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Data on the feeding of a *Rana ridibunda* population from Sarighiol de Deal, Tulcea County, Romania

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Abstract. We analyzed the trophic spectrum of 86 *Rana ridibunda* individuals from Sarighiol de Deal, Tulcea County, Romania. The most important preys are represented by the Coleoptera, Diptera and Homeoptera (Cicada). Certain variations in feeding appear during the ontogenetic development, the juveniles feeding the most intensively, in the spectrum of which appear the lipid-rich Ephemeroptera larvae. The food diversity is negatively correlated with the feeding intensity, the males having the maximum diversity. The majority of preys have a terrestrial origin. The presence of different size preys indicates an opportunistic feeding.

Key words: feeding, *Rana ridibunda*, prey taxa, Dobrudja, Romania

Introduction

Rana ridibunda is a large-sized species (sometimes reaching even 19 cm) which, in Europe, is spread in the central and southern parts of the continent (Fuhn 1960). It was present on this continent before the quaternary glaciations, and along with them reached the southern areas (Stugren 1957). It was first described by Pallas in 1771 in Kazakhstan (Budak & Tok 2000). It prefers the large-sized habitats, being especially seen in the field areas. In Romania the maximum altitude at which it has been found is 700m (Covaciu Marcov et al. 2003a).

In the scientific literature there are many studies regarding this species, from which we can identify the ones referring to the trophic spectrum, published abroad (Török & Csörgő 1992, Simic et al. 1992, Çicek & Mermer 2006, 2007, Mollov 2008) as well as in Romania (Sin et al. 1975, Ghira et al. 1997, Covaciu Marcov et al. 2000, 2003b, 2005, Sas et al. 2004a, Balint et al. 2008).

The analysis of the trophic spectrum of a species offers information about the way in which it uses the trophic resources from its environment (Bellocq et al. 2000). Our study focuses on the composition of the trophic spectrum of the lake frog from Sarighiol de Deal, thus analyzing the positive and negative changes that the environment has on this species.

Materials and methods

Our study took place in 08.07.2007 in Sarighiol de Deal locality, Tulcea County. We captured 86 *Rana ridibunda* individuals, of which 44 were males, 34 females and 8 juveniles.

The habitat is represented by a system of puddles situated alongside the road near Sarighiol locality. The vegetation is represented by grass and *Juncus sp.*, while the fauna is mostly composed of typical field invertebrates and amphibians. These puddles have a relatively high degree of pollution, being placed near a stable. With regards to their surface, the largest ones have several tens of m^2, while the smaller ones have only a few m^2. The water level is highly influenced by the amount of precipitation, these puddles being in no connection with a permanent drain. In the warm period of the year, the majority of the smaller puddles dry out, the water being permanent only in the three larger ones.

The frogs were captured with the help of a net, or directly by hand, being afterwards released in their natural environment. The samples were obtained using the stomach flushing method (Legler & Sullivan 1979, Opatrňy 1980, Griffits 1986, Leclerc & Courtois 1993), thus avoiding the killing of the studied individuals. The samples were preserved in a 4% formol solution and analyzed in the laboratory using scientific literature (Radu & Radu 1967, Ionescu & Lăcătuşu. 1971, Móczár 1990, Crişan & Mureşan 1999).

The raw data were statistically analyzed, following several parameters. Thus, we investigated the taxonomic affiliation of the preys, the feeding intensity, the origin, the amount and the frequency of the consumed preys, as well as the frequency of the vegetal fragments and shed skin. We studied the differences that appear in the feeding diversity between the sexes and in the case of the adults-juveniles, using the Shannon-Weaver index (Magurran 1988). We also examined the feeding similarities between the individuals using the Sorrenson index (Chao et al. 2005) and we calculated the minimum number of samples (Kovács & Török 1996). In order to estimate the feeding intensity we analyzed the average number of prey/individual, the maximum number of prey/individual and the feeding intensity rate.

Results

We analyzed the trophic spectrum of 86 frog lake individuals near Sarighiol de Deal locality, Tulcea County. In their stomach contents we identified 434 preys belonging to 23 taxonomic categories, including vertebrates as well as invertebrates. Beside these, we also identified vegetal fragments and shed skin.

Using the rarefaction analysis, we highlighted the necessary minimum number of studied individuals above which the feeding diversity doesn't change anymore. Thus, in the case of males the minimum number is 16, and in that of females, 13. We analyzed 44 male individuals and 34 females.

With regards to the feeding intensity, the amount of empty stomachs is quite high, 13.95%, thus the feeding activity rate being 86.05%. The maximum number of preys/individual is 12 (Fig. 1), which was registered in the case of a female and two juveniles. In order to estimate this parameter, we also calculated the average number of preys, which has the smallest value in the case of the males (5); the females registered 5.94 and the juveniles 7. If we correlate the size of the studied individuals, it emphasizes what the previous values suggested. The most intensive feeding is noticed in the case of those with a 3-6cm size (the juveniles); the feeding slightly declines just above this value, the smallest being in the case of individuals over 10 cm.

With concern to the origin of the prey taxa, there are no differences between sexes or adults/juveniles. Over 30% of the consumed preys have an aquatic origin, the majority being terrestrial.

In order to estimate the food diversity we calculated the Shannon Wiever index (Table 1). The values point out important differences between males, females and juveniles. We can notice that the food diversity is in a negative correlation with the feeding intensity. Thus the highest value is registered in the case of males (2.74), being slightly decreased in the case of females (2.57). In comparison to the adults, the juveniles have a lower value (2.22).

Regarding the food similarity we calculated the Sorrenson index (Table 1). There are big differences concerning the males, females and juveniles. The maximum value is registered in the case of juveniles (0.39); in the case of females it is lower (0.25) and in the case of males it is 0.15. We can observe that these values are in a positive connection with the feeding intensity.

The most important preys are the invertebrates. We calculated the amount (Table 1), respectively the frequency of these.

With regards to the amount of the prey taxa, there are certain differences depending on the sexes, respectively the stage of the ontogenetic development. In the case of the males, the first place is occupied by the Coleoptera, represented by the Curculionidae, Scarabaeidae, Carabidae and Dytiscidae. Here, we can also identify the Heteroptera, Diptera, Homoptera and Odonata. The most important aquatic preys are the aquatic snails Planorbis. The situation is almost similar in the case of the females, with small differences. Thus, in their case, the Coleoptera are not only represented by the Dytiscidae and Scarabaeidae, respectively we can notice a higher amount of the Cicadillidae. In the case of the juveniles, we can observe after the Coleoptera, the Homoptera, Diptera and the appearance of Ephemeroptera larvae.

The situation is slightly different regarding the frequency of the prey taxa. We can notice the high frequency of certain taxa, which had a lower amount value. The Coleoptera had a significant value, but their frequency is much higher. The difference is even higher in the case of the Muscidae and Cicadillidae, which didn't occupy first place in the case of the amount, but had the highest value in the case of the frequency, at least in the case of juveniles. With respect to the adults, the differences weren't so obvious from this point of view.

Besides the invertebrates, we also identified the presence of another *Rana ridibunda* individual in a stomach content.

Besides the animal prey, we also identified the presence of vegetal fragments, respectively shed skin in the stomach contents (Table 2). These elements are only present in the case of adults. Concerning their frequency, the highest values have been registered in the case of females.

Discussions

From the rarefaction analysis, we can establish that the minimum number of samples is much smaller than the studied individuals. This minimum number of samples is distinct at different species of amphibians; in the case of the *Rana ridibunda* species, the number is 22-24 (Kovács & Török 1996), but this value can vary according to the environmental conditions. Other authors calculated a higher number of necessary samples in order to estimate the specific food diversity, this number being 45 (Cogălniceanu et al. 2000).

In the scientific literature, the feeding activity rate is almost 100% in many cases (e.g. Sas et al. 2003, 2005,

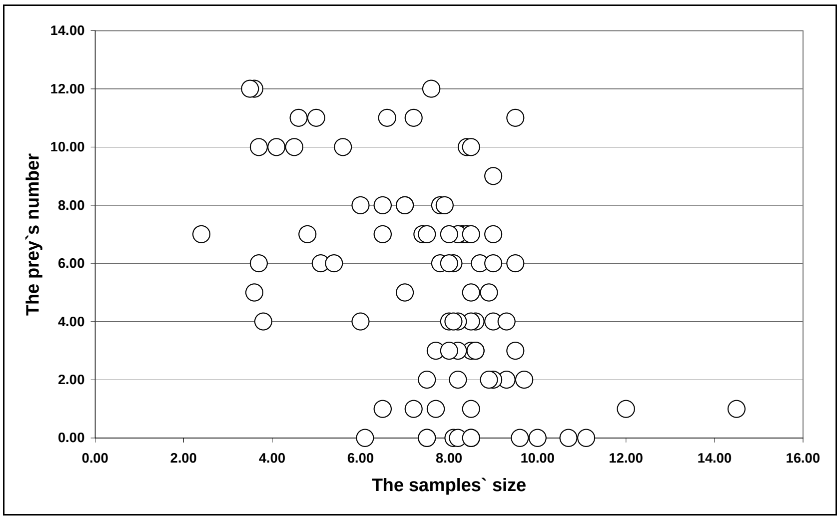

Figure 1. The feeding intensity of the studied frogs

Table 1. The percentage amount of the prey taxa, the food diversity (H - Shannon-Weaver index) and the similarity (S - Sorrensen Index). (L.- larvae; Aq- aquatic; Tr.- terrestrial)

	Male	Female	Juvenile
Prey categories			
Gastropoda	10.23	13.37	0.00
Araneida	3.41	3.96	3.57
Ephemeroptera [L.]	2.84	0.50	17.86
Odonata [L.]	6.25	3.47	3.57
Homoptera-Cicadillidae	7.39	10.89	16.07
Heteroptera (Aq.)	3.41	3.96	0.00
Heteroptera (Tr.)	6.82	5.45	1.79
Coleoptera – undet. (Tr.)	14.77	21.29	17.86
Coleoptera – Dytiscida [L.]	1.14	0.00	3.57
Coleoptera – Dytiscida	6.25	5.45	1.79
Coleoptera – Carabida	3.98	1.98	0.00
Coleoptera – Stafilinida	2.27	2.48	0.00
Coleoptera – Scarabeida	7.95	4.46	8.93
Coleoptera – Curculionida	4.55	1.49	8.93
Coleoptera – Cryzomelida	1.70	0.99	0.00
Lepidoptera [L.]	0.57	0.99	0.00
Nematocera [L.]	0.57	0.50	0.00
Nematocera - Typulida	0.00	0.99	0.00
Nematocera - Culicida	5.11	4.46	3.57
Brahicera - Muscida	9.66	11.39	12.50
Hymenoptera - Formicida	0.57	0.00	0.00
Anura [L.]	0.57	0.99	0.00
Anura	0.00	0.99	0.00
Feeding Niche			
Diversity (H)	2.74	2.57	2.22
Similarity (S)	0.15	0.25	0.39

2007, Ghiurcă & Zaharia 2006, Cicort Lucaciu et al. 2007), which indicates favourable feeding conditions. In our case, over 10% of the studied individuals presented an empty stomach, which suggests that the environmental conditions weren't so propitious. This can be easily understood if we take into consideration the position of the habitats on the field, respectively the high degree of pollution of the puddles.

Table 2. The frequency of the vegetal fragments and shed skin

	Male	Female	Juvenile
Vegetal	25.00	38.24	0.00
Shed skin	13.64	29.41	0.00

With regards to the feeding intensity, we can notice higher values of the maximum and average prey/individual number in the case of the juveniles and the females. The females, which need a higher quantity of energy, fed more intensively because of the reproduction, this being similar to the juveniles, which need more energy for growth. The link between the size of the individuals and the number of preys/individual points out that the juveniles are the ones that feed more intensively, according to the optimum feeding theory, after which the maximum efficiency of the consumed energy is favoured by natural selection (Pyke 1984).

The feeding intensity is in a negative connection with the food diversity. This fact suggests that if we can talk about food selectivity, this can be observed more in the males' case, even if the intensity is smaller. In the case of females and especially in that of juveniles we can notice an opportunistic feeding behaviour, with fewer taxa, but consumed in a higher number (Ephemeroptera larvae, Cicadillidae).

Simultaneously, we can remark a higher resemblance between the individuals in the case of the juveniles, probably due to the more homogeneous food, the diversity being the smallest in their case. The fact that this value varies depending on food diversity increase can be explained in the same manner, but can also suggest the difference between the trophic niches (Cogălniceanu et al. 2000).

We can notice a very high amount of the Coleoptera and of the field representatives, thus the Curculionidae. This fact can be correlated with the characteristics of the habitat, but it is also in a direct relation with the scientific literature. It is considered that these frogs hunt at the groundmark and at the low vegetation level (Kovács & Török, 1995).

Despite the fact that *Rana ridibunda* is considered to be the most aquatic of the amphibians from our country (Fuhn 1960), leaving the water very rarely (Basoglu & Ozeti 1973), the majority of the consumed preys have terrestrial origin. Capturing the preys isn't necessarily done on land, these being accessible from the water plants or even from the surface of the water. The presence of a majority of terrestrial preys has also been recorded in other *Rana ridibunda* populations (Covaciu Marcov et al. 2000, Çicek & Mermer 2006, 2007).

The appearance of larger preys (Coleoptera), together with the smaller ones (Cicadillidae) suggests an opportunistic feeding behaviour, the feeding of these frogs not being selective, green frogs capturing all the moving preys which have a suitable size for consumption (Török & Csörgő 1992, Mollov 2008).

However, selectivity can be observed in the case of juveniles to a certain extent, which isn't reflected only in the more intensive feeding. The significant amount of the Ephemeroptera larvae in their trophic spectrum can be regarded as a way of achieving energy as easily and profitably as possible, the juveniles having higher energy needs, being in an intensive growth process. Some authors consider that the insects' larvae are richer in lipids and thus, are more nourishing (Brooks et al. 1996).

The frequency of certain preys doesn't always present similarities with their amount. In our case this fact can be observed in the case of the Coleoptera, which have a higher frequency value. This phenomenon appears always as a result of their size and their high energetic content, thus the frogs don't have to consume them in a high number. But this phenomenon can also be observed in the case of the small sized preys (Cicadillidae, Ephemeroptera larvae). This fact shows that these preys are present in the habitat, because the frogs' food can be considered as a very important indicator of the environment (Bellocq et al. 2000).

We can observe a positive connection between the size of the consumed prey and the size of the frogs. The size of the preys is a factor that generates certain selectivity in the trophic spectrum of these frogs, the juveniles feeding with smaller-sized preys (Ephemeroptera larvae, Cicadillidae), while the trophic spectrum of the larger individuals is constituted of larger preys (Coleoptera, Muscidae). This phenomenon has been mentioned in the scientific literature, when the consumption of a certain prey was influenced by its size (Altig & Brodie 1971, Freed 1988, Wheather 1986, Çicek & Mermer 2006).

Cannibalism is signalled in the scientific literature in the case of green frogs (Kovács & Török, 1992, Mollov 2008, Sas et al. 2009), some authors considering it to be accidental (Vancea et al. 1961). In our case we encountered this phenomenon in only one individual, suggesting that it is accidental, which proves that they have an opportunistic feeding.

Besides the animal prey, we also identified vegetal fragments and shed skin in the stomach contents of the adults. The vegetal remains are consumed only by the tadpoles (Sousa-Filho et al. 2007) because of the difficulties in digesting the fibres (Zug 1993). In the case of the amphibian adults, the consumption of vegetal fragments is considered to be accidental (Whitaker et al. 1977, Stebbins & Cohen 1995), together with the followed prey. The swallowing of the shed skin fragments is considered by some authors as a way of recycling the epidermal proteins (Weldon et al. 1993), or an additional food in unfavourable conditions (Sas et al. 2003, Cicort Lucaciu et al. 2006, Kovacs et al. 2006). If we take into consideration that these elements appear only in the case of the adults, we can not say that it is a solution in the lack of food, the juveniles being the ones that have the highest feeding intensity in our case. Thus, we can affirm that the appearance of plant and shed skin fragments is an accidental one in the case of these frogs.

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