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Feeding Ecology of the Green Toad (*Bufotes viridis* complex) in Urban Environments

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Abstract: Data about the feeding ecology of the green toad (*Bufotes viridis* complex) from two hills near the city of Plovdiv, Mladezhki Hill and Bunardzhik Hill, are presented. The diet of the green toad consists mainly of insects, predominantly Hymenoptera (mostly Formicidae) and Coleoptera. When comparing the quantitative composition of the trophic spectrum between the two populations, we did not detect statistically significant differences. However, the value of the trophic niche breadth of the population from the Mladezhki Hill was significantly greater than that of the population from the Bunardzhik Hill, indicating that the first population feeds on more diverse prey. The overlapping of food niches between the two populations is low due to the different conditions and microhabitats of the two studied hills. The green toad can be classified as a polyphage (zoophage), which plays an important role in food chains, both in natural and urban ecosystems.

Key words: green toad, diet, trophic niche, Plovdiv hills

Introduction

Food is the main link between the organism and its habitat; the trophic spectrum determines the species' place in the food chains (Kennett & Troy 1996). For this reason, studies on the trophic spectrum of animals and the peculiarities in their feeding are of increasing importance in modern ecology. The feeding ecology of amphibians is of major interest due to their role in the ecosystems (Cortés-Gomez et al. 2015), both natural and anthropogenically-transformed. For the successful colonisation of new territories, species needs to have a wide trophic niche as well as high ecological plasticity, which, in combination with appropriate environmental conditions, will lead to the successful expansion of the geographical range (Rödder et al. 2008). From this point of view, the study of the ecological role of species in ecosystems and the assessment of the prospect of survival and existence in natural and anthropogenically-transformed landscapes (such as cities) is a necessary part of the ecological characterisation of each taxon (Semenov & Schönbrot 1988).

The green toads of the genus *Bufotes* Rafinesque, 1815 have a wide geographical range, extending from Northwest Africa to Central Asia (Stöck et al. 2006). Currently, members of this complex cannot be reliably identified at the species level based only on morphological characteristics. There are probably two species in Bulgaria – *Bufotes variabilis* (Pallas, 1769) and *Bufotes viridis*

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(Laurenti, 1768) as can be judged on data about the general distribution of the species in this complex (see Stöck et al. 2006). These two species are found respectively: in Central and Eastern Europe in the south to the northern parts of the Apennines and in the southern parts of the Balkan Peninsula (*Bufotes viridis*); in Asia Minor, Central Asia, the Caucasus Region, isolated populations in the southern part of the Balkan Peninsula as well as Jutland and the south of the Scandinavian Peninsula (*Bufotes variabilis*). As there are no studies on specimens from Bulgaria, the taxonomic status of the species in the country is not yet clear and it is assigned as belonging to the „*Bufotes viridis* complex" in the current study. In Bulgaria, the complex is widespread practically all over the country, from the sea level to the alpine zone, being one of the few species of amphibians adhering to urban areas, where it is encountered in greater numbers (Beshkov & Nanev 2002).

The green toad is considered by many authors as „useful", since it preys on several species of insect pests (Angelov 1960, Beshkov 1961, Angelov & Batschwarov 1972). The trophic spectrum of the species has been relatively well studied abroad and in Bulgaria. Most of the studies, however, are focused mainly on the composition and the quantitative characterisation of the food and have been conducted mostly in the 1960s and 1970s. There are still some unknown aspects regarding the feeding ecology of the green toad, such as the trophic specialisation, the amount and volume of food intake as well as the trophic niche.

This paper presents data on the qualitative and quantitative composition of food, volume proportion, trophic specialisation and overlapping of trophic niches between two populations of *Bufotes viridis* complex from the Mladezhki Hill and the Bunardzhik Hill in Plovdiv City. In addition, we sampled prey availability in the studied habitat and calculated prey electivity in order to test for a preference towards certain taxa.

Materials and Methods

For the purposes of the present study, 224 individuals (123 ♂♂, 101 ♀♀ adult and subadult toads) of the green toad (*Bufotes viridis* complex) were captured. The toads were collected seasonally in March-October 2017 from Mladezhki Hill and Bunardzhik Hill in the city of Plovdiv. A permit for work with this species during the present study was issued by the Ministry of Environment and Waters of Bulgaria.

Immediately after their capture, the sex and age of the toads were determined, the snout-vent length was measured (using digital calliper with accuracy of 0.01 mm) and the stomach contents were extracted (using the stomach-flushing technique, see Solé et al. 2005). This method has been considered as the most appropriate approach by many specialists due to its accuracy, allowing the complete removal of food particles without injuring or killing animals. The collected stomach contents were fixed in 70% ethanol and the material was stored in the herpetological collection of the Department of Ecology and Environmental Conservation at the Plovdiv University. The food remains were sorted and identified to the lowest possible taxonomic level depending on their degree of decomposition. For identification, we used various guides (Angelov 1994, Ivanov et al. 1981). The taxonomic list followed the arrangement used by Fauna Europaea (de Jong et al. 2014).

We provided the number of prey items and percentage proportion, the number of stomachs that contained the taxon and frequency of occurrence (the ratio between the number of stomachs that contain a certain taxon prey and the total of analysed stomachs, the obtained value being expressed in percentages) for each recorded taxon.

Sampling adequacy was determined using Lehner's formula (Lehner 1996):

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

ranging from 0 to 1, where N_1 was the number of the food components occurring only once, while I was the total number of the food components.

For determining the volume of the food, we used the formula for volume of ellipsoid, following the methodology of Colli & Zamboni (1999):

$$V = \frac{4\pi}{3}\frac{L}{2}\left(\frac{W}{2}\right)^2,$$

where V was the volume of a ellipsoid body, L – body length and W – body width.

The diversity of the diet (niche breadth) was calculated using the reciprocal value of the Simpson's Diversity Index (Magurran 1988):

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

where S was trophic niche breadth and P_i was proportion of food component i.

To determine the level of trophic specialisation 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 of 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 specialisation in the choice of food; a value closer to 1/N is typical for a species that is a general feeder (polyphage).

The trophic niche overlap between sexes and populations was calculated using Pianka's formula (Pianka 1986):

$$O_{j,k} = \frac{\sum P_j . P_k}{\sqrt{\sum P_j^{\,2} . \sum P_k^{\,2}}},$$

where j and k were the two groups being compared, O – trophic niche overlap, P_i – proportion of the food component i.

In September 2017, pit-fall traps were used to account for prey availability (Samways et al. 2010), with a total of five traps placed in the park zone of each hill, where the toads were captured (17 ♂♂, 31 ♀♀ adults and subadults). Each trap was a two-litre plastic cylinder filled with one litre of 4% formalin solution. Drainage holes were drilled at 2/3 of the cylinder height to avoid overflow and loss of catch in case of rainfall. Traps were placed in a straight line at a distance of 10-15 m from each other and were left for 14 days, while the minimal recommended duration for similar studies is ten days (Borgelt & New 2006).

To determine the food preference of the green toad in the study areas, we used two electivity indices. Both indices could take values from +1 to –1, where a value of +1 indicated a complete preference for a given prey taxon, a value of about 0 – a neutral ratio and –1 means a total avoidance of a certain prey taxon. The two indices are:

Jacobs Electivity Index (Jacobs 1974):

$$J = \frac{R_i - P_i}{(R_i + P_i) - (2R_iP_i)},$$

where R_i was the proportion of the prey taxon i in the stomach contents, P_i was the proportion of the prey taxon i in the habitat.

Strauss Electivity Index (Strauss 1979):

$$S_i = R_i - P_i,$$

where R_i was the proportion of the prey taxon i in the stomach contents, P_i was the proportion of the prey taxon i in the habitat.

The results were statistically processed using descriptive statistics. The trophic spectrum was compared between the two studied populations and between sexes using Student's t-test for two independent samples (data normality was tested using Shapiro-Wilk test), while the season comparison was done using Fisher's F-test (Fowler et al. 1998). For calculation the Lehner's formula and the trophic niche overlap, Libre Office Spreadsheets, v. 6.1. was used. For the statistical processing of the data as well as for calculation of the Simpson's Diversity Index and the Berger-Parker Index of Dominance, we used the computer software PAST, v.3.0 (Hammer et al. 2001).

Results

During the study period, 3258 food items (1801 from the Mladezhki Hill and 1457 from the Bunardzhik Hill) were recovered from 224 individuals belonging to the *Bufotes viridis* complex. From all examined stomachs, 73 were empty, which was 32.59% of the total. From the 151 full stomachs, we identified a total of 45 trophic categories. The average number of food items consumed by a toad individual was 21.58.

The sample adequacy, calculated using the Lehner's formula, was 0.84 in total for the two studied populations in the city of Plovdiv, recognised as for such studies (Bam-E-Zar et al. 2019, Fathinia et al. 2019). For the qualitative and quantitative composition of the food of the green toad (*B. viridis* complex) from the two studied hills in Plovdiv City for the whole study period, see Table 1. The diet of the green toad consisted mainly of insects, with non-insect food predominating by myriapods, which were mainly represented by the families Polydesmidae and Julidae, followed by the Isopoda (Oniscidea) and Araneae. Of the insects, the Hymenoptera was the most abundant taxon, represented mainly by the family Formicidae, followed by the orders Coleoptera and Hemiptera.

The insects represented the dominant volume of the trophic spectrum, with predominating taxa regarding their volume proportion of the food: Hemiptera (mostly represented by the families Pentatomidae and Pyrrhocoridae, Cicadidae), followed by Coleoptera (predominantly represented by the families Carabidae, Tenebrionidae, Curculionidae), Dermaptera and Hymenoptera (mainly representatives of the family Formicidae). Predominating in volume of the non-insect taxa were Isopoda (Oniscidea), followed by Myriapoda (families Julidae and Polydesmidae).

The trophic spectrum of the green toad from the two hills in Plovdiv City consisted mainly of terrestrial taxa. The only identified aquatic taxon was Diptera (larvae), which has a negligible share of the diet.

From the Mladezhki Hill, we captured 142 green toads and 56 (39.44%) of them had empty stomachs. The high percentage of empty stomachs was probably due to the fact that some of the toads were caught during the breeding period. From the 86 full stomachs, we recovered a total of 1801 food items divided into 35 food categories. The average number of food items consumed by an individual was 20.94. The sample adequacy from the Mladezhki Hill (Lehner's formula) was 0.91 (considered sufficient). The diet of the green toad from this hill consisted mainly of insects (Table 1). Of the non-insect food, the following taxa were predominating: Myriapoda, followed by Isopoda (Oniscidea) and Araneae. Of insects, Hymenoptera had the largest share, represented almost completely by the family Formicidae. The shares of the Coleoptera (represented mainly by the families Carabidae and Curculionidae) and Dermaptera were significant.

Regarding the volume of the trophic spectrum of the green toads from the Mladezhki Hill, the predominating taxa were Coleoptera (represented mainly by Carabidae, Tenebrionidae and Cerambycidae), followed by Hymenoptera (mainly Formicidae), Dermaptera and Hemiptera. From the non-insect food, the predominating taxa in regards of volume were Isopoda (Oniscidea) followed by Myriapoda (Polydesmidae and Geophilidae).

At the Bunardzhik Hill, we captured 82 green toads. Of them, 17 were with empty stomachs (20.7%). From the 65 full stomachs, we identified a total of 1457 food items belonging to 36 food categories. The average number of food items consumed per individual was 22.41.

The sample adequacy of the Bunardzhik Hill population (Lehner's formula) was 0.66 (considered sufficient). Similarly to the data about the other population, the food of toads caught at the Bunardzhik Hill consisted mainly of insects. The predominating taxa were Hymenoptera, represented almost entirely by the family Formicidae, followed by Hemiptera and Coleoptera. The non-insect prey was represented mainly by Araneae, followed by Myriapoda and Isopoda (Oniscidea).

Predominating taxa regarding food volume at Bunardzhik Hill were Hemiptera (represented predominantly by Cicadoidea, Pentatomidae and Pyrrhocoridae), followed by Dermaptera, Hymenoptera (mainly Formicidae) and Coleoptera (mainly Carabidae and Curculionidae). The highest volume from the non-insect taxa was taken by Myriapoda (mainly Julidae and Glomeridae), followed by Araneae and Isopoda (Oniscidea).

Comparing the results of the trophic spectrum of *Bufotes viridis* complex from the two studied hills in Plovdiv City, it can be concluded that, for both populations, ants represented the major numerical portion of the diet, which, however were less significant in regards to volume. The most important food source in regards of volume for the toads from the Mladezhki Hill was Coleoptera, represented by several families, while for the population from the Bunardzhik Hill, the predominating taxon was Hemiptera, which was probably due to differences in habitats and microclimatic conditions of the two hills.

When comparing the quantitative composition of the trophic spectrum between the two populations, we found no statistically significant differences (t-test, t=0.22; p=0.83). However, there were some differences in the trophic niche of the two populations. Although the number of recorded trophic categories in the diet of the two populations was almost equal (Mladezhki Hill – 35, Bunardzhik Hill – 36), the trophic niche breadth of the Bunardzhik Hill population was significantly lower (0.60) compared to that from the Mladezhki Hill – 2.45 (Table 1). The trophic spectrum of the green toad from the Mladezhki Hill consisted of a much more diverse food. According to a previous study (Mollov et al. 2006), the trophic niche breadth of the species from Plovdiv City was 4.98.

The overlapping of the trophic niches between the two populations calculated by us was 20.28%. Such a low percentage suggested that, despite the similarities in the trophic spectrum of the toads from the two populations, there were also significant differences due to the specific conditions and microhabitats of the two hills.

The data about the prey availability in the stomach contents and in the two habitats obtained in September 2017 (Tables 2 and 3) were used for calculation of electivity indices. For the Mladezhki Hill, we recorded 19 taxa in the stomachs of the toads and 17 in the habitat. Seven taxa were registered only in the habitat, but not in the stomach contents. Eight taxa were found only in the stomach contents but not in the habitat. For the Bunardzhik Hill, we registered 19 taxa in the stomach contents and 22 in the habitat, seven of which were registered only in the habitat (but not in the stom-

Table 1. Qualitative, quantitative and volume composition of the trophic spectrum of the green toad (*Bufotes viridis* complex) from the two studied hills in Plovdiv City for the whole study period (March–October 2017). Legend: n – number of specimens of a given taxon; n% – percentage (proportion) of the total; s – number of stomachs containing a given taxon; s% – the percentage of stomachs containing a given taxon (frequency of occurrence of a given taxon); v – volume of a given taxon. v% – volume percentage of a given taxon of the total food volume.

Taxa	Mladezhki Hill						Bunardzhik Hill						Total					
	N	n%	S	s%	v	v%	N	n%	S	s%	v	v%	n	n%	s	s%	v	v%
Araneae	18	1.00	13	4.05	504.1	1.57	23	1.58	18	7.50	600.98	2.25	41	1.26	31	5.53	1105.08	1.88
Myriapoda, Chilopoda, Geophilidae	31	1.72	18	5.61	601.6	1.88	0	0.00	0	0.00	0	0.00	31	0.95	18	3.21	601.6	1.02
Myriapoda, Diplopoda, Glomeridae	0	0.00	0	0.00	0	0.00	4	0.27	2	0.83	414.86	1.55	4	0.12	2	0.36	414.86	0.71
Myriapoda, Diplopoda, Julidae	88	4.89	23	7.17	521.2	1.63	21	1.44	9	3.75	552.48	2.07	109	3.35	32	5.70	1073.68	1.83
Myriapoda, Chilopoda, Lithobiidae	0	0.00	0	0.00	0	0.00	2	0.14	2	0.83	31.55	0.12	2	0.06	2	0.36	31.55	0.05
Myriapoda, Diplopoda, Polydesmidae	116	6.44	21	6.54	937.2	2.93	2	0.14	2	0.83	137.38	0.51	118	3.62	23	4.10	1074.58	1.83
Myriapoda,Chilopoda, Scolopendridae	0	0.00	0	0.00	0	0.00	1	0.07	1	0.42	41.63	0.16	1	0.03	1	0.18	41.63	0.07
Oligochaeta, Lumbricidae	2	0.11	2	0.62	293.4	0.92	1	0.07	1	0.42	68.09	0.26	3	0.09	3	0.53	361.49	0.62
Gastropoda	12	0.67	2	0.62	298.1	0.93	2	0.14	2	0.83	167.63	0.63	14	0.43	4	0.71	465.73	0.79
Collembola	3	0.17	3	0.93	16.1	0.05	1	0.07	1	0.42	0.22	0.00	4	0.12	4	0.71	16.32	0.03
Isopoda, Oniscidea	64	3.55	17	5.30	1507.7	4.71	12	0.82	12	5.00	501.24	1.88	76	2.33	29	5.17	2008.94	3.42
Zygentoma, Lepismatidae	3	0.17	1	0.31	15.2	0.05	2	0.14	1	0.42	82.56	0.31	5	0.15	2	0.36	97.76	0.17
Coleoptera - undet.	0	0.00	0	0.00	0	0.00	1	0.07	1	0.42	29	0.11	1	0.03	1	0.18	29	0.05
Coleoptera, Buprestidae	0	0.00	0	0.00	0	0.00	1	0.07	1	0.42	72.87	0.27	1	0.03	1	0.18	72.87	0.12
Coleoptera, Carabidae	82	4.55	35	10.90	3631.8	11.34	34	2.33	21	8.75	1938.31	7.26	116	3.56	56	9.98	5570.11	9.49
Coleoptera, Chrysomelidae	4	0.22	3	0.93	96.6	0.30	3	0.21	1	0.42	49.33	0.18	7	0.21	4	0.71	145.93	0.25
Coleoptera, Coccinelidae	0	0.00	0	0.00	0	0.00	18	1.24	11	4.58	299.71	1.12	18	0.55	11	1.96	299.71	0.51
Coleoptera, Curculionidae	20	1.11	15	4.67	638	1.99	11	0.75	8	3.33	435.53	1.63	31	0.95	23	4.10	1073.53	1.83
Coleoptera, Tenebrionidae	11	0.61	8	2.49	3277.8	10.24	0	0.00	0	0.00	0	0.00	11	0.34	8	1.43	3277.8	5.58
Coleoptera, Elateridae	4	0.22	3	0.93	329	1.03	0	0.00	0	0.00	0	0.00	4	0.12	3	0.53	329	0.56
Coleoptera, Cerambycidae	2	0.11	2	0.62	882.5	2.76	1	0.07	1	0.42	144.88	0.54	3	0.09	3	0.53	1027.38	1.75
Coleoptera, Cantharidae	5	0.28	2	0.62	123.8	0.39	0	0.00	0	0.00	0	0.00	5	0.15	2	0.36	123.8	0.21
Coleoptera, Staphylinidae	0	0.00	0	0.00	0	0.00	1	0.07	1	0.42	1.16	0.00	1	0.03	1	0.18	1.16	0.00
Coleoptera (larvae)	10	0.56	6	1.87	168.3	0.53	1	0.07	1	0.42	2.84	0.01	11	0.34	7	1.25	171.14	0.29

Taxa	Mladezhki Hill						Bunardzhik Hill						Total					
	N	n%	S	s%	v	v%	N	n%	S	s%	v	v%	n	n%	s	s%	v	v%
Dermaptera – undet.	42	2.33	15	4.67	3750.1	11.71	51	3.50	19	7.92	5376.01	20.15	93	2.85	34	6.06	9126.11	15.54
Diptera – undet.	16	0.89	8	2.49	766.3	2.39	2	0.14	1	0.42	0.44	0.00	18	0.55	9	1.60	766.74	1.31
Diptera, Muscidae	0	0.00	0	0.00	0	0.00	4	0.27	2	0.83	134.29	0.50	4	0.12	2	0.36	134.29	0.23
Diptera, Nematocera, Culu-cidae	4	0.22	2	0.62	25.9	0.08	0	0.00	0	0.00	0	0.00	4	0.12	2	0.36	25.9	0.04
Diptera (larvae)	23	1.28	6	1.87	1061	3.31	9	0.62	2	0.83	366.93	1.37	32	0.98	8	1.43	1427.93	2.43
Hemiptera (Heteroptera) - undet.	0	0.00	0	0.00	0	0.00	1	0.07	1	0.42	37.14	0.14	1	0.03	1	0.18	37.14	0.06
Hemiptera, Aphidoidea	1	0.06	1	0.31	8.6	0.03	0	0.00	0	0.00	0	0.00	1	0.03	1	0.18	8.6	0.01
Hemiptera, Cicadoidea	3	0.17	3	0.93	42.6	0.13	6	0.41	6	2.50	3681.67	13.80	9	0.28	9	1.60	3724.27	6.34
Hemiptera, Heteroptera,Pentatomidae	11	0.61	9	2.80	1272	3.97	21	1.44	12	5.00	3196.51	11.98	32	0.98	21	3.74	4468.51	7.61
Hemiptera, Heteroptera, Ger-ridae	1	0.06	1	0.31	25.2	0.08	0	0.00	0	0.00	0	0.00	1	0.03	1	0.18	25.2	0.04
Hemiptera, Heteroptera, Pyr-rhocoridae	16	0.89	11	3.43	990	3.09	55	3.77	22	9.17	2767.47	10.37	71	2.18	33	5.88	3757.47	6.40
Hymenoptera, Apoidea	2	0.11	2	0.62	283.2	0.88	1	0.07	1	0.42	99.89	0.37	3	0.09	3	0.53	383.09	0.65
Hymenoptera, Formicidae	1133	62.91	57	17.76	3772.9	11.78	1121	76.94	53	22.08	3960.71	14.84	2254	69.18	110	19.61	7733.61	13.17
Hymenoptera, Vespidae	2	0.11	2	0.62	78.5	0.25	1	0.07	1	0.42	2.94	0.01	3	0.09	3	0.53	81.44	0.14
Lepidoptera – undet.	1	0.06	1	0.31	53.6	0.17	1	0.07	1	0.42	122.56	0.46	2	0.06	2	0.36	176.16	0.30
Lepidoptera (larvae)	4	0.22	4	1.25	709	2.21	7	0.48	3	1.25	538.36	2.02	11	0.34	7	1.25	1247.36	2.12
Neuroptera – undet.	0	0.00	0	0.00	0	0.00	4	0.27	2	0.83	8.95	0.03	4	0.12	2	0.36	8.95	0.02
Neuroptera (larvae)	6	0.33	5	1.56	65.4	0.20	0	0.00	0	0.00	0	0.00	6	0.18	5	0.89	65.4	0.11
Orthoptera, Caelifera	2	0.11	1	0.31	379.8	1.19	0	0.00	0	0.00	0	0.00	2	0.06	1	0.18	379.8	0.65
Non-organic components	13	0.72	4	1.25	59.3	0.19	5	0.34	3	1.25	21.3	0.08	18	0.55	7	1.25	80.6	0.14
Plant remains	46	2.55	15	4.67	4839.6	15.11	26	1.78	14	5.83	798.57	2.99	72	2.21	29	5.17	5638.17	9.60
Total	1801	100	321	100	32025.4	100	1457	100	240	100	26685.99	100	3258	100.00	561	100.00	58711.39	100.00
Lehner’s index	0.91						0.66						0.84					
Berger-Parker	0.63						0.77						0.69					
Trophic niche breadth (1/ Simpson)	2.45						0.6						2.06					

ach contents) and eight were only in the stomach contents (but not in the habitat). Some taxa – Gastropoda, Collembola, Oligochaeta, Lumbricidae, Coleoptera (larvae) and Lepidoptera (larvae) – are usually caught using pit-fall traps, as it was during our previous studies on epigeal invertebrate communities in the green parks and hills of Plovdiv City (Mollov et al. 2018a, 2018b); their absence from the habitat during this study was probably due to the fact that the present survey was done only in one month (September 2017).

Of the taxa, registered only in the habitat but not in the stomach contents, only two taxa, Coleoptera (Alleculidae) and Hemiptera (larvae), could be considered as really avoided by the green toad. We have not recorded these taxa in our previous studies and they have not been mentioned by other authors. In our opinion, this could probably be explained by the fact that the family Alleculidae are mostly diurnally active species and the green toads are primarily active and hunt during the night. On the other hand, the larvae of Hemiptera are met primarily on the vegetation and rarely on the ground where the toads hunt; most of them have very soft body, which is easily decomposed by the stomach acids and this may be another reason for the absence of this taxon in stomach contents. The other taxa marked with (*) in Table 2 and Table 3 are either registered by us or other authors, so their absence in the stomachs in this study does not necessarily mean that the toads are avoiding them.

For the population at the Mladezhki Hill, we recorded high values of both electivity indices for Hymenoptera (Formicidae), Coleoptera, Curculionidae and Myriapoda (Table 2). For the population at the Bunardzhik Hill, we registered a medium level of preference to Hymenoptera (Formicidae) while the preference towards Hemiptera was higher (Table 3). For both populations, the electivity indices show slight variations between the sexes but exhibiting the same trend. It seems that the green toad shows slight preference towards ants, similar to other toad species. Since there are no other studies on the trophic preferences of the *Bufotes viridis* complex using electivity indices, we are unable to compare our results.

Discussion

The present data confirm the results from previous studies on the diet of the green toad carried out in Bulgaria (Angelov 1960, Beshkov 1961, Angelov & Batschwarov 1972, Mollov et al. 2006), which also indicate that the two most numerous taxa in the trophic spectrum of the green toad are Hymenoptera, Formicidae and Coleoptera. According to the data on the diet of the *Bufo viridis* complex conducted in other countries, Hymenoptera (Formicidae) and Coleoptera are also the most commonly registered prey taxa. According to Shterbak (1966), mainly terrestrial invertebrates participate in the diet of the green toad in the Crimea; of them, 42.9% are Coleoptera, (Curculionidae, Carabidae and larvae) followed by Lepidoptera (larvae) – 12.5%. Nicoara et al. (2005) report that the diet of *B. viridis* complex from the Ciric River near Iasi, Romania, consists mainly of Hymenoptera (Formicidae – 64.5%), followed by Diptera (20%) and Coleoptera (9%), where 94% of the food is of terrestrial origin. Nicoara et al. (2008) has reported from the town of Sulina near the Danube Delta also Hymenoptera (of which ants predominate) as the most numerous taxon (49.83%), followed by Diptera (19.31%) and Coleoptera (14.2%); 84.17% of the food items were of terrestrial origin. Covaciu-Marcov et al. (2010) have analysed the trophic spectrum of four amphibian species (*Pelobates syriacus*, *Pelobates fuscus*, *Hyla arborea* and *Bufotes viridis* complex) from Fortress Histria, Romania; they have confirmed that *B. viridis* complex feeds primarily on ants, which is indicative of its trophic selectivity.

In our previous study (Mollov & Stojanova 2010), we have examined the stomach contents of the green toad from Poland. The most numerous taxa are Coleoptera (Carabidae) with 63.16% of total registered taxa, followed by Dermaptera (10.53%) and Cicadinea (6.53%). Food specialisation is high – 0.73 (Berger-Parker index).

In urban environments the green toad is known to be attracted by artificial lights and consumes insects near street lamps (Covaciu-Marcov et al. 2010). Generally, this species feeds on the most abundant potential prey in the feeding territory (and thus is considered an opportunistic predator). Beetles and ants are the basic food, most probably due to their abundance and the wide range of habitats where they can be found (Mollov 2008). According to Clarke (1974), another possible explanation for the preference towards ants and beetles by the green toad could be the fact that these taxa are in general unappealing to other predators due to the fact that the ants produce formic acid or have stings and the beetles have hard chitin armour. The preference to ants is probably due to the use of formic acid and alkaloids in the production of skin secretions used as defence by toads; toads acquire ingredients for skin secretion

Table 2. Taxonomic composition, number of individuals of the registered taxa in the stomachs of the green toads and the habitat on the Mladezhki Hill (September 2017). Legend: *Ni* – number of individuals from taxon *i;* Jacobs – Jacob electivity index; Strauss - Strauss electivity index; * - taxa registered in the habitat, but not in the stomach contents; ! – taxa register only in the stomach contents, but not in the habitat.

Taxa	Stomachs (N_i)			Habitat (N_i)	Jacobs (♂)	Jacobs (♀)	Jacobs Total	Strauss (♂)	Strauss (♀)	Strauss Total
	♂	♀	Total							
Acari*	0	0	0	7	-1.000	-1.000	-1.000	-0.023	-0.023	-0.023
Araneae	1	3	4	29	-0.948	-0.868	-0.905	-0.092	-0.088	-0.090
Opiliones*	0	0	0	38	-1.000	-1.000	-1.000	-0.125	-0.125	-0.125
Crustacea, Isopoda	11	46	57	11	-0.084	0.545	0.364	-0.005	0.077	0.038
Myriapoda	11	12	23	2	0.655	0.642	0.648	0.024	0.023	0.023
Gastropoda!	7	0	7	0	1.000	-	1.000	0.019	0.000	0.009
Collembola!	1	2	3	0	1.000	1.000	1.000	0.003	0.005	0.004
Oligochaeta, Lumbricidae!	0	1	1	0	-	1.000	1.000	0.000	0.002	0.001
Zygentoma, Lepismatidae!	0	3	3	0	-	1.000	1.000	0.000	0.007	0.004
Coleoptera, Alleculidae*	0	0	0	10	-1.000	-1.000	-1.000	-0.033	-0.033	-0.033
Coleoptera, Carabidae	6	22	28	46	-0.825	-0.514	-0.648	-0.134	-0.097	-0.114
Coleoptera, Chrysomelidae	0	2	2	2	-1.000	-0.145	-0.433	-0.007	-0.002	-0.004
Coleoptera, Curculionidae	6	6	12	1	0.676	0.639	0.657	0.013	0.011	0.012
Coleoptera, Staphylinidae*	0	0	0	1	-1.000	-1.000	-1.000	-0.003	-0.003	-0.003
Coleoptera, Tenebrionidae*	0	0	0	17	-1.000	-1.000	-1.000	-0.056	-0.056	-0.056
Coleoptera (larvae)!	5	4	9	0	1.000	1.000	1.000	0.014	0.010	0.012
Dermaptera	2	14	16	2	-0.082	0.687	0.527	-0.001	0.028	0.014
Diptera	0	2	2	35	-1.000	-0.927	-0.960	-0.115	-0.110	-0.112
Diptera (larve)!	14	7	21	0	1.000	1.000	1.000	0.039	0.017	0.027
Hemiptera	7	9	16	4	0.199	0.259	0.232	0.006	0.009	0.008
Hemiptera (larvae)*	0	0	0	2	-1.000	-1.000	-1.000	-0.007	-0.007	-0.007
Hymenoptera, Formicidae	284	274	558	97	0.781	0.629	0.703	0.473	0.354	0.409
Neuroptera (larvae)!	2	0	2	0	1.000	-	1.000	0.006	0.000	0.003
Lepidoptera*	0	0	0	1	-1.000	-1.000	-1.000	-0.003	-0.003	-0.003
Lepidoptera (larvae)!	0	1	1	0	-	1.000	1.000	0.000	0.002	0.001
Orthoptera!	2	0	2	0	1.000	-	1.000	0.006	0.000	0.003
Total	359	408	767	305	-	-	-	-	-	-

through their food (Jones et al. 1999, Daly et al. 2005).

Plant remains and non-organic particles (pebbles, sand, etc.) were found in the stomachs, accounting for a relatively small percentage. We also share the opinion of other authors (Sas et al. 2007, Covaciu-Marcov et al. 2010, Cicort-Lucaciu et al. 2013) that plant remains and non-organic particles should not be considered part of the trophic spectrum of the species, as they enter the stomach accidentally during the feeding.

In our opinion, the green toad can be classified as a polyphage (zoophage), and this species mainly hunts on land, since aquatic taxa are almost absent from its food. In our opinion, this species hunts entirely on land, and the capture of aquatic taxa should be considered more or less accidental. The species has opportunistic feeding behaviour and uses both hunting techniques – ambush and active search, depending on climatic conditions and season.

Conclusions

The diet of the green toad (*Bufotes viridis* complex) consisted mainly of insects. Representatives of the family Formicidae and the order Coleoptera were predominating in the food contents, with some differences between the numerical and the volume ratios between taxa. This species has medium trophic specialisation and could be classified as a

Table 3. Taxonomic composition, number of individuals of the registered taxa in the stomachs of the green toads and the habitat on the Bunardzhik Hill (September 2017). Legend: please see Table 2.

Taxa	Stomachs (N_i)			Hab-itat	Jacobs (♂)	Jacobs (♀)	Jacobs Total	Strauss (♂)	Strauss (♀)	Strauss Total
	♂	♀	To-tal							
Acarı*	0	0	0	1	-1.000	-1.000	-1.000	-0.004	-0.004	-0.004
Araneae	8	10	18	41	-0.636	-0.861	-0.808	-0.121	-0.148	-0.142
Opiliones*	0	0	0	7	-1.000	-1.000	-1.000	-0.028	-0.028	-0.028
Pseudoscorpiones	0	0	0	10	-1.000	-1.000	-1.000	-0.040	-0.040	-0.040
Myriapoda	14	7	21	31	-0.284	-0.865	-0.706	-0.050	-0.113	-0.099
Gastropoda	0	1	1	8	-1.000	-0.916	-0.934	-0.032	-0.030	-0.031
Collembola	0	1	1	34	-1.000	-0.982	-0.986	-0.135	-0.133	-0.134
Crustacea, Isopoda	1	6	7	53	-0.962	-0.937	-0.942	-0.205	-0.202	-0.202
Oligochaeta, Lumbricidae	0	1	1	2	-1.000	-0.695	-0.753	-0.008	-0.007	-0.007
Zygentoma, Lepismatidae!	0	2	2	0	-	1.000	1.000	0.000	0.003	0.002
Coleoptera*	0	0	0	9	-1.000	-1.000	-1.000	-0.036	-0.036	-0.036
Coleoptera, Alleculidae*	0	0	0	4	-1.000	-1.000	-1.000	-0.016	-0.016	-0.016
Coleoptera, Carabidae	7	10	17	8	0.069	-0.385	-0.255	0.005	-0.017	-0.013
Coleoptera, Chrysomelidae*	0	0	0	1	-1.000	-1.000	-1.000	-0.004	-0.004	-0.004
Coleoptera, Coccinelidae!	7	5	12	0	1.000	1.000	1.000	0.036	0.007	0.013
Coleoptera, Curculionidae	2	1	3	2	0.134	-0.695	-0.406	0.002	-0.007	-0.005
Coleoptera, Staphylinidae*	0	0	0	40	-1.000	-1.000	-1.000	-0.159	-0.159	-0.159
Coleoptera, Tenebrionidae*	0	0	0	37	-1.000	-1.000	-1.000	-0.147	-0.147	-0.147
Coleoptera (larvae)*	0	0	0	3	-1.000	-1.000	-1.000	-0.012	-0.012	-0.012
Dermaptera!	17	27	44	0	1.000	1.000	1.000	0.088	0.039	0.049
Diptera	2	0	2	34	-0.874	-1.000	-0.972	-0.125	-0.135	-0.133
Diptera (larvae)	1	0	1	48	-0.957	-1.000	-0.990	-0.185	-0.190	-0.189
Hemiptera	22	32	54	6	0.681	0.327	0.452	0.090	0.022	0.037
Hymenoptera, Formicidae	110	592	702	164	-0.169	0.503	0.334	-0.081	0.199	0.138
Hymenoptera, Apoidea!	0	1	1	0	-	1.000	1.000	0.000	0.001	0.001
Hymenoptera, Vespidae!	1	0	1	0	1.000	-	1.000	0.005	0.000	0.001
Lepidoptera!	0	1	1	0	-	1.000	1.000	0.000	0.001	0.001
Total	**193**	**697**	**890**	**252**	-	-	-	-	-	-

polyphage (zoophage). Generally, it has opportunistic feeding behaviour in urban environments. The trophic niche breadth of the Mladezhki Hill population was significantly greater than the niche breadth of the population at the Bunardzhik Hill, indicating that the former used more diverse food, which was probably due to the more diverse microhabitats and conditions on that hill, probably leading to greater food availability. The trophic niche overlap between the two populations was low, which was probably due to the different conditions and microhabitats of the two studied hills. In the city of Plovdiv, the green toad showed slight preference towards Hymenoptera (Formicidae) and some families of Coleoptera, Hemiptera and Myriapoda.

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