

SPECIES DIVERSITY OF BREEDING COMMUNITIES AND NESTING PHENOLOGY OF AMPHIBIANS IN PONDS OF BELARUS

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Temporal reproductive aggregations of amphibians, emerging in spring and early summer in the ponds of Belarus, is usually represented by 3-5 species (up to 10). Species structure of communities is determined by a many different natural impacts. Maximum number of species is observed in a range water bodies characterized by set of favorable conditions for spawning, embryonic and larval development of amphibians (optimal hydrological regime, depth, temperature, current velocity, vegetation). Reproductive associations include all shades combinations of species, but there are often found peculiar types. According to differences of main phenological characteristics 4 groups selected: an early spring species with short breeding period (*Rana temporaria*, *R. arvalis*, *Bufo bufo*), late-spring species with short breeding period (*Pelobates fuscus*, *Pelophylax lessonae*, *P. ridibundus*, *P. kl. esculentus*), spring and early summer species with long period of breeding (*Lissotriton vulgaris*), summer species with long period of reproduction (*Pseudepidalea viridis*, *Epidalea calamita*, *Bombina bombina*, *Hyla arborea* and *Triturus cristatus*). Phenological differences of amphibian reproduction facilitate the ecological differentiation of species, the formation of a balanced structure of breeding communities and making better use of limited resources environment.

Key words: Amphibian, species, community, breeding phenology, spawning pond, Belarus.

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INTRODUCTION

Fauna of Belarus is represented by 13 species of amphibians (2 Caudata and 11 Anura), spawning in the spring and early summer in warm, shallow and very similar water bodies (Pikulik 1985, Bakharev 1986, Drobenkov et al. 2005). In the ponds during the breeding season diverse temporary associations of amphibians, including, mostly, few jointly spawning species are formed. After spawning in the communal ponds emerge a mass larval

aggregations of different species, therefore the growth, survival and abundance of amphibians (as an example *Bombina bombina*) depend not only on geography (Kuzmin et al. 2008), climate (Tytar et al. 2018), environmental parameters (hydrological, biochemical), native and invasive competitors and predators (Pupins & Pupina 2012), and resources (food) water bodies (Pupina & Pupins 2008), but also on the composition and interspecific relationships collectively breeding amphibians (Pupina & Pupins 2009).

Breeding phenology and related species composition of reproductive associations in amphibian spawning aggregations has plays important role in the reproducing of populations and their viability (Hartel et al. 2007, Pupina & Pupins 2015). Temporal dynamics of development the spring aquatic associations of amphibians in a consequence in the summer is affected in their structure and function in terrestrial communities. Any phenomena occurring in the ecosystem related to time, therefore chronological dynamics of the different components of ecosystems, including amphibians, represents one of the most important aspects of their analysis (The reproductive biology of amphibians 1977, Pupina & Pupins 2009).

The study of patterns temporal organization of multispecies communities of amphibians, which are the most widespread and important components of natural ecosystems in Europe, is a great theoretical significance for understanding self-organization processes, of the factors determining the spatio-temporal changes and features of their functioning in different natural conditions and geographical zones.

Despite the obvious importance of this issue, the major trends of the temporal organization of amphibian spawning communities during the breeding season in the forest zone of Europe with temperate climate presently not been explored. In this regard, this work aims to study ecological and biological characteristics of reproduction the different species of amphibians and structural organization of their temporary communities during the breeding season in Belarus.

MATERIAL AND METHODS

Field data on species diversity, temporal dynamics of spawning aggregations and breeding phenology of amphibians in Belarus collected in the 1985-2015 from late March to mid-July. The studies were performed mainly in the Central part of the country in few monitoring points located in various areas of the Minsk

region. Some studies for comparative purposes conducted in the southern and Northern part of Belarus.

Species numbers and structure of the spawning communities of amphibians were estimated in 176 water bodies located in different climatic and landscape zones of the country, both in natural and transformed ecosystems. Species number was evaluated by the results of registration adult breeding specimens from April to June each year, at intervals no less than 2 times in 10 days. The presence of rare species with low number in the pond in some cases defined at their eggs and tadpoles. Due to difficulties in field identification of the species and similarity of the reproductive biology of three species of green frogs (*Pelophylax kl. esculentus*) was studied as a single group.

Description of environmental conditions, including the hydrological, biochemical and ecosystem parameters (area, depth, form, type of ground, structure of bottom, speed of the current, temperature, *pH*, aquatic and coastal vegetation and others) was conducted for each pond (Bannikov et al. 1977, Kuzmin 1999).

To investigate breeding phenology the data of start and end of spawning period, its duration, the peak of reproductive activity and attendant weather conditions (dynamics of air and water temperature, rainfall) have been defined. To analyze temporal and spatial patterns of nesting assemblages the species composition, structure (number proportion of species), abundance and distribution of individuals in the pond was determined. The relative abundance (density) of the species populations was assessed by the results of the visual survey of the habitat, providing data in ind./1 m².

RESULTS AND DISCUSSION

Species diversity of spawning amphibian aggregations

Estimation of the species number in temporal

Table 1. Degree of similarity between spawning ponds of different species amphibians in Belarus

Species	Similarity of species habitats by abundance, Jaccard index KJ										
	<i>L. vulgaris</i>	<i>T. cristatus</i>	<i>B. bombina</i>	<i>P. fuscus</i>	<i>B. bufo</i>	<i>P. viridis</i>	<i>E. calamita</i>	<i>H. arborea</i>	<i>P. cl. esculentus</i>	<i>R. arvalis</i>	<i>R. temporaria</i>
<i>L. vulgaris</i>	-	0,26	0,16	0,18	0,23	0,05	0,06	0,14	0,21	0,07	0,05
<i>T. cristatus</i>	-	-	0,18	0,1	0,11	-	-	0,12	0,11	-	-
<i>B. bombina</i>	-	-	-	0,03	0,08	0,21	0,11	0,38	0,43	-	-
<i>P. fuscus</i>	-	-	-	-	0,21	-	0,05	0,07	0,03	0,09	0,03
<i>B. bufo</i>	-	-	-	-	-	0,04	-	-	-	0,41	0,38
<i>P. viridis</i>	-	-	-	-	-	-	0,28	0,15	0,23	0,09	-
<i>E. calamita</i>	-	-	-	-	-	-	-	0,06	0,14	-	-
<i>H. arborea</i>	-	-	-	-	-	-	-	-	0,38	0,05	0,09
<i>P. cl. esculentus</i>	-	-	-	-	-	-	-	-	-	-	-
<i>R. arvalis</i>	-	-	-	-	-	-	-	-	-	-	0,48
<i>R. temporaria</i>	-	-	-	-	-	-	-	-	-	-	-

Note: Maximum values of K_j marked with bold style

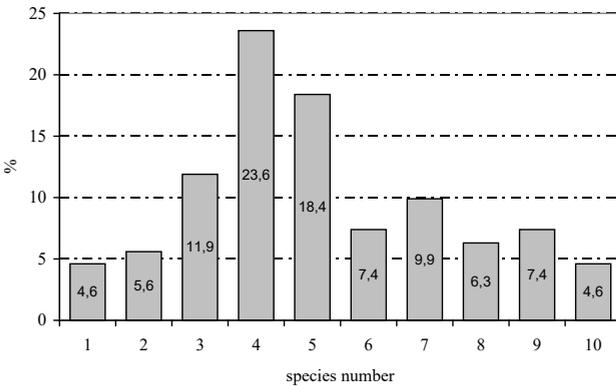


Fig. 1. Species richness of the spring-early summer spawning aggregations of amphibians in ponds of Belarus.

reproductive groups of amphibians, emerging in the spring and early summer in Belarus, showed that in each water body up to 10 species bred (Fig. 1). Most often the spawning assemblages were represented by 3-5 species of amphibians. Associations, which included both the most high and the most low taxonomic diversity of this group of animals, were found rarely.

The maximal richness of species has been noted usually in relatively large water bodies (area more than 0.5 ha), characterized by wide range of environmental conditions. The highest ecological capacity is characteristic for ponds possessing of number favorable conditions for spawning, embryonic and larval development of amphibians such as: stable hydrological regime (not dry up in the summer and during many years), shallow depth (0.5-1 m), high temperature, standing or weakly running water and well-developed coastal and aquatic vegetation.

In the reproductive associations of amphibians in the ponds in Belarus very different combinations of species occur (Tables 1). The composition of the aquatic community is formed mainly under the influence of similar ecological requirements amphibians to their conditions of reproduction.

Along with high variability in species

composition of breeding aggregations, there are also some geographical features of different natural regions, which emerge in the form of a «typical» variants of community. So, for instance, in southern Belarus, nearly 40% of all spawning assemblages were represented by a set of species, which includes moor frog (*Rana arvalis*) and green frogs (*P. kl. esculentus*), fire-bellied toad (*Bombina bombina*) and tree frog (*Hyla arborea*). All other species of batrachofauna were presented in the aggregations very rarely and in small numbers. In central and northern regions of the country a common composition of the community (about 50% of surveyed ponds) included common frog (*Rana temporaria*) and moor frog (*Rana arvalis*), common toad (*Bufo bufo*) and green frogs (*P. kl. esculentus*).

Crested newt (*Triturus cristatus*), natterjack toad (*Epidalea calamita*), which are included in the Red Data Book of the Republic of Belarus (Krasnaja kniga Respubliki Belarus, 2015), and green toad (*Pseudepidalea viridis*), that have been observed only in unsaturated interspecific associations are the rarest members of spawning aggregations in Belarus. Common and green toads, using the shallowest and warm ponds in open habitats, are among species avoiding the presence of any other amphibians at reproduction.

Comparative analysis of the ecological requirements of various species to the conditions of nesting sites shows that the most important parameters of the aquatic habitats of amphibians are average water depth, temperature, speed of current, structure of bottom and characteristic of littoral vegetation. Despite the fact that the ranges of variability of the ecological parameters of water bodies of most species is much overlap, many of them have unique environmental preferendum.

For this reason, if sufficient high diversity of natural water resources the marked selectivity of breeding sites is characterized for many species. So, in Central Belarus common toads spawns predominantly in floodplain lakes of the

rivers and in standing or slowly current drainage channels, moor and common frogs prefer small forest ponds and fens, green and natterjack toads choose to use warm ponds in open landscapes, newts gather for oviposition in small forest ponds.

Nevertheless, in the conditions of limit water resources, which is typical for some dry regions of territory, majority of species reproduces in cooperative habitats, selecting the optimal sites and changing each other in the pond at the time breeding season.

In Belarus, amphibians spawn in almost all small natural and semi-natural water bodies. In middle and big ponds (artificial ponds, lakes, water storages) oviposition sites are located only the littoral zone. Flowing water reservoirs with rapid current as breeding sites are not used.

Breeding phenology of amphibians. For the main seasonal reproduction characteristics (calendar date of the beginning and end of spawning, duration of nesting period, peak of reproductive activity, temperature of water) several well-distinguished groups stands out among the amphibians in Belarus (Fig. 2):

A. Early spring species with a short breeding period. This group includes common frog (*Rana temporaria*) and moor frog (*Rana arvalis*) and common toad (*Bufo bufo*). Spawning in these species in the central part of Belarus usually occurs from 5 to 20 April, but it might shift to 5-7 days earlier or later due to weather fluctuations. The water temperature at the spawning time varies from +7 to + 15°C. Species of this group for reproduction use standing or slowly dwindling water bodies.

B. Late spring species with short breeding period. The group includes four species: common spadefoot (*Pelobates fuscus*), pond frog (*Pelophylax lessonae*), lake frog (*Pelophylax ridibundus*) and hybrid frog (*Pelophylax kl. esculentus*), which form a complex of green frogs (*P. kl. esculentus*). In the central part of the country the nesting of these species takes

place from 25-30 April to 15-25 May at a water temperature between +12 and +20°C. Breeding sites present by a wide range of water bodies from small to large, both standing and poorly flowing.

C. Spring-early summer species with a long period of reproduction. This category includes only one species – the common newt (*Lissotriton vulgaris*). The breeding season this amphibian continues from mid-April to middle June. Water temperature in the breeding period varies widely from +7 to +22°C. Small forest ponds with stagnant water are usually the reproductive habitats.

D. Summer species with a long breeding period

The group includes green toad (*Pseudepidalea viridis*) and natterjack toad (*Epidalea calamita*),

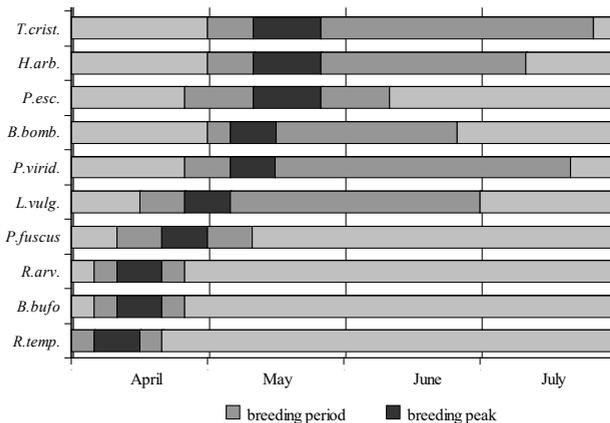


Fig.2. Calendar terms and duration of the amphibians spawning period in the Central part of Belarus.

The month is divided into six 5-days period: 1st – from 1st to 5 th, 2-nd – from 6-th to 10-th, 3-nd – from 11-th to 15-th, 4-nd – 16-th to 20-th, 5-nd – from 21-th to 25-th, 6-nd – from 26th to 30th (31th).

R.temp. - common frog, *B.bufo* - common toad, *R.arv.* - moor frog, *P.fuscus* - common spadefoot toad, *P.esc.* - complex of green frogs, *L.vulg.* - common triton, *P.virid.* - green toad, *B.bomb.* - fire-beied toad, *H.arb.* – common tree-frog, *T.crist.* - crested triton, *E.calam.* – natterjack toad.

a fire-bellied toad (*Bombina bombina*), common tree-frog (*Hyla arborea*) and crested newt (*Triturus cristatus*). This is most thermophilous group of amphibians spawning from early May to early July at a temperature of +15-25°C. These amphibians usually reproduce in small heat both open and forest ponds.

Multicomponent communities of amphibians spawning in some pond, consisting 5-10 species, are usually represented by species with different phenorhythms of reproduction. From early April to early July, a gradual change of reproductive association compositions occurs from the most cold-resistant (common and moor frog) to the most thermophilic (natterjack toad, common tree-frog and crested triton).

The duration of the existence numerous interspecies breeding amphibian communities in water bodies varies somewhat each year, due to changes in weather and temperature conditions in spring and early summer.

Reproductive differentiation of amphibian species by terms and duration of spawning period has a significant impact on the state of their terrestrial populations. According to the findings, early spring group consists of the most abundance species characterized by a high number and wide range of suitable terrestrial habitats (common and moor frogs, common toad). The group of amphibians, spawning in the summer is represented by the species with low number and a narrow range of breeding sites (natterjack and green toads, crested triton and others

In General, distinctions in the seasonal reproduction of different species of amphibians, caused by peculiarities of their breeding process and asynchronous reproductive cycles, appear to be one of the most important factors contributing to the ecological differentiation of species,

a more uniform distribution of residence time in water bodies and the formation of more balanced structure of spawning communities. In a temperate zone of Europe with a relatively short warm period, different seasonal cycles of amphibian reproductive activity, contributing to the fuller use of limited environmental resources and a more even distribution of the load in biocoenosis, play an important role.

However, in conditions of excessively high number of populations spawning species, which are often observed in ponds, both in the mating aggregations of adults and among the larval population of amphibians, competition for spatial and other resources is increasing.

CONCLUSION

1. Spawning aggregations of amphibians, emerging in spring and early summer in the ponds of Belarus, is normally represented by 3-5 successive species (up to 10).

2. Species structure of the breeding communities is determined by a many different natural impacts. Maximum number of species is observed in a range water bodies characterized by set of favorable conditions for spawning, embryonic and larval development of amphibians (optimal hydrological regime, depth, temperature, current velocity, vegetation).

3. According to differences of main phenological characteristics 4 groups of amphibians selected in study area: an early spring species with short breeding period (*Rana temporaria*, *R. arvalis*, *Bufo bufo*), late-spring species with short breeding period (*Pelobates fuscus*, *Pelophylax lessonae*, *P. ridibundus*, *P. kl. esculentus*), spring and early summer species with long period of breeding (*Lissotriton vulgaris*), summer species with long period of reproduction (*Pseudepidalea viridis*, *Epidalea calamita*, *Bombina bombina*, *Hyla arborea* and *Triturus cristatus*).

4. Phenological differences of amphibian reproduction facilitate the ecological

differentiation of species, the formation of a balanced structure of breeding communities and making better use of limited resources environment.

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