THE STUDY OF THE TROPHIC SPECTRUM OF SOME *BOMBINA VARIEGATA* POPULATIONS FROM ARAD COUNTY

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Summary. We analysed the trophic spectrum of 154 individuals of Bombina variegata from Arad county, Mădrigeşti locality. The most important preys were the Hymenopteras Formicides, Coleopteras and Dipteras. We can notice the larger larvae consumption in the females' case. In the stomachal contents we also identified besides animal prey, vegetal remains and shed-skin. There is a pozitive connection between the consumption of vegetales and the weight of the terrestrial prey, and a negative one between the consumption of the vegetales and shed-skin. The yellow bellied toad fed mostly terrestrial.

Rezumat **Studiul spectrului trofic al unor populaţii de Bombina variegata din Judeţul Arad.** Am analizat spectrul trofic a 154 de exemplare de Bombina variegata din Judeţul Arad, localitatea Mădrigeşti. Prăzile cele mai importante erau Hymenopterele Formicide, Coleopterele şi Dipterele. Se observă consumul în număr mai mare a larvelor de către femele. În conţinuturile stomacale pe lângă prăzi de natură animală am mai identificat şi fragmente de vegetale şi exuvie. Există o corelaţie pozitivă între consumul de vegetale şi ponderea prăzilor terestre, respectiv o corelaţie negativă între consumul de vegetale şi de exuvie. Izvoraşii de baltă cu burtă galbenă s-au hrănit majoritar terestru.

Introduction

Bombina variegata has a stronger connection with the terrestrial environment than the similar species, Bombina bombina (Madej, 1973). It is a species attached to the ecological conditions of the hilly and mountainous areas, being found from 150m upward, but we can sometimes find pure yellow bellied toads at 100m (Madej, 1964).

Because of the global decline of amphibians (Wake 1991), it is necessary to take measures in preserving the biodiversity, which can be accomplished through the conservation of the habitats of the amphibians. Food is a very important factor which can provide indicators concerning the state of the environment (Inger&Colwell, 1977), which is necessary in regards to its protection. The feeding of these frogs is dealt with in many specialised articles (Sas et al. 2004b,2005a,2006b, Ghiurcă & Zaharia 2005, Toth et al. 2007). The aim of our study is to analyse the composition of the yellow bellied toads' food, using the results as a very important indicator in the conservation methods of the habitat and thus, the environment.

Materials and methods

Our study took place in 2006, when we analysed the food composition of 154 Bombina variegata individuals, captured from a habitat near Madrigesti locality, Arad county. We colected data on several occasions, gathering stomachal contents monthly, starting from May and ending with September.

The habitat from which the yellow bellied tods were captured is close to a country road. The puddle is limited by the forest, which offers diverse living conditions. Just because of this the fauna is very diverse, here we can find invertebrates, characteristic to the forest, as well as vertebrates, especially tritons.The depth of the puddle is about 50cm, but this depends on the rain. The surface of the puddle is approximately 5m2. The vegetation is very rich, represented by grassy vegetation and pewter, but the puddle is surrounded by trees and bushes. This is why the bottom of it is covered with a thick layer of silt and decomposed leaves.

We used the stomachal flushing method so as not to harm the analysed animals. This method is recommended and suggested by many authors (Sole et al. 2005, Legler & Sullivan 1979, Opatriny 1980, Griffiths 1986, Leclerc & Curtois 1993), because of the low proportion of injured individuals, if it is correctly applied (Sole et al.2005). The samples were preserved in a 4% solution of formaldehyde and identified in the laboratory, using a magnifying glass and scientific literature (Radu & Radu 1967; Chinery, 1998; Paulian, 1971).

The results were statisticaly processed. Thus we calculated the feeding rate, the maximum and average number of prey/individual, the weight

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and frequency of prey taxa and the weight of the taxons varying on its origin. These results were analysed depending on the differences between the sexes, respectively we followed the changes which appear in the food composition throughout the activity period of this population.

Results

Our study was realised between May and September 2006. We analysed 154 yellow bellied toads, from which 80 were males, 50 females and 24 juveniles. The individuals were captured monthly, starting from May until September, the results being analysed with regards to the period and sex.

The feeding activity ratio was high , recording a value of 95,46%. Considering the sexes, there are no differences from this aspect, and with concern to the periods, the majority of individuals that have no stomachal content are present in July and August.

With regards to the feeding intensity, this was the highest in the first months of the year, in May, the maximum number of preys being registered here, and even 32 in the case of the females. We can observe the decline of this number towards the beginning of fall, the total maximum number of prey/individual is 20 in June,19 in July, 12 in August and 8 in September. With concern to the average number of prey/individual it was similar to the previous values.

The majority of prey taxa have a terrestrial origin, with small unimportant variations with regards to the sexes and the ontogenetic development stage. Depending on the period, in September we can observe the presence of aquatic prey, which is 30% in the case of the females, 21% in the case of the males and19% in the case of the juveniles.

The majority of the stomachal contents was represented by invertebrates. We calculated the weight of these and compared the results depending on the sex, development stage and period.

There are certain differences that appear with regards to the weight of prey taxa varying on the sexes. In the case of the males first place is occupied by the Hymenoptera Formicides, followed by the Araneida, Diplopoda, Coleoptera and terrestrial Gastropoda. In the case of the females, the first three taxons are identical with concern to their weight, with the difference that the Gastropodas are replaced by the Diptera Brahicera larvae. The juveniles consumed Afidine and terrestrial Coleopteras in a very large amount. Here the Formicides appear only in the third place and in the fourth place appear the Culicides besides the Araneidas.

Certain variations can be seen depending on the period. In the first period the Diptera register the highest value, represented especially by terrestrial Brahicera larvae and Culicides. The Coleopteras, Hymenopteras Formicides and Araneida also have a semnificative weight. In June the situation slightly changes. The Hymenopteras were consumed in a very large amount, thus occuping first place, but here the Afidines, terrestrial Coleoptera and Diptera Brahicera Muscidae also have a very high value.

Table no.1. The weight of the prey taxa

	20.05	17.06	29.07	19.08	08.09
Gasteropode-(acv)	0	0	0	0	9,09
Planorbis	0	0	0	0	1,52
Gasteropode(t)	2,34	0	1,93	17,3	7,58
Limax	0	0	0,39	0	0
Pseudoscorpionide	0	0,9	0,39	0	0
Araneide	7,48	6,01	10,8	12,5	18,2
Acarieni	0	0	0	1,92	0
Opilionide	0	0	1,16	0	0
Izopode(t)	1,87	0,9	0,39	3,85	1,52
Gamaride	5,14	0	0	0	0
Diplopode	1,4	5,11	20,1	4,81	4,55
Chilopode	0,47	0	0	0	0
Efemeroptere	0	0,3	0	0	0
Odonate-larve	0	0	0,39	0	0
Odonate	0	0,3	0,39	0	0
Plecoptere	3,27	1,8	0	0	0
Blatoidee	0	0,3	0	0	0

Cicadine	0,47	0,3	1,54	0	3,03
Afidine	0,93	15,9	2,7	2,88	9,09
Heteroptere(acv)	0	0	0	0	0
Heteroptere(t)	0	1,2	4,25	3,85	0
Coleoptere-larve(t)	0	0,3	0,77	0	3,03
Coleoptere(t)	13,6	16,2	6,18	3,85	7,58
Dytiscide-larve	0	0,3	3,47	5,77	1,52
Dytiscide (ad)	0	0	0,39	0	0
Carabide	0	0,3	0	0	0
Cantaride	0	2,1	0	0	0
Stafilinide	0,93	0	0,77	0	1,52
Elateride	1,87	1,8	0,39	0	0
Scarabeide	0	0,3	0	0	0
Cerambicide	0,47	0	0	0,96	0
Coccinelide	0,47	3,3	0	0	0
Curculionide	0,47	0,6	0	0	0
Crizomelide	0	1,2	0	0,96	0
Neuroptere	0	0,3	0	0	0
Lepidoptere-larve	0,47	1,5	1,93	2,88	0
Lepidoptere	0	0	0,39	0,96	0
Tricoptere-larve	0,47	0	0	0	0
Tricoptere	0,47	0	0	0,96	0
Nematocere-larve	0	0,9	0	0	0
Typulide	1,4	1,5	6,95	0,96	0
Culicide	18,7	4,5	5,79	0,96	0
Brahicere-larve (acv)	0	0,3	0	0	6,06
Brahicere larve(t)	20,1	0,9	8,11	0	1,52
Brahicere (ad)	0	0	1,54	0	0
Muscide	6,07	6,91	8,88	3,85	1,52
Hymenoptere	1,4	1,2	1,54	2,88	4,55
Formicide	8,88	21,3	7,34	26,9	18,2
Apide	0	0,3	0	0	0
Vespide	0	0	0,39	0	0
Ihneumonide	0	0,9	0	0,96	0
Mecoptere	0,47	0	0,39	0	0
Mormoloc	0,47	0	0,39	0	0

Table no. 2. The frequency of the prey taxa

	20.05	17.06	29.07	19.08	08.09
Vegetal	56,3	52,6	76,2	52	52,9
Exuvie	6,25	34,2	19	20	11,8
Gasteropode-melci(acv)	0	0	0	0	23,5
Planorbis	0	0	0	0	5,88
Gasteropode (t)	9,38	0	9,52	36	23,5
Limax	0	0	2,38	0	0
Pseudoscorpionide	0	5,26	2,38	0	0
Araneide	31,3	42,1	47,6	36	52,9
Acarieni	0	0	0	8	0
Opilionide	0	0	7,14	0	0
Izopode(t)	12,5	7,89	2,38	12	5,88
Gamaride	3,13	0	0	0	0
Diplopode	9,38	36,8	61,9	20	17,6

Chilopode	3,13	0	0	0	0
Efemeroptere	0	2,63	0	0	0
Odonate-larve	0	0	2,38	0	0
Odonate	0	2,63	2,38	0	0
Plecoptere	15,6	7,89	0	0	0
Blatoidee	0	2,63	0	0	0
Cicadine	3,13	2,63	7,14	0	11,8
Afidine	6,25	28,9	11,9	4	11,8
Heteroptere(t)	0	10,5	21,4	12	0
Coleoptere-larve(t)	0	2,63	4,76	0	5,88
Coleoptere(t)	46,9	57,9	31	16	29,4
Dytiscide-larve	0	2,63	16,7	12	5,88
Dytiscide	0	0	2,38	0	0
Carabide	0	2,63	0	0	0
Cantaride	0	18,4	0	0	0
Stafilinide	6,25	0	4,76	0	5,88
Elateride	12,5	10,5	2,38	0	0
Scarabeide	0	2,63	0	0	0
Cerambicide	3,13	0	0	4	0
Coccinelide	3,13	21,1	0	0	0
Curculionide	3,13	5,26	0	0	0
Crizomelide	0	10,5	0	4	0
Neuroptere	0	2,63	0	0	0
Lepidoptere-larve	3,13	7,89	11,9	12	0
Lepidoptere	0	0	2,38	4	0
Tricoptere-larve	3,13	0	0	0	0
Tricoptere	3,13	0	0	4	0
Nematocere-larve	0	5,26	0	0	0
Typulide	3,13	13,2	42,9	4	0
Culicide	46,9	21,1	26,2	4	0
Brahicere-larve (acv)	0	2,63	0	0	11,8
Brahicere larve(t)	15,6	7,89	19	0	5,88
Brahicere terestre	0	0	2,38	0	0
Muscide	25	42,1	33,3	16	5,88
Hymenoptere	9,38	10,5	9,52	12	17,6
Formicide	34,4	57,9	28,6	64	41,2
Apide	0	2,63	0	0	0
Vespide	0	0	2,38	0	0
Ihneumonide	0	5,26	0	4	0
Mecoptere	3,13	0	2,38	0	0
Mormoloc	3,13	0	2,38	0	0

In July the Dipteras reappear in the trophic spectrum of the Bombina variegata, which are represented by Typulide adult and larvae flies. A new taxon can be observed here, which is the Miriapoda represented by the Diplopoda. The Araneida and Hymenoptera Formicides are also present in a semnificative amount. In August we identified in a large amount the terrestrial Gastropoda beside the Hymenoptera Formicides and Araneida. September is vey similar to June, here we have observed the presence of the Hymenoptera Formicida, Araneida, Afidina, terrestrial Gatropoda and Coleoptera.

With regards to the frequency of prey taxa depending on the sexes, we can observe that the frogs eat totally differently. In the case of the males, in the first place we can see the Hymenoptera Formicida, followed by the Miriapoda Diplopoda, terrestrial Coleopteras and Musticidae. Considering the females, the most frequent prey taxa are the Araneida and Hymenoptera Formicides. Also with a high value we can notice the presence of the Diplopoda, Coleoptera and Diptera, which are represented by the Muscidae, Culicidae and Typulidae. The

juveniles frequently eat terrestrial Coleopteras, Hymenopteras Formicides, Afidine and Diptera.

Varying on the period there are also differences concerning the weight of these taxas. Thus, in May the Coleopteras have a high value, in June appear, beside these, the Hymenoptera Formicida. In July first place is occupied by the Diplopoda and Araneida, in August the Hymenopteras and in September the Araneida.

In the stomachal contents we also identified vegetal fragments and shed-skin, beside animal prey. The vegetales are more frequently consumed by the adults. With concern to the consumption of shed-skin we can also notice a higher consumption in the case of the adult males.

With regards to the seasonal variation of plant consumption, these were consumed monthly by more than 50% of the individuals. In July we can observe a 76% consumption. With concern to the shed-skin consumption we can remark a negative correlation of this towards the vegetal frequency. Thus in June, when the vegetal consumption registered the lowest value, the frequency of shed-skin consumption recorded the highest value (34%).

Discussions

Different studies suggest that food is an important factor in the relation between Amphibians and the environment (Duellman 1994). The reduced number of empty stomachs suggests the fact that they had good feeding conditions. The fact that the few individuals which do not present a stomachal content appear only in the warmest months of the year (July and August), can be explained through the fact that, in that period, the puddle was smaller, thus the living contidions were relatively more severe.

The number of consumed preys can be influenced by their size, the smaller ones being eaten in a larger number, having a lower energetic value than those that are larger in size. This fact can be observed in our case as well, when in the first months the maximum number of prey/individual is very high because of the large consumption of Brahicera, Culicida and Afidina larvae. Together with the appearance of larger preys (terrestrial Coleoptera, Diplopoda and terrestrial Gastropoda) this value decreases. Situations such as these have also been observed in the case of the vicariant Bombina bombina species (Szeplaki et al. 2006).

The high weight of consumed terrestrial prey is due to the fact that the frogs hunt in the terrestrial environment. The appearance of aquatic prey in September is due to the autumn rain, when the puddle is quite large, thus having better feeding conditions. The results highlight that with concern to the sexes, the females spend more time in the water, whereas the males and juveniles are more terrestrial. On the one hand, this fact can be explained through the differences that occur in the hunting strategies (Huey and Pianka1981; Perry and Pianka 1997). On the other hand juveniles need to go out on dry land, being forced to find more food in order to grow, whereas the adults have a tendancy to retreat in hibernation. Even scientific literature considered that the terrestrial prey holds a majority in the case of the Bombina bombina (Szeplaki et al. 2006; Sas et al.2004a), Bombina variegata (Ghiurcă şi Zaharia 2005; Peter et al 2005; Sas et al.2005a; Groza et al. 2006) or Bombina hybrids (Sas et al.2005b; Ferenti et al. 2007).

With regards to the weight of prey taxa, we can notice the presence of the larger preys as well as that of the smaller ones. This fact suggests that their feeding is not selective, so they capture the richest food in their vicinity, essentially feeding with mobile preys that have the proper size to be captured (Török and Csörgő, 1992).

In the case of the females, we can remark the presence of larvae, especially in the first periods of the year. According to Brooks et al. (1996), larvae are more nutritious because of their higher lipide contents. Due to this fact, they are prefered by the females, which need energy in mantaining their reproductive activity, particularly in the first periods of the year.

The large consumption of Coleoptera is a very common phenomenon for the case of Bombina. They represent a very important element in the feeding spectrum of other Bombina populations as well (Peter et al. 2006).

Considering the vegetal consumption, the adults consumed them more. We can observe a positive correlation between the consumption of terrestrial prey and the vegetal one. Perhaps the plant fragments reached into the frogs' stomach along with the capture of the terrestrial preys' from the plants' surface. There were some other occurrences in the case of the adult frog ,when the vegetals were actively consumed (daSilva et. al 1989). From the species in our country, the consumption of plants and acicular leaves has been noticed at the red mountain frog, Rana temporaria (Itämies & Koskela, 1970). Some authors consider that vegetals are consumed in order to help crush the exoskeleton of the eaten insects' , or to contribute to the elimination of some intestinal parasites. (Evans and Lampo 1996). In the case of the yellow bellied toad, the consumption of plants can not be considered as active, because they are regarded as carnivores

(Cogălniceanu et al. 2000) that feed only with mobile preys (Zimka 1966). In this case, the vegetal fragments are considered to be accidentally swallowed together with the followed moving prey (Whitaker et al. 1977, Stebbins and Cohen 1995).

Shed-skin can be considered as being similar to plant fragments, and thus swallowed together with the moving prey. Some consider that their consumption can be regarded as a way of recycling epidermal protein, because of their rich protein content (Weldon et al. 1993). There is a negative correlation in our case between the consumption of shed-skin and vegetal fragments. This suggests that shed-skins are consumed exclusively in water, while plant consumption is closely related to the terrestrial hunting.

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