THE SEASONAL VARIATION OF THE FOOD OF A NON-HIBERNATED *Rana ridibunda* PALLAS 1771 POPULATION FROM THE THERMAL LAKE FROM 1 MAI SPA, ROMANIA

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Abstract. The seasonal variation of the food of the lake frog is determined by environment factors which have a much more radical and obvious action in the cold season. In winter time, a decrease is noted in the feeding of the frogs, from both the quantity's and the diversity of prey's point of view. The feeding of the frogs from thermal waters presents a series of particularities caused by the special conditions from the thermal habitat, although the composition of the trophic spectrum resembles that of a non hibernated population.

INTRODUCTION

Rana ridibunda hibernates in the substratum of the aquatic basins that it populates (Berger 1982). As such, if the water temperatures do not drop, these populations will not enter a hibernation state. This is the case of some habitats from the North-Western part of Romania where *Rana ridibunda* remains active during all the winter. The temperature of the air is not important because of the high and constant one of the water (Covaciu – Marcov et al 2003 a, 2004 a). The most important biotope from this part of the country is that from 1 Mai Spa. It has a large surface, it is natural, and it hosts a numerous non-hibernating population of *Rana ridibunda*. Until now, there aren't any records of any studies referring to the seasonal variation of the feeding of the lake frogs from 1 Mai Spa, studies that would have lasted a whole year and would have compared the trophic spectrum in the warm and cold seasons. There are only data of the trophic spectrum from the winter months (Covaciu – Marcov et al 2005). Similar studies were made upon other non-hibernating populations from the thermal waters from Chişlaz, Livada and Mădăras (Covaciu-Marcov et al 2003 b, 2004 b, Sas et al 2004), indicating important seasonal differences in the trophic spectrum. The feeding of the lake frog was the subject of many scientific articles (Gutowski & Krzystofiac 1998, Ratajski & Vojtkova 1971, Sin et al 1975, Vancea et al 1961, Cogălniceanu et al 2000, Covaciu – Marcov et al 2000). Those data are incomplete either because there were too few analyzed specimens or because the samples were taken only once, not following their seasonal evolution. In this work, we set of to analyze the composition and seasonal variation of the feeding of a non-hibernating population of *Rana ridibunda* from 1 Mai Spa, during a whole year.

MATERIAL AND METHODS

The thermal lake from 1 Mai Spa is situated at about 10 km South-East of Oradea, in the resort with the same name, near the hill of Şomleu. It has a non-thermal permanent tributary. The water temperature is maintained high all winter, being about 31°C near the spring and about 20°C near the banks. The lake has a permanent thermal spring. Near it the water level reaches about 3m, elsewhere the depth being somewhere around 0.5m. The substratum of lake is mostly covered by mud. The lake has very rich vegetation out of which we can mention the thermal water lily and numerous aquatic superior plants (Marrosy 1999).

The study took place between III 2001 – II 2002, summing up a total number of 260 samples. These samples were taken monthly, the number of captured frogs being about 20 to 30 / month. The animals were captured using nets mounted on long metallic tubes or, rarely, by hand. The stomach contents were taken as soon as possible after capturing because the amphibians digest their food very quickly (Caldwell 1996). The stomach contents were taken using the stomach wash method (Joly 1987, Leclerc & Curtois 1993, Cogălniceanu 1997) using a syringe with a plastic tube mounted on its end. After taking the samples, the animals were set free. The stomach contents were stocked in sealed test tubes and conserved with 4% formalin. The preys were determined with a binocular magnifying glass, with the help of the specific literature (Crişan & Mureşan 1999, Crişan & Cupşa 1999, Dierl 1978, Radu & Radu 1967, 1972, Ionescu et al 1971).

Photo 1. The studied habitat et 1 Mai Spa

We analyzed the following parameters of the trophic spectrum:

1. The taxonomical appurtenance of the consumed preys

2. The variation of the maximum and average number of preys / single of *Rana ridibunda*

3. The amount of a certain prey taxon from the total number of identified preys (the ration between the preys belonging to that prey taxon and the total number of identified preys)

4. The frequency with which the frogs consume a specific prey taxon (the ratio between the number of frogs which consumed that certain taxon and the total number of frogs)

5. The appurtenance of the prey taxa to the aquatic or terrestrial environments and the amount of preys from each environment

RESULTS

The composition of the trophic spectrum of a *Rana ridibunda* population from 1Mai Spa resembles the one recorded at other populations, both hibernated and non-hibernated, the lake frogs consuming about the same prey taxa (Gutowski & Krzystofiac 1998, Sin et al 1975, Vancea et al 1961, Cogălniceanu et al 2000, Covaciu – Marcov et al 2000).

A part of the studied frogs had no stomach content. The situation is widely spread at amphibians, frogs that didn't feed being found in numerous previous studies (Hodar et al 1990, Das 1996). There is a seasonal variation of the amount of unfed frogs. Empty stomachs are recorded with the biggest amount in the winter, in December being over 42%. In opposition, all the frogs presented stomach contents in the summer (July – September).

In the stomach contents we encountered many elements. Firstly, prey animals belonging to different taxa were present, adult amphibians being predators (Reeder 1964). Beside prey animals, the frogs also consumed vegetation. In each month of the study, a significant part of the frogs presented vegetal remains in their stomach contents. These were generally represented by remains of terrestrial vegetation, leaves, branches and small seeds. Not so often, we observed fragments of aquatic vegetation, remains of algae or aquatic superior plants. A part of the lake frogs consumed exclusively vegetation. Their amount is very big in winter time. Frogs that present only vegetal remains in their stomach contents are totally absent in the summer.

The number of preys / specimen of *Rana ridibunda* varies very much during a whole year. The lowest values of the average and maximum numbers of preys / frog are recorded in the winter, in December and January. The highest value is reached in the summer. The maximum number of consumed prey animals by a *Rana ridibunda* specimen is of 505 and it is recorded in September. This very large number is due to the consumption of Homopterans Aphides, which are really abundant on the leaves of the water lilies in early fall. The extremely small size of the Aphides determines the frog's ability to consume such a big number of them.

We've identified 27 prey taxa in the stomach contents of the *Rana ridibunda* population from I Mai Spa. Only Coleopterans appear constantly, in all 12 months, this being the order with the biggest number of species in the living world (Radu & Radu 1967). Coleopterans occupy an important role in the trophic spectrum of other amphibian species, too (Hodar & Camacho 1991, Torok & Csorgo 1992). When it comes

Table 1. The number of the analyzed samples; The amount of empty stomachs and the stomachs with vegetal remains

Period 2001-2002	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**I**	**II**
No. of analyzed stomachs	20	30	20	20	20	20	22	20	21	21	25	21
% of empty stomachs	10	3.33	10	2	-	-	-	20	9.52	42.85	32	14.28
% of stomachs with vegetal remains	75	43.3	70	70	75	85	81.81	45	66.66	42.85	60	66.66
% of stomachs exclusively with vegetal remains	20	13.33	2	-	-	-	9.09	2	47.61	28.57	48	9.52

Table 2 Seasonal variation of the average and the maxim number of preys / samples

Period 2001-2002	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**I**	**II**
Maxim no. of preys / stomach	8	8	49	8	10	9	505	48	7	1	2	6
Average no. of preys / stomach	2.25	2.2	5.5	2.55	3.9	3.9	53.4	9.9	0.8	0.28	0.24	2.23

Table 3. Seasonal variation of the amounts of aquatic and terrestrial preys

Period 2001-2002		**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**I**	**F**
Aquatic preys	**Nr**	14	14	6	1	16	12	4	10	6	4	5	31
	%	31.11	21.21	5.45	1.96	20.51	15.38	0.34	5.05	35.29	66.66	83.33	65.95
Terrestrial preys	**Nr**	31	52	104	50	62	66	1171	188	11	2	1	16
	%	68.88	78.78	94.54	98.03	79.48	84.61	99.65	94.94	64.7	33.33	16.66	34.04

to this order, we've also identified the families of the preys, whenever it was possible. Representatives from the Carabides and the Cryzomelides families were consumed in most of the months during the study. A seasonal variation of the number of consumed prey taxa is present, as well. The lake frog constantly consumes terrestrial prey animals, even in the cold season. For example, we recognized Chilopods in November and December when the ground was covered with snow. This fact confirms the previous suppositions according to which, in the heated areas near thermal habitats, some terrestrial invertebrates are maintained active even in winter time (Covaciu – Marcov et al 2003 b, 2004 b, 2005). Therefore, in each of the months of our study, both terrestrial and aquatic preys were consumed.

From the amount's point of view, all the preys present a strong variation determined by the period. The highest amount is reached by Aphids, in September, when they represent over 90% of the prey animals. The frequency with which the frogs consume different preys varies quite a lot, too. Coleopterans are preys consumed constantly with a high frequency. There are differences between the amount and the frequency of consumption of a certain prey taxon. Thus, in September, Aphids represent 94.72% from the total number of preys, but they were consumed only by 54.54% of the frogs from the lake. In conclusion, although Aphids are important as quantity to some *Rana ridibunda* specimens, they aren't that important to the whole population.

DISCUSSIONS

There is a strong seasonal variation of the feeding of the frogs caused by the climate modifications throughout the year. The feeding is strongly influenced by these fluctuations which actually determine the trophic offer. In many cases, the trophic spectrum of the frogs is an image of the offer, the variation of a prey taxon from the trophic spectrum of the frogs being caused by the variation of prey taxon itself (Lamb 1984). The variation of the environments' factors can induce changes in the food composition depending on the period of the year (Dodd 1994). These environment changes and their influence over the feeding of the frogs become more ample in the winter time.

The rate of the frogs' feeding is drastically reduced in the cold season. It can be estimated as being the ratio between the number of stomachs with content and the total number of stomachs (Sala & Ballesteros 1997). The fact that the amount of empty stomach is growing in the winter is a clue of the installation of unfavorable feeding conditions for the frogs. This fact is a consequence to the diminution of the trophic offer which is a result of the entrance of the majority of terrestrial preys in a state of inactivity due to the low temperatures of the air. The terrestrial invertebrates that are maintained active in the coterminous areas to the thermal habitat are consumed in the winter.

In the winter time, the amount of frogs that consumed exclusively vegetation is increasing. In parallel with this, the number of consumed prey taxa drops, and with it, the maximum and average number of preys / specimen, too. Next to the high amount of empty stomachs, these parameters indicate a decline in the rate of the frog's feeding in the cold season.

In the summer, not one frog has been found to have consumed strictly vegetation. Yet their amount is very high in winter, in November over 47% of the frogs consuming only vegetation. It is considered that amphibians consume vegetation accidentally, swallowing them altogether with the preys (Whitaker et al 1977). This supposition was backed up by the fact that at other species of frogs the consumption of vegetation intensifies with the increase of the number of preys (Covaciu – Marcov et al 2002 a, b). Other authors consider that the frogs consume vegetation to eliminate intestinal parasites (Evans & Lampo 1996). The consumption of vegetation altogether with pursued prey is plausible in the case of those amphibians which captured different animal preys beside the vegetation. In this case, the amount of frogs which consumed vegetation amplifies with the increase of the number of preys / specimen. Actually, the consumption of only vegetation doesn't quite follow this rule, being determined by the conditions from during the winter. Most probably, in winter time, the starved frogs attack and swallow different vegetal capsules carried around by the water, after mistaking them with a prey animal. Thus, the consumption of only vegetation is determined by the absence of prey animals. In some cases, it is considered that the amphibians' consumption of vegetation is intended, vegetation presenting a certain alimentary and nutritive value (Das 1996).

The number of prey taxa is reduced as it gets closer to the cold season because of the decrease in the trophic offer. Thus, in December and in January there were only 4 prey taxa consumed, mostly aquatic. The biggest number of prey taxa, 16, was consumed in April and September. Thus, in these months we have the maximum food diversity. In June and July the number of prey taxa is reduced to 10, some prey taxa, like Lubricates, which are bonded to the humidity disappearing due to the heat. The variation of the number of consumed prey taxa is directly influenced by the climate conditions, this influence being even more obvious in the winter. A similar variation is recorded in the case of the maximum and average number of preys / specimen, the cause being the same.

In winter time, once with the reduction of the diversity of terrestrial preys, the feeding of the frogs is oriented towards aquatic preys. These represent the thermal ecosystem's resources, not being therefore

Table 4. The amount of the identified prey items

	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	F
Nematoda	-	-	-	1.96	-	-	-	-	-	-	-	-
Lumbricida	-	1.51	-	-	-	3.84	0.17	-	-	-	-	-
Arahneida	-	4.54	1.81	5.88	8.97	8.97	0.85	-	17.6	-	-	-
Opilionida	-	-	-	-	-	-	0.08	-	-	-	-	-
Crustacea – Izopoda	8.88	-	5.45	7.84	-	7.69	0.17	-	23.5	-	-	-
- Gamarida	8.88	1.51	-	-	-	-	0.08	1.01	29.4	33.3	50	59.5
- Copepoda	-	-	-	-	-	-	0.08	-	-	-	-	-
Miriapoda-Diplopoda	2.22	1.51	-	-	-	-	0.25	-	-	-	-	2.12
-Chilopoda	-	-	-	-	-	-	0.17	-	5.88	-	16.6	-
Gasteropoda	15.5	7.57	1.81	3.92	19.2	3.84	0.68	5.05	5.88	16.6	-	4.25
Colembola	-	-	-	-	-	-	-	0.5	-	-	-	-
Ortoptera	-	-	-	-	1.28	6.41	0.25	1.01	-	-	-	-
Homoptera	-	-	68.18	-	1.28	2.56	94.72	80.3	-	-	-	14.89
Heteroptera	4.44	12.1	-	-	16.6	14.1	-	1.01	-	-	-	2.12
Dermaptera	-	1.51	1.81	3.92	-	-	1.02	-	-	-	-	-
Odonata	-	1.51	1.81	1.96	1.28	15.3	-	0.5	-	-	-	-
Coleoptera	8.88	30.3	9.09	50.9	30.7	17.9	0.68	1.51	5.88	33.3	-	4.25
Diptera	24.4	13.	3.63	-	2.56	7.69	0.17	5.55	5.88	-	16.6	4.25
Chironomida Larva	-	1.51	0.9	-	-	-	-	-	-	-	-	2.12
Trichoptera Larva	-	-	-	-	-	1.28	-	-	-	-	-	2.12
Plecopter Larva	-	-	-	-	-	1.28	-	-	-	-	-	-
HymenopterA-FormicidA	22.2	7.57	0.9	5.88	8.97	2.56	0.42	0.5	-	-	-	2.12
- undet.	-	4.54	-	3.92	3.84	5.12	0.08	-	-	-	-	2.12
Lepidoptera - larva	-	-	1.81	3.92	-	-	0.08	2.52	3.88	-	-	-
- imago	-	1.51	-	9.8	-	-	-	-	-	-	-	-
Anura - adults	-	1.51	1.81	-	-	1.28	-	-	-	-	16.6	-
- tadpoles	4.44	7.57	0.9	-	-	-	-	0.5	-	16.6	-	-
Pisces	-	-	-	-	5.12	-	-	-	-	-	-	-

Table 5 The frequency of occurence of the identified prey items

	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	F
Nematoda	-	-	-	5	-	-	-	-	-	-	-	-
Lumbricida	-	3.33	-	-	-	15	9.09	-	-	-	-	-
Arahneida	-	10	10	15	30	30	36.36	-	14.28	-	-	-
Opilionida	-	-	-	-	-	-	4.54	-	-	-	-	-
Crustacea – Izopoda	15	-	10	20	-	10	9.09	-	9.52	-	-	-
- Gamarida	15	3.33	-	-	-	-	4.54	10	23.8	9.52	8	57.14
- Copepoda	-	-	-	-	-	-	4.54	-	-	-	-	-
Miriapoda-Diplopoda	5	3.33	-	-	-	-	13.63	-	-	-	-	4.76
-Chilopoda	-	-	-	-	-	-	9.09	-	4.76	-	4	-
Gasteropoda	10	10	5	10	45	15	22.72	25	4.76	4.76	-	9.52
Colembola	-	-	-	-	-	-	-	5	-	-	-	-
Ortoptera	-	-	-	-	5	25	13.63	10	-	-	-	-
Homoptera	-	-	20	-	5	10	54.54	45	-	-	-	9.52
Heteroptera	5	26.66	-	-	35	50	-	10	-	-	-	4.76
Dermaptera	-	3.33	10	10	-	-	40.9-	-	-	-	-	-
Odonata	-	3.33	10	5	5	45	-	5	-	-	-	-
Coleoptera	20	53.33	45	75	50	45	27.27	15	4.76	9.52	4	9.52
Diptera	45	30	20	-	10	25	4.54	30	4.76	-	-	9.52
Chironomida Larva	-	3.33	5	-	-	-	-	-	-	-	-	4.76
Trichoptera Larva	-	-	-	-	-	5	-	-	-	-	-	4.76
Plecopter Larva	-	-	-		-	5	-	-	-	-	-	-
HymenopterA-FormicidA	30	13.33	5	15	25	10	18.18	5	-	-	-	4.76
- undet.	-	10	-	10	15	20	4.54	-	-	-	-	4.76
Lepidoptera - larva	-	-	5	10	-	-	4.54	20	4.76	-	-	-
- imago	-	3.33	-	25	-	-	-	-	-	-	-	-
Anura - adults	-	3.33	10	-	-	5	-	-	-	-	4	-
- tadpoles	10	13.33	5	-	-	-	-	5	-	4.76	-	-
Pisces	-	-	-	-	10	-	-	-	-	-	-	-

influenced by the air's temperature. The aquatic preys are available all winter, but are less plenty and less accessible for *Rana ridibunda*, a species adapted to hunting in the terrestrial environment (Ghira et al 1997). Obtaining the preys from the aquatic environment implies other mechanisms than in the terrestrial background (Lauder &Reilly 1994). In the winter, the aquatic preys represent the majority of the amount, a situation that is reversed in the summer. In the cold season the vertebrates have more significant amounts, being represented by adults and tadpoles of their own species. Tadpoles are a relatively important resource for the adults, being consumed in 5 months of our study. Tadpoles are present throughout all the year, the *Rana ridibunda* population reproducing continuously (Covaciu – Marcov et al 2003 a). After a more laborious analysis it can be stated that the amount of aquatic preys is bigger. Thus, Aphids are terrestrial animals, being considered as these when determining the amount of the terrestrial preys. In this case, the Aphids attack the water lily leaves which belong to the thermal ecosystem. Aphides were consumed in October, because of the high temperature of the water.

In a previous study, we published only data on the composition of the trophic spectrum of the lake frog in the winter time (Covaciu – Marcov et al 2005). Between the two studies, there isn't any important difference regarding the composition of the trophic spectrum. There is however a dissimilarity: in this here study, in December, the feeding rate has been drastically reduced. In our previous study, from two years ago, the feeding was much more intense. The dissimilarity is caused by the important thermal differences between the two periods. Thus, in the case of the present study, December was very cold, the ground having a permanent snow coating. In the previous case, in the first part of the month the daily temperatures sometimes even reached 10°C, hereby allowing the active maintenance of some terrestrial prey taxa. This is how we underline the important differences between the feeding of the frogs in two distinct years, determined by the variation of the climate conditions.

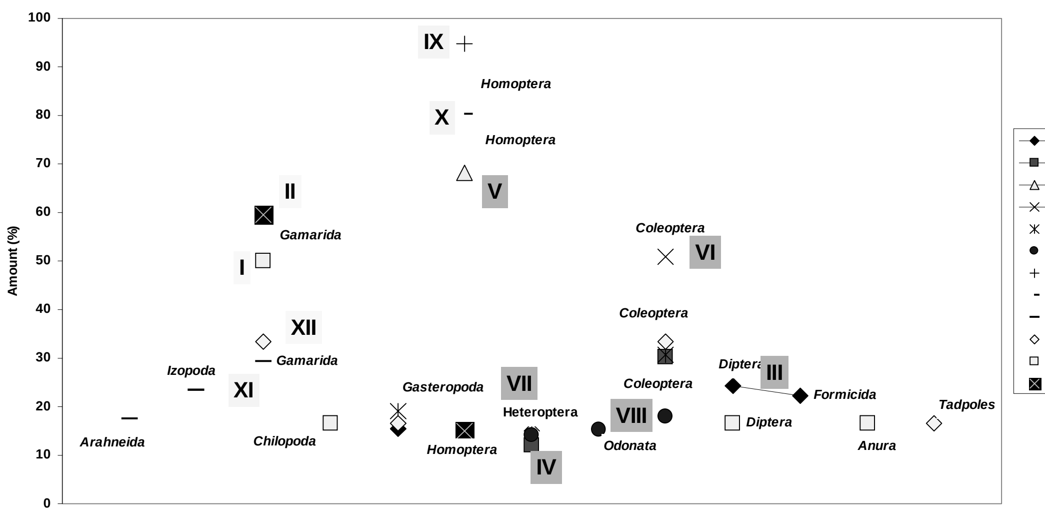

Fig. 1 Seasonal variation in the preference of prey items

The feeding of the *Rana ridibunda* population from 1 Mai Spa isn't that negatively influenced by the winter time conditions just like when it comes to other thermal habitats. Thus, at Chişlaz, the amount of empty stomachs throughout the winter is much bigger than that from 1 Mai Spa (Covaciu – Marcov et al 2003 b). The more reduced rate of the feeding from Chişlaz is a consequence of the fact that the biotope is an artificial drain with an extremely poor aquatic fauna. Thus, in the winter, the frogs cannot replace the terrestrial preys with the aquatic ones. At Chişlaz the amount of specimens that consume strictly vegetation in the winter time is much larger (Covaciu – Marcov et al 2003 b). In the cold season, in all the investigated thermal habitats, the frogs consume only vegetal remains (Covaciu – Marcov et al 2003 b, 2004 b, 2005, Sas et al 2004). There are differences in the composition of the trophic spectrum among different thermal habitats depending on local conditions. Thus, at Livada Crustacea Phyllopoda are consumed (Covaciu – Marcov et al 2004 b), where at Chişlaz, Rodent Mammals (Covaciu – Marcov et al 2003 b). At 1 Mai Spa, characteristic is the very high amount with which Aphids are consumed, numerous due to the water lilies. Besides these, at 1 Mai Spa, larvae of their own species are consumed, too. Aphids and tadpoles are an important trophic resource for the frogs, characteristic fact for this biotope and determined by its conditions. All these facts underline the importance of each thermal habitat's own conditions for the feeding of the *Rana ridibunda* populations in the cold season.

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