

Comparative Data on the Trophic Spectrum of Syntopic Bombina variegata and Rana temporaria (Amphibia: Anura) Populations from the Iezer Mountains, Romania

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Abstract: In August 2009, we compared the trophic spectrum of syntopic *Bombina variegata* and *Rana temporaria* populations from the Bratia Valley in the Iezer Mountains. The separation of the trophic niche observed between the juveniles and the adults of *R. temporaria* is caused by the differences in size between them, differences that influence their jump. The main consumed prey taxa by *Rana temporaria* is represented by Arachnida, Gastropoda and Hymenoptera. Furthermore, the differences between the sizes of their mouths separate the trophic niche between the two species. Our results indicate a trophic selectiveness for *B. variegata*, which prefers ants. Despite the fact that the two species share the same habitat, the ants were consumed mostly by *B. variegata*. This is probably a consequence of the fact that *B. variegata* is a poisonous species, the toxins being able to originate from their preys – as are ants – as well. The lack of competition for the two species indicates a rich trophic offer, enough to satisfy the energy needs of both species in contact in a limited space.

Key words: *Bombina variegata*, *Rana temporaria*, food composition, trophic niche, Romania.

Introduction

The trophic niche represents the entire trophic relations of a species, of its relationships with its prey and with its enemies (ELTON, 1927). The overlapping of this niche means partially exploring the same resources in the same physical space by two or more species, each niche comprising an own domain and an overlapping domain with at least one related species (STUGREN, 1994). Organisms may have a high degree of liberty in terms of their physiological capacities in order to exist under the influence of various environment factors, especially the biotic ones – whether they are trophic or just the interaction with other organisms with which they share their special niche

(COHEN, 1977). A variety of factors may cause community-wide patterns such as resource partitioning, and the relative importance of these factors may differ among taxa or communities at different geographical locations (TOFT, 1985).

Comparative studies between two related species that occupy the same habitat were done before in the specialized literature (e.g. JONES *et al.*, 2006; STOJANOVA & MOLLOV, 2008; etc.). Comparison of the trophic spectrum of two species offers the possibility to study the feeding behavior in a more accurate way, in relation with the other species. We compared the trophic spectrum of *Rana temporaria* and *Bombina variegata*, species for which the trophic spectrum was analyzed separately (e.g.

BLACKITH & SPEIGHT, 1974; FERENTI *et al.*, 2010 etc.) or together with many other species (e.g. KUZMIN, 1990).

Material and methods

We analyzed the feeding of a *Bombina variegata* and *Rana temporaria* populations respectively, from the Bratia Valley (Candesti locality, Arges County, Romania). The study took place in August 2009. We analyzed 54 individuals (males and females) of *B. variegata* and 62 individuals of *R. temporaria* (22 adults (males and females) and 40 juveniles). The habitat is represented by a large wet area in the Candestului meadow. This pool system is made out of smaller puddles with 30-40 cm deep waters and with variable surface. In some areas the puddles are connected and form a temporary canal. Larger pools directly linked with the river, which - at this stage - already has a high and fast flow, represent the upstream of this zone.

For taking our samples we used a method recommended by the specialized literature (SOLE *et al.*, 2005): namely stomach flushing. This way our study does not affect the sizes of each population. The stomach contents were later analyzed and identified in the laboratory, with the help of the specialized literature.

In analyzing our results we used the following parameters. For the intensity of the feeding we used the feeding rate, the maximum and the average numbers of preys/individual. Other parameters used are the amounts of each prey taxa, the frequency of the prey taxa, their origin, and for the diversity of the preys we also calculated the Shannon-Wiever index. In order to estimate the similarity of the feeding among the individuals of the studied population, we determined the Sørensen index (CHAO *et al.*, 2005) using EstimateS 7.0 (COLWELL, 2005). Also, for analyzing the significance of the differences between the trophic spectrums of the two species we used Statistica 6.0 to calculate the Mann Whitney U-test (STATSOFT INC., 2004).

Results

The feeding rate does not differ a lot

between the two species, the values of empty stomachs for *R. temporaria* being 4.84% and for *B. variegata* 3.7% respectively. The frequency of stomachs with vegetal remains is high for both species. However, the higher values are met in the case of *R. temporaria*. That aside, we can observe a parallel between the terrestrial preys and the presence of vegetal debris in the stomach samples.

The frequency of stomachs with shed skin and minerals shows very clearly the place where both species hunt. For shed skin, the higher frequency is observed in the case of *B. variegata*. The intensity of the feeding differs a lot between these two species. We observed that the yellow-bellied toad has a much higher intensity for the case of each parameter (Table 1).

Table 1. Number of studied individuals, empty stomachs and the consumed preys, the feeding intensity and the origin of preys

	<i>Rana temporaria</i>	<i>Bombina variegata</i>
No. of the studied individuals	62	54
% Empty stomachs	4,83	3,70
The total number of the preys	370	410
The max. no. of prey/individual	14	25
The average no. of prey/individual	5,96	7,59
% Aquatic preys	1,89	10,48
% Terrestrial preys	98,10	89,51

From the prey taxa percentage abundances' point of view, we can detect the same differences mentioned above. For *R. temporaria* the highest amount is represented by Araneida, followed then by Hymenoptera, Coleoptera, Gastropoda, Muscidae, etc. For *B. variegata* the first place is taken by the Formicidae, followed after by the same taxa as those recorded for *R. temporaria* (Table 2). It is easy to observe the presence in relatively high amounts of preys like Formicidae and Collembola in the diet of this species. For the case of *R. temporaria*, the preys with the greatest amounts (especially for the adults) are the bigger sized ones as

well (Coleoptera, Araneida, Gastropoda, *Limax sp.*, etc). On the other hand, small preys are present in the diet of *R. temporaria* juveniles, but the Formicidae do not represent an important amount. Collembola and Aphida are present in the stomach contents of *B. variegata*, too, but most likely because of their opportunistic feeding behavior. The composition of the trophic spectrum of both species and the presence of taxa of different prey and way of life respectively suggest that the selection of preys is not voluntary for neither of the two species (except for the Formicidae in the case of *B. variegata*).

In the case of the frequencies of occurrence of the prey taxa, a parallel between them and amounts of those prey taxa can be observed. Formicidae not only appear with a high amount, but their frequency is also very high, a fact that suggests that *B. variegata* consumes ants by actually selecting them. We also noticed the presence of small-sized preys for *R. temporaria* juveniles – due to their smaller size – but the Formicidae did not represent a high amount in this case (Table 2). The biggest difference between the trophic spectrums of these two species can be observed when it comes to the origin of the prey taxa. While in the case of *R. temporaria* the aquatic preys represent only 1.89 %, for *B. variegata* they have a value of 10.49% from all preys (Table 1).

In terms of diversity, the differences aren't very considerable. For *R. temporaria* the values of the diversity are $H=2.95$ where as for *B. variegata* $H=2.97$. Also, for the similarity of the feeding we calculated the Sørensen index. Its values are again close: $S=0.25$ for *R. temporaria* and $S=0.26$ for *B. variegata*. While comparing the differences between the trophic spectrums after applying the Mann-Whitney U-test, the values are not significant ($p>0.05$, $p=0.59$).

Discussion

The presence of a small number of individuals that had no stomach contents suggests that the habitat had the necessary conditions for feeding, almost optimally, being thus favorable for both species.

The different foraging areas of the two species can cause the dissimilarities between the feeding rates. Even if *B. variegata* is considered a more terrestrial species than its congener one – *Bombina bombina* (NEČAS *et al.*, 1997), it hunts in both terrestrial and aquatic environments. Meanwhile, *R. temporaria* uses the aquatic environment almost exclusively for reproducing (COGĂLNICEANU *et al.*, 2000), hunting only on land (KOVACS *et al.*, 2010). Thus, the higher feeding rate of *B. variegata* can be caused by its ability to hunt in both environments, a fact that doubles its chances of capturing preys. On the other hand, though, these values suggest less optimal conditions in the terrestrial environment. However, the parallel between the frequency of ingested vegetation fragments and the presence of terrestrial food leads to the idea that vegetation was swallow on land. The higher value for the frequency of vegetal remains in the case of *R. temporaria* is a consequence of the fact that it hunts strictly in the terrestrial environment.

For amphibians, the specialty literature indicates cases where the amounts of aquatic preys are in positive correlation with the frequency of shed skin, which in turn suggests that these were in fact consumed in the water (CICORT-LUCACIU *et al.*, 2007; FERENTI *et al.*, 2008). For *R. temporaria*, the absence of aquatic preys from their trophic spectrum demonstrates that shed skin weren't consumed from the water. Such is also the case of other terrestrial species where shed skin consumption was recorded (KOVACS *et al.*, 2007; KOVACS *et al.*, 2010) and the explanation of the phenomenon is similar.

The differences between the behaviors of the two species deduced from the differences of their feeding intensities can appear due to the size of both preys and predator. Thus, the size of the mouth is a limiting factor for selecting preys, being considerably smaller for *B. variegata*. Hence, it resorts to smaller preys, which in turn, in order to meet the energy needs, have to be consumed in greater numbers. Thus, the common brown frogs don't have to consume a great number of these preys in order to

Table 2. Trophic spectrum of both studied amphibian species. **Legend:** *R. t.* – *Rana temporaria*, *B. v.* – *Bombina variegata*, ad. – adults, J.-juveniles, ter. – terrestrial, L. – larvae, aq. – aquatic.

Prey taxa	Percentage abundance			Frequency of occurrence		
	<i>R. t.</i>		<i>B. v.</i>	<i>R. t.</i>		<i>B. v.</i>
	<i>Ad.</i>	<i>J.</i>		<i>Ad.</i>	<i>J.</i>	
Oligocheta - Lumbricidae	2.59	1.18	1.12	13.64	7.5	22.22
Gastropoda (ter.)	10.34	7.09	1.95	27.27	35	14.81
Gastropoda - <i>Limax</i> sp.	0	1.57	1.95	0	10	11.11
Lamellibranchiata	0	0.79	0	0	2.5	0
Arahnida - Pseudoscorpionidae	0.86	0.79	0.48	4.55	5	3.70
Arahnida - Araneae	12.07	16.54	11.70	54.55	67.5	57.40
Arahnida - Acari	0	9.06	0.73	0	35	5.55
Arahnida - Opiliones	0.86	0.79	0	4.55	5	0
Crustacea -Isopoda(ter.)	0	0	0.48	0	0	3.70
Crustacea - Gamaridae	0	0	4.63	0	0	12.96
Myriapoda - Diplopoda	1.72	1.18	0.73	9.09	7.5	5.55
Myriapoda - Chilopoda	0.86	1.18	0.24	4.55	7.5	1.85
Thysanura	0	0	0.24	0	0	1.85
Collembolla	1.72	7.48	2.19	4.55	30	7.40
Ephemeroptera (L.)	0	0	0.24	0	0	1.85
Ephemeroptera (ad.)	0	0	0.24	0	0	1.85
Odonata (L.)	0	0	0.48	0	0	3.70
Plecoptera (L.)	2.59	0	0.97	9.09	0	3.70
Plecoptera (ad.)	0	0	0.24	0	0	1.85
Orthoptera	11.21	0.79	0.73	54.55	5	3.70
Dermaptera	3.45	0.39	1.70	18.18	2.5	12.96
Homoptera - Cicadillidae	2.59	2.36	2.92	13.64	15	16.66
Homoptera - Afidinidae	0	1.18	3.17	0	5	16.66
Heteroptera (ter.)	7.76	0.79	1.21	31.82	5	7.40
Coleoptera (L. ter.)	0.86	0.39	0.97	4.55	2.5	5.55
Coleoptera (ad. ter.)	6.90	9.84	6.82	31.82	45	40.74
Coleoptera - Dytiscidae (L. aq.)	0	0.79	3.90	0	2.5	20.37
Coleoptera - Dytiscidae (ad. aq.)	0	0	0.24	0	0	1.85
Coleoptera - Carabidae	7.76	2.76	2.43	31.82	15	14.81
Coleoptera - Stafilinidae	1.72	1.18	2.68	4.55	7.5	12.96
Coleoptera - Elateridae	0	0	0.24	0	0	1.85
Coleoptera - Coccinelidae	0	0	0.24	0	0	1.85
Coleoptera - Curculionidae	0.86	0.39	0	4.55	2.5	0
Coleoptera - Crizomelidae	0	0.39	0.24	0	2.5	1.85
Neuroptera	0	0	1.21	0	0	7.40
Lepidoptera (L.)	7.76	7.09	2.19	40.91	30	14.81
Lepidoptera (ad.)	0	1.18	0	0	7.5	0
Diptera - Nematocera - Typulidae	0.86	0.39	0	4.55	2.5	0
Diptera - Nematocera - Culicidae	1.72	1.97	3.17	9.09	12.5	22.22
Diptera - Brahicera (L. ter.)	0	0	0.97	0	0	5.55
Diptera - Brahicera (ad. ter.)	0	0	0.48	0	0	1.85
Diptera - Brahicera- Muscidae	5.17	5.91	6.34	22.73	25	31.48
Hymenoptera	3.45	12.99	3.17	18.18	40	20.37
Hymenoptera - Formicidae	3.45	1.57	21.95	9.09	5	66.66
Hymenoptera - Apidae	0	0	0.24	0	0	1.85
Hymenoptera - Vespidae	0.86	0	0	4.55	0	0
Vegetal fragments	-	-	-	77.27	67.5	61.11
Shed skin	-	-	-	13.64	22.5	22.22
Minerals	-	-	-	-	5	7.40

obtain the same quantity of energy. The differences brought by the size of their mouths separate thus, invariably, the trophic niches of these two species, as well as dividing the niches between those of adults and juveniles. *R. temporaria* juveniles and *B. variegata* adults present very little differences due to their similar sizes. Such a phenomenon of trophic niche overlap between one species' juveniles and another's adults was documented in the specialty literature before (KUZMIN, 1990). This is how the ontogenetic evolutionary state plays an important role in trophic niche overlapping for other amphibians as well (SOLE *et al.*, 2009; FRANCA *et al.*, 2004).

The separation of the trophic niche observed between adults and juveniles of *R. temporaria* also appears between the two species and is founded on their difference in size. *R. temporaria*, being a bigger species and having larger leaps, has a facile access to preys that are, for example, on higher plants, whereas *B. variegata* does not. The influence of amphibians' leap distance in the composition of their trophic spectrum was recorded for other amphibian populations from the Carpathian Mountains (KUZMIN, 1990). The separation of their trophic niches is consequently done vertically in space.

R. temporaria captures preys from the substratum as well, but only larger preys and not at all Formicidae – a taxon that holds very high amounts in the trophic spectrum of *B. variegata*. This fact strengthens the statement of some authors according to which insects rich in alkaloids, formic acid etc. are consumed more intensively by species with a toxic skin secretion, these alkaloids being discovered in their toxin (MEBS *et al.*, 2005; DALY, 1998).

Due to its way of life, the common brown frog consumes aquatic preys only accidentally and these are represented only by Plecoptera larvae. It is possible that these larvae were consumed shortly after they left the aquatic environment or in a time when the water level dropped. A similar explanation was given not long ago in regards to another terrestrial amphibian - *Salamandra salamandra* – and its aquatic prey consump-

tion (COVACIU-MARCOV *et al.*, 2002). As of *B. variegata* the aquatic preys are represented by various taxa, which indicates that the food acquired from this environment completes its trophic spectrum. The consumption of about 10% aquatic preys was pointed out by other authors for other populations, but each time it depended on the environment's conditions (SAS *et al.*, 2004; PETER *et al.*, 2005; GHIURCĂ & ZAHARIA, 2005, SZEPLAKI *et al.*, 2006).

The lack of competitiveness between the two species that occupy the same habitat seems to be a general rule for amphibian species. Thus, situations in which two species residing in the same habitat did not compete for food and did not bother each other were previously documented for newts (COVACIU-MARCOV *et al.*, 2010), two species of brown frogs (KOVACS *et al.*, 2010) and even some snake species (METZGER *et al.*, 2009). Such a fact may seem surprising, because in many cases the habitat occupied by those species was limited in surface, which only brought them more frequently in contact. The absence of competition between synoptic amphibian species, despite using the same trophic base, can only suggest a rich trophic offer that those species exploit. As a result, the trophic offer is probably sufficient to meet the trophic needs of more amphibians, despite the fact that they are aiming for the same target prey groups and have relatively similar hunting methods. As such, the differences between their trophic niches (vertical and horizontal) that appear between the trophic spectrum of some species that occupy the same ecological niche look like the result of limits caused by the morphologic particularities of each species (KUZMIN, 1990).

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