, 1846)	4	Zoophage
4	*Calathus (Dolichus) halensis* (Schall, 1783)	4	Zoophage
5	*Cicindela campestris* (Linn., 1758)	62	Zoophage
6	*Cymindis laticollis* (Say, 1830)	2	Zoophage
7	*Cymindis miliaris* (Fabricius 1801)	1	Zoophage
8	*Cymindis picta* (Pallas, 1771)	2	Zoophage
9	*Harpalus rufipes* (De Geer, 1774)	11	Mixophage
10	*Licinus cassideus* (Fabricius, 1792)	2	Zoophage
11	*Poecilus versicolor* (Sturm, 1824)	3	Zoophage
	Family Curculionidae — Weevils		
12	*Otiorhynchus conspersus* (Herbst, 1795)	1	Phytophages

Continuation of Table 1.

No.	Type name	Quantity, pcs	Mode of nutrition
	1	**2**	**3**
	Family Lucanidae — Pinch beetles		
13	*Dorcus parallelipipedus* (Linnaeus, 1758)	1	Phytophages,
	Family Silphidae — Burying beetles		
14	*Silpha obscura* (Linnaeus, 1758)	4	Necrophage
	Family Tenebrionidae — Darkling beetles		
15	*Crypticus quisquilius* (Linnaeus, 1761)	1	Necrophage

The biodiversity of ground insects on the territory of the Botanical Garden of the VSPU is small. Perhaps this is due to the short duration of the existence of this ecosystem. The entomocomplex of herpetobionts of the botanical garden consists of 15 species from 5 families. The number of collected specimens is 291 pcs. The most numerous ground beetles, the dominant species are Calathus ambiguus (64.9%) and green tiger beetle (21.3%). The subdominant species is the strawberry seed beetle (3.8%), the usual species are the Rhacodiaptomus calatus (1.4%), the multicolored poecile (1.0%), the Silpha obscura (1.4%). Rare species are lesser stag beetle, Crypticus quisquilius, Cymindis: *C. laticollis, C. picta* - (0.7%); *C.miliaris*, weevils *Otiorhynchus conspersus* (0.34%).

Among all the abiotic factors for most ground beetles, the most important is soil moisture, which is provided by systematic watering in the Botanical Garden. The percentage of different groups of herpetobiont insects is shown in Table 2.

Table 2. Percentage of insect species diversity.

Name of families	Quantity,%
1	**2**
Ground Beetles (*Carabidae)*	73.2
Burying beetles (*Silphidae)*	6.7
Pinch beetles (Lucanidae*)*	6.7
Darkling beetles (Tenebrionidae*)*	6.7
Weevils (*Curculionidae)*	6.7

Despite the small species diversity, the number of beneficial insects in the botanical garden is more than 70%. Among the ground insects, most of the species are from the family *Carabidae,* the proportion of species of 4 more families is the same and small. The monotony and species poverty of the Botanical Garden ecosystem is determined by a special complex system of agrotechnical measures, the use of chemicals to exterminate insect pests, the intensity of anthropogenic pressure and man-made pollution, all this leads to instability and variability of the ecosystem.

These findings confirm the thesis that overdomination is characteristic of unstable communities with disturbed equilibrium [6]. This is the reason for the accumulation in the artificial biocenosis of insect pests of plants, such as: species of aphids *(Aphidoidea* Latreille*),* spider mites (*Tetranychidae* Donnadieu), as well as banded rose sawfly (*Arge ochropus* Gmemelin), fox-coloured sawfly (*Neodiprion sertifer* Geeoffroy.), common silvery moth (*Autographa gamma* Linnaeus), et al.

The data obtained indicate a high sensitivity of the herpetobiont entomocomplex in plantings subject to intensive recreational load and man-made pollution [7]. This group of

insects can be used as indicators of the state of the environment. The distribution of ground insects by mode of nutrition is shown in Table 3.

Table 3. Percentage of insects by mode of nutrition.

Mode of nutrition	Quantity, %
1	2
Zoophages	66.7
Phytophages	6.7
Mixophages	13.3
Necrophages	13.3

The spread of zoophages in the Botanical Garden is explained by the abundance of small invertebrates, the nature of vegetation, the level of humidity. Zoophages regulate the number of various invertebrates and the leading place here belongs to ground beetles. Thus, ground beetles take an active role in the extermination of eggs, pupae, larvae and imago of insect pests [8]. In order to increase the diversity of the species composition of beneficial insects, it is necessary to create favorable living conditions for them, namely: to provide a food reserve, to provide a botanical garden with an assortment of plants that attract insects; to create shelters where insects can hide during the day; to create decorative houses for wintering.

In the task of attracting useful insects, the creation of shelters for them will help, which are built from a wooden frame in the form of cells of different sizes and such improvised means as cones, bricks, straw, dry leaves, wooden blocks, colored pots, tubular plants, tree bark, moss and so on. Not very stable structures are fixed with nails and ropes.

The creation of a food reserve for insects is solved by planting mixborders – multi-tiered flower compositions [9]. The assortment of plants for flower arrangements was selected taking into account the ability to attract herpetobiont insects to the Botanical Garden. The most effective in this regard are many species of legumes (*Fabaceae* Lindl.), mint family (Lamiaceae *L.*), sunflower family (Asteraceae BERCHT. & J. Presl), et al. They provide useful insects with constant food and moisture, enrich the soil with nitrogen. To create the first mixborder, the following were used: aster camomile *(Aster amellus),* hybrid goldenrod *(Solidago hybridum),* common oregano *(Origanum vulgare),* sanguinary *(Achillea millefolium),* summer phlox *(Phlox paniculata),* small-flowered marigolds *(Tagetes patula),* brilliant coneflower *(Rudbeckia fulgida),* garden sage *(Salvia officinalis),* awl-shaped moss *(Sagina subulata)*. For the second mixborder, the following were used: Chinese chive *(Allium ramosum),* tarragon wormwood *(Artemisia dracunculus),* maiden pink *(Dianthus deltoides),* garden sage *(Salvia officinalis),* pyramidal houseleek (*Ajuga pyramidalis),* white sweet clover *(Melilotus albus),* common pink *(Dianthus plumarius),* pepper clove *(Dianthus piperita),* peppermint *(Mentha piperita),* awl-shaped moss *(Sagina subulata),* scarlet clover *(Trifolium incarnatum*), pot marigold *(Calendula officinalis)* [10].

Each mixborder is selected in such a way as to ensure flowering from spring to late autumn. Each mixborder consists mainly of perennials, located in an open sunny place. Watering on the territory is carried out as the soil dries, depending on weather conditions, without waterlogging the soil.

Attracting various types of insects to the botanical garden will help to achieve a natural balance in the artificial biocenosis and in protecting plantings from insect pests.

4 Conclusion

The Botanical Garden as an artificial ecosystem in the conditions of a technogenic press is an unstable biocenosis. Especially sensitive in such conditions is a group of ground insects. Its composition is dominated by zoophages of the family Ground beetles (*Carabidae*),

because they have a rich food reserve and favorable environmental conditions for existence in this territory. The task of increasing the stability of this biocenosis is solved by expanding the species composition of its parts and, above all, phytocenosis by planting new plant species. This, in turn, will give not only an ecological, but also a practical effect.

References

1. A. A. Korotkova, Vestnik novyh medicinskih tekhnologij: periodicheskij teoreticheskij i nauchno-prakticheskij zhurnal **3**, 98-100 (2003)
2. T. G. Tokareva, The use of gymnosperms in urban landscaping of the dry steppe zon. IOP Conference Series: Earth and Environmental Science **421**, 22037 (2020)
3. T. G. Tokareva, Proceedings of the All-Russian scientific-practical conference with international participation, Yalta, September 9-14, 2018 - Collection of scientific papers of the GNSS **147**, 157-9 (2018)
4. N. V. Demidenko, *Metodiki sbora mezogerpetobiontnyh bespozvonochnyh* **1** (KemGU, Kemerovo, 2003), pp. 15-21
5. G. Ya. Bej-Bienko, *Opredelitel' nasekomyh evropejskoj chasti SSSR v pyati tomah* **2** («Nauka», Moskva—Leningrad, 1965)
6. A. A. Elanceva, "Biotopicheskaya differenciaciya gerpetobiontnyh nasekomyh v gorodskih nasazhdeniyah", in *Bioekologicheskoe kraevedenie: Mirovye, Rossijskie i Regional'nye problemy. Mater. 2-j Vseros. nauchno-praktich. konf. s mezhdunar. uchastiem, posvyashchennoj 110-letnemu yubileyu d.b.n., prof. D. N. Frolova i 75-letnemu yubileyu k.b.n., prof. M. S. Gorelova* (2013), pp. 219-224.
7. N. I. Savosin, G.A. Timofeeva, Okruzhayushchaya sreda i ustojchivoe razvitie: novye metody i tekhnologii issledovanij **3**, 303-306 (2009)
8. N. I. Savosin, Ekologo – faunisticheskaya harakteristika gerpetobiontnogo naseleniya chlenistonogih krupnogo promyshlennogo centra (gorod Kemerovo): avtoref. dis. kand. biol. nauk (Barnaul, 2010).
9. T. G. Tokareva, Features of the phytocenosis structure in the urban ecosystem of the southern industrial centre IOP Conf. Series: Earth and Environmental Science **315**, 072012 (2019)
10. A. A. Semenchuk, O. I. Docenko, T. G. Tokareva, "Sad aromatov v gorodskoj srede", in *Aktual'nye voprosy teorii i praktiki biologicheskogo obrazovaniya» XI Vseros. s mezhdun.uchast.nauchn-prakt. konf.* (2017), pp. 86 – 89