THE DYNAMICS OF A YELLOW BELLIED TOAD POPULATION (*BOMBINA VARIEGATA*) (AMPHIBIA: DISCOGLOSSIDAE) FROM MADRIGESTI AREA (ARAD COUNTY, ROMANIA)

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Abstract. Our study was realised in 2006, periodically in every month from June to September. The habitats are localised in Arad County, the studied populations being from Madrigesti. We analysed the dynamics of the migration within a metapopulation and the variations of the sex ratio. For marking individuals we used the toe-clipping method. The environmental conditions can influence the conditions of the habitats, such as drying in warm periods and refilling in rainy periods. This phenomenon creates ideal conditions for toads, which cause the re-colonization of this habitat. A site fidelity phenomenon was registered, the yellow bellied toads moving on to other habitats being just a manifestation of surviving. Regarding the sex ratio, we can generally observe the high percentage of females in the aquatic environment in the first periods, but towards the rest of the year the percentage of males increases. This is caused by the yellow bellied toads` breeding period, this phenomenon being a manifestation of energy saving, females having increased energy needs because of the egg laying.

Keywords: sex ratio, population dynamics, habitat, environmental conditions.

Rezumat. Dinamica unei populaţii de izvoraş cu burta galbenă (*Bombina variegata*) din zona Mădrigeşti (judeţul Arad, România). Studiul a fost realizat în anul 2006, în fiecare lună din iunie până în septembrie. Habitatele sunt localizate în judeţul Arad, populaţiile analizate fiind din Mădrigeşti. Am analizat dinamica migraţiei într-o metapopulaţie şi variaţia raportului dintre sexe. Pentru marcarea indivizilor am folosit metoda tăierii vârfului unui deget. Condiţiile de mediu pot influenţa condiţiile de la nivelul habitatelor, de exemplu secarea bălţilor în sezonul cald şi reumplerea acestora în zilele ploioase. Acest fenomen crează condiţii ideale pentru broaşte, cauzând recolonizarea acestui habitat. A fost înregistrat fenomenul fidelităţii pentru baltă, mutarea izvoraşilor cu burtă galbenă în alt habitat fiind doar o manifestare pentru supravieţuire. În ceea ce priveşte raportul dintre sexe, se poate observa procentul mai mare la femelelor în mediul acvatic în primele perioade, dar spre sfârşitul studiului procentul masculilor creşte. Acest fapt este cauzat de perioada de înmulţire a izvoraşilor cu burtă galbenă, acest fenomen fiind o manifestare pentru păstrarea energiei, femelele având nevoie de o mare cantitate de energie pentru depunerea pontei.

Cuvinte cheie: sex ratio, dinamica populaţiei, habitat, condiţii de mediu.

INTRODUCTION

The presence of habitat types that serve as permanent sources of dispersers increases the total population size in the landscape and lowers the probability of extinction (PULLIAM et al., 1992). Species have adapted to their environments and hence, according to the common wisdom in ecology, the distribution of species' abundances in space rejects the match between the environment and the species' ecological requirements, with an appropriate caveat for ecological interactions such as competition and predation and recent perturbations caused by humans (HANSKI, 1998). The complete spectrum of dynamical behaviors, ranging from exponential stability to chaos, is likely to be found among natural populations (TURCHIN & TAYLOR, 1992). With our study we tried to detect the essential moments of a *B. variegata* population's life variations during a year in its natural habitats.

Amphibians are particularly sensitive bioindicators of anthropogenic stresses (PECHMANN & WILBUR, 1994), so their behavioral fluctuations can indicate disturbance in both the aquatic and terrestrial habitat that they occupy. A method for studying the environmental changes on amphibians (taking advantage from their bioindicator-treasure) is analysing their feeding behaviour (HOPKINS, 2007). This type of analysis on this *B. variegata* population from Madrigesti (Arad County, Romania) was performed (FERENTI et al., 2008). The other analysis type is by the methods of the landscape ecology (DODD, 2009). The aim of this paper is to analyse the ecology and biology of this population, taking into account the variations of sex ratio by different periods of the year and the role of more habitats in their population dynamics.

MATERIAL AND METHODS

Our study was realised in 2006, periodically in every month from June to September. The habitats are localised in Arad County, the studied populations being from Madrigesti. We analysed the dynamics of the migration within a metapopulation and the variations of the sex ratio.

Within Madrigesti there are 4 habitats. These are close to each other, situated near a road. The first habitat is localised near the road on the plain. This is the smallest pond, drying in the warm season. On the other side of the road, there are two other close habitats. One is a bigger pond, situated on the cross of the stream with the road. This is a permanent pond, even in summer having water. It has a rich amphibian fauna; during spring we also found crested newts. The other pond is smaller, situated close to the forest. This pond's water has a small surface, being the first that

dries during summer. The last habitat is represented by a stream that crosses the forest. The distance between these habitats is very short, the longest being 50 m between the stream and the pond on the plain. These small distances allow the yellow bellied toads` migration.

Capturing was made directly by hand or using a limnological net. For the subsequently identification of these frogs, we used the toe clipping method (BEAUSOLEIL et al., 2004; MCCARTHY & PARRIS, 2004). Some studies showed that the effect of the toe clipping on *B. variegata* is minimal, because it has no effect on its health or behaviour (HARTEL & NEMES, 2006). Because we studied individuals from four different ponds, we clipped different fingers from the toads from each habitat. We cut the finger from the last limb of the toads, and after we applied ointment on the injury.

We released the individuals in their original habitat, following their recapture in the following months of the study period.

By every recapturing we separated the sexes, even if they were not marked, these data being useful for studying the sex ratio of these populations. This aspect of the study took place from May to September.

RESULTS

In June we performed the toad marking at Madrigesti, in total we marked 178 *B. variegata* individuals (Table 1). These were re-captured in the following months. We tried to capture more individuals; their number differs by the size of the habitat.

Table 1. The marked yellow bellied toads.
Tabel 1. Izvoraşii cu burtă galbenă marcați.

	Male	Female	Juvenile	Total
Pond with newts	29	13	17	59
Pond on the plain	12	36	4	52
Stream	27	13	4	44
Pond from the forest	3	20	-	23

The first recapturing was performed in July. In this month the pond near the forest and on the plain dried. In the pond with the newts we identified 10 individuals marked from this habitat, 1 individual from the stream, 1 from the pond near the forest and 2 from the pond on the plain. 28 of the captured individuals were not marked. In the stream we identified 4 individuals from the pond with newts, 8 from the stream, 2 from the pond near the forest, and 1 individual from the pond on the plain. 40 individuals were not marked.

On the second recapturing in August in the pond with the newts we identified 3 individuals from the same habitat. We did not find any marked individual from the other habitats. 22 of the captured individuals were not marked. In the stream we found 2 individuals from the pond with newts, 2 from the stream and 1 from the pond on the plain. 12 individuals had no marking. In this period the pond on the plain also presented water, so we could capture 1 individual that migrated from the pond with newts, 4 from the same habitat and 16 were not marked.

In the same period we also analysed the sex ratio of these populations. In total we analysed 453 individuals, of which 218 were males and 253 females. We also found 47 juveniles, but these were not taken into account. At Madrigesti we captured and counted the individuals for 6 times from May to September.

From the results (Table 2) we can observe the dominant presence of the females in the pond from the plain, and in the pond near the forest. In the case of the last period we had data only in June, in the rest of the year this pond being dry. In the case of the other habitats we can observe the majority of the males.

Table 2. Sex ratio of the *B. variegata* populations from Madrigesti.
Tabel 2. Raportul dintre sexe la populația de *B. variegata* din Mădrigeşti.

		May 6	May 20	June 17	July 29	August 19	September 8
Pond with newts	M(%)	-	47.82	75.86	51.21	69.56	71.42
	F(%)	-	52.17	24.13	48.78	30.43	28.57
Pond on the plain	M(%)	37.51	20	28.57	-	75	52.94
	F(%)	64.28	80	71.42	-	25	47.05
Stream	M(%)	-	-	58.53	62.79	69.23	55.55
	F(%)	-	-	41.46	37.20	30.76	44.44
Pond near the forest	M(%)	36.36	21.42	13.04	-	-	-
	F(%)	63.63	78.57	86.95	-	-	-

As a general phenomenon the number of males grows towards summer and autumn, but in spring we can observe a higher number of females in the habitat. This phenomenon is the most obvious in the case of the pond on the plain, where in the first period we can observe the majority of the females, but after its drying, when it refills with water, the males register the higher number.

DISCUSSIONS

Amphibians often migrate between their aquatic and terrestrial habitats (SINSCH, 1990). Many amphibian species are adapted for efficiently exploring aquatic habitats for reproduction, of which quality is often unpredictably changing in time (HARTEL, 2008). In our case the presence of individuals in habitats that dry in summer, can be a manifestation of their breeding-centred habitat colonization, after this period they leave this. According to the scientific literature, the success of the movements of the yellow bellied toad is highly dependent on the environmental conditions, especially those linked to the microclimate (HARTEL, 2008). On the other hand the yellow bellied toad is adapted to breed in temporary ponds, this act being dependent of intensive movements (BARANDUN & REYER, 1998; HARTEL et al., 2007; HARTEL, 2008). There are several studies that register leaving their breeding habitat, moving in more suitable habitats (SEMLITSCH et al., 2008).

The environmental conditions can influence the conditions of the habitats, such as drying in warm periods and refilling in rainy periods. This phenomenon creates ideal conditions for toads, which cause the re-colonization of this habitat. The re-colonization processes of amphibians are influenced by the quality and localization of various patches and corridors (WIENS, 1997). Because of the small distances between the habitats the yellow bellied toads` moving between the habitats can be realised easier, and the absence of major predators can temporary save the population of these habitats (VREDENBURG, 2004). The males of the yellow bellied toad registered moving distances from the breeding habitat of 63 m, while the females moved only 20 m (BESHKOV & JAMESON, 1980). In our case the maximum distance between the habitats is about 50 m, allowing the toads` movement.

Local extinction and re-colonization based on the environmental condition occur frequently on amphibians (MARSH & TRENHAM, 2001), being the essence of the non-equilibrium view of community dynamics (CHESSON, 1986; MURDOCH, 1991). This can have multiple reasons, like unfavourable conditions (TWITTY, 1966) and regular movement activity of amphibians between the ponds (SPIELER & LINSENMAIR, 1997). While local extinctions can occur, populations can persist regionally (BLAUSTEIN et al., 1994). In our case the local extinction was caused by the conditions, which can influence the equilibrium of the entire population.

It is interesting the re-appearance of relatively many individuals in the pond on the plain marked by the same habitat. This suggests fidelity of these yellow bellied toads to the habitat, their moving on to other habitats being just a manifestation of surviving. Site fidelity was registered at many populations of amphibians, even after many years, when the conditions of the habitat were re-established (BEVIER, 2006; PITTMAN et al., 2008; etc.).

The presence of the habitats in vicinity is crucial for the surviving of these toads. The presence of temporary ponds in a metapopulation (because of the clusters) increases the persistence of the population in the permanent ponds (HARTEL & OLLERER, 2009). The distribution of these populations in such small surfaced areas in different quality habitats can be a manifestation of reducing competition in the same habitat by reducing the number of the individuals. But the appearance of individuals from other habitats in the permanent ponds shows that the competition is less important than the variety of the quality of the habitats (BUSKIRK, 2005).

After re-capturing we found very few marked individuals. This fact could be affected by the unpropitious environmental conditions, which caused their mortality. On the other hand, they hunted very much in the terrestrial environment (STUGREN & RUSU, 1978) that causes their reduced number in the aquatic environment after the breeding season. This fact, as a major cause of low re-capturing, was also registered in other studies (BARANDUN & REYER, 1998). The sub-adult mortality can also influence the low re-capture (HARTEL, 2008). In our case the reason of the low re-capture can mostly be the migration of the marked individuals from the studied habitats. We studied four habitats situated close to a forest, the marked individuals having possibility to migrate along the stream, or in the forest, looking for possible new ponds. This fact suggests that this population is bigger, existing interconnections between these habitats and eventually wet zones from the forest.

Regarding the sex ratio, we can generally observe the high percentage of females in the aquatic environment in the first periods, but towards the rest of the year the percentage of males increases. This is caused by the yellow bellied toads` breeding period, this phenomenon being a manifestation of energy saving, females having increased energy needs because of the egg laying. The eggs are more costly to produce than sperm (HALLIDAY, 1994). This is the reason why they stay more in water, while males hunt and move more in the terrestrial environment.

In the pond near the forest we found individuals (and of course water) only during spring, but the females represented the highest percentage. This fact is in parallel with our statement. On the other hand, the females are those who populate even new habitats for egg laying (SMITH & GREEN, 2006), their presence becoming thus important in the population's dynamics.

In the latest periods we can observe a lower percentage of females. This is caused by the fact that they ended the breeding period and, like the males, they also use the terrestrial environment for hunting. Regarding the number of the individuals, the males from the pond record no variations concerning the period, but in the latest periods the reduced number of females from the pond determines the high percentage of males.

The number of males in the bigger ponds is higher even in the breeding period. This is caused by the favourable conditions from here. In the case of ephemeral ponds, the males come out in the terrestrial environment for hunting because of the insufficient quantity of food from the aquatic environment. In the case of bigger ponds, males do not need to come out, the food quantity and quality being probably optimal.

The pressing caused by the presence of the ephemeral ponds on the population can result in the raised mortality of the individuals (e.g. the high mortality of larvae because of the pond drying, migration from the studied habitats), and can produce a disturbance in the balance of the population dynamics. The presence of the permanent ponds can equalise this disturbance, being a refuge for yellow bellied toads when the ephemeral ponds do not present water. Preservation of native biodiversity is dependent on maintaining an appropriate disturbance regime that, in turn, maintains a habitat mosaic conductive to the presence of native species adapted to a broad disturbance-succession continuum (WARREN & BÜTTNER, 2008).

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