

A SYNOPSIS OF THE STUDIES ON THE TROPHIC SPECTRUM OF THE AMPHIBIANS IN BULGARIA

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Abstract: Is made. A synopsis of the studies on the trophic spectrum of the Bulgarian batrachofauna. The analysis of the Bulgarian herpetological literature showed that so far 16 specialized studies on the diet of the Bulgarian species of amphibians have been conducted. From all 18 amphibian species that occur in Bulgaria, 11 (61.11 %) were studied concerning their trophic spectrum, and for 7 (38.89%) there is only partial data. All Bulgarian species of amphibians are zoophagous, mainly insectivorous. All studied species are general feeders (polyphages), except *Salamandra salamandra*, which prefers slugs and terrestrial worms; *Bombina variegata*, which shows slight preference to Coleoptera and *Pseudepidalea viridis* which show slight preference to Formicidae and Coleoptera. Cannibalism was recorded only in *Pelophylax ridibundus*. New data about the trophic spectrum of four species (*Pelophylax ridibundus*, *Bombina bombina*, *Bombina variegata* and *Pseudepidalea viridis*) are given.

Key words: diet, trophic spectrum, synopsis, amphibians, Amphibia, Bulgaria

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 aim of the current publication is to make a synopsis of the studies on the trophic spectrum of the amphibians, conducted in Bulgaria; to supplement, compare

and analyze the data concerning the qualitative and quantitative composition of the diet, the food specialization between the amphibians.

MATERIAL AND METHODS

For the purposes of the current synopsis all available literary data on the feeding and the trophic spectrum of the Bulgarian batrachofauna were used.

Currently there are 16 specialized studies conducted on the trophic spectrum of the amphibians in Bulgaria (АНГЕЛОВ, 1960; БЕШКОВ, 1961a, 1961b; ХРИСТОВА, 1962; БЕШКОВ & ЦОНЧЕВ, 1963; БЪЧВАРОВ, 1965b, 1967; БЕШКОВ, 1970; ANGELOV & BATSCHWAROV, 1972; АНГЕЛОВ & БЪЧВАРОВ, 1972; ДОНЕВ, 1984a, 1984b, 1986; ТОМОВ, 1989, 1990, 1991). Except these publications there are partial data on the diet of the Bulgarian amphibian species, but they are not based on specialized studies (БУРЕШ & ЦОНКОВ, 1942; БЕШКОВ, 1961a; БЪЧВАРОВ, 1965a, 1968; КОВАЧЕВ, 1979; БЕШКОВ & НАНЕВ, 2002) and others.

From the available data we have summarized the data about the extend of studies on the trophic spectrum of all amphibian species that occur in Bulgaria; the number of the studied specimens in each study, date and region of study, as well as the percentage of the three predominant taxa from the trophic spectrum of each species.

Based on the available data the breadth of the trophic niche (B) is calculated for each species, using the reciprocal value of the Simpson's diversity index (PIANKA, 1973; BEGON *et al.*, 1986):

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

where:

- B – 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 (COGĂLNICEANU *et al.*, 1998):

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

where:

- N – the number of all recorded food components (taxa);
- n_imax – the number of the specimens from 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 (polyphage).

For the calculations of both indexes we used a computer software – Bio-DAP (THOMAS & CLAY, 2000).

In the current publication are included unpublished data about the trophic spectrum of four species of amphibians (*Pelophylax ridibundus*, *Bombina bombina*, *Bombina variegata* and *Pseudepidalea viridis*), which are published here for the first time (Table 4-7). The material was collected in the period April-August 1974 from the surroundings of: Hrabrino Village, Parvenets Village, Plovdiv (Komatevo and Proslav residential districts and “Ostrova” area), Tsalapitsa Village, Karlovo, Tsarimir Village, Tseretelevo Village, Manole Village, Asenovgrad and Krumovo Village (Plovdiv district, South Bulgaria) and it was kept in the herpetological collection of Department of Zoology (University of Plovdiv, Faculty of Biology). The number of the studied specimens is as follows: *Pelophylax ridibundus* – 100, *Bombina bombina* – 46, *Bombina variegata* – 100 and *Pseudepidalea viridis* – 55.

The common and Latin names of the amphibian species is after БИСЕРКОВ И ДР. (2007), the systematic of the invertebrates follows Fauna Europaea (2008).

RESULTS AND DISCUSSION

Summarized data about the conducted studies, specified by species, is presented in Table 1. With „+“ are marked the species for which there are conducted specialized scientific studies from the corresponding authors; with „?“ are marked the species for which there is only partial data and with „-“ – all the rest.

From the Table 1 it is visible that from all species from the Bulgarian batrachofauna specialized studies on the trophic were are conducted on 11 species (61,11%) and by number of studies they are: *Pelophylax ridibundus* – 8; *Pseudepidalea viridis* – 6; *Bombina variegata* – 5; *Salamandra salamandra* and *Hyla arborea* – by 3; *Bombina bombina* – 2, *Triturus karelinii*, *Bufo bufo*, *Rana temporaria*, *Rana graeca* and *Rana dalmatina* – by 1. For the other 7 species (38,89 %), that occur in Bulgaria, there is only partial or no data, concerning their feeding ecology and trophic spectrum.

In Table 2 are presented the number of the studied specimens, the date and the region of each study from the corresponding authors by species.

All studies were conducted in the period 1954-1985 and most of them took place in South Bulgaria (Plovdiv, Pazardzhik, Burgas, Sofia and Kardzhali Districts, the valley of Tundzha River and various sites in Southwestern Bulgaria) and in the area of Lom in North Bulgaria (Table. 2).

On Table 3 are presented summarized data about the percentage proportion of the three predominated taxa in the diet by species from the corresponding authors. Based on the available data we calculated the breadth of the trophic niche (B) and the level of food specialization using the dominance index of Berger-Parker (d).

Table 1. Summary of the conducted studies on the trophic spectrum on the amphibians in Bulgaria by species

Species	Author(s)	AHTEJIOB (1960)	BEIHKOB (1961a)	BEIHKOB (1961b)	XPICTOBA (1962)	BEIHKOB & IOHHEB (1963)	БЪРБАPOB (1965b)	БЪРБАPOB (1967)	BEIHKOB (1970)	AHTEJIOB & БЪРБАPOB (1972)	ANGELLOV & BATSCHWAROV (1972)	ИOHEB (1984a)	ИOHEB (1984b)	ИOHEB (1986)	TOMOB (1989)	TOMOB (1990)	TOMOB (1991)
Fire salamander (<i>Salamandra salamandra</i>)		-				+	-	-	-	-	-	-	-	-	-	-	-
Alpine newt (<i>Mesotriton alpestris</i>)		-				-	-	-	-	-	-	-	-	-	-	-	-
Smooth newt (<i>Lissotriton vulgaris</i>)		-	?			-	-	-	-	-	-	-	-	-	-	-	-
Northern Crested newt (<i>Triturus cristatus</i>)		-				-	-	+	-	-	-	-	-	-	-	-	-
Sothern Crested newt (<i>Triturus karelinii</i>)		-				-	-	-	-	-	-	-	-	-	-	-	-
Danube Crested newt (<i>Truturus dobrogicus</i>)		-				-	-	-	-	-	-	-	-	-	-	-	-
Fire-bellied toad (<i>Bombina bombina</i>)		-	?			-	-	-	-	-	+	-	-	-	-	-	+
Yellow-bellied toad (<i>Bombina variegata</i>)		+				-	+	+	-	-	+	+	+	-	-	-	-
Common Spadefoot toad (<i>Pelobates fuscus</i>)		-				-	-	-	-	-	-	-	-	-	-	-	-
Eastern Spadefoot toad (<i>Pelobates syriacus</i>)		-				-	-	-	-	-	-	-	-	-	-	-	-
Common toad (<i>Bufo bufo</i>)		-				-	-	-	-	-	+	-	-	-	-	-	-
Green toad (<i>Pseudepidalea viridis</i>)		+	+			-	+	+	-	-	+	-	-	-	-	+	-
Marsh frog (<i>Pelophylax ridibundus</i>)		+	?		+	-	+	+	-	+	-	+	-	+	-	-	-
Green frog (<i>Pelophylax kl. esculentus</i>)		-				-	-	-	-	-	-	-	-	-	-	-	-
Stream frog (<i>Rana graeca</i>)		-				-	-	-	+	-	-	-	-	-	-	-	-
Common frog (<i>Rana temporaria</i>)		-				-	-	-	-	-	+	-	-	-	-	-	-
Spring frog (<i>Rana dalmatina</i>)		-				-	-	-	-	-	+	-	-	-	-	-	-
Common Tree frog (<i>Hyla arborea</i>)		+				-	-	+	-	-	+	-	-	-	-	-	-

Table 2. Summary of the number of studied specimens, the date and the region of study from the authors in hand by species

Species	Number of studied specimens	Date	Region of study	Author(s)
<i>Salamandra salamandra</i>	10	IV	Vitosha, Boyanska reka River	БЕШКОВ (1961a)
	70	N/A	Vitosha, Boyanska reka River	БЕШКОВ (1961b)
	118	IV,X-XI 1956-1961	Vitosha, Boyanska reka River	БЕШКОВ & ЦОНЧЕВ (1963)
<i>Triturus karelinii</i>	66	V.1965	Tundzha River Valley	БЪЧВАРОВ (1967)
<i>Bombina bombina</i>	7	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)
	248	1980-1981	the surroundings of Lom	ТОМОВ (1991)
<i>Bombina variegata</i>	35	IV-IX. 1954-1955	Sofia District	АНГЕЛОВ (1960)
	27	1962-1964	Kardzhali District	БЪЧВАРОВ (1965b)
	6	V.1965	Tundzha River Valley	БЪЧВАРОВ (1967)
	38	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)
	197	IV-IX.	Plovdiv District	ДОНЕВ (1984b)
<i>Bufo bufo</i>	6	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)
<i>Pseudepidalea viridis</i>	20	IV-IX. 1954-1955	Plovdiv District	АНГЕЛОВ (1960)
	180	N/A	Sofia District	БЕШКОВ (1961a)
	11	1962-1964	Kardzhali District	БЪЧВАРОВ (1965b)
	27	V.1965	Tundzha River Valley	БЪЧВАРОВ (1967)
	23	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)
	394	III-X. 1980-1982	the surroundings of Lom	ТОМОВ (1990)
<i>Pelophylax ridibundus</i>		IV-IX. 1954-1955	Plovdiv District	АНГЕЛОВ (1960)
	893	1954-1955	Chelopechene, Sofia	ХРИСТОВА (1962)
	248	1962-1964	Kardzhali District	БЪЧВАРОВ (1965b)
	97	V.1965	Tundzha River Valley	БЪЧВАРОВ (1967)
	160	1962-1965	Plovdiv and Burgas District	АНГЕЛОВ & БЪЧВАРОВ (1972)
	500	N/A	Plovdiv	ДОНЕВ (1984a)
	1089	III-XI.1985	Plovdiv	ДОНЕВ (1986)
	388	III-X. 1981-1983	the surroundings of Lom	ТОМОВ (1989)
<i>Rana graeca</i>	155	III-XI. 1966-1967	Southwestern Bulgaria	БЕШКОВ (1970)
<i>Rana temporaria</i>	25	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)
<i>Rana dalmatina</i>	12	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)
<i>Hyla arborea</i>	35	IV-IX. 1954-1955	Plovdiv District	АНГЕЛОВ (1960)
	1	V.1965	Tundzha River Valley	БЪЧВАРОВ (1967)
	28	1962-1965	the surroundings of Plovdiv, Pazardzhik and Burgas	ANGELOV & BATSCHWAROV (1972)

Table 3. Summary of the percentage proportion of the predominated prey taxa, the trophical niche breadth (B) and the degree of trophic specialization (d) by species

Species	Predominated prey taxa	1/Simpson (B)	Berger-Parker (d)	Author(s)
<i>Salamandra salamandra</i>	Gastropoda – 31,15 % Arachnida – 19,67 % Myriapoda – 14,75 %	5,86	0,31	БЕШКОВ (1961a)
	Gastropoda – 44,5 % Coleoptera – 7,2 % Lepidoptera – 5,7 %	N/A	0,45	БЕШКОВ (1961b) ¹
	Gastropoda – 58,35 % Lumbriculidae – 8,25 % Arachnida – 4,84%	3,14	0,58	БЕШКОВ & ЦОНЧЕВ (1963)
<i>Triturus karelinii</i>	Insecta – larvae Lumbriculidae	N/A	N/A	БЪЧВАРОВ (1967) ²
<i>Bombina bombina</i>	Formicidae – 84,85 % Coleoptera – 9,09 % Gastropoda – 0,30 % Isopoda – 0,30 %	1,37	0,85	ANGELOV & BATSCHWAROV (1972)
	Coleoptera – 26,95 % Formicidae – 19,43 % Myriapoda – 9,14 %	7,54	0,27	ТОМОВ (1991)
<i>Bombina variegata</i>	Coleoptera – 49,4 % Diptera – 24,0 % Hymenoptera – 16,9 %	3,08	0,49	АНГЕЛОВ (1960)
	Coleoptera (Carabidae) Diptera Isopoda Arachnida	N/A	N/A	БЪЧВАРОВ (1965b) ³
	Coleoptera – larvae	N/A	N/A	БЪЧВАРОВ (1967) ²
	Coleoptera – 61,74 % Arachnida – 26,47 % Myriapoda – 19,12 %	5,87	0,62	ANGELOV & BATSCHWAROV (1972)
	Diptera – 53,76 % Coleoptera – 19,34 % Hymenoptera – 9,79 %	2,95	0,54	ДОНЕВ (1984b)
	Coleoptera – 36,36 % Hymenoptera – 27,27 % Arachnida – 10,60 %	9,13	0,36	ANGELOV & BATSCHWAROV (1972)
<i>Pseudepidalea viridis</i>	Hymenoptera – 64,6 % Coleoptera – 17,8 % Hemiptera – 14,4 %	2,13	0,65	АНГЕЛОВ (1960)

¹ In the publication by БЕШКОВ (1961b) are given only the percentage proportion of the food components without their quantities, which makes it impossible to calculate the niche breadth from the available data.

² In the publication by БЪЧВАРОВ (1967) is not given the quantitative characteristics of the food components, but only their composition. Due to this reason it is impossible to calculate neither the niche breadth nor the Berger-Parker index.

³ In the publication by БЪЧВАРОВ (1965b) is not given the quantitative characteristics of the food components, but only their composition. Due to this reason it is impossible to calculate neither the niche breadth nor the Berger-Parker index.

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Species	Predominated prey taxa	1/Simpson (B)	Berger-Parker (d)	Author(s)
	Formicidae – 46,89 % Aphidoidea – 18,97 % Diptera – 11,90 %	N/A	0,47	БЕШКОВ (1961a) ⁴
	Coleoptera Gastropoda (Clausiliidae) Diptera	N/A	N/A	БЪЧВАРОВ (1965b) ³
	Coleoptera Diptera Hymenoptera	N/A	N/A	БЪЧВАРОВ (1967) ²
	Coleoptera – 46,38 % Formicidae – 18,52 % Hemiptera – 16,91 %	8,38	0,46	АНГЕЛОВ & БАТШВАРОВ (1972)
	Formicidae – 75,88 % Coleoptera – 12,42 % Hemiptera (Heteroptera) – 0,22 %	1,72	0,76	ТОМОВ (1990)
	<i>Pelophylax ridibundus</i>	Coleoptera – 47,2 % Hymenoptera – 16,8 % Diptera – 13,6 %	3,65	0,47
Coleoptera – 57,83% Diptera – 20,63 % Crustacea – 19,42%		N/A	0,58	ХРИСТОВА (1962) ⁵
Coleoptera Hymenoptera Diptera		N/A	N/A	БЪЧВАРОВ (1965b) ³
Coleoptera Hymenoptera Diptera		N/A	N/A	БЪЧВАРОВ (1967) ²
Coleoptera – 34,20 % Hymenoptera – 17,01 % Diptera – 11,45 %		5,94	0,34	АНГЕЛОВ & БЪЧВАРОВ (1972)
Coleoptera – 27,42 % Hymenoptera – 17,43 % Arachnida – 7,85 %		19,21	0,27	ДОНЕВ (1984a)
Collembola – 16,97 % Hymenoptera – 11,51 % Pisces – 10,78 %		13,76	0,17	ДОНЕВ (1986)
Hymenoptera – 35,56 % Diptera – 30,57 % Coleoptera – 5,70 %		4,48	0,35	ТОМОВ (1989)
<i>Rana graeca</i>	Coleoptera – 15,73 % Diptera – 13,48 % Arachnida – 9,81 %	12,85	0,16	БЕШКОВ (1970)

⁴ In the publication by БЕШКОВ (1961a) are given only the percentage proportion of the food components without their quantities, which makes it impossible to calculate the niche breadth from the available data.

⁵ In the publication by ХРИСТОВА (1962) are given only the percentage proportion of the food components without their quantities, which makes it impossible to calculate the niche breadth from the available data.

Species	Predominated prey taxa	1/Simpson (B)	Berger-Parker (d)	Author(s)
<i>Rana temporaria</i>	Arachnida – 14,23 % Formicidae – 9,61 % Diptera – 8,18 %	16,01	0,14	ANGELOV & BATSCHWAROV (1972)
<i>Rana dalmatina</i>	Coleoptera – 56 % Gastropoda – 16 % Myriapoda – 8 %	8,11	0,56	ANGELOV & BATSCHWAROV (1972)
<i>Hyla arborea</i>	Coleoptera – 67,1 % Hymenoptera – 14,6 % Diptera – 7,3 %	2,11	0,67	АНГЕЛОВ (1960)
	Coleoptera	N/A	N/A	БЪЧВАРОВ (1967) ²
	Lepidoptera (larvae) – 30,59 % Arachnida – 23,53 % Diptera (larvae) – 16,47 %	5,68	0,31	ANGELOV & BATSCHWAROV (1972)

The synopsis on the studies on the trophic spectrum by species is as follows:

Fire Salamander (*Salamandra salamandra*). Data on the trophic spectrum of this species in Bulgaria until now are presented in the works of БЕШКОВ (1961a,b), БЕШКОВ & ЦОНЧЕВ (1963). All three studies are conducted in the valley of Boyanska Reka River (Vitosha Mt.) on total of 198 specimens. From these publications it is visible the clearly distinguished preference of the fire salamander to Gastropoda, especially to slugs, which are the most numerous in its trophic spectrum (Table 3). The Berger-Parker index in some measure confirms this tendency ($d=0,31-0,58$). The trophic niche breadth of this species, the calculation is based on these three studies, varies between 3,14 and 5,86.

Southern Crested Newt (*Triturus karelinii*). Data on the trophic spectrum of the southern crested newt are given by БЪЧВАРОВ (1967). The author studies the ways of infection of few amphibian species in the valley of Tundzha River with helminths and simultaneously he gives data concerning the trophic spectrum of this species. In this paper the author gives only the food composition without its quantities (Table 3), so based only on that data it is not possible to draw any conclusions about this species in Bulgaria. Studies on the feeding ecology of the other newt species have not been conducted so far.

Fire-bellied Toad (*Bombina bombina*). Data on the diet of this species in Bulgaria is presented in the works ANGELOV & BATSCHWAROV (1972) and ТОМОБ (1991). The first study is based on the stomach contents of 7 specimens from South Bulgaria. ТОМОБ (1991) analyzed the trophic spectrum of 248 specimens from the region of the town of Lom (North Bulgaria) – Table 2. From the publication by ANGELOV & BATSCHWAROV (1972) it is visible that the fire-bellied toad has distinguished preferences to ants (Formicidae) – $d=0,85$ (Table 3). Since their study is based on little number of specimens it is not correct to consider ants as the main food of this species. ТОМОБ (1991) gives more specific data on the diet of *Bombina bombina*. The most numerous are Coleoptera, without showing any particular preference to them ($d=0,27$), and ants (Formicidae) are on the second place.

The unpublished data from our study showed that the most numerous taxa in the diet of the fire-bellied toad is Coleoptera (31,0%) and Diptera (31,0%) – $d=0,31$, and Formicidae are on the third place with 8,3 % (Table 6).

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Table 4. *New data on the trophic spectrum of Pelophylax ridibundus from Plovdiv District*

Prey taxa	Number of stomachs	Number of prey	Percentage
Gastropoda	7	8	1,6
Oniscidae	4	4	0,8
Gammarus	1	1	0,2
Arachnida	15	20	4,1
Acari	1	3	0,6
Diplopoda	1	2	0,4
Chilopoda	1	1	0,2
Collembola	3	13	2,7
Ephemeroptera	1	1	0,2
Orthoptera	3	3	0,6
Hemiptera	24	78	17,1
Aphidida	1	10	2,0
Coleoptera	29	46	10,3
Coleoptera – larvae	7	12	2,4
Carabidae	23	39	8,0
Dytiscidae	5	6	1,2
Hydrophilidae	7	7	1,4
Staphylinidae	15	24	4,9
Histeridae	2	6	1,2
Ptinidae (Anobiidae)	2	2	0,4
Elateridae	5	6	1,2
Malachiidae	1	1	0,2
Coccinellidae	1	1	0,2
Chrysomelidae	9	9	1,9
Curculionidae	16	22	4,5
Lepidoptera	1	2	0,4
Lepidoptera – larvae	2	2	0,4
Hymenoptera	9	17	3,5
Formicidae	26	55	11,4
Vespidae	1	1	0,2
Apidae	1	3	0,6
Diptera	36	57	12,8
Diptera – larvae	1	1	0,2
Nematocera	2	2	0,4
Tipulidae	1	2	0,4
Amphibia	3	3	0,6
Plant remains	1	1	0,2
Pebbles	2	3	0,6
Empty	11	-	-
Total	281	474	100 %
Berger-Parker (d)		0,37	
Niche Breadth (B)		14,31	

Table 5. *New data on the trophic spectrum of Bombina variegata from Plovdiv District*

Prey taxa	Number of stomachs	Number of prey	Percentage
Lumbricidae	1	1	0,25
Gastropoda	6	9	2,25
Amphipoda	3	10	2,50
Arachnida	10	11	2,75
Pseudoscorpiones	1	1	0,25
Diplopoda	1	1	0,25
Chilopoda	1	1	0,25
Ephemeroptera – larvae	12	45	11,25
Odonata – larvae	1	1	0,25
Orthoptera	1	1	0,25
Orthoptera – larvae	1	1	0,25
Fulgoromorpha	3	3	0,75
Aphididae	1	1	0,25
Hemiptera	6	6	1,50
Coleoptera	5	9	2,25
Carabidae	4	4	1,00
Staphylinidae	6	6	1,50
Dytiscidae	2	2	0,50
Hydrophilidae	21	111	28,25
Halipidae	1	8	2,00
Scarabaeidae	2	2	0,50
Malachiidae	1	1	0,25
Melyridae	2	2	0,75
Coccinellidae	1	2	0,50
Elateridae	2	2	0,50
Chrysomelidae	8	9	2,25
Curculionidae	11	13	3,25
Lepidoptera – larvae	3	4	1,00
Trichoptera – larvae	4	6	1,50
Hymenoptera	4	4	1,00
Formicidae	27	74	18,5
Diptera	9	39	9,75
Diptera – larvae	4	7	1,75
Empty	26	-	-
Total	191	397	100 %
Berger-Parker (d)		0,44	
Niche Breadth (B)		7,22	

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Table 6. *New data on the trophic spectrum of Bombina bombina from Plovdiv District*

Prey taxa	Number of stomachs	Number of prey	Percentage
Gastropoda	5	6	10,0
Arachnida	2	2	3,3
Orthoptera	1	1	1,7
Hemiptera	3	3	8,3
Carabidae	1	1	1,7
Dytiscidae	4	4	6,7
Hydrophilidae	7	10	16,7
Scarabaeidae	2	2	3,3
Elateridae	1	1	1,7
Chrysomelidae	1	1	1,7
Hymenoptera – larvae	1	1	1,7
Formicidae	4	5	8,3
Trichoptera – larvae	2	2	3,3
Diptera	4	6	10,0
Diptera – larvae	4	13	21,6
Empty	6	-	-
Total	48	58	100 %
Berger-Parker (d)		0,31	
Niche Breadth (B)		10,23	

Table 7. *New data on the trophic spectrum of Pseudepidalea viridis from Plovdiv District*

Prey taxa	Number of stomachs	Number of prey	Percentage
Gastropoda	2	2	1,0
Crustacea	8	23	11,0
Arachnida	3	3	1,4
Diplopoda	6	12	5,7
Dermaptera	1	4	1,9
Coleoptera	2	2	1,0
Coleoptera – larvae	2	2	1,0
Carabidae	32	77	36,9
Staphylinidae	3	3	1,4
Hydrophilidae	1	1	0,5
Scarabaeidae	3	3	1,4
Elateridae	7	8	3,8
Tenebrionidae	1	1	0,5
Chrysomelidae	5	5	2,4
Curculionidae	5	7	3,3
Lepidoptera – larvae	1	1	0,5
Formicidae	10	50	23,9
Diptera	1	1	0,5
Plant remains	2	3	1,4
Pebbles	1	1	0,5
Empty	9	-	-
Total	105	209	100%
Berger-Parker (d)		0,52	
Niche Breadth (B)		4,98	

The trophic niche breadth shows great variety due to the great difference in the number of the studied specimens in the two studies – from 1,37 (ANGELOV & BATSCHWAROV, 1972) to 7,54 (ТОМОВ, 1991). Calculated based on our data the niche breadth is 10,23.

Yellow-bellied Toad (*Bombina variegata*). This is a quite well studied species concerning its trophic spectrum (АНГЕЛОВ, 1960; БЪЧВАРОВ, 1965b, 1967; ANGELOV & BATSCHWAROV, 1972; ДОНЕВ, 1984b). The available up to this moment data shows that the yellow-bellied toad shows certain preference to Coleoptera ($d=0,49-0,63$). The only exception is the study done by ДОНЕВ (1984b), which shows that the most preferred prey is Diptera – $d=0,54$ (Table 3). According to the data given by these authors the trophic niche breadth of the yellow-bellied toad varies from 2,95 to 5,87. Except for the above mentioned studies, data on the diet of this species is given from the analyzed by us material (Table 5). The data shows the following predominating prey taxa: Coleoptera – 43,5%, Formicidae – 18,5%, Diptera – 11,5% ($d=0,44$), which confirms the acquired results by above mentioned authors. The niche breadth calculated from our data is 7,22.

Common Toad (*Bufo bufo*). The available data on the diet of this species are extremely scarce. ANGELOV & BATSCHWAROV (1972) studied the stomach contents of 6 specimens from this species. The data about its food preferences are presented in Table 3. The low food specialization of the species ($d=0,36$) is noteworthy, which may be due to the little number of studied specimens, but having in mind the high value of the niche breadth (9,13) it is possible that this species is polyphage.

Green Toad (*Pseudepidalea viridis*). The diet of the green toad is quite well studied in Bulgaria (АНГЕЛОВ, 1960; БЕШКОВ, 1961a; БЪЧВАРОВ, 1965b, 1967; ANGELOV & BATSCHWAROV, 1972; ТОМОВ, 1990). The majority of the conducted studies show that this species has distinct preference to Formicidae, which has highest value in the data given by ТОМОВ (1990) – $d=76$ (Table 3). The second preferred taxon, which is presented as first in some studies (БЪЧВАРОВ, 1965b, 1967; ANGELOV & BATSCHWAROV, 1972) is Coleoptera. According to our data Coleoptera is the most numerous prey item in the food spectrum of the green toad (Coleoptera – 52,2% – $d=0,52$; Formicidae – 23,9%; Crustacea – 11,0%) – Table 7. The trophic niche breadth of the green toad varies from 1,72 to 8,38 and according to our study it is 4,98.

Marsh Frog (*Pelophylax ridibundus*). This is the most well studied species concerning its trophic spectrum in Bulgaria (АНГЕЛОВ, 1960; ХРИСТОВА, 1962; БЪЧВАРОВ, 1965b, 1967; АНГЕЛОВ & БЪЧВАРОВ, 1972; ДОНЕВ, 1984a, 1986; ТОМОВ, 1989). From these publications Coleoptera are pointed out as the most numerous prey taxa of the marsh frog and it has its highest value in the study by ХРИСТОВА (1962) – $d=0,58$ (Table 3). In the publication by ДОНЕВ (1986) as the most preferred taxon is pointed out Collembola ($d=0,17$). ТОМОВ (1989) points Hymenoptera as the most numerous prey taxon ($d=0,35$). The results from our study (Table 4) showed that Coleoptera is the most numerous food component used by *Pelophylax ridibundus* (Coleoptera – 36,8%, Diptera – 13,0%, Hymenoptera – 12,2%; $d=0,37$). From the men-

tioned above we can conclude that the marsh frog does not have any particular preferences to its food and it could be classified as polyphage. This is confirmed by the high values of the trophic niche. Based on the data from the above mentioned authors, it varies from 3,65 to 19,21. According to our data its value is 14,31. This is the only amphibian, that occurs in our country in which cannibalism is recorded, which except for the above mentioned authors is studied in detail by BOŽKOV (1968); БОЖКОВ (1969); КОВАЧЕВ (1979) and others.

Stream Frog (*Rana graeca*). On the diet of this species in Bulgaria there was conducted only one study by БЕШКОВ (1970). Despite this fact, since the study is based on considerable number of specimens (155) and it was conducted in a quite large area (Table 2) we can make some conclusions about the feeding ecology of this species. From the data presented in Table 3 it is visible that the stream frog does not show any preferences to a particular taxon ($d=0,16$) and could be classified as polyphage. The trophic niche breadth has quite high values – 12,85, which confirms this statement.

Common Frog (*Rana temporaria*). The trophic spectrum of this species is studied only by ANGELOV & BATSCHWAROV (1972). The data given by the two authors is similar to the one about the spring frog, which can be explained by the fact that they inhabit very similar habitats – mountain springs, brooks and rivers. The common frog does not show any particular food preferences ($d=0,14$) and has high values of the niche breadth – 16,01 (Table 3), which makes us conclude that it is probably polyphage.

Spring Frog (*Rana dalmatina*). This is also a poorly studied species concerning its trophic spectrum. Data about the diet of *Rana dalmatina* until now is given only by ANGELOV & BATSCHWAROV (1972). From Table 3 it is visible that the spring frog shows weak preferences to Coleoptera – $d=0,56$ and it has high value of the trophic niche breadth – 8,11.

Common Tree Frog (*Hyla arborea*). Three studies on the trophic spectrum of this species in Bulgaria are made so far (АНГЕЛОВ, 1960; БЪЧВАРОВ, 1967; ANGELOV & BATSCHWAROV, 1972). Unfortunately, all three studies are conducted on small number of specimens and give very contradictory results and due to this fact we cannot make any conclusions (Table 3). Probably the common tree frog is a polyphage, and this is partly confirmed by the values of the species' niche breadth, which varies from 2,11 to 5,68.

Currently, in Bulgaria there is no data concerning the trophic spectrum of the following species: *Mesotriton alpestris*, *Lissotriton vulgaris*, *Triturus cristatus*, *Truturus dobrogicus*, *Pelobates fuscus*, *Pelobates syriacus* and *Pelophylax kl. esculentus*.

From the analysis of the summarized data we can conclude that all of our species of amphibians are zoophages, mainly insectophages, because insects take a considerable part of their trophic spectrum (except the fire salamander). Some authors

point out the presence of plant and non-organic (pebbles, sand etc.) components in the trophic spectrum of the studied species, which is considered accidental.

All studies conducted in Bulgaria up to this moment are characterized with study only of the qualitative and quantitative food composition of the amphibians and analyzing what part of the prey are pests in the agriculture, forestry and fisheries. Some authors analyze the seasonal change in the trophic spectrum of the studied species, but currently there are no studies concerning the trophic niche breadths, their overlap to the species occurring together, the energetics and the position of the amphibians in the food chains in the biocenoses.

Part of the Bulgarian batrachofauna is poorly studied concerning the trophic spectrum. In future studies the qualitative and quantitative composition of the amphibians in Bulgaria will be clarified as well as extended to more detailed studies on their feeding ecology.

CONCLUSIONS

1. With the data presented in the current paper there are overall 17 studies conducted in Bulgaria concerning the trophic spectrum of the amphibians.
2. The studies include 11 species, which represents 61,11% from the Bulgarian batrachofauna. For 7 species currently there is no data on their trophic spectrum.
3. All studied species are zoophages, mainly insectophages.
4. Except *Salamandra salamandra*, *Bombina variegata* and *Pseudepidalea viridis* all studied amphibian species are typical polyphages.
5. Cannibalism was recorded only in the marsh frog (*Pelophylax ridibundus*).

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ОБЗОР НА ИЗСЛЕДВАНИЯТА ВЪРХУ ХРАНИТЕЛНИЯ СПЕКТЪР НА ЗЕМНОВОДНИТЕ В БЪЛГАРИЯ

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(резюме)

Настоящата статия представлява обзор на проучванията върху хранителния спектър на земноводните, проведени в България. Литературния обзор на статиите посветени на този проблем показва, че с данните представени в настоящата работа, до този момент в страната са проведени общо 17 специализирани проучвания върху хранителния спектър на земноводните. Проучванията обхващат 11 вида земноводни, което представлява 61,11 % от Българската батрахофауна. За 7 вида – *Mesotriton alpestris*, *Lissotriton vulgaris*, *Triturus cristatus*, *Truturus dobrogicus*, *Pelobates fuscus*, *Pelobates syriacus* и *Pelophylax kl. esculentus* до момента липсват подробни данни относно храненето.

Анализът на наличните данни показва, че всички наши земноводни са зоофаги и главно инсектофаги, понеже насекомите (Insecta) присъстват с най-голям процент в храната им. Изключение прави дъждовникът, който проявява известно предпочитание към голите охлюви и земните червеи. Всички наши представители на клас Amphibia са полифаги (нямат изразено предпочитание към определен таксон) – като изключим дъждовника, жълтокоремната бумка и зелената крастава жаба; жълтокоремната бумка проявява известни предпочитания към твърдокрилите насекоми (Coleoptera), а зелената крастава жаба – към мравките (Formicidae) и твърдокрилите.

Канибализъм е установен само при голямата водна жаба.

