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FORMATION DYNAMICS OF HERPETOCOMPLEXES ON SECTIONS OF SECONDARY SUCCESSION IN TERRESTRIAL ECOSYSTEMS OF BELARUS

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Long-term observation carried out in Belarus during 25-30 years showed that formation of herpetocomplexes on secondary succession sections connected with dynamics of the developing phytocenosis, changes in environmental conditions and the community composition in neighboring preserved ecosystems. The main trend of the amphibian and reptile complexes changes is associated with an increase in species diversity and abundance. There are several stages of community formation, differing in time, species structure and number. At the initial stage, covering the first 4-5 years, there is a rapid colonization of the site by the first species-immigrants, coming from neighboring preserved ecosystems. At this period, almost all species inhabiting the neighboring ecosystems found in the successions areas, but only the most adapted species remain. At middle stage, continuing from 6-7 to 12-20 years, some new species, mainly meso- and stenotopic, adapted to a narrower range of environmental conditions, remain in the community. After 20 years in some succession areas comes final stage of zoocenosis formation, characterized by a stable species structure. During successions, there is a gradual addition of species, the change of dominants and the formation of certain combinations of species that are most appropriate to the definite conditions of the environment. The results of present study indicate the high ability of wild communities to recover after anthropogenic impact.

Key words: Succession, herpetocomplex, amphibian, reptile, ecosystem, Belarus.

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INTRODUCTION

According to modern provisions of phylocenosis concept, biotic communities are adapted to changes in the environment, capable to self-organization, self-regulation and maintenance of integrity and stability in space and time (Zherikhin 2003). The study of various aspects of self-organization and dynamics of community development during of natural and anthropogenic successions are one of the main methodological approaches in the learning of ecosystems (Mirkin 2002).

Succession, as a directed process of serial changes in the state of the ecosystem, is a gradual organization relatively stable of functioning (Razumovskiy 1981, Clements 1916). During development of the succession series, a certain stability and balance of the system with the

environment is reached, which is associated with complex changes in the structure and transformation of feeding links in communities (Whittaker 1980).

The analysis of secondary successions associated with the implication of active anthropogenic transformation of landscapes has recently become particularly relevant, since human impact has spread to all biomes and regions of the biosphere (Titlyanova 2009). As a result of the transformation, some herpetofauna species become rare and disappear, while others successfully occupy transformed landscapes (Pupina & Pupins 2007, 2008) and even can benefit from the relationships with humans (Tytar et al. 2019).

The processes of organization and structuring of faunistic complexes of amphibians and reptiles, which make up one of the important components of the zoocenoses of the temperate climatic zone of the forest belt of Europe, during anthropogenic successions, despite their relevance, have been poorly studied (Lebedinskiy & Pestov 2017).

The work focus on assessing the recovery dynamics of herpetocomplexes on the anthropogenic successions plots during environmental changes in terrestrial ecosystems of Belarus.

MATERIAL AND METHODS

The formation of faunistic complexes of amphibians and reptiles during the dynamic change of vegetation in modified landscapes was studied in 1985-2017 in the Central (Minsk upland) and South (Polessiye lowland) regions of Belarus.

Field investigations were carried out on 7 model plots with area of 3.1-11.2 ha including forest felling sites (continuous felling of the main use), post-pyrogene biotopes (appeared after the ground fire), overgrown arable lands and the areas of drained lowland bogs after their secondary swamping.

The dynamics of recovery succession, species composition changes, number (density) of complexes of amphibians and reptiles estimated on the model plots. The composition and number of herpetological communities were estimated both on model sites and in neighboring surviving habitats using the method of route accounting on fixed-width transects (Measuring and Monitoring Biological Diversity 2003). For this purpose, during the period of research on stationary sites, 314 counts were conducted.

For analyze ecological conditions changes at secondary succession on sites of disturbed ecosystems a number of parameters characterizing the relief, hydrological regime, soil and vegetation cover, and microclimate have been used (Diamond & Case 1986, Morin 2011).

In the analysis of temporal trends long-term changes in the species structure, complex of dominant species and abundance of studied groups of animals were used statistical methods (Borovikov 2008). Species ocurrence, diversity and equalization of community were calculated using appropriate indices (Puzachenko 2004).

RESULTS AND DISCUSSION

In the last three decades in terrestrial ecosystems of Belarus large-scale allogenic successions, caused by mainly anthropogenic factors, occur (Drobenkov et al. 2005). Restoration of vegetation and animal communities in disturbed landscapes is observed in the areas of forest felling, fires, pastures, recreation, open pit mining (Gusev 2001, 2015).

Succession of plant communities covers a long period (from 15-20 to 100 years), so it is difficult to trace all the successional stages of their development (Whittaker 1980, Pianka 1981). In this regard, the most complete observations were made on the areas of short-term successions after continuous forest felling and wildfires, covering 25-30 years. Additional material for the reconstruction of successional processes was the data obtained in neighboring ecosystems after

exposure to the same factor at later stages.

Results longstanding monitoring has shown that for the dynamics of herpetocomplexes, emerging in secondary succession sections are typical both general tendencies and some specific features related to the differences in the original vegetation and forms of anthropogenic impact. Therefore, the peculiarity of forest habitats restoration are their clear dependence on the composition and ratio of the main tree species (populations of pine, birch and spruce).

The development of amphibians and reptiles communities in secondary succession areas had a clear trend associated with directed changes in their structure and abundance. The process of herpetocomplex formation is a sequential change of species composition and abundance in which we can distinguish several stages (Fig. 1-3).

At the first stage, covering the first 4-5 years after the destruction of vegetation, there is a rapid colonization of the restoration area by the first species, coming from neighboring preserved

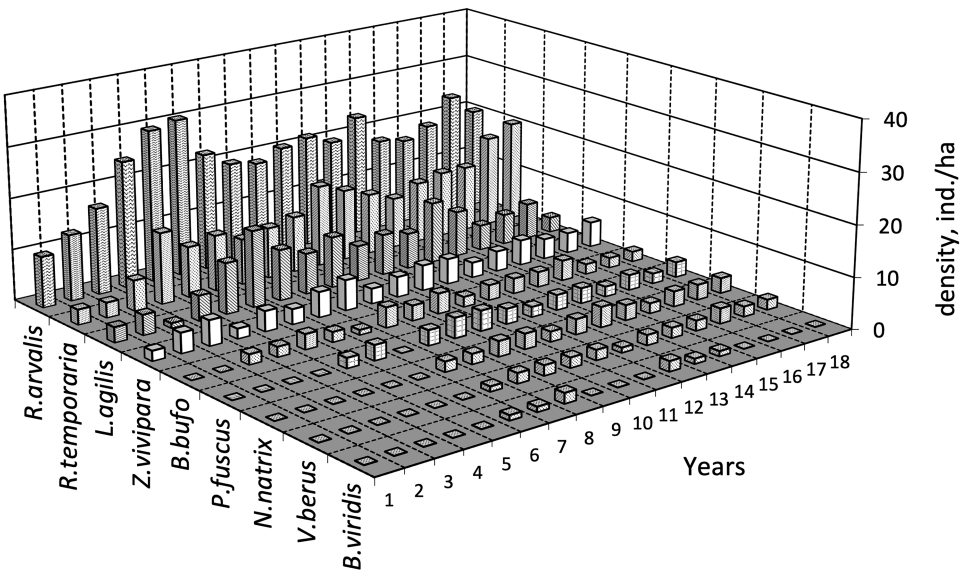

Fig. 1. Formation the species composition of amphibians and reptiles faunal complexes on sections restoration succession (deforestation site**).**

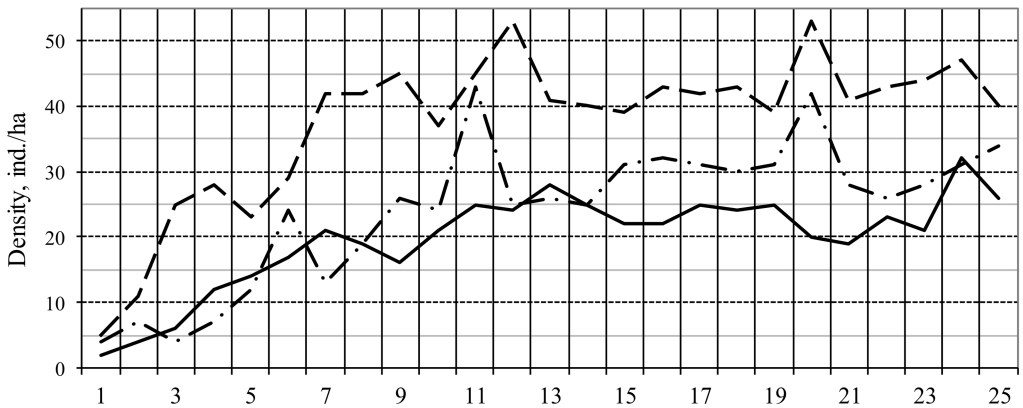

Fig. 2. Dynamics of number the herpetocomplexes on the plots of secondary succession.

ecosystems. At this stage, rapid growth of species richness has been observed and a primary, relatively simple structure of the community is formed.

In the early years in the restoration succession areas almost all the species inhabiting neighboring ecosystems are found, however, only the most adapted to the open biotopes, or tolerant of a wide range of conditions remain: Moor frog (*Rana arvalis*) and Common frog (*R. temporaria*), Common toad (*Bufo bufo*), Sand lizard (*Lacerta agilis*) and Viviparous lizard (*Zootoca vivipara*). Pioneer species are characterized by small size, high fecundity and wide range of consumable food items (consumers of 2-3 levels of the trophic piramide). They form the main component of the community, its most significant and stable part. Migrants from neighboring surviving ecosystems mainly determine the abundance of emerging communities in the succession areas in the first years. For amphibians, an important condition in the primary settlement is the humidity of the biotope, for most species of reptiles require semi-shaded sites.

The composition of the pioneer species in the secondary succession sites, strongly differing in their environmental conditions, area, original vegetation, was, generally, similar.

Forming the herpetocomplexes at the initial stage of succession is closely related to the main direction of the restoration process of vegetation, rapid growth of grass cover, and decrease in illumination, increases in humidity and change in temperature regime of the habitat.

At the middle stage of succession, which covers a time period from 5-6 to 12-20 years, several new species, mainly meso- and stenotopic, adapted to a narrower range of conditions are included in the primary communities (Fig. 3). Common newt (*Lissotriton vulgaris*) and Slowworm (*Anguis fragilis*) are most typical for this stage. During the same period, the structure of communities is supplemented by predators of higher (4-5) trophic levels (Grass snake *Natrix natrix* and Common adder *Pelias berus*), which appear only after the formation of required trophic resources. By the end of the stage, at the recovery areas relative steady species composition and community abundance are formed.

At the first and middle stages of succession, relationship between the dynamics of zoo - and phytocenosis formation is clearly visible, which is manifested, for example, in the attachment of animals to places with developing vegetation and areas with high forage supply.

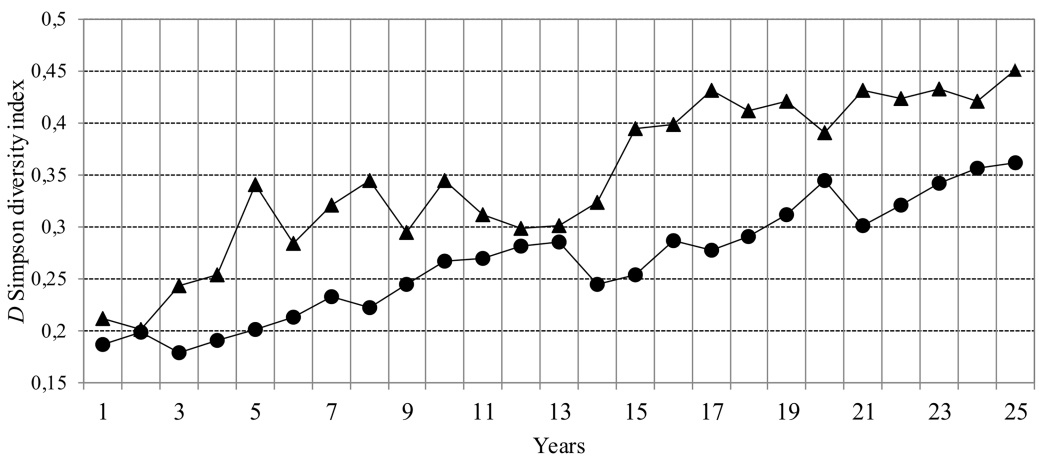

Fig. 3. Changes in species diversity (*D*, Simpson index of diversity) of herpetocomplexes at sites of secondary succession.

18-20 years later, in some areas of recovery succession comes the final stage of biocenosis formation, which is characterized by a stable species composition of the community of a certain type (forest, meadow, swamp), the most appropriate to environmental conditions. Further in herpetocomplexes slight fluctuations in composition and abundance, without a radical restructuring or change of species and taxonomic groups occur. The duration of formation community associated with forms and levels of anthropogenic transformation of landscapes, the area of fragment and structure of neighboring ecosystems.
Nevertheless, even at the final stage, in the community sometimes some changes in the structure of herpetocomplexes occur associated with microsuccession (due to the death of individual trees, destruction of soil cover, activity of digging animals, etc.).

As a whole, during process of the species structure formation in anthropogenic succession areas communities there is a transition from polydomination to monodomination. Dominants usually are eurybiont species such as Moor (*Rana arvalis*) and Common frog (*Rana temporaria*), Sand (*Lacerta agilis*) and Viviparous lizard (*Zootoca vivipara*), adapted to a wide range of environmental conditions.

Specialized species, occurring at the final stage of succession, are stenobiontic Natterjack toad (*Epidalea calamita*), Crested newt (*Triturus cristatus*), and Smooth snake (*Coronella austriaca*), which exist in specific environment. In gradient of many environmental factors, for example, humidity or temperature, in the new habitats there are distinct changes of spatial distribution most species population in the form increasing or decreasing their abundance. In homogeneous conditions more simple species structure of the emerging ecological community is formed.

Observations of the recovery successions, processes of origin and development of communities, on the model of amphibian and reptile complexes in Belarus, showed that the ecological niche of the species is formed during gradual change of environment and formation of necessary habitat conditions. A niche is created by the abiotic and biotic components and conditions of an ecosystem and is filled by the species as a result of its adaptation over a period.

Biotic complex of the studied groups of animals are integrated community with certain properties, indicated in a clear spatial integration of populations of different species, a certain species diversity and structure of food links and niches. During secondary successions, natural communities and all their components including herpetocomplexes receive, a number of stages characterized by environmental changes and adaptations to them the species composition and structural elements (guilds), and is created community, signs of which are determined by the properties of the environment. The question of temporary changes of the structure of the community is closely related to the practical tasks, the search for the basis of their sustainability and the development of measures aimed at improving stability in the conditions of intensive impact of various anthropogenic factors. The data obtained indicate a high capacity of communities to recover from human impact.

SUMMARY

1. The formation of herpetocomplexes on the recovery succession areas occur several stages that differ in duration, species composition and abundance of amphibians and reptiles. At the first stage small, fecund, feeding on invertebrates species come, while consumers of higher levels (snakes) appearing on a middle stage of the succession.
2. Changes of the structure of amphibian and reptile faunistic complexes are closely related to the processes of phytocenosis development and the formation of ecological conditions of new habitats, especially microclimatic ones. The rate of formation of herpetocomplexes is associated with the forms and level of anthropogenic transformation of landscapes, the area of the restored fragment and the structure of the

community of neighboring natuaral ecosystems. 3. The data obtained indicate a high capacity of communities to recover from human impact.

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