THE TROPHIC SPECTRUM OF A *HYLA ARBOREA* POPULATION FROM THE FOIENI AREA, SATU MARE COUNTY, ROMANIA

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Abstract. *In the course of this study we analyzed the food composition of 146 subjects belonging to the Hyla arborea species, which were captured in the perimeter of the sand dunes of Foieni in Satu Mare County from May until September 2008. Of the 526 consumed preys, the Araneide have the highest share. These are important regardless of the period or gender of the frogs. Other preys that were consumed in large quantities were the Formicida and the Nematocera. The diversity of the food has a high value during this study, in this habitat the frogs having access to a large variety of prey.*

Keywords: *Hyla arborea, feeding, period.*

Rezumat. Spectrul trofic al unei populaţii de *Hyla arborea* din zona Foieni, judeţul Satu Mare, România. *Pe parcursul acestui studiu am analizat compoziţia hranei la 146 de exemplare aparţinând speciei Hyla arborea, începând din luna mai şi până în luna septembrie a anului 2008, brotăceii fiind capturaţi din perimetrul Dunelor de Nisip de la Foieni din judeţul Satu Mare. Din cele 526 de prăzi consumate cea mai mare pondere o au araneidele. Acestea sunt importante indiferent de perioadă sau sexul brotăceilor. Alţi taxoni pradă care au fost consumaţi în cantitate mare sunt şi formicidele şi nematocerele. Diversitatea hranei are o valoare ridicată pe întreg parcursul studiului, în acest habitat broaştele având la dispoziţie a gamă variată de prăzi.*

Cuvinte cheie: *Hyla arborea, hrănire, perioadă.*

INTRODUCTION

Amphibians are considered to be potential indicators for modifications in the environmental conditions of the ecosystem in which they live (VITT et al., 1990, BOWERS et al., 1998). Therefore data that presents aspects of the ecology of these species are important for preventing the extinction of certain populations as well as for establishing management plans regarding the preservation of habitats or regarding the impact modifications to these habitats have on amphibians (STORK & SAMWAYS, 1995).

The *H. arborea* species registers a considerable decline in most of Europe, especially due to destruction of habitats, urbanization, climate changes etc. (BORGULA, 1993; STUMPEL, 1993; KUZMIN, 1999). Because this species is sensitive to pollution and drought, in Romania it requires local measures of protection (COGĂLNICEANU et al., 2000a).

In the expert literature there are few papers referring to the trophic specter of this species (KOVÁCS & TÖRÖK, 1997; CLAUSNITZER, 1986). However there are some studies that analyse other specters, like the consequences of habitat fragmentation (ANDERSEN et al., 2004), estimations regarding the number of individuals in a population (PELLET et al., 2007) or estimations about the disposition of the frogs in the trees crown (SCHMIDT et al., 2003).

In our country, papers on the seasonal variation of the trophic spectrum of these frogs are very few. There is only one paper dedicated to this theme (KOVACS et al., 2007). Comparative studies between the food of this frog and the food of other amphibian species are also few (COGĂLNICEANU et al., 2000b; NICOARĂ & COSTICĂ, 2005); therefore it is important to follow the seasonal variations in the frog's feedings. Herpetological studies have recently been done in this area, but they refer only to the composition of the herpetofauna (COVACIU-MARCOV et al., 2008, 2009).

The purpose of this study was to observe the variations in the composition of the food in the different periods of the study as well as the differences between the food of the males and that of the females.

Even if the population the trophic spectrum of which was observed during this study is in a protected area, the quantitative information referring to the role of the amphibians in the ecosystem is important (WHILES et al., 2006), therefore through observation we can obtain useful information about the habitat's state or about the positive or negative changes that appear at the biotope level.

MATERIAL AND METHODS

The samples were collected in 2008 during five periods at the following dates: May 10, June 8, July 4, August 10 and September 6. During the field trips the stomach content of 146 individuals was sampled, of these individuals 92 were females and 54 males. The habitat is situated on the flank of an oak forest from the sand dunes of Foieni (47°42'0'' N, 22°23'0'' E, 118 m a.s.l). Near the habitat there is also a water canal, as well as several puddles, therefore this biotope also confers the necessary conditions for laying eggs in the reproductive season. The tree frogs were captured by hand from the bushes situated on the two sides of a forest road, but a few individuals were found on the ground.

The method used to extract the stomach content was the stomach flushing method (SOLÉ et al., 2005). The advantage of this method is that it allows amphibian feeding studies to be conducted without killing the researched

individuals (COGĂLNICEANU et al., 2000b). 20-50 cm^3 syringes with a perfusion tube of different lengths and exterior diameters attached, according to the frog's dimensions, were used to extract the stomach content. Considering the fact that frogs can digest food in a short period of time (CALDWELL, 1996), which can determine errors in results, we tried to shorten the length of time between capture and the stomach flushing as much as possible. The collected samples were preserved separately in a 4% formalin solution, and stored in sealed test tubes with labels containing information about the frog's sex.

After taking the stomach content, the frogs were released back to their environment, thus trying to diminish as much as possible the impact of our activity on the amphibians. The material was examined in the laboratory with the aid of a binocular magnifying glass. Determining the prey was done by using the expert literature (RADU & RADU, 1967).

The trophic specter was analysed according to the frequency and weight of the preyed taxa, and the diversity and similarity of the food was estimated using the Shannon-Wiener (1949) diversity index (*H*) and the similarity with Sorrensen index (CHAO et al. 2005). The similarity between the feeding of the males and females was calculated with the Mann-Whitney (*U*) test using EstimateS 7.0 software (COLWELL, 2005).

RESULTS AND DISCUSSIONS

During the study the analysed individuals' feeding was intense, but in the first period of the study there were 7 individuals, and in the last period there were 2 individuals with no stomach content. Generally, the lack of food is caused by certain less than favourable conditions in the environment (too low or too high temperatures) that does not allow some prey, which is sensible to the environmental conditions to become active. Considering that specimens without stomach content were found only at the beginning and the end of the study, we consider this to be the cause of the lack in prey. Still, the small number of individuals that did not eat a prey indicates that the frogs have optimal feeding conditions in this habitat. Individuals without a stomach content were also found by KOVÁCS &TÖRÖK (1997) and by KOVACS et al. (2007), and same as here this was more the case of tree frogs collected off the ground at the beginning and at the end of the active period.

In the case of the tree frogs with stomach content, alongside the animal prey we identified vegetal fragments, shed skin and minerals. The vegetal fragments were present in every period, their weight increasing with the number of preys, suggesting that the vegetal fragments were accidentally consumed with the prey or because they were confused with the intended prey. Also we observed that the weight of vegetal fragments is higher in females, because of consuming a higher number of preys than males. There were not found vegetal fragments alone in any of the investigated individuals, which underlines their accidental consumption. Vegetal remains were also identified in the stomach content of tree frogs by other authors (CHIMINELLO & GENERANI, 1992) as well as in other amphibian species (COVACIU-MARCOV et al., 2003a, b).

Shed skin remains were identified in the first two periods of the study, in the stomachs of 13.8% and respectively 11.1% of the analysed tree frogs as well as in September when their weight was a lot smaller (Table 1). In the last period there was one specimen whose stomach content contained only shed skin fragments. Some authors consider that shed skins are consumed to recycle the epidermal proteins (WELDON, 1993), these have nutritional value and are consumed when the trophic offer is low (CICORT-LUCACIU et al., 2007), but in this case the shed skin consumption is low, the frogs having at their disposal enough animal preys to fulfil their energetic necessities.

Table 1. Number of samples and prey taxa; maximum and average number of prey/individual.
Tabel 1. Numărul de probe şi de taxoni pradă; numărul mediu şi maxim de prăzi/individ.

	The periods of the study					**The sex of the frogs**		
	10.05	***8.06***	***04.07***	***10.08***	***6.09***	***Females***	***Males***	***Total***
No. Sample	29	45	22	20	30	92	54	146
No.Taxon Prey	56	267	27	59	131	388	138	526
No.max.prey/ individual	5	11	4	10	14	14	11	14
Average No. Prey/individual	1.93	5.93	2.45	5.9	4.37	4.79	3,37	4.43

Inorganic materials were identified only in one period (June), and were accidentally ingested.

The maximum and average prey per individual number registers modifications according to period and sex, their highest value being 8, in June, and 10, in August (Table 1). Therefore, we can consider that in these two periods during the study, the analysed population had the best feeding conditions because the environmental conditions were favourable for the development of a large number of preys. In July, the average number prey/individual was only 2.27, this period not being favourable for frog activity, as well as for the invertebrates they consumed because of high temperatures. For the females the average number of preys is 4.79, for the males this number is lower (3.37), females needing more energy in the mating season (VANCEA et al., 1961). The 526 identified preys from the analysed stomach content were classified in 33 taxonomical categories.

Regarding the taxonomical prey weight, it registers variations according to period and gender. Among the most important preys in the trophic spectrum of the studied population are the Araneida, which were consumed during the

entire duration of the study and also have a high weight (Table 2). In July, their weight was 25.9%. Also in the case of the males, the Araneida have the first place from the total of consumed taxa.

Table 2. The weight of the prey taxa.
Tabel 2. Ponderea taxonilor pradă.

	The periods of the study					**The sex of the frogs**		
Prey Taxa Category	**V 10**	**VI 8**	**VII 4**	**VIII 10**	**IX 6**	***Females***	***Males***	***Total***
Gasteropoda-snails	1.79	2.62	3.7	5.08	2.29	2.58	3.62	2.78
Gasteropoda-Limax	-	0.37	-	-	-	0.26	-	0.19
Crustacean-Izopoda(t)	-	4.49	3.7	25.4	11.5	7.99	8.7	7.96
Arahnida Pseudoscorpionida	-	0.37	-	-	-	0.26	-	0.19
Arahnida-Acarian	-	0.37	-	-	-	0.26	-	0.19
Arahnida-Araneida	19.6	16.9	25.9	11.9	14.5	15.7	19.6	16.5
Myriapoda-Chilopoda	-	-	-	-	0.76	0.26	-	0.19
Myriapoda-Diplopoda	-	-	-	5.08	4.58	1.29	2.9	1.67
Ephemeroptera	-	0.37	-	-	-	-	0.72	0.19
Ortoptera	-	-	-	1.69	-	-	0.72	0.19
Plecoptera	-	0.37	-	-	-	0.26	-	0.19
Heteroptera(t)	-	4.49	-	-	-	2.58	1.45	2.22
Homoptera-Cicadina	1.79	0.75	18.5	1.69	2.29	2.06	2.9	2.22
Lepidoptera (L)	7.14	5.24	-	1.69	19.8	6.96	13	8.33
Lepidoptera	-	3.75	3.7	10.2	3.82	4.12	3.62	4.07
Trihoptera	-	-	-	-	0.76	0.26	-	0.19
Coleoptera-undet.	14.3	3.37	3.7	3.39	2.29	3.35	7.25	4.26
Coleoptera-Carabidae	-	2.25	3.7	-	0.76	2.06	-	1.48
Coleoptera-Cryzomelidae	10.7	3.37	-	-	1.53	2.58	2.9	3.15
Coleoptera-Coccinelidae	-	0.75	-	-	-	0.52	-	0.37
Coleoptera-Curculionidae	5.36	5.62	-	1.69	0.76	4.12	2.17	3.7
Coleoptera-Elateridae	7.14	2.62	7.41	-	-	2.58	1.45	2.41
Coleoptera-Stafilinidae	-	-	-	-	0.76	0.26	-	0.19
Coleoptera-Cantaridae	3.57	0.75	7.41	-	-	1.55	-	1.11
Diptera-Nematocera	10.7	24	-	-	5.34	16.5	6.52	14.3
Diptera-Brahicera (L)	-	1.5	3.7	-	0.76	1.55	-	1.11
Diptera-Brahicera	16.1	4.87	3.7	6.78	9.92	5.93	11.6	7.41
Neuroptera	-	-	-	1.69	-	0.26	-	0.19
Hymenoptera-undet.	1.79	1.5	3.7	-	1.53	1.03	2.17	1.48
Hymenoptera-Formicidae	-	5.24	11.1	18.6	16	10.3	6.52	9.07
Hymenoptera-Apidae	-	0.37	-	-	-	0.26	-	0.19
Panorpata	-	-	-	5.08	-	-	2.17	0.56
Blatoidea	-	3.75	-	-	-	2.32	-	1.85

Regarding the females, although spiders have a high weight, the prey that was consumed in the largest quantity was Diptera Nematocera. Because these are of smaller dimensions, they are consumed in larger numbers which leads to an increase in the value of their weight. If we refer to the consumption frequency of this taxonomical category, we can observe that it is situated, in all five periods of the study, on the first or on the second position. Spiders were found in 50% of the analysed tree frogs. Both in the case of the males and females, the most consumed preys were spiders. We can observe a connection between the frequency and the weight of this group in the composition of the tree frog's food. Spiders are accessible to a large number of individuals and are also available in large quantities. Spiders also have an important value for a population of *Pelophylax kl. esculenta* which is also located in the forest of Foieni (SAS et al., 2009). In this way we can observe the opportunistic character of the Amphibians, which feed on the most abundant preys in their habitat.

The Araneida are a largely spread group of arthropods, which are not pretentious to the environmental conditions and are present in the food of the frogs during the entire length of their active period. Spiders also represented an important trophic category in the food of other populations of tree frogs, like the one from Resighea (KOVACS et al., 2007) but also in the trophic spectrum of other Amphibian species (COVACIU-MARCOV et al., 2000).

The Nematocera are situated on the second position, according to the quantity in which they were consumed, during the study, even though they are missing in the third and forth months because of bad environmental conditions. The high temperatures led to the drying up of the pools, prohibiting their reproduction in that period. Unlike the males,

the females were the ones that consumed the mosquitoes in high number and quantity. In periods favourable for reproduction, the Nematocera are abundant in the habitat, being a small and flying species, they can be consumed in large quantity by the frogs. In June, mosquitoes were consumed by 75.6% of the individuals, meaning the highest frequency at which a prey was consumed.

The Formicida are situated on the third place both as frequency and as weight. Because they are small preys, they can be consumed in large quantities, but also by many tree frogs, because they are also spread evenly through the habitat (Table 3). Ants are missing from the first part of the study, but after that, they are consistently found in the stomach content of the tree frogs. This situation was also observed by COGĂLNICEANU et al. (2000b), who, following a study, identified Formicida in a high weight in the stomach content of tree frogs.

Table 3. The frequency of the vegetal, shed skin, mineral and prey taxa.
Tabel 3. Frecvența fragmentelor vegetale, exuvie, minerale şi taxoni pradă.

	The periods of the study					**The sex of the frogs**		
	V 10	**VI 8**	**VII 4**	**VIII 10**	**IX 6**	***Females***	***Males***	***Total***
%Vegetal	24.1	55.6	27.3	20	26.7	40.7	24.4	36.9
%Shed skin	13.8	11.1	-	-	6.67	7.41	12.2	9.02
%Mineral	-	2.22	-	10	-	1.23	2.44	1.64
Prey taxa								
Gasteropoda-snails	3.45	11.1	9.09	30	10	9.88	12.2	10.7
Gasteropoda-Limax	-	2.22	-	-	-	1.23	-	0.82
Crustacean-Izopoda (t)	-	20	9.09	70	26.7	21	19.5	20.5
Arahnida-Pseudoscorpionida	-	2.22	-	-	-	1.23	-	0.82
Arahnida-Acariena	-	2.22	-	-	-	1.23	-	0.82
Arahnida-Araneida	31	66.7	63.6	50	36.7	54.3	41.5	50.8
Myriapoda-Chilopoda	-	-	-	-	3.33	1.23	-	0.82
Myriapoda-Diplopoda	-	-	-	30	20	6.17	9.76	7.38
Ephemeroptera	-	2.22	-	-	-	-	2.44	0.82
Ortoptera	-	-	-	10	-	-	2.44	0.82
Plecoptera	-	2.22	-	-	-	1.23	-	0.82
Heteroptera (t)	-	22.2	-	-	-	9.88	4.88	8.2
Homoptera-Cicadina	3.45	4.44	36.4	10	6.67	8.64	7.32	8.2
Lepidoptera (L)	10.3	22.2	-	10	50	22.2	26.8	23.8
Lepidoptera	-	22.2	9.09	50	16.7	18.5	12.2	17.2
Trihoptera	-	-	-	-	3.33	1.23	-	0.82
Coleoptera-undet.	24.1	17.8	9.09	20	10	13.6	24.4	17.2
Coleoptera-Carabidae	-	11.1	9.09	-	3.33	8.64	-	5.74
Coleoptera-Cryzomelidae	13.8	15.6	-	-	6.67	9.88	7.32	10.7
Coleoptera-Coccinelidae	-	2.22	-	-	-	1.23	-	0.82
Coleoptera-Curculionidae	6.9	26.7	-	10	3.33	14.8	7.32	13.1
Coleoptera-Elateridae	10.3	13.3	18.2	-	-	9.88	4.88	9.02
Coleoptera-Stafilinidae	-	-	-	-	3.33	1.23	-	0.82
Coleoptera-Cantharidae	6.9	4.44	9.09	-	-	6.17	-	4.1
Diptera-Nematocera	17.2	75.6	-	-	16.7	42	17.1	36.1
Diptera-Brahicera (L)	-	8.89	9.09	-	3.33	7.41	-	4.92
Diptera-Brahicera	24.1	24.4	9.09	40	33.3	24.7	29.3	27
Neuroptera	-	-	-	10	-	1.23	-	0.82
Hymenoptera-undet.	3.45	6.67	9.09	-	6.67	4.94	4.88	5.74
Hymenoptera-Formicidae	-	28.9	27.3	40	26.7	29.6	9.76	23
Hymenoptera-Apidae	-	2.22	-	-	-	1.23	-	0.82
Panorpata	-	-	-	20	-	-	4.88	1.64
Blatoidea	-	20	-	-	-	9.88	-	7.38

Another category of prey that presents interest for the tree frogs diet are Lepidoptera; these are consumed in either form, adult or larva. Even so, between the two forms, the caterpillars are predominant. In the last part of the study, their weight was 19.8% and they were present in half of the analysed stomach content, situating themselves on the first position according to both frequency and weight. They are consumed by both males and females, and are easy to capture because of their slow movements. They are important preys because of the high content in lipids (BROOKS et al., 1996).

The Coleoptera are also present during the entire length of the study. They are represented by a few families, among which the most important are the Chryzomelida, Curculionida and Elaterida. This can be explained because of the abundance of Coleoptera in nature, the order with the most species in nature (RADU & RADU, 1967).

It is also interesting the presence of terrestrial Isopoda, which have a high frequency and weight, especially in August and September. In the fourth period, their weight was 25.4% and their frequency was 70%, therefore they are an important prey for the studied population. Also we can observe that the values are similar for both genders, this can be explained through the fact that Isopoda are easy to capture and are wildly spread through the habitat, therefore accessible to a large number of individuals. Being dependent on humidity, we can deduce the fact that only in these periods the conditions were favourable for the development of this prey category, in all the other periods they are missing or have little importance in the trophic spectrum of the population. Isopoda were also identified in the population from Resighea, but unlike our case, they were present in March when the analysed specimens were captured off the ground or from the water in the mating season (KOVACS et al., 2007).

In July, when the high temperature confined the activity of potential prey, we noted that the Cicada and the Araneida represent the main trophic category for the tree frog, due to these taxonomical groups being linked to heat and dryness. They were also identified in the diet of other populations of *H. arborea* especially during the summer months (KOVACS et al., 2007; COGĂLNICEANU et al. 2000).

Hereby we can deduce that the individuals of this species are general and opportunistic predators, which consume the preys that are available at that time in the habitat. This is a characteristic trait of the Hyla Genus species (HIRAI & MATSUI, 2000) as well as of other Amphibian species (TÖRÖK & CSÖRGŐ, 1992).

Regarding the gender of the frogs, even though the females had greater food diversity, we observed that the base trophic categories for this population were similar, fact that also resulted from the use of the Mann-Whitney (U) test. We obtained $p=0.11$, $p>5$ so the differences that appear in the trophic spectrum of the two genders are negligible.

The greatest diversity was registered in June, 2.48. In this period, the environmental conditions were favourable for the development of different taxonomical groups of prey. In this month, a more intense feeding of the tree frogs was also observed. In the next month the diversity value was lower (Table 4), probably because of the high temperatures that reduced the trophic offer.

In the first period of the study the food similarity index between analysed individuals had a value of 0.10, the lowest value, because in this period there was not a taxonomical category of prey with a high frequency, the frogs consuming different types of prey from different categories.

Table 4. Food diversity and similarity between individuals.
Tabel 4. Diversitatea şi similaritatea hranei între indivizi.

The periods of the study	**V** **10**	**VI** **8**	**VII** **4**	**VIII** **10**	**IX** **6**
Diversity (Shannon)	1.95	2.48	1.83	1.99	2.17
Similarity (Sorrensen)	0.10	0.33	0.25	0.31	0.19

CONCLUSIONS

There is a season variation of the trophic spectrum composition of *H. arborea*, primarily determined by the variations in availability of the taxonomical groups of prey in the tree frogs environment, due to environmental conditions as well as due to the invertebrates' growth cycles. The tree frogs have an opportunistic and general feeding style, consuming the prey that is more abundant in their perimeter, reflecting the food sources that are available in their habitat.

There are no notable differences between males and females, both having a similar life style, roughly equal body dimensions and populating the same microhabitats, so there are no major differences between taxonomical groups of prey they consume.

During the five periods of the study, the tree frogs intensively fed, having available in this habitat, regardless of the environmental conditions, different categories of prey. Therefore, this habitat offers the necessary conditions for feeding and reproduction for the tree frogs, conditions that in time led to the maintenance and development of the population.

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