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OCCURRENCE OF TRUE FROGS (RANIDAE L.) IN THE REGION OF SZEGED AS RELATED TO AQUATIC HABITAT PARAMETERS

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Abstract. If there is any kind of change in their habitats, it is always indicated by the reaction of the amphibians. Their presence is a good indicator of environmental and ecological health. The effect of pond temperature, water depth, pH, predators and vegetation inside the ponds were investigated during one breeding period in seven different types of habitats. We also carried out a visual (capture and spawn monitoring) and an acoustic (call monitoring) method in every study site. Our goal was to ascertain which parameter of the ones mentioned above affects the True frogs the best and to identify how many species of anuran occur around Szeged. Our results show that water temperature and predators have a positive correlation with the occurring True frogs. Furthermore, pH does not seem to be an influential parameter since the measured values ranged between 7,13-8,98. As far as the faunistic study is concerned, 9 of the 10 existing anuran species in the lower Tisza region were identified and the occurrence of the 10th's one was also theoretically proved.

Keywords: correlation, True Frogs, habitat parameters, ecological health, pond temperature, predators.

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Introduction

Due to their skin, anurans are very sensitive to any change occurring to their habitat; therefore their presence in wetlands is a good indicator of environmental and ecological health (Piotr 2006). Nevertheless, Hungarian scientific herpetological literature does not mention any ecological study on the frogs of the region of Szeged. The last potamo-biological study on the Lower Tisza's herpetofauna was made by Miklós Marián in 1960 during which he also took some ecological facts into consideration. This museologist identified 8 anuran species in the region of Szeged. Meanwhile, the frogs' habitats have seen many changes like road constructions, agriculture and the different kinds of pollution of the river Tisza. These facts made us plan and carry out an ecological study on the true frogs' population in Szeged and its neighbourhood. The investigation took place in 7 different types of aquatic habitats: Hattyas (oxbow), Nagyfa (marsh), Gyálarét (clay pits), Nagyszéksós (saline lake), Zsombó (fen and an artificial pond) and Atka (fishpond).

Our research efforts focused on the family of True frogs. On the Great Hungarian Plain this family falls into two groups: the often aquatic, noisy Water or Green Frogs (3 species) and the frequently more terrestrial, quieter voiced Brown Frogs (2 species) (Arnold and Ovenden 2004). As amphibians, Ranids have aquatic and terrestrial habitats. The choice of the aquatic habitat in our study is due to the fact that every frog needs water during the breeding season; therefore it is the best place to monitor the occurring species. Moreover, the Green Frogs are strictly aquatic species hence water body is the only habitat where they can be found (Dely 1976). In the light of these, in our study we aimed to answer the following questions: which aquatic habitat parameters correlate the best with the occurrence of the true frogs? Is there any change in the number of species compared to the results of Miklós Marián (Marián 1963)? Five habitat parameters were chosen to answer the first question and we carried out our investigation in seven study sites that are located far from each other to get the optimum number of species around Szeged. We grouped the parameters into physicochemical (water temperature, pH and depth) and biological (abundance of potential frog predators and the percentage of emergent aquatic vegetation cover).

Among the mentioned parameters, temperature is one of the environmental factors that strongly affects the development and growth of poikilothermic organisms (Orizaola *et al*. 2010). In ectotherms, low temperature reduces growth and development rates (Gillooly and Dodson 2000, Angilletta *et al*. 2004). Thus in cold-blooded species with complex life cycles, temperature experienced during early development can influence individual body condition and fitness and have a strong effect on later performance. One of our study sites is proved to be strongly polluted that is why the water acidity (pH) is taken into consideration in our study (Györffy 2005). Field studies on amphibian abundance and species diversity have shown a clear correlation between the acidification of breeding ponds and the decline of amphibian populations (Glos *et al*. 2003). Although for anurans the critical pH value is 4,5-5 (Horne and Dunson 1994, Tattersall *et al*. 1996), the higher values may also cause different abnormalities during the metamorphosis, thus that may decrease species' abundance. As for the last parameter, many studies have already shown that anurans have several predators (Kats *et al*. 1988, Wilson *et al*. 2005, Hossie and Murray 2010). Predation is an important factor in ecology and frogs are regularly fed upon by great variety of predators (Glaw and Vences 2007). According to their life cycle, the following species are all potential predators of frogs: European perch (*Perca fluviatilis* L.) consume spawns (Pintér 2002), dragonfly and diving beetle nymphs peck tadpoles' extremities (Ohba 2009, Anssi and Kujasalo 1999), finally pike (*Esox lucius* L.), asp (*Aspius aspius* L.) grass snakes (*Natrix natrix* L.), white storks (*Ciconia ciconia* L.) and black-crowned night heron (*Nycticorax nycticorax* L.) all prey on adult frogs (Mark and Tim 2001, Haraszthy 2000). According to the data from the Csongrád County Anglers' Clubs Association, one of the ponds contains some potential anuran predator fishes like pikes (*Esox lucius* L.) and asps (*Aspius aspius* L.) (Petrik 2010).

Materials and methods

Study sites

We chose two study sites in the Northern (Atka, Nagyfa), Southern (Gyálarét, Hattyas) and three study sites in the Western (Zsombó, Nagyszéksós) region from Szeged, out of which 3 (Algyő, Nagyfa and Gyálarét) are located next to the Tisza River (Table 1). Maps of the sites with the indication of sampling plots are listed in the Appendix.

Table 1. Study sites and their geographical parameters

Sites	Area (Hectares)	GPS coordinates
Atka	7,5	N 46°23'93" E 20°10'47"
Nagyfa	4	N 46°17'52" E 20°15'14"
Gyálarét	2,5	N 46°21'41" E 20°12'13"
Hattyas	4	N 46°13'40" E 20°6'9"
Zsombó (art. pond)	0,5	N 46°18'53" E 19°59'3"
Zsombó (fen)	1	N 46°18'54" E19°59'17"
Nagyszéksós	105	N 46°12'41" E 19°57'7"

Sampling methods

The samplings were performed from the end of February until the first half of May of the year 2010. During this period we completed 4 sampling in each study site and every single sampling was divided into two: diurnal and nocturnal part. Around every single aquatic habitat we regularly chose ten sites that are more frequented by the Green frogs. For the sampling we placed 5×5 meters quadrates in every single chosen site directly next to the aquatic habitats. To avoid recapturing the same specimen, every quadrate was at the minimum distance of 10 meters from each other. Two methods were used to collect frogs from the quadrates: catching manually and fishing out (especially the water frogs) with scoop net. The collected frogs were morphologically identified, counted and then released.

To determine the presence of Brown frogs we used egg masses' monitoring. But for the data set we counted only the captured adult frogs. Acoustic method was also used to check the presence of the other species that do not belong to the family Ranidae, still, this time we only counted the visually and morphologically identified species.

Parameters

Water depth influences the water temperature and also the success of eggs to get hatched for those frogs that lay their eggs on floating plants (for example brown frogs). The mentioned variable was measured with a 10-meter-long tape measure. We measured water depth five times in every sampling site, which means that 50 data per measurement were collected in every single aquatic habitat. Measuring was repeated four times during the field work. The water temperatures were measured with iButton® data loggers placed to the aquatic habitat from the end of February until the first half of May. In every study site we put one data logger that was set up to record the water temperature in every 40 minutes. Thus we could get as many data as possible and due to their capacity we only had to reset the data loggers once. For the data analyses we considered the recorded temperatures from four days around the sampling (three days before – which can influence the appearance of species – and the day of sampling). The water acidity was measured with Voltcraft® pH-100 ATC pH-meter. During our field works we measured pH-values on each of the ten sampling sites three times, in the course of the second, third and fourth samplings. In the first sampling we have not had the appropriate pH-meter at our disposal yet. As for the potential anuran predators, we only mentioned those species that we have found in the field sites during the surveys done in 2009 and 2010. We added them together and grouped them into 4 categories: bug's larvae, fishes, grass snakes and birds. Then we got 9 species of predators. For the statistical data processing we numbered the group of predators that we found in the study sites (Table 2).

Table 2. Classification of the occurring predators for the statistical data processing

Number of the predator's group	**Occurring predator**
1	if only one kind of predators occurs
2	if two kinds of predators occur
3	if three kinds of predators occur
4	if all kinds of predators occur

Statistical analysis

The correlation between the variables and the occurring frogs was calculated with Microsoft Excel® to get the R- and R^2-values. Then we used the independent one-sample t-test to test the significance of the correlation values calculated. We only had to calculate the degrees of freedom and then adjust them to the desired p-values. As null hypothesis we considered that there is no correlation between the variables and the estimated number of the true frogs' individuals. Consequently null hypothesis was rejected when the observed *t*-value exceeded the tabulated value in the *t*-test table according to the calculated degree of freedom.

Results

Faunistic results show that ten species of anurans mentioned in the Hungarian herpetological scientific literature occur in the regions around Szeged (Puky *et al*. 2005, Vörös 2008, Schäffer and Purger 2005), including Fire-bellied toad (*Bombina bombina* L.), Common spadefoot (*Pelobates fuscus* L.), Common toad (*Bufo bufo* L.), Green toad (*Bufo viridis* L.), Common tree frog (*Hyla arborea* L.), Moor frog (*Rana arvalis* L.), Agile frog (*Rana Dalmatina* L.), Marsh frog (*Pelophylax Ridibundus*) and Edible frog (*Pelophylax* kl. *esculenta* L.). We did not identify the Pool frog (*Pelophylax lessonae* L.) but its presence is theoretically indicated by the Marsh and Edible frogs, since the latter species is an offspring of the interbreeding between Marsh frog and Pool frog (Arnold and Ovenden 2004). Geographically, the region of Szeged belongs to the Hungarian flood plain thus two anuran species – Yellow-bellied toad (*Bombina variegata* L.) and Common frog (*Pelophylax temporaria* L.) – cannot occur in the mentioned region, since they only live in higher (up to 400 m altitudes) habitats (Dely 1967). All ten species occurred in the clay pit of Gyálarét and only three species occurred in the fen in Zsombó (Table 3).

Table 3. Result of the visual method containing the total numbers of counted individuals per species. BOBO: *Bombina bombina* (Fire-bellied toad), PEFU: *Pelobates fuscus* (Common spadefoot), BUBU: *Bufo bufo* (Common toad), BUVR: *Bufo viridis* (Green toad), HYAR: *Hyla arborea* (European tree frog), RARV: *Rana arvalis* (Moor frog), RDAL: *Rana dalmatina* (Agile frog), PRID: *Pelophylax ridibundus* (Marsh frog), PLES: *Pelophylax lessonae* (Pool frog), PESC: *Pelophylax esculenta* (Edible Frog)

	Atka	Gyálarét	Hattyas	Nagyfa	Nagyszéksós tó	Zsombó artificial pond	Zsombó fen
BOBO	0	11	1	16	58	4	3
PEFU	0	4	0	0	10	9	0
BUBU	0	11	0	0	0	0	0
BUVR	0	4	0	4	0	0	0
HYAR	7	17	9	15	12	14	25
RARV	0	2	0	17	0	0	0
RDAL	0	5	0	20	0	0	0
PRID	51	53	17	31	63	17	2
PLES	0	0	0	0	0	0	0
PESC	47	39	12	21	60	13	0

Correlation between habitat parameters and the occurrence of True Frogs. Due to the Tisza-River, the level of water depth oscillated in those habitats that are in the floodplain and remain mainly constant in the other study sites. There was no significant correlation between the water depth and the occurring True Frogs. However, we noticed that water level oscillation harms the frogs' development since the low tides dry Ranid eggs. As for the water temperature, the obtained average values were between 10 and 15°C. Nagyfa's marsh was the coldest (average 10°C) and Atka's fishpond was the warmest (average 15°C). Moreover, we have noticed that the aquatic habitat's vegetation cover has an important role in warming up the water, which means that those habitats which are more covered by vegetations (i.e. trees) were colder than those that have less vegetation cover. Considering the average temperature registered four days around the sampling (three days before and the day of the sampling), our result shows that temperature has significant correlation with the occurrence of True Frogs (Fig. 1).

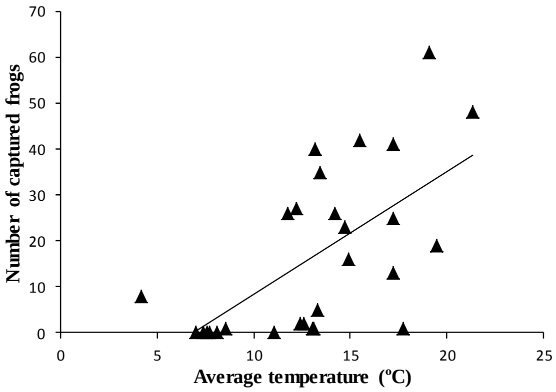

Fig. 1. Correlation between the number of captured True Frogs in each sampling and the registered water temperatures four days around the samplings (three days before the day of the sampling, y = 2,6636x - 18,231; R² = 0,3983)

We still have to clear whether the significant correlation is represented in every single aquatic habitat or not (Table 4). Table 4 shows that we got significant correlations in three study sites. This means that the warmer the aquatic habitats get, the more frogs occur. Moreover, the rise of water temperature is one of the factors that break the Frogs' hibernation. Finally, the end of hibernation does happen at the same temperature among the Ranids. It would be interesting to make an investigation in the autumn whether or not the True Frogs' occurrence decreases according to the fall of water temperature.

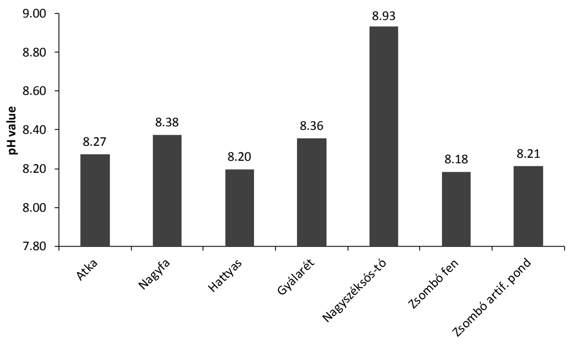

Fig. 2. Measured pH values per study site

Furthermore, we calculated the correlation between pH values from the data of the 7 study sites and the number of the captured frogs (R(exp) = 0,82, R(obs) = 0,31, p = 0,05, N = 32, DF = 22) but the result was not significant.

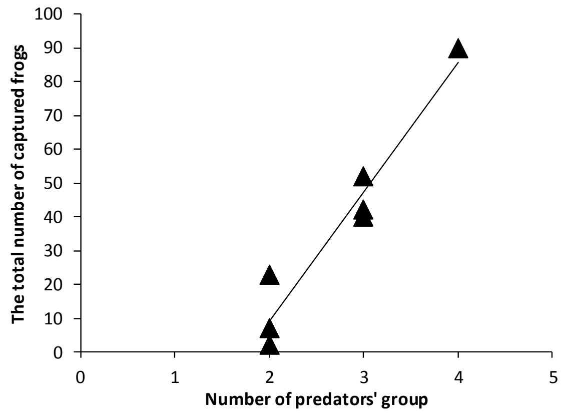

Fig. 3. Correlation between the total numbers of captured frogs in each study site and the number of occurred predators' group (R^2 = 0, 93; N = 7)

Finally, our null hypothesis was rejected regarding the correlation between the occurring predator groups' number and the total number of captured True Frogs (Fig. 3). Furthermore, we analyzed the correlation between the total number of observed predators in each study site and the average number of captured frogs during the four samplings (Fig. 4). The results show that the more True Frogs occurred, the more predators and predators' group we found.

Table 4. Correlation between total number of captured frogs and the average water temperature, where the * is significant at p = 0, 1 and the ** is significant at both p = 0, 1 and p = 0, 05

Study sites	R-values	R^2-values	t_{crt}
Atka	0,86	0,75	2,48
Hattyas	0,92	0,85	3,35*
Gyálarét	0,74	0,55	1,56
Nagyfa	0,95	0,91	4,47**
Nagyszéksós	0,5	0,27	0,83
Zsombó art. pond	0,9	0,81	3,13*
Zsombó fen	0,86	0,74	2,38

Discussion

Compared to the survey made by M. Marián, we have identified two more species (*Pelobates fuscus* L. and *Pelophylax lessonae* L.) in the region of Szeged. According to its habitat, *P. fuscus* typically occurs in light soiled places (Puky et al. 2005), thus its occurrence in the Tisza-River's floodplain is rare.

This can be the reason why M. Marián could not find the mentioned species, since his surveys focused on the Tisza-River's floodplain. The oscillation of water depth seems to have a negative effect on frogs' spawns because the eggs laid on floating parts of plants dry out at low tides, nevertheless this phenomenon can be considered as a part of natural selection that frogs living in those habitats got used to. The phenomenon is common in the aquatic habitats located in the floodplain of the Tisza-River. Furthermore, our study shows that the pH values measured in the study sites are nearly identical which are between 8,18 (the fen in Zsombó) and 8,93 (the saline lake in Nagyszéksós), thus amphibians living in the chosen 7 study sites are not exposed to critical low pH values (pH 4,5 – 5). Although several studies made in Hattyas showed that the aquatic habitat is highly polluted (Györffy 2005), it seems that the pollution is – inter alia – due to the low level of oxygen which leads to the fact that only Green Frogs occur there. Our study shows exclusively the occurrence of Green Frogs in Hattyas; hence further research is still needed to be done in order to prove whether or not the frog species can reproduce in the aquatic habitat mentioned. Certainly we did not find any spawn either tadpole during our field work. As for the water temperature, we noticed that there is correlation between the total number of captured frogs from the whole study sites and the average water temperature.

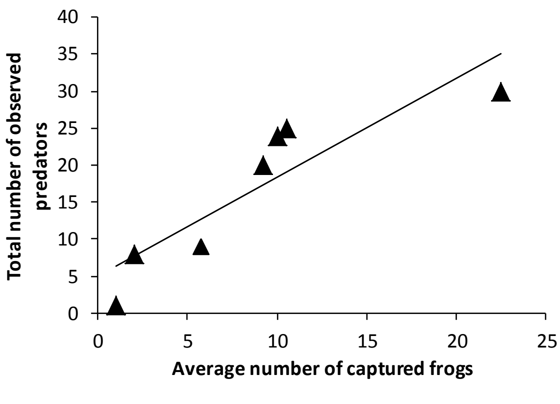

Fig. 4. The correlation between the total number of observed predators in each study site and the average number of captured frogs during the four samplings (y=1,3342x + 5,0875; R^2=0, 7944)

As far as predators are concerned, our result proves that the presence of predators does not disturb the True Frogs. At first sight, our data does not seem to be reliable since predators decimate the mentioned anurans hence frogs should fear them. Therefore, where there are predators few frogs should occur. But if we take stock of the frogs' physical aptitudes such as the capability of changing the intensity of their skin's colour according to the environment which help them to camouflage and the ability to jump high and quickly and also to swim agily thanks to their strong forelimbs and well webbed toes, we immediately understand why they can live together with their predators. The mentioned abilities reduce predators' success hence they allow the cohabitation of frogs and their predators. As for the predators, it is more remunerative to prey upon frogs where there are more anurans therefore they increase their predatory success.

Acknowledgement

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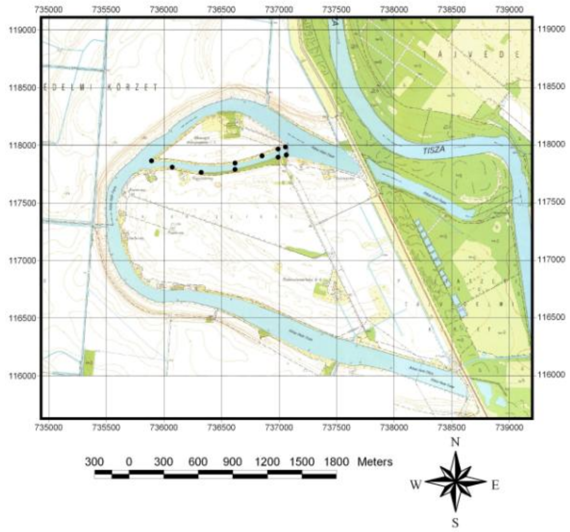
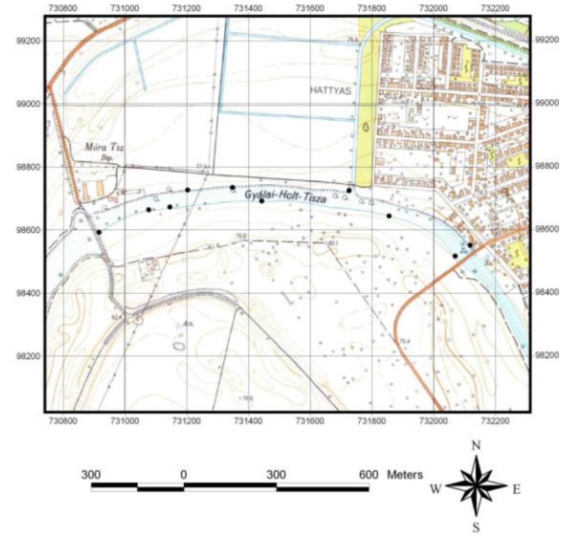
Appendix

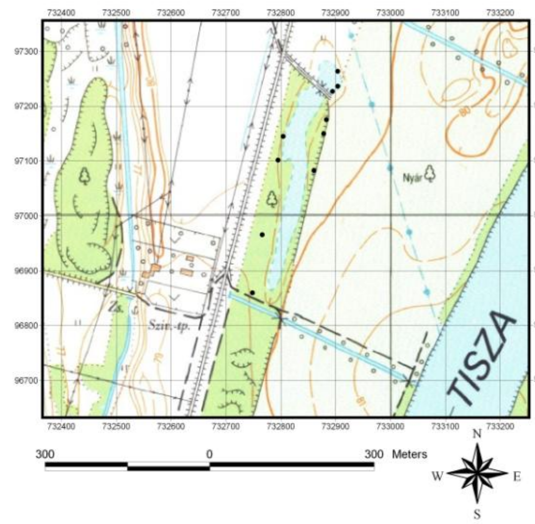
Distribution of sampling plots at the seven study sites



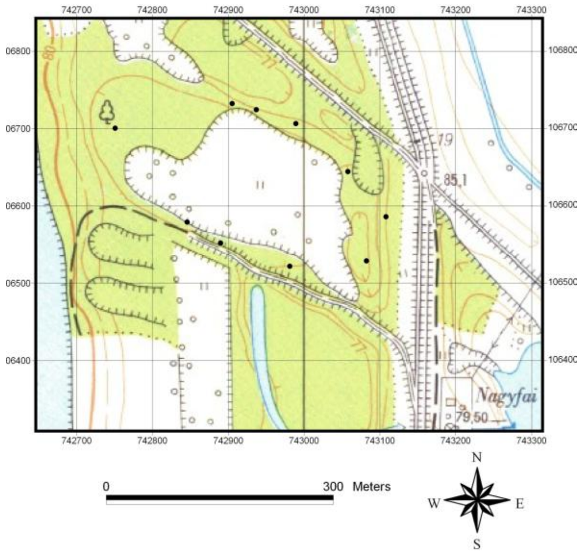
Atka



Hattyas

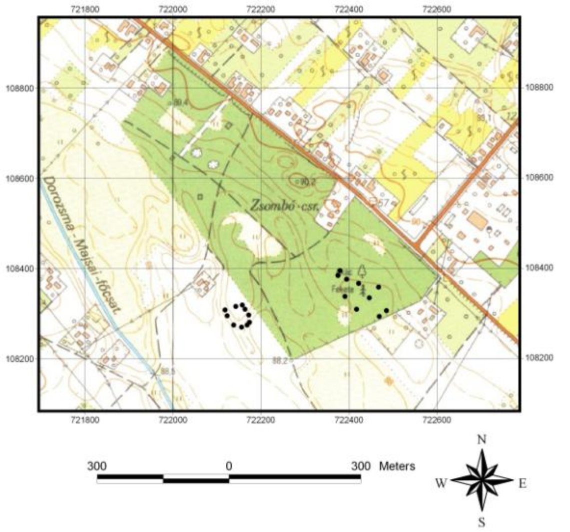


Gyálarét



Nagyfa

Nagyszéksós tó



Zsombó fen and artificial pond