ЮБИЛЕЙНА НАУЧНА КОНФЕРЕНЦИЯ ПО ЕКОЛОГИЯ (СБОРНИК С ДОКЛАДИ)
Ред. Илиана Г. Велчева, Ангел Г. Цеков • Пловдив, 1ви ноември 2008 • стр. 181-190

PROCEEDINGS OF THE ANNIVERSARY SCIENTIFIC CONFERENCE OF ECOLOGY
Eds. Iliana G. Velcheva, Angel G. Tsekov • Plovdiv, November 1st 2008 • p. 181-190

DIET AND TROPHIC NICHE OVERLAP OF THE MOOR FROG (*Rana arvalis* Nilsson, 1842) AND THE COMMON FROG (*Rana temporaria* L., 1758) FROM POLAND

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Abstract: During our study we identified 79 prey items in the trophic spectrum of the Moor frog (*Rana arvalis* Nilsson, 1842) with average number of prey items per stomach – 5.27 and 100 prey items in the trophic spectrum of the Common frog (*Rana temporaria* L., 1758) with average number of prey items per stomach – 3.84. In both species the most important prey category is Coleoptera (Insecta). Other important prey animals are from Hemiptera, Hymenoptera and Diptera orders (Insecta) as well as non-insect invertebrates (Gastropoda, Arachnida, Myriapoda) which also play significant role. Both frogs consume almost only terrestrial prey. The trophic niche breadths for both species are quite high (*Rana arvalis* – 23.70; *Rana temporaria* – 12.25). The estimated trophic niche overlap between the species is moderate (63.5%), but the numeric proportion of all prey taxa occurring in the stomachs do not differ significantly between the species. *Rana arvalis* and *Rana temporaria* are polyphagous zoophages, like other amphibian species and they are probably consuming all mobile objects which they come in contact with and can swallow.

Key words: diet, trophic spectrum, niche overlap, *Rana arvalis, Rana temporaria*, Poland

INTRODUCTION

Amphibians are important components of ecosystems, because they direct energy from invertebrates, mainly detritivores and phytophages, to higher trophic levels (BURTON & LIKENS, 1975). To understand the position of amphibians in the trophic chains it is important to know their food composition (GUNZBURGER, 1999), studying of which is one of the primary directions in the ecological studies and there are quite a lot of publications in the field.

The Moor frog (*Rana arvalis*) and the Common frog (*Rana temporaria*) are two of the most common anuran species in Central and Eastern Europe as well as in

Poland (ARNOLD & OVENDEN, 2002). In most of their range both species have sympatric distribution. That is why studying the potential competition for food between them is an interesting case study. Currently such studies are scares. Studies on the quantitive and qualitative trophic spectrum of these species in Poland are done by MAZUR (1966), ZIMKA (1966, 1974), LOMAN (1979), NOVITSKY (2000, 2006), MAKSIMOVA & NOVITSKY (2007) and others.

The aim of the current study is to present the trophic spectrum of both species; their trophic niche breadth and niche overlap from several localities in Poland.

MATERIAL AND METHODS

For the purposes of the current study we examined a total of 100 stomachs – 46 belonging to the Moor frog (*Rana arvalis*) and 54 belonging to the Common frog (*Rana temporaria*), preserved in 70% alcohol and kept in the herpetological collection of the Department of Ecology and Environmental Conservation in the Faculty of Biology at the University of Plovdiv, Bulgaria. The material was collected in June 1977 and August 1978 from the following localities (Fig. 1): *Rana arvalis* – Dymaczewo (Poznańskie District); Gluche (Gdańskie District); Koscierzyna (Gdańskie District); Rudno (Gdańskie District); Lubin (Legnickie District); Tuchów (Tarnow District) and Zgorzelec (Jeleniogórskie District); *Rana temporaria* – Dobrzyca (Poznańskie District); Klodzko (Walbrzyskie District) and Tczew (Gdańskie District).

Fig. 1. *Localities of the collected material from Poland.*

The stomachs were dissected in petri dishes and the stomach contents were analyzed by means of binocular stereomicroscope. The prey taxa were determined to the lowest possible taxon, based on the degree of composition. The systematic of the identified invertebrate taxa follows FAUNA EUROPAEA (2007).

For each species are given the number of prey categories, the number of prey items and percentage proportion. Beside the amount of preys (numeric proportion), an important parameter for the study of the trophic spectrum is the frequency with which the preys are consumed. It is important for the determining of the value that a certain taxon prey has for the analyzed species, as a consequence to the fact that an individual frog can eat not just different prey taxa but also more individuals of a certain taxon prey. The frequency can be defined as the ratio between the number of stomachs that contain a certain taxon prey and the total of analyzed stomachs, the obtained value being expressed in percentages.

We classified each prey item as either terrestrial or aquatic on the basis of the habitats in which it typically occurs.

Sampling adequacy was determined using Lehner`s formula (LEHNER, 1996):

$$Q = 1 - \frac{N_1}{I},$$

rising from 0 to 1, where Q is sampling adequacy; N_1 is the number of the food components occurring only once, and I is the total number of the food components.

The diversity of the diet (niche breadth) was calculated for each species, using the reciprocal value of the Simpson’s diversity index (PIANKA, 1973; BEGON *et al.*, 1986):

$$S = \frac{1}{\sum p_i^2},$$

where: S – trophic niche breadth; p_i – proportion of food component i.

To determine the level of the food specialization of each species we used the index of dominance of Berger-Parker (d), calculated by the following formula (MAGURRAN, 1988):

$$d = \frac{n_i \max}{N},$$

where: N – the number of all recorded food components (taxa); n_i max – the number of the specimens form taxon i (the most numerous taxon in the diet). The Berger-Parker index (d) varies between 1/N and 1. A value closer to 1 means a higher specialization in the choice of food; a value closer to 1/N is typical for a species that is a general feeder (polyphagous).

The food niche overlap was calculated by Pianka`s adaptation of Mac Arthur and Levin's formula (PIANKA, 1973):

$$O_{j,k} = \frac{\sum P_{ij}.P_{ik}}{\sqrt{\sum P_{ij}^{2}.\sum P_{ik}^{2}}},$$

where: O – niche overlap, j and k refer to the two species under comparison, P_i – proportion of food component i.

The results were statistically processed using descriptive statistics and the Mann-Whitney U-test was used to compare the numeric proportion of all prey taxa between species in order to detect differences in the use of food resources, when the data were not normally distributed (FOWLER *et al.* 1998).

For the statistical processing of the data we used the software package "Statistica 7.0" (STATSOFT INC., 2004). For the calculations of Simpson's diversity index and the Berger-Parker index we used the computer software "Bio-DAP" (THOMAS & CLAY, 2000) and for the calculation of the niche overlap – the computer program "EcoSim 7.0" (GOTELLI & ENTSMINGER, 2001).

RESULTS

The analyzed stomach contents – a total 46 stomachs of *Rana arvalis* showed that 26 were empty and 5 contained only digested remains. A total of 15 stomachs contained 79 prey items (Fig. 2, Table 1). The average number of prey items per stomach is 5.27 (SD=4.54). The sampling adequacy is considered sufficient – 0.64.

From total of 54 stomachs of *Rana temporaria*, 18 were empty and 10 contained only digested remains. A total of 26 stomachs contained 100 prey items (Fig. 2, Table 1). The average number of prey items per stomach is 3.84 (SD=2.88). The sampling adequacy is considered sufficient – 0.72.

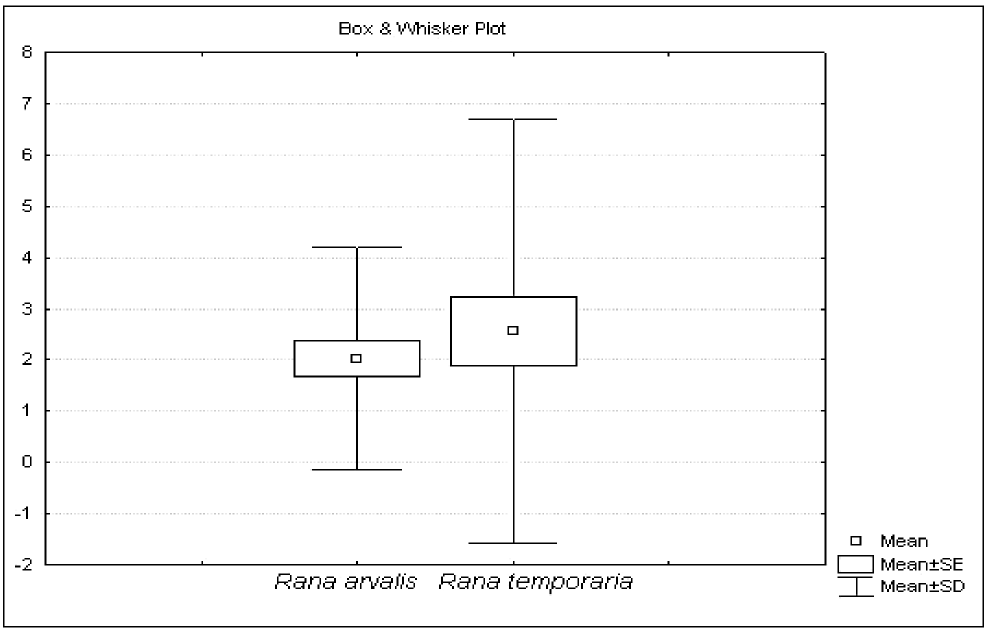

Fig. 2. *Box & Whisker Plot of the trophic spectrum of both species.*

Table 1. *Descriptive statistics of the studied diet of both species.*

Species	Number of prey categories	Number of prey items	Mean	Standard Deviation (SD)
Rana arvalis	39	79	2.03	2.17
Rana temporaria		100	2.56	4.14

Table 2 presents the qualitative and quantitive proportion and frequency of occurrence of the trophic spectrum of *Rana arvalis* and *Rana temporaria*. The numeric percentage of the main prey taxa is presented for both species in Fig. 3.

The predominated food type in the diet of the Moor frog is insects (77.22%). The most numerous prey taxon is the Coleoptera order (29.11%), followed by Hemiptera (20.25%) and Hymenoptera orders (11.39%). The Berger-Parker index showed considerably low value – 0.29 (Table 2). All of the recorded prey taxa are classified as terrestrial.

The predominated food type in the diet of the Common frog is also insects with much higher percentage proportion – 92.00%. The most numerous prey taxon is Coleoptera (51.00%), followed by Diptera (14.00%) and Hemiptera (9.00%). The Berger-Parker index showed a medium value of 0.51 (Table 2). The majority of the prey is classified as terrestrial and only 3.81 % of the prey is classified as aquatic.

The trophic niche breadth for *Rana arvalis* is quite high (23.70) compared to *Rana temporaria* (12.25). The estimated trophic niche overlap between the species is 63.5% (Table 2), but the numeric proportion of all prey taxa occurring in the stomachs did not differ significantly between the species (U-test, $U=46.0$, $P=0.14$, $P>0.05$).

Unidentified insects in this study usually consisted of a wings, legs, or body segments, which may indicate that either the frog was unable to capture the entire prey item or the remaining portion of the prey item was not detected because it had passed through the digestive system at a different rate.

Because of the fact that the material was collected only in one season it is impossible to analyze the seasonal variations of the trophic spectrum.

DISCUSSION

The stomach contents of the Moor frog (*Rana arvalis*) and the Common frog (*Rana temporaria*) underlines the fact that these species are a opportunistic predators, having a generalist feeding, generally using the *"sit and wait"* method (PERRY & PIANKA, 1997), consuming every animal that reaches their perimeter and has the right size to be captured (ZIMKA, 1966). Both frogs do not show a specialization in feeding, consuming both high and low energetic content preys.

The preys of animal nature are the most important category in the stomach contents, regarding the fact that the adult amphibians are predators (COGĂLNICEANU *et al.,* 2000). The insect larvae are given separately from the imagos considering that they are different prey categories as mobility and as the environment of their capture.

Table 2. *Results from the food niche study of the diet of Rana arvalis and Rana temporaria.* **Legend:** *n – number of prey items; n % –- numeric proportion (percentage proportion from the total number of prey items); f % – frequency of occurrence (percentage proportion of the frogs that consumed the prey taxon).*

Prey taxa	*Rana arvalis*			*Rana temporaria*		
	n	**n %**	**f %**	**n**	**n %**	**f %**
Gastropoda	7	8.86	13.33	1	1.0	3.85
Myriapoda						
Chilopoda	1	1.26	6.67	—	—	—
Diplopoda	—	—	—	3	3.0	7.69
Arachnida						
Aranei	5	6.33	26.67	3	3.0	11.54
Opiliones	2	2.54	13.33	—	—	—
Crustacea (Isopoda)	3	3.81	6.67	1	1.0	3.85
Insecta (undet.)	1	1.26	6.67	—	—	—
Hemiptera (undet.)	4	5.07	20.0	—	—	—
Auchenorrhyncha	1	1.26	6.67	9	9.0	19.23
Corixidae	3	3.81	13.33	—	—	—
Cicadinea	8	10.13	13.33	—	—	—
Heteroptera	1	1.26	6.67	—	—	—
Hymenoptera (undet.)	1	1.26	6.67	1	1.0	3.85
Apidae	1	1.26	6.67	—	—	—
Braconidae	1	1.26	6.67	1	1.0	3.85
Diapriidae	—	—	—	1	1.0	3.85
Formicidae	5	6.33	26.67	—	—	—
Proctotrupidae	—	—	—	1	1.0	3.85
Sphecidae	1	1.26	6.67	—	—	—
Diptera (undet.)	1	1.26	6.67	—	—	—
Brachycera	—	—	—	4	4.0	7.69
Nematocera	4	5.07	20.0	6	6.0	19.23
Diptera (larvae)	—	—	—	4	4.0	7.69
Coleoptera (undet.)	5	6.33	26.67	13	13.0	30.77
Bupresidae	1	1.26	6.67	—	—	—
Carabidae	5	6.33	20.0	20	20.0	30.77
Chrysomelidae	3	3.81	20.0	2	2.0	7.69
Coccinelidae	1	1.26	6.67	1	1.0	3.85
Curculionidae	6	7.59	26.67	2	2.0	7.69
Elateridae	—	—	—	10	10.0	26.93
Silphidae	—	—	—	1	1.0	3.85
Staphylinidae	2	2.54	13.33	1	1.0	3.85
Coleoptera (larvae)	1	1.26	6.67	1	1.0	3.85
Dermatoptera (*Forficula auricularia*)	1	1.26	6.67	2	2.0	3.85
Orthoptera	1	1.26	6.67	—	—	—
Plecoptera (Panorpidae)	—	—	—	1	1.0	3.85
Lepidoptera (larvae)	3	3.81	13.33	3	3.0	11.54
plant remains	—	—	—	2	2.0	3.85
pebbles	—	—	—	6	6.0	7.69
Sampling adequacy		**0.64**			**0.72**	
Berger-Parker index		**0.29**			**0.51**	
1/Simpson		**23.70**			**12.25**	
Niche overlap			**63.5 %**			

REDFORD & DOREA (1984) claimed that adult insects do not vary much as nutrition content but still it is considered that the larvae and pupae of holo–metabolic insects are rich in lipids and thus, more nutritive (BROOKS *et al.,* 1996).

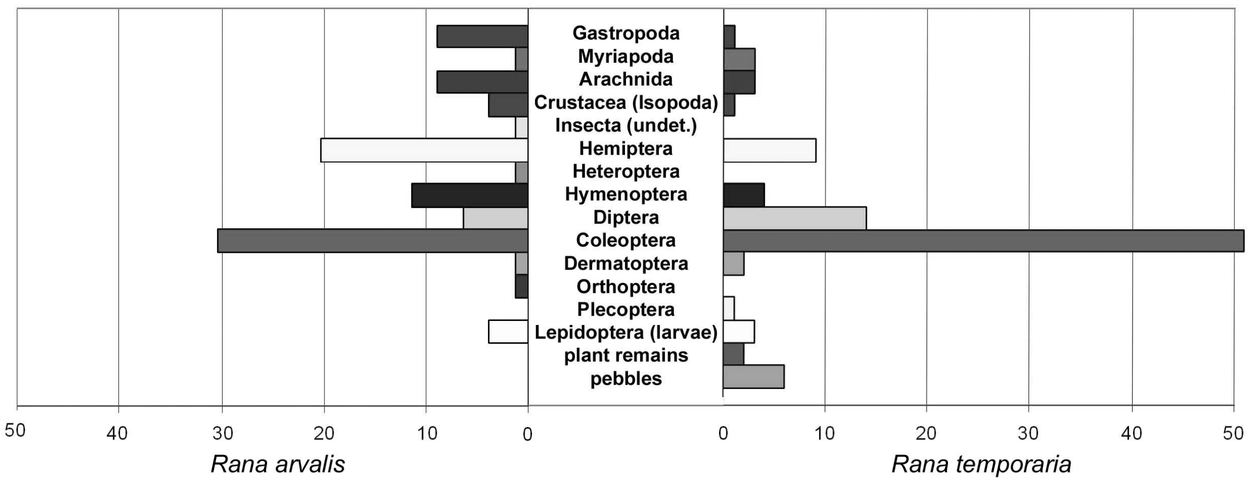

Fig. 3. *Percentage proportion of the main prey taxa for both species.*

The most important prey category is Coleopterans (Fig. 3), being consumed frequently by both analyzed species. The beetles are basic food most probably due to the abundance of this food and the wide range of habitats where it could be found. Other important prey animals are Hemiptera, Hymenoptera and Diptera as well as non-insect invertebrates (Gastropoda, Arachnida, Myriapoda), which also play significant role.

In the stomach contents of the Common frog we obtained plant remains and little pebbles. Their presence in the trophic spectrum should be considered as accidental.

The diet of both studied species is consisted with almost only terrestrial prey. These are frogs that outside the breeding season can drift away from their aquatic habitat (MAZUR, 1966; ZIMKA, 1974). The adult Moor and Common frogs are adapted to hunt in terrestrial biotopes and aquatic preys becoming accessible when the puddles dry out or in puddles with an extremely low water level.

Despite the large variety in the diet composition, differences in the numeric proportion of the prey and the trophic niche breadths, there were no statistically significant differences in the diet between the two species. However the niche overlap was moderate, this parameter should be accepted with caution because it could be affected by sample size (RICKLEFS & LAU, 1980) and the number of resource categories (SMITH & ZARET, 1982).

In conclusion we could say that the two species of brown frogs have very common feeding behaviour, but there are certain differences in their trophic niche. The niche overlap between *Rana arvalis* and *Rana temporaria* is moderate and probably there is no or insignificant competition for food resources between these two species in the places with sympatric distribution.

CONCLUSIONS

1. During our study we identified 79 prey items in the trophic spectrum of *Rana arvalis* with average number of prey items per stomach – 5.27 and 100 prey items in the trophic spectrum of *Rana temporaria* with average number of prey items per stomach – 3.84.

2. In both species the most important prey category is Coleoptera. Other important prey animals are Hemiptera, Hymenoptera and Diptera as well as non-insect invertebrates (Gastropoda, Arachnida, Myriapoda) which also play significant role.

3. Both frogs consume almost only terrestrial prey, an accountable fact for terrestrial species.

4. The trophic niche breadths for both species are quite high (*Rana arvalis* – 23.70; *Rana temporaria* – 12.25). The estimated trophic niche overlap between the species is moderate (63.5%), but the numeric proportion of all prey taxa occurring in the stomachs did not differ significantly between the species (U-test, U=46.0, P=0.14, P>0.05).

5. *Rana arvalis* and *Rana temporaria* are polyphagous zoophages, like other amphibian species and they are probably consuming all mobile objects which they come in contact with and can swallow.

ACKNOWLEDGEMENTS

The authors would like to express their sincerest gratitude to Prof. GEORGI BATCHVAROV for the given collection of stomachs used in the current study, to Prof. VLADIMIR VERSHININ (Institute of Plant and Animal ecology, Yekaterinburg, Russia) and Dr. RUSLAN NOVITSKY (Institute of Zoology – NAS, Belarus) for the given literature.

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ХРАНИТЕЛЕН СПЕКТЪР И ХРАНИТЕЛНА НИША НА *Rana arvalis* Nilsson, 1842 И *Rana temporaria* L., 1758 ОТ ПОЛША

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(Резюме)

В настоящото проучване бяха установени 79 хранителни обекта в хранителния спектър на *Rana arvalis* със среден брой хранителни частици на стомах – 5.27 и 100 хранителни компонента в хранителния спектър на *Rana temporaria*) със среден брой хранителни частици на стомах – 3.84. И при двата вида най-многобройния таксон в хранителния рацион са насекомите от разред Coleoptera. Други важни хранителни компоненти са от разредите Hemiptera, Hymenoptera и Diptera (Insecta), както и ненасекомните безгръбначни (Gastropoda, Arachnida, Myriapoda), които също играят съществена роля. И двата вида жаби консумират почти изцяло сухоземна плячка. Ширината на трофичните ниши и за двата вида е доста висока (*Rana arvalis* – 23.70; *Rana temporaria* – 12.25). Изчисленото препокриване на хранителните ниши между двата вида е средно (63.5%), но разликите между всички хранителни компоненти не са статистически достоверни. *Rana arvalis* и *Rana temporaria* са полифагни зоофаги, като повечето земноводни и вероятно консумират всички движещи се обекти, които могат да погълнат, попаднали в техния обсег.