ON SOME FACTORS DRIVING THE PRESENCE OF AMPHIBIANS IN WATER BODIES OF THE UPPER OKA BASIN (CENTRAL RUSSIA)

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A better understanding of the factors influencing the distribution of amphibians is needed to conserve amphibian species in regions highly populated by people. A total of 71 water bodies were examined in the Upper Oka Basin (the Central Part of the Russian Plain, Russia, Kaluga Oblast and adjacent regions). For each site, the presence and absence of 11 amphibian species were determined. We use the logistic regression within the *glm* function from the R Stats Package to estimate the influence of predictors on the probability of the species presence. The species with the highest occurrence were *Pelophylax lessonae*, *P. ridibundus*, *Rana temporaria*, and *Bufo bufo*. The type of terrestrial vegetation that surrounded the water body was a significant factor for three amphibian species. We found *R. temporaria* and *B. bufo* avoiding open habitats; and *P. ridibundus* avoiding wooded habitats. The degree of water moving was a significant factor for two amphibian species. *Lissotriton vulgaris* was present more frequent at lentic waters, and *P. ridibundus* preferred lotic waters. The percentage of the vegetation covering the water surface was a significant factor for *Rana arvalis*, which was more often present in water with 50% or more coverage. Acidity was a significant factor for *Pseudepidalea viridis*, which was detected only in neutral and alkaline waters. Total dissolved salts and the area of water body were significant predictors for no amphibian species. The presence of the Chinese sleeper (*Perccottus glenii*), an invasive fish species, was not significantly important in predicting detection or non-detection for any species. Many water bodies in the Upper Oka Basin that were likely once suitable for amphibians may not be occupied by amphibians due to barriers to dispersal from other sites and due to stochastic extinction. To estimate the capability of amphibian immigration from other sources, we identified the presence of lotic and lentic permanent water bodies within 1 km of a surveyed site. These factors were not significant for any species. Further investigations may achieve the best measure of connectivity of amphibian habitats. To conserve amphibians we need to keep terrestrial habitats surrounding the water bodies, especially wooded habitats.

Key words: acidity, Amphibia, aquatic vegetation coverage, Chinese sleeper, lentic water, lotic water, River Oka, terrestrial vegetation, total dissolved salts, wooded habitat

Introduction

Amphibians have been the object of numerous ecological investigations in both field and in laboratory settings (Beebee, 1981, 1983; Kaufman, 1989; Fayzulin, 2010; Smirnov, 2013). Many investigations in amphibian ecology are concerned with the quality of breeding and residential water bodies, which has great value for the continued persistence of amphibian populations. The quality of amphibian habitats is influenced by the type of vegetation in the water body and surrounding terrestrial habitat, the hydroperiod and water quality, the presence of predators and competitors, the prevalence of diseases, and the nature and frequency of human disturbances (Hamer & McDonnell, 2008; Collins et al., 2009). Specifically, aquatic vegetation provides shelter for larval and adult amphibians and oviposition sites (Hartel et al., 2007). Terrestrial vegetation provides opportunities for dispersal, food, shelter and overwintering sites once individuals have metamorphosed (Hamer & McDonnell, 2008). The terrestrial vegetation influences the water temperature, and the water temperature determines the development of eggs of amphibians (Nikolaev, 2007). The most important factor of water quality is water acidity, which can affect the success of reproduction and causes various morphological anomalies in some frogs (Flax, 1986; Nikolaev, 2007; Fayzulin, 2010). Amphibians are highly sensitive to environmental pollutants in the water; particularly, the presence of dissolved metals and salts in water (i.e. high conductivity) and high nutrient loads negatively affect amphibian populations in urban and suburban areas (Hamer & McDonnell, 2008). Water current and water transparency are also important to amphibians (Semenov et al., 2000).

Populations of amphibians across the globe have been declining for the last few decades due to climate change, habitat loss and diseases (Alford & Richards, 1999; Lips et al., 2003; Stuart et al., 2004; Collins et al., 2009). To conserve threatened amphibian species we need to identify species' tolerance and optimal environmental conditions especially under increasing urbanisation and the development of recreational activities. Understanding why threatened species and biological communities persist in urbanised areas can help us create successful conservation management plans for preventing and reversing future declines (Valdez et al., 2015).

The vulnerability of amphibians to disturbance relates to their limited dispersal ability (Araújo et al., 2006). Many ponds may be not inhabited by amphibians due to the isolation of ponds and the limited dispersal distance of amphibians (Semenov et al., 2000; Smith & Green, 2005). For example, the number of permanent water bodies within a given distance of a surveyed water body has been shown to be the most important predictor for occupancy, colonisation, and abundance of amphibian species (Valdez et al., 2015). However, it has been shown that dispersal distance might be much larger than expected for amphibians (Smith & Green, 2005).

There is significant geographic variation in life-history characteristics of amphibians and in tolerance to some environmental factors (Vershinin, 1995; Morrison & Hero, 2003; Kuzmin, 2012). The different abilities of amphibians to cope with the effects of urbanisation are also likely to generate regionally contrasting long-term trends in their community dynamics (Hamer & McDonnell, 2008). So it is necessary to survey ecological features of species to conserve amphibians in a given region.

The Upper Oka Basin is one of the most populated and anthropogenically disturbed regions of Russia. Previous research focused on the species composition, distribution and abundance of amphibians in terrestrial habitats, bionomics, and feeding of amphibian species in this region (Alekseev & Sionova, 2002; Ruchin & Alekseev, 2008; Korzikov et al., 2014; Korzikov, 2016); but a better understanding of the factors influencing distributions of amphibians is needed to plan further investigations. Therefore, the aim of the study was to evaluate the parameters of water bodies, which determine the presence or absence of different amphibian species in the Upper Oka Basin.

Material and Methods

Study area

The Upper Oka Basin is located in the centre of the Russian Plain and contains the Basin of the River Oka from its source to the mouth of the River Nara near Serpukhov in Moscow Oblast. This region encompasses primary areas of the Kaluga oblast excluding western territories.

We surveyed a total of 71 water bodies from different districts of the Kaluga and Tula Oblast. We observed water bodies such as puddles, quarries, ponds, rivers, streams, and streams with one or several dams, backwaters (parts of a river in which there is little or no current), bogs, oxbows, and waterworks (Table 1). Sixty water bodies were permanent, and eleven water bodies were temporal. Forty-one sites were located in rural areas, and twenty-nine sites in urban areas.

We analysed four quantitative and five qualitative parameters of water bodies (Table 1).

Table 1. Examined parameters of water bodies of the Upper Oka Basin in which amphibians were surveyed

Parameters	Levels / Range	Number of sites
Type of terrestrial vegetation surrounding the water body	Wooded habitat – with dense tree layer	21
	Open habitat – with herbaceous vegetation without trees	28
	Edge habitat – with intermediate features	22
Degree of water moving	Lentic – water bodies with permanent flow	46
	Semi-lentic – water bodies with permanent flow and limited with dam	13
	Lotic – water bodies without flow	12
Presence of lentic permanent water bodies within a kilometre of a surveyed water body	present	35
	absent	36
Presence of lotic permanent water bodies within a kilometre of a surveyed water body	present	32
	absent	39
Presence of *Perccottus glenii*	present	12
	absent	59
Percentage of vegetation cover, %	3–100	71
pH	4.7–10.0 (precision = 0.01)	37
Total dissolved salts (TDS), mg/L	19–851 (precision – integer)	37
Area of water body, sq. m	10–63 006	71

Field surveys

Amphibian surveys were conducted from March to August in 2005–2016. The presence or absence of amphibian species was registered in every water body. Amphibians were detected in the daytime visually by hand and using a net with 0.6 m diameter of mouth, 1.7 m length of handle, and 2 mm diameter mesh. Most of the water bodies were surveyed at least three times during the season. A few ponds were surveyed one time during the season because they were located in hard-to-reach areas, and we assumed that single surveys are sufficient for the detection of amphibians based on expert experience (Alekseev, personal communication).

Species were identified using sounds and morphological characteristics. Species of the genus *Pelophylax*, which are not distinguishable by morphological characteristics, were identified using analysis of intron-1 of the serum albumin gene (SAI-1) from tissue of frogs through polymerase chain reaction (Plötner et al., 2009).

The Chinese sleeper, *Perccottus glenii* (Dybowski, 1877), is an introduced fish species, which is known to negatively impact populations of amphibians (Semenov et al., 2000; Reshetnikov, 2003). This fish was detected using dipnetting. The pH and total dissolved salts (TDS) were measured in 37 water bodies using portative electronic readers pH-009 and TDS-3 (equipment consisted 0.1 for pH and 1 mg to litre for TDS). Areas of water bodies were detected using satellite images on Google Maps Calculator (https://3planeta.com/googlemaps/googlemaps-calculator-ploschadei.html).

Data analysis

Data were analysed using R (R Core Team, 2014). The logistic regression within *glm* function from the R Stats Package was applied to estimate the influence of predictors on the probability of presence of every species using two different models. First, we computed the *glm* model for six factors which were measured in all 71 water bodies: type of terrestrial vegetation, degree of water moving, presence of lentic and lotic water bodies within 1 km, presence of *Perccottus glenii*, and percentage of the vegetation covering the water surface. Secondly, we computed the *glm* model for three factors, which were measured in the subset of 37 waterbodies: surface area, pH, TDS. Independent variables were uncorrelated ($p > 0.2$ for Pearson's correlation).

Results

There were 11 amphibian species in water bodies of the Upper Poochye (Table 2). No species occupied more than half of all examined sites. Species with the highest frequency of occurrence were the Pool Frog (*Pelophylax lessonae* Camerano, 1882), the Common Frog (*Rana temporaria* Linnaeus, 1758), the Common Toad (*Bufo bufo* Linnaeus, 1758), and the Marsh Frog (*Pelophylax ridibundus* Pallas, 1771).

Table 2. Number of water bodies of different kinds, which were inhabited by different species of amphibians. Sample size in brackets after water body type

Species	Puddle (7)	Quarry (5)	Pond (24)	Cascade of ponds (5)	Stream with dam (6)	Stream (3)	River (8)	Backwater (2)	Bog (3)	Oxbow (5)	Other artificial water bodies (3)	Percentage of occupied sites
Lissotriton vulgaris (Linnaeus, 1758)	2	1	7	2	1	–	–	–	1	1	1	23
Triturus cristatus (Laurenti, 1768)	1	1	4	1	–	–	–	–	1	–	–	11
Bombina bombina (Linnaeus, 1761)	1	–	4	–	–	–	–	–	–	1	–	8
Pelobates fuscus (Laurenti, 1768)	–	–	5	–	–	–	–	–	–	1	1	10
Bufo bufo (Linnaeus, 1758)	4	1	11	2	2	1	–	–	1	–	–	31
Pseudepidalea viridis (Laurenti, 1768)	1	1	3	–	1	–	–	–	–	–	1	10
Rana temporaria Linnaeus, 1758	4	–	10	2	4	1	1	1	1	1	–	35
Rana arvalis (Nilsson, 1842)	–	1	8	2	2	–	–	1	3	1	–	25
Pelophylax ridibundus (Pallas, 1771)	2	2	6	–	1	–	7	1	–	2	–	30
Pelophylax lessonae (Camerano, 1882)	–	3	14	3	5	2	–	–	1	2	2	45
Pelophylax esculentus (Linnaeus, 1758)	–	–	4	2	2	–	2	–	1	1	–	17

The type of terrestrial vegetation that surrounded the water body was a significant factor for three amphibian species (Appendix 1). *Rana temporaria* (p = 0.001) and *Bufo bufo* (p = 0.049) avoided open habitats, and *Pelophylax ridibundus* (p < 0.001) avoided wooded habitats (Table 3).

The degree of water flow was a significant factor for two amphibian species (Appendix 1, Table 4). The Smooth Newt (*Lissotriton vulgaris* Linnaeus, 1758) was present more frequently in lentic waters (p = 0.016), and *Pelophylax ridibundus* preferred lotic waters (p = 0.040).

The percentage of the vegetation covering the water surface was a significant factor (p=0.019) for *Rana arvalis* (Nilsson, 1842). This frog was more often present in waters with 50% or more coverage.

The presence of the Chinese sleeper and the presence of lotic or lentic water bodies within 1 km were not significant in predicting detection or non-detection for any species (Appendix 1).

The acidity was a significant factor (p = 0.048) for *Pseudepidalea viridis* (Laurenti, 1768), which was detected only in neutral and alkaline waters, with pH = 7–10 (Appendix 2). Total dissolved salts and the area of water body were significant predictors for no amphibian species (Appendix 2).

Discussion

The terrestrial vegetation was the best predictor of the presence of three amphibian species (*Rana temporaria*, *Bufo bufo*, and *Pelophylax ridibundus*). This result agrees with previous research from other regions: terrestrial habitat factors were found to be especially important in determining the suitability of breeding sites for *Rana temporaria* in Ireland (Marnell, 1998) and Sweden (Loman & Lardner, 2006). Previous studies have also found the importance of terrestrial habitats for amphibians within conservation programmes (Valdez et al., 2017) and for females of the green and golden bell frog *Litoria aurea* (Lesson, 1830) (Valdez et al., 2016). The terrestrial vegetation can determine the temperature of water, which plays an important role in amphibian breeding and development (Moore, 1939). Wooded sites can provide superior refugia and feeding for adult amphibians, and some species require forests for part of their life cycle (Guerry & Hunter, 2002; Kuzmin, 2012). *Rana temporaria* is sensitive to air humidity (Dinesman, 1948), so it is a forest species to minimize the exposure to drier conditions (Kutenkov, 2017). *Bufo bufo* is also characterised as a forest species although it is less sensitive to humidity than the Common Frog (Kuzmin, 2012). *Pelophylax ridibundus* prefers open habitats because open habitats are often due to overflowing large rivers and ponds, and this species is connected with large rivers and ponds (Ruchin et al., 2009; Svinin, 2013).

The water quality significantly influenced the presence of *Pseudepidalea viridis*, a species that is not abundant in the Upper Oka Basin (Korzikov, 2016). The range of pH in which *P. viridis* was present in the Upper Oka Basin was close to those observed in the Middle Volga (6.6–10.0; Fayzulin, 2010). This species is qualified as synanthropic, e.g. it lives near, and benefit from, an association with humans and the somewhat artificial habitats that humans create around them (Alekseev & Sionova, 2002), and artificial water bodies tend to be more often alkaline than natural ones.

Table 3. Numbers of water bodies of different kinds occupied by amphibians in the Upper Oka Basin

Species	Type of vegetation			Degree of water moving		
	wooded (n = 21)	edge (n = 22)	open (n = 28)	lentic (n = 46)	semi-lentic (n = 13)	lotic (n = 12)
Lissotriton vulgaris	6	7	3	14	2	0
Triturus cristatus	3	4	1	7	1	0
Bombina bombina	1	2	3	5	1	0
Pelobates fuscus	1	4	3	8	0	0
Bufo bufo	7	14	1	17	4	1
Pseudepidalea viridis	1	3	3	5	2	0
Rana temporaria	11	13	1	18	4	3
Rana arvalis	6	10	2	15	2	1
Pelophylax ridibundus	0	9	12	12	2	7
Pelophylax lessonae	11	15	6	22	8	2
Pelophylax esculentus	4	4	4	6	4	2

Table 4. Numbers of water bodies occupied by amphibians given presence or absence of other permanent water bodies within 1 km of a surveyed water body in the Upper Oka Basin

Species	Lentic water bodies		Lotic water bodies	
	Absent (n = 39)	Present (n = 32)	Absent (n = 36)	Present (n = 35)
Lissotriton vulgaris	8	8	10	6
Triturus cristatus	3	5	5	3
Bombina bombina	3	3	1	5
Pelobates fuscus	2	6	4	4
Bufo bufo	10	12	14	8
Pseudepidalea viridis	6	1	4	3
Rana temporaria	10	15	14	11
Rana arvalis	7	11	10	8
Pelophylax ridibundus	12	9	9	12
Pelophylax lessonae	16	16	12	20
Pelophylax esculentus	7	5	4	8

Generally, the range of acidity and total dissolved salts sets were not limiting factors to the occurrence of amphibians in the Upper Oka Basin: the focal species in this study can tolerate a wide range of variation in pH and TDS (Kuzmin, 2012). Besides, the non-significance might be explained by the absence of extremely low or high values at the water bodies surveyed. Our data agrees with the results of research in Sweden (Loman & Lardner, 2006) that found the scarcity of amphibians in some areas could not be explained by water quality alone but the quality of the terrestrial habitat surrounding the ponds and the metapopulation structure.

Our results indicated that many water bodies are suitable for amphibians but are not occupied by amphibians now. It is known that some ponds may not be inhabited by amphibians owing to their isolation and barriers to migration of amphibians (Semenov et al., 2000). To estimate the capability of amphibians' immigrations from other sources we identified the presence of lotic and lentic permanent water bodies within 1 km of a surveyed site. These factors were not significant for any species. This fact contrasts with Valdez et al. (2015) who found that the number of permanent water bodies within a kilometre of surveyed sites was the best predictor of the occupancy of the green and golden bell frog (*Litoria aurea*), and also with the paper of Pellet et al. (2004) who found that the presence of calling males of the tree frog (*Hyla arborea* (Linnaeus, 1758)) is influenced by urbanisation around the pond and closeness of roads. This difference may be due to the fact that Valdez et al. (2015) used the number of water bodies rather than our study that simply used the presence or absence of water bodies. Furthermore, forest landscapes of the Upper Oka Basin due to relative soft microclimatic conditions in wooded habitats and numerous puddles of water may be less stressful for amphibians than industrial landscapes of Australia and landscapes of Switzerland, so the «ponds-as-patches» view (Marsh & Trenham, 2001) is less applicable to our data. Lastly, investigations of this subject require more rigorous assessment of amphibian populations based on the metapopulation approach (Marsh & Trenham, 2001; Smith & Green, 2005; Griffiths et al., 2010).

Our results suggest that the presence of our eleven species of amphibians was not entirely predicted from the environmental variables measured. Further research could better investigate amphibian habitats using field surveys and an occupancy-modelling framework. Now only two amphibian species – *Bombina bombina* (Linnaeus, 1761) and *Pelophylax esculentus* (Linnaeus, 1758) – are considered as rare species in this region (Red Data Book of Kaluga Region, 2017). However, anthropogenic transformation of forest landscapes can cause a decline of populations of other amphibian species. To conserve amphibians in the Upper Oka Basin, we suggest conserving not just separate ponds but the whole assemblage of water bodies and terrestrial habitats, especially forest habitats.

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Appendix 1. Logistic regression model of presence of amphibian species in water bodies in the Upper Oka Basin from five predictors: coefficients (Coef.) with standard errors (SE)

Species, predictors	Coef.	SE	Z value	P value
Lissotriton vulgaris				
Intercept	-0.20	0.88	-0.23	0.816
Type of terrestrial vegetation	0.51	0.45	1.12	0.261
Degree of water moving	-1.81	0.75	-2.40	**0.016**
Percentage of vegetation cover	-0.002	0.01	-0.14	0.891
Presence of lotic water bodies within 1 km	-1.13	0.71	-1.60	0.109
Presence of lentic water bodies within 1 km	-0.18	0.73	-0.25	0.802
Presence of *Perccottus glenii*	-17.99	1746.0	-0.01	0.992
Triturus cristatus				
Intercept	-2.05	1.89	-1.89	0.059
Type of terrestrial vegetation	0.50	0.57	0.88	0.381
Degree of water moving	-1.36	0.96	-1.42	0.157
Percentage of vegetation cover	< 0.01	0.01	0.29	0.771
Presence of lotic water bodies within 1 km	-0.67	0.85	-0.78	0.437
Presence of lentic water bodies within 1 km	0.49	0.89	0.55	0.582
Presence of *Perccottus glenii*	-16.91	1807.00	-0.01	0.993
Bombina bombina				
Intercept	-3.88	1.69	-2.30	**0.022**
Type of terrestrial vegetation	-0.65	0.64	-1.01	0.312
Degree of water moving	-0.60	1.01	-0.59	0.554
Percentage of vegetation cover	0.03	0.02	1.58	0.114
Presence of lotic water bodies within 1 km	1.70	1.26	1.35	0.176
Presence of lentic water bodies within 1 km	0.59	1.02	0.58	0.562
Presence of *Perccottus glenii*	-17.28	2824.09	-0.01	0.995
Pelobates fuscus				
Intercept	-1.31	1.24	-1.05	0.293
Type of terrestrial vegetation	-0.78	0.61	-1.29	0.198

Species, predictors	Coef.	SE	Z value	P value
Degree of water moving	-17.31	2419.00	-0.01	0.994
Percentage of vegetation cover	0.00	0.02	0.05	0.963
Presence of lotic water bodies within 1 km	-0.22	0.93	-0.24	0.812
Presence of lentic water bodies within 1 km	1.26	0.98	1.29	0.196
Presence of *Perccottus glenii*	-19.03	4616.00	-0.004	0.997
Bufo bufo				
Intercept	-1.13	0.74	-1.52	0.128
Type of terrestrial vegetation	0.77	0.39	1.97	**0.049**
Degree of water moving	-0.83	0.46	-1.81	0.071
Percentage of vegetation cover	< 0.01	0.01	0.30	0.762
Presence of lotic water bodies within 1 km	-0.96	0.58	-1.64	0.101
Presence of lentic water bodies within 1 km	0.27	0.59	0.46	0.644
Presence of *Perccottus glenii*	0.41	0.70	0.58	0.560
Pseudepidalea viridis				
Intercept	0.29	1.10	0.26	0.793
Type of terrestrial vegetation	-0.74	0.62	-1.19	0.232
Degree of water moving	-1.15	0.76	-1.51	0.132
Percentage of vegetation cover	-0.01	0.02	-0.42	0.673
Presence of lotic water bodies within 1 km	-1.04	1.03	-1.02	0.307
Presence of lentic water bodies within 1 km	-2.29	1.22	-1.88	0.060
Presence of *Perccottus glenii*	-0.47	1.29	-0.37	0.714
Rana temporaria				
Intercept	-1.88	0.78	-2.41	**0.016**
Type of terrestrial vegetation	1.39	0.43	3.22	**0.001**
Degree of water moving	-0.54	0.43	-1.28	0.202
Percentage of vegetation cover	-0.01	0.01	-0.99	0.324
Presence of lotic water bodies within 1 km	-0.30	0.57	-0.52	0.604
Presence of lentic water bodies within 1 km	1.10	0.60	1.85	0.065
Presence of *Perccottus glenii*	-0.40	0.77	-0.53	0.599
Rana arvalis				
Intercept	-2.17	0.86	-2.53	**0.012**
Type of terrestrial vegetation	0.45	0.41	1.09	0.278
Degree of water moving	-0.76	0.54	-1.39	0.164
Percentage of vegetation cover	0.03	0.01	2.35	**0.019**
Presence of lotic water bodies within 1 km	-0.48	0.64	-0.75	0.452
Presence of lentic water bodies within 1 km	0.60	0.64	0.94	0.346
Presence of *Perccottus glenii*	-0.17	0.78	-0.21	0.831
Pelophylax ridibundus				
Intercept	-0.49	0.85	-0.58	0.565
Type of terrestrial vegetation	-1.74	0.49	-3.56	**< 0.001**
Degree of water moving	0.93	0.45	2.05	**0.040**
Percentage of vegetation cover	-0.01	0.01	-0.77	0.445
Presence of lotic water bodies within 1 km	1.04	0.71	1.47	0.143
Presence of lentic water bodies within 1 km	0.06	0.66	0.10	0.924
Presence of *Perccottus glenii*	0.85	0.82	1.03	0.305
Pelophylax lessonae				
Intercept	-1.66	0.74	-2.25	**0.024**
Type of terrestrial vegetation	0.59	0.35	1.65	0.099
Degree of water moving	-0.31	0.38	-0.83	0.408
Percentage of vegetation cover	0.02	0.01	1.54	0.124
Presence of lotic water bodies within 1 km	1.00	0.54	1.85	0.064
Presence of lentic water bodies within 1 km	0.40	0.54	0.75	0.453
Presence of *Perccottus glenii*	-0.78	0.75	-1.04	0.301
Pelophylax esculentus				
Intercept	-2.90	1.00	-2.90	**0.004**
Type of terrestrial vegetation	< 0.01	0.42	0.01	0.994
Degree of water moving	0.57	0.46	1.26	0.209
Percentage of vegetation cover	0.02	0.01	1.35	0.177
Presence of lotic water bodies within 1 km	1.03	0.72	1.44	0.151
Presence of lentic water bodies within 1 km	-0.04	0.68	-0.06	0.951
Presence of *Perccottus glenii*	-0.97	1.15	-0.84	0.401

Appendix 2. Logistic regression model of presence of amphibian species in 37 water bodies of the Upper Oka Basin from three predictors: coefficients (Coef.) with standard errors (SE)

Species, predictors	Coef.	SE	Z value	P value
		Lissotriton vulgaris		
Intercept	-3.90	4.36	-0.90	0.371
Area	-0.00	0.00	-0.90	0.367
pH	0.42	0.61	0.69	0.490
TDS	-0.00	0.00	-0.40	0.686
		Triturus cristatus		
Intercept	-4.49	5.56	-0.81	0.419
Area	-0.00	< 0.01	-0.65	0.514
pH	0.38	0.77	0.50	0.620
TDS	-0.00	< 0.01	-0.10	0.917
		Bombina bombina		
Intercept	-6.34	8.75	-0.73	0.468
Area	-0.00	< 0.01	-0.39	0.701
pH	0.39	1.18	0.33	0.744
TDS	< 0.01	< 0.01	1.58	0.115
		Pelobates fuscus		
Intercept	-3.75	5.10	-0.74	0.462
Area	< 0.01	< 0.01	-0.64	0.526
pH	0.30	0.71	0.42	0.678
TDS	-0.00	< 0.01	-0.40	0.690
		Bufo bufo		
Intercept	-4.96	3.88	-1.28	0.201
Area	-0.00	< 0.01	-1.26	0.208
pH	0.62	0.54	1.15	0.249
TDS	0.00	< 0.01	-0.01	0.992
		Pseudepidalea viridis		
Intercept	-22.75	10.59	-2.15	**0.032**
Area	-0.05	0.06	-1.00	0.340
pH	2.57	1.30	1.98	**0.048**
TDS	0.01	< 0.01	1.60	0.110
		Rana temporaria		
Intercept	0.62	3.12	0.20	0.843
Area	< 0.01	< 0.01	-0.45	0.655
pH	-0.09	0.46	-0.19	0.853
TDS	-0.01	< 0.01	-1.56	0.120
		Rana arvalis		
Intercept	2.22	3.17	0.70	0.483
Area	< 0.01	< 0.01	0.80	0.426
pH	-0.37	0.46	-0.80	0.424
TDS	-0.003	< 0.01	-1.14	0.254
		Pelophylax ridibundus		
Intercept	-1.74	3.60	-0.48	0.630
Area	0.00	0.00	0.70	0.482
pH	0.01	0.51	0.02	0.986
TDS	< 0.01	0.002	1.14	0.255
		Pelophylax lessonae		
Intercept	-5.63	3.69	-1.53	0.126
Area	< 0.01	< 0.01	-0.67	0.505
pH	0.78	0.52	1.50	0.134
TDS	-0.003	< 0.01	-1.13	0.257
		Pelophylax esculentus		
Intercept	-6.76	4.22	-1.60	0.110
Area	0.03	0.05	0.54	0.587
pH	0.60	0.56	1.07	0.287
TDS	-0.003	< 0.01	-0.76	0.447

О НЕКОТОРЫХ ФАКТОРАХ РАСПРЕДЕЛЕНИЯ АМФИБИЙ В ВОДОЕМАХ ВЕРХНЕГО ПООЧЬЯ (ЦЕНТРАЛЬНАЯ РОССИЯ)

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Обследован 71 водный объект на территории Верхнего Поочья (Россия, Калужская область и сопредельные регионы). В каждом местообитании выявлялось наличие либо отсутствие каждого из 11 видов земноводных. Влияние девяти параметров водных объектов на вероятность присутствия каждого вида оценивали при помощи логистической регрессии в среде R. Наиболее высокой встречаемостью обладали прудовая лягушка *Pelophylax lessonae*, озерная лягушка *P. ridibundus*, травяная лягушка *Rana temporaria* и серая жаба *Bufo bufo.* Тип наземной растительности оказался значимым фактором для трех видов амфибий. Травяная лягушка и серая жаба избегали открытых биотопов, озерная лягушка избегала лесных биотопов. Проточность водного объекта оказалась значимым фактором для двух видов: обыкновенный тритон *Lissotriton vulgaris* тяготел к стоячим водоемам, озерная лягушка – к проточным водным объектам. Процент покрытия зеркала воды водной растительностью был значим для остромордой лягушки *Rana arvalis*, которая чаще встречалась в водоемах, заросших более чем на 50%. Присутствие инвазионного вида рыб ротана головешки (*Perccottus glenii*) не оказалось значимым ни для одного вида земноводных. Кислотность была значима для зеленой жабы *Pseudepidalea viridis*, которая обнаружена только в нейтральных и щелочных водоемах. Общая минерализация и площадь водного объекта не оказались значимыми параметрами для амфибий. По-видимому, в условиях Верхнего Поочья значительная часть водных объектов, которые пригодны для обитания земноводных по параметрам среды, не заселены земноводными по причине затруднения миграций. В качестве показателя возможности заселения водного объекта мы определяли наличие постоянных проточных и стоячих водных объектов в радиусе 1 км от изучаемого объекта, однако влияние этих факторов на присутствие амфибий не обнаружено. Дальнейшие исследования экологии земноводных в условиях Верхнего Поочья требуют использования более точных показателей связности местообитаний земноводных.

Ключевые слова: Amphibia, кислотность, лесное местообитание, наземная растительность, общая жесткость, проточная вода, река Ока, ротан, степень зарастания водного зеркала водной растительностью, стоячая вода