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Food composition of Uludağ frog, *Rana macrocnemis* Boulenger, 1885 in Uludağ (Bursa, Turkey)

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Abstract. Feeding habit and food preferences of Uludağ frog, *Rana macrocnemis* were studied in 2006 and 2007 in Uludağ (Bursa, Turkey). Stomach contents of 165 (87 males, 58 females, 20 juveniles) individuals were analyzed and a total of 2,129 prey items were determined. It was found that the species fed mainly on a variety of invertebrates and especially on insects (96.5%). The most frequently consumed prey items were Coleoptera (62.8%), Diptera (14.4%), and Hymenoptera (9.8%). There was no significant sex- and age-dependent difference in the feeding regime. It appears that the species is feeding less in the breeding period and more in the post-breeding period. It was also evident that there was an increase in the consumption of Coleoptera depending on the elevation.

Keywords. *Rana macrocnemis*, food composition, Uludağ, Turkey.

INTRODUCTION

Amphibians are among the indispensable elements of the ecosystem as they are a bridge for energy flow between invertebrates and higher trophic levels (Burton and Likens, 1975). Determination and understanding of their role on this trophic network is an essential step for understanding the amphibian ecology (e.g. Duellmand and Trueb, 1986; Cogălniceanu et al., 2000), and to evaluate the quality of their occupied habitats (e.g. Kovács et al., 2007; Lima et al., 2010).

The Uludağ frog, *R. macrocnemis*, has a quite broad distribution area of 891,072 km^2 (Kuzmin et al., 2008). The species is widely distributed in the forest and subalpine belt of the Caucasus and the adjacent territories of Turkey and Iran (Başoğlu and Özeti, 1973; Tarkhnishvili and Gokhelashvili, 1999), and its vertical distribution in Anatolia is from the sea level up to 2,600 m (Veith et al., 2003). The species is included in LC category in the IUCN Red List, and it is reported that its populations tend to decrease (Kuzmin et al.,

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2008). Although there have been numerous studies on its food composition in Caucasus (e.g. Khonyakina, 1973; Velia, 1977; Tertyshnikov et al., 1979; Ushakov and Tusnolobova, 1986; Kuzmin and Tarkhnishvili, 1997; Meschersky, 1997), there are limited studies on the Anatolian population (Uğurtaş et al., 2004).

Uludağ (Bursa, Turkey) is located in the east of Lake Uluabat and in the south of the Gulf of Gemlik. It is bordered by Nilüfer Tributary in the west and south and by Bursa and Inegöl Plains in the north and east (Eken et al., 2006). It has an area of 136,480 ha, and it has an elevation of 130-2,543 m. The Uludağ population of *Rana macrocnemis* is particularly exposed to anthropogenic pressure (Çiçek, 2009). The objective of the present study is to obtained detailed information on the food habits of the Uludağ frog, *Rana macrocnemis* inhabiting Uludağ (Bursa, Turkey), depending on season and elevation.

MATERIALS AND METHODS

The study was conducted at four stations in Uludağ. Kirazlıyayla (40°07'210"N, 29°05'259"E, 1476 m a.s.l.) and Sarıalan (40°07'964"N, 29°06'753"E, 1617 m a.s.l.) (Fig. 1A) are located in the fir forest (*Abies bornmuelleriana*). In both stations, *R. macrocnemis* breeds in temporary ponds which size ranges 10–40 m^2. After the breeding period, the individuals spend their time on the shore of brooks near 1–100 m from ponds. Lake Kilimli (40°04'627"N, 29°13'293"E, 2,275 m a.s.l.) (Fig. 1B) and Lake Kara (40°04'491"N, 29°13'761"E, 2,214 m a.s.l.) stations are located in the subalpine belt of Uludağ. These lakes are permanent and glacial lakes. However, water level decreases 1–3 m from shore during the summer months.

Field surveys were conducted at night (19.00–03.00) between April 2006 and September 2007. To be able to compare their food contents, the populations were classified as forest (Kirazlıyayla and Sarıalan) and subalpine belt (Lakes Kilimli and Kara) according to their location and as breeding [from the beginning of April to the end of June (Çiçek, 2009)] and post-breeding (from the beginning of July to the end of September) according to season. During the study, four samplings were made each year, two in the breeding period and two in the post-breeding period. First of all, the sex of the captured individuals was determined, and snout-urostyle length (SUL, mm) was measured with a digital calliper. Within an hour following capture, individuals were anaesthetized in a 1% solution of MS-222 (methane tricaine sulfonate) in the field and their stomach contents were extracted by forced regurgitation with forceps (Hirai and Matsui, 2000). The stomach contents were

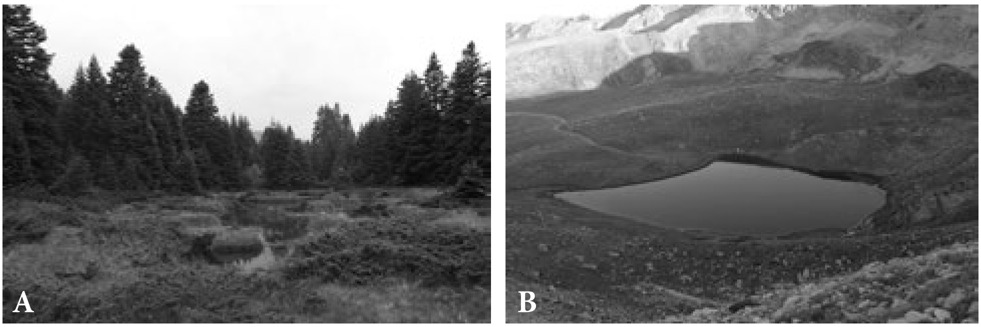

Fig. 1. Habitat types of *Rana macrocnemis* at Uludağ (Bursa, Turkey). A: Sarıalan, B: Lake Kilimli.

preserved in 70% ethanol for later analysis. After these procedures, frogs were released on the spot where they had been captured. At least two days before each sampling, two-liter volume pitfall traps were placed at the study stations; they were filled with 40% ethylene glycol (Cogălniceanu et al., 2000); and placed 1–5 m around the all stations in order to compare stomach contents with prey availability. Number of pitfall traps changed between four to eight according to the size of sampling station. In addition, sampling was also carried out on flying and diving invertebrates using a trap and a dip net, respectively, during each sampling. Obtained items were determined to the order level and compared to prey items in the stomach contents.

The prey items were identified to the lowest possible taxon. Vegetal materials, sand and little pebbles were also encountered in the food content. However, these materials were most likely ingested accidentally during foraging and we did not consider them as food. The food contents were assessed with respect to numeric proportion (n%) (the number of a particular prey item in all preys, n%) and frequency of occurrence (the frequency of frog stomachs containing a particular prey type, f%). Trophic niche overlap between sexes and habitat types were measured using Pianka's index (*O*, Pianka, 1973):

$$O_{jk} = \frac{\sum_{i}^{n} p_{ij} p_{ik}}{\sqrt{\sum_{i}^{n} p_{ij}^2 \sum_{i}^{n} p_{ik}^2}}$$

Where p_{ij}= proportion of prey item i of the stomach contents used by species j; p_{ik}= proportion of prey item i of the total resources in the environment k. This index varies between 0 (no similarity) and 1 (total similarity). For comparison, food-niche breadth between sexes and habitat types was determined using Shannon's index (*H*, Shannon, 1948):

$$H' = -\sum_{i} p_i \ln p_i$$

Where p_i is proportion of prey item i found in stomach contents (Krebs, 1989). All niche calculations were done using the "EcoSim 700" program (Gotelli and Entsminger, 2010).

In order to determine food preference, we used the Vanderploeg and Scavia's (1979) relativized electivity index (E^*):

$$W_i = (r_i / p_i) / \sum_{i} r_i / p_i$$

$$E^* = [W_i - (1/n)]/(W_i + (1/n)]$$

Where r_i = proportion of prey item i in the stomach content; p_i = proportion of the prey item i in the environment; W_i= selectivity coefficient of prey item i; and n = category number of prey items. E^* ranges between -1 (avoidance) and 1 (preferences). The index was used to compare the potential surrounding prey items having fallen into the traps and the prey items detected in the stomach contents of the individuals. The t-test, Kruskal-Wallis test and Mann-Whitney U test were used to compare sexes; statistical analyses were performed using SPSS 10.0; and the alpha level was set at 0.05. In the results section, the mean values are given with their standard deviations.

RESULTS

During the study, 165 (87 males, 58 females, 20 juveniles) individuals of *R. macrocnemis* from Uludağ (Bursa, Turkey) were examined. The average snout-urostyle length was 27.8 (SD = 7.65, range= 17.7–43.7) mm for juveniles, 59.2 (5.40, 42 –69.9) mm for males, and 59.7 (5.76, 48.3–72.7) mm for females. Females are slightly larger than males (SUL values), but no statistically significant difference was observed between sexes in terms of their sizes (*t*-test, $t = 0.548$, $p \leq 0.585$). Besides there is variation in SUL among individuals depending on elevation. The greatest values were observed in subalpine population (Table 1).

We found 2,129 prey items in the stomach contents of 165 individuals, (177 in juveniles, 1,192 in males, and 760 in females), with body lengths ranging from 1 to 130 mm, resulting in a median number of 9 (range= 1-60) prey items. The number of median prey items was 6.5 (2–37) in juveniles, 8.5 (1–60) in males and 10.0 (2–54) in females. No statistically significant difference was detected between sexes considering the number of prey items in the stomach (Kruskal-Wallis test, $X^2 = 5.45$, $P \leq 0.06$). Juveniles generally consume smaller items (1–25 mm) and prey upon less preys than adults (Table 2).

The individuals consumed 668 prey items in the breeding period (from the beginning of April to the end of June) and 1,461 prey items in the post-breeding period (from the beginning of July to the end of September). The median number of prey items in males was 8.0 during the breeding period, while this value rose to 16.0 in the post-breeding period (Table 2). The median number of prey items in females was 6.0 in the breeding period, whereas it rose to 18.0 in the post-breeding period. In juveniles, the median numbers of prey items were 5.5 and 13.5 by period, respectively. In the post-breeding period, a partial increase was observed in the feeding rates of individuals (Mann Whitney U test, $Z = 8.43$, $P < 0.0001$).

Some 653 prey items were observed in the stomachs of 90 (42 males, 33 females, 15 juveniles) individuals in the forest population, while 1,476 prey items were observed in the stomachs of 75 (45 males, 25 females, 5 juveniles) individuals in the population of the subalpine belt. Generally, the median number of prey items in the forest population was 6.5 (1-30), while it was found as 17.0 (1-60) in the population of the subalpine belt (Mann Whitney U test, $Z = 7.95$, $P < 0.0001$). A higher number of prey items were observed in the stomachs of individuals inhabiting the subalpine belt.

Table 1. Measures on snout-urostyle length (SUL, in mm) of *R. macrocnemis*, according to sex, age class and habitat type.

Habitat	SUL (mm)	Juveniles	Males	Females
Fir forest	Mean±SD	27.6 ± 8.69	55.3 ± 4.24	56.3 ± 3.84
	Median	26.7	55.6	56.1
	Range	17.7-43.7	42.9-61.42	48.30-64.89
Subalpine belt	Mean±SD	28.1 ± 3.68	62.1 ± 3.66	64.1 ± 4.86
	Median	28.9	62.5	64.7
	Range	21.8-72.7	56.5-69.9	54.7-72.7
Overall	Mean±SD	27.8 ± 7.65	59.2 ± 5.40	59.7 ± 5.76
	Median	28.6	59.5	59.2
	Range	17.7-43.7	42.9-69.9	48.3-72.7
t test		t = 0.16, P = 0.877	t = 8.55, P < 0.0001	t = 6.57, P < 0.0001

Table 2. Number of prey recorded in stomach contents of *R. macrocnemis* according to sex, age class, habitat type and season.

Period		Fir forest			Subalpine Belt			Overall		
		Juveniles	Males	Females	Juveniles	Males	Females	Juveniles	Males	Females
Breeding	Mean±SD	5.6±2.47	7.8±5.54	6.2±3.83		10.8±8.35	11.5±5.32	5.6±2.47	8.2±5.88	6.7±4.29
	Median	5.5	8.0	5.0	-	8.0	11.5	5.5	8.0	6.0
	Range	2-11	2-30	1-19		3-22	6-17	2-11	2-30	1-19
Post-Breeding	Mean±SD		14.0±2.16	10.0±2.83	17.8±11.72	19.6±11.90	23.9±15.32	16.3±11.01	19.1±11.49	22.7±15.16
	Median	9.0	13.5	10.0	15.0	16.5	19.0	13.5	16.0	18.0
	Range		12-17	8-12	6-37	5-54	6-60	6-37	5-54	6-60
Overall	Mean±SD	5.9±2.53	8.4±5.60	6.4±3.85	17.8±11.7	18.6±11.8	22.0±14.9	8.8±7.86	13.7±10.63	13.1±12.72
	Median	6.0	8.0	6.0	15.0	16.0	18.0	6.5	8.5	10.0
	Range	2-11	2-30	1-19	6-37	3-54	6-60	2-37	1-60	2-54
Kruskal-Wallis test		X^2= 3.689, P= 0.158				X^2= 4.41, P= 0.08			X^2= 4.41, P= 0.08	

A total of 2,129 prey items were found to belong to eight classes, 17 orders and 37 families in the stomach contents of 165 individuals (Table 3). The prey groups included the classes Arachnida (Araneae), Chilopoda (Lithobiomorpha), Diplopoda (Julida), Insecta (Odonata, Plecoptera, Heteroptera, Homoptera, Hymenoptera, Coleoptera, Diptera, Tricoptera, Lepidoptera, and Colembolla), Gastropoda (Basommatophora), Oligocheta (Haplotaxida), Malacostraca (Isopoda), and Amphibia (Anura). Insects form the highest number of prey groups (97%) and ten orders were identified within the class. Among them, the largest groups by numeric proportion (n%) found in the stomach contents were Coleoptera (62.8%), Diptera (14.4%), and Hymenoptera (9.8%), respectively. The largest rate by frequency of occurrence also belonged to these groups: Coleoptera (84.2%), Diptera (44.2%), and Hymenoptera (32.1%). A total of 1,073 (n%= 50.4%, f%= 49.7%) terrestrial and 1,056 (49.6%, 50.3%) aquatic prey items were discovered in the stomach contents of all individuals. In addition, 1,388 (65.2%, 65.5%) adult and 742 (34.8%, 34.5%) larval preys were found within the class Insecta.

Within the forest population, the most frequently encountered prey orders in the food content were Coleoptera (n%= 47.8, f%=76.7), Diptera (17.9%, 28.9%), and Hymenoptera (11.5%, 22.2%). The prey orders most consumed by the population of the subalpine belt were Coleoptera (69.5%, 93.3%), Diptera (12.8%, 62.7%), and Hymenoptera (9.0%, 44.0%) (Table 3). As it is seen, the order Coleoptera is the most preferred prey group in both the subalpine and forest populations. Especially the aquatic preys (959, 45.0% of total preys) were consumed at a higher rate by the subalpine population. Nevertheless, only 97 (n%= 4.5%) of the aquatic preys were found in the forest population. The forest population consumed 53 (n%= 2.5) larval prey items, while the subalpine population consumed 689 (32.4%) larval prey items. The prey groups most consumed during both breeding [Coleoptera (n = 330, n% = 49.4%), Diptera (120, 18.0%), and Hymenoptera (64, 9.6%)] and post-breeding periods [Coleoptera (1,008, 69.0%), Diptera (186, 12.7%), and Hymenoptera (144, 9.9%)] were the same.

Table 3. Food composition of 165 (87 males 58 females, and 20 juveniles) Uludağ frog, *Rana macrocnemis* according to sex, age class and habitat type. n(%): Numeric proportion, f(%): Frequency of occurrence.

Prey taxa	Fir forest (42 males, 33 females, and 15 juveniles)					Subalpine (45 males, 25 females, 5 juveniles)					Overall	
	J	M	F	n (n%)	f (f%)	J	M	F	n (n%)	f (f%)	n (n%)	f (f%)
ARACHNIDA	18.2	6.5	2.8	45 (6.9)	9 (10.0)		0.4	0.9	8 (0.5)	3 (4.0)	53 (2.5)	12 (7.3)
ARANEA	18.2	6.5	2.8	45 (6.9)	9 (10.0)		0.4	0.9	8 (0.5)	3 (4.0)	53 (2.5)	12 (7.3)
Agelenidae	4.5	0.8	0.9	9 (1.4)	6 (6.7)			0.2	1 (0.1)	1 (1.3)	10 (0.5)	7 (4.2)
Cybaeidae[a]		0.6		2 (0.3)	2 (2.2)			0.2	1 (0.1)	1 (1.3)	3 (0.1)	3 (1.8)
Lycosidae	2.3	1.4	1.9	11 (1.7)	6 (6.7)		0.4		3 (0.2)	2 (2.7)	14 (0.7)	8 (4.8)
CHILOPODA, Lithobiomorpha	1.1	0.28	0.9	4 (0.6)	3 (3.3)			0.7	4 (0.3)	2 (2.7)	8 (0.4)	5 (3.0)
Lithobiidae, *Lithobius* sp.	1.1	0.28	0.9	4 (0.6)	3 (3.3)			0.7	4 (0.3)	2 (2.7)	8 (0.4)	5 (3.0)
DIPLOPODA, Julida							0.2		2 (0.1)	1 (1.3)	2 (0.1)	1 (0.6)
INSECTA	80.7	92.9	96.2	603 (92.3)	89 (98.9)	100	99.5	98.4	1463 (99.1)	74 (98.7)	2066 (97)	163 (98.8)
Terrestrial larvae		1.7	0.5	7 (1.1)	4 (4.4)		1.7	3.1	31 (2.1)	7 (9.3)	38 (1.8)	11 (6.7)
ODONATA		0.3	0.9	3 (0.5)	2 (2.2)		1.3		11 (0.7)	11 (14.7)	14 (0.7)	13 (7.9)
PLECOPTERA		1.1		4 (0.6)	2 (2.2)		0.1	0.7	5 (0.3)	2 (2.7)	9 (0.4)	4 (2.4)
HETEROPTERA		1.1	1.9	8 (1.2)	2 (2.2)		1.1	2.7	24 (1.6)	10 (13.3)	32 (1.5)	12 (7.3)
Corixidae, *Corixa* sp.[a]								0.4	2 (0.1)	1 (1.3)	2 (0.1)	1 (0.6)
Gerridae, *Gerris* sp.[a]			1.9	4 (0.6)	1 (1.1)					1 (1.3)	4 (0.2)	1 (0.6)
Lygaeidae							0.5	1.3	11 (0.7)	5 (6.7)	11 (0.5)	5 (3.0)
Notonectidae, *Notonecta* sp.[a]								0.4	2 (0.1)	1 (1.3)	2 (0.1)	1 (0.6)
Pentatomidae, *Pentatoma* sp.		1.1		4 (0.6)	2 (2.2)		0.6	0.7	9 (0.6)	5 (6.7)	13 (0.6)	7 (4.2)
HOMOPTERA			0.5	1 (0.1)	1 (1.1)		0.1		1 (0.1)	1 (1.3)	2 (0.1)	2 (1.2)
Cicadellidae, *Cicada* sp.			0.5	1 (0.1)	1 (1.1)		0.1		1 (0.1)	1 (1.3)	2 (0.1)	2 (1.2)
HYMENOPTERA	6.8	15.2	7.1	75 (11.5)	20 (22.2)	8.99	6.8	12.4	133 (9.0)	33 (44.0)	208 (9.8)	53 (32.1)
Formicidae	5.7	13.8	7.1	69 (10.6)	21 (23.3)	8.99	3.2	7.3	75 (5.1)	23 (30.7)	144 (6.8)	44 (26.7)
Ichneumonidae		0.6		2 (0.3)	1 (1.1)		0.7	0.2	7 (0.5)	4 (5.3)	9 (0.4)	5 (3.0)
Pompilidae		0.3		1 (0.1)	1 (1.1)		0.9	0.5	11 (0.7)	3 (4.0)	12 (0.6)	4 (2.4)

Prey taxa	Fir forest (42 males, 33 females, and 15 juveniles)					Subalpine (45 males, 25 females, 5 juveniles)					Overall	
	J	M	F	n (n%)	f (f%)	J	M	F	n (n%)	f (f%)	n (n%)	f (f%)
Sphecidae							0.6	1.5	13 (0.9)	4 (5.3)	13 (0.6)	4 (2.4)
Vespidae		0.3		1 (0.1)	1 (1.1)		0.1	1.1	7 (0.5)	4 (5.3)	8 (0.4)	5 (3.0)
COLEOPTERA	28.4	44.9	60.7	312 (47.8)	69 (76.7)	84.27	71.6	63.9	1026 (69.5)	70 (93.3)	1338 (62.8)	139 (84.2)
Cantharidae							0.1		1 (0.1)	1 (1.3)	1 (<0.1)	1 (0.6)
Carabidae	18.2	24.9	34.6	177 (27.1)	52 (57.8)	5.62	7.4	6.4	102 (6.9)	38 (50.7)	279 (13.1)	90 (54.5)
Cerambycidae		1.7	5.2	17 (2.6)	7 (7.8)		0.6	1.1	11 (0.7)	6 (8.0)	28 (1.3)	13 (7.9)
Coccinellidae, *Coccinella* sp.		0.6	0.9	4 (0.6)	3 (3.3)	2.25	0.9	1.1	16 (1.1)	6 (8.0)	20 (0.9)	9 (5.5)
Curculionidae	2.3	1.1		6 (0.9)	2 (2.2)	0.00	4.2	4.2	58 (3.9)	12 (16.0)	64 (3.0)	14 (8.5)
Dytiscidae, *Agabus* sp. [a]		1.1	6.2	17 (2.6)	5 (5.6)	2.2	12.5	9.1	157 (10.6)	40 (53.3)	174 (8.2)	45 (27.3)
Dytiscidae, larvae[a]		7.9	7.1	43 (6.6)	15 (16.7)	74.2	44.3	40.1	657 (44.5)	28 (37.3)	700 (32.9)	43 (26.1)
Elateridae		0.6		2 (0.3)	1 (1.1)			0.4	2 (0.1)	1 (1.3)	4 (0.2)	2 (1.2)
Hydrophilidae, *Enchrus* sp[a]								0.2	1 (0.1)	1 (1.3)	1 (<0.1)	1 (0.6)
Scarabaeidae			0.9	2 (0.3)	1 (1.1)						2 (0.1)	1 (0.6)
Staphylinidae	3.4	0.6		5 (0.8)	2 (2.2)		0.6	0.4	7 (0.5)	4 (5.3)	12 (0.6)	6 (3.6)
Tenebrionidae	2.3	4.5	0.9	20 (3.1)	8 (8.9)		0.9	1.1	14 (0.9)	4 (5.3)	34 (1.6)	12 (7.3)
DIPTERA	23.9	16.7	17.5	117 (17.9)	26 (28.9)	6.74	13.8	12.2	189 (12.8)	47 (62.7)	306 (14.4)	73 (44.2)
Asilidae	2.3	2.3	0.5	11 (1.7)	5 (5.6)		0.2		2 (0.1)	1 (1.3)	13 (0.6)	6 (3.6)
Culicidae, *Aedes* sp.[a]	6.8	2.3	1.4	17 (2.6)	6 (6.7)		10.0	7.6	126 (8.5)	31 (41.3)	143 (6.7)	37 (22.4)
Muscidae	3.4	0.6	0.5	6 (0.9)	4 (4.4)		1.1	1.1	15 (1.0)	5 (6.7)	21 (1.0)	9 (5.5)
Syrphidae		4.5		16 (2.4)	2 (2.2)			0.4	2 (0.1)	1 (1.3)	18 (0.8)	3 (1.8)
Tabanidae	6.8	1.7	2.4	17 (2.6)	6 (6.7)			2.0	11 (0.7)	2 (2.7)	28 (1.3)	8 (4.8)
TRICOPTERA	6.8	8.8	4.3	46 (7.0)	9 (10.0)		1.5	2.5	27 (1.8)	5 (6.7)	73 (3.4)	14 (8.5)
Limnephilidae, adult	6.8	8.2	4.3	44 (6.7)	8 (8.9)		1.4	2.5	26 (1.8)	4 (5.3)	70 (3.3)	12 (7.3)
Limnephilidae, larvae[a]		0.6		2 (0.3)	1 (1.1)		0.1		1 (0.1)	1 (1.3)	3 (0.1)	2 (1.2)
LEPIDOPTERA	11.4	1.7	1.9	20 (3.1)	6 (6.7)		1.1	0.5	12 (0.8)	3 (4.0)	32 (1.5)	9 (5.5)
Noctuidae	3.4	1.7		9 (1.4)	3 (3.3)		0.4		3 (0.2)	1 (1.3)	12 (0.6)	4 (2.4)

Prey taxa	Fir forest (42 males, 33 females, and 15 juveniles)					Subalpine (45 males, 25 females, 5 juveniles)					Overall	
	J	M	F	n (n%)	f (f%)	J	M	F	n (n%)	f (f%)	n (n%)	f (f%)
COLEMBOLLA							0.2		2 (0.1)	1 (1.3)	2 (0.1)	1 (0.6)
GASTROPODA		0.3		1 (0.1)	1 (1.1)						1 (<0.1)	1 (0.6)
Planorbidae, *Planorbis* sp.[a]		0.3		1 (0.1)	1 (1.1)						1 (<0.1)	1 (0.6)
OLIGOCHETA	1.1	1.1	0.5	6 (0.9)	5 (5.6)			0.2	1 (0.1)	1 (1.3)	7 (0.3)	6 (3.6)
Lumbricidae, *Lumbricus* sp.[a]	1.1	1.1	0.5	6 (0.9)	5 (5.6)			0.2	1 (0.1)	1 (1.3)	7 (0.3)	6 (3.6)
MALACOSTRACA	2.3			2 (0.3)	1 (1.1)						2 (0.1)	1 (0.6)
Oniscidae, *Oniscus* sp.	2.3			2 (0.3)	1 (1.1)						2 (0.1)	1 (0.6)
AMPHIBIA			0.5	1 (0.1)	1 (1.1)		0.1		1 (0.1)	1 (1.3)	2 (0.1)	2 (1.2)
Ranidae												
Rana macrocnemis[a]			0.5	1 (0.1)	1 (1.1)						1 (<0.1)	1 (0.6)
R. macrocnemis tadpole[a]							0.1		1 (0.1)	1 (1.3)	1 (<0.1)	1 (0.6)
Total number of prey item	88	353	211			89	839	549			2129	
Shannon's index *H'*	2.24	2.37	2.08			2.03	2.14	2.24				

a: aquatic and semiaquatic preys.

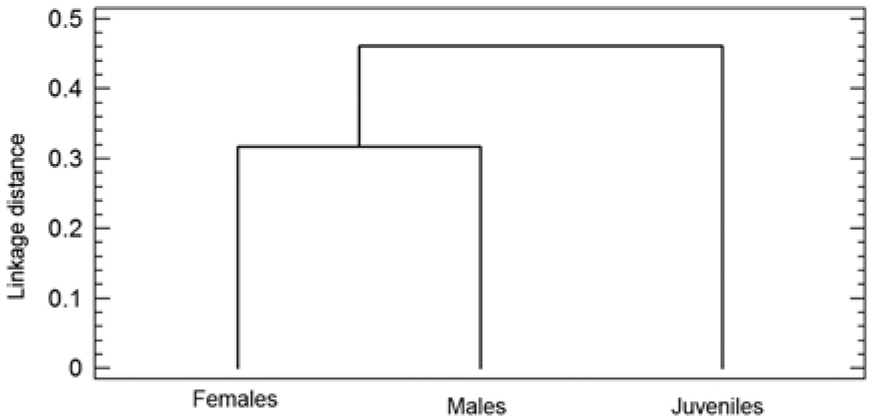

Fig. 2. Cladogram for food niche similarity (*O*) between sexes.

According to the Pianka's niche overlap index (*O*), food compositions of sexes are mostly similar ($O_{m, f}$= 0.99, $O_{m, j}$= 0.95, $O_{f, j}$= 0.94) (Fig. 2). In forest ($O_{m, f}$= 0.99, $O_{m, j}$= 0.95, $O_{f, j}$= 0.94) and subalpine ($O_{m, f}$= 0.99, $O_{m, j}$= 0.92, $O_{f, j}$= 0.93) populations as well, the food contents considerably overlapped within their respective populations. Nevertheless, there are differences between forest and subalpine populations in terms of food composition ($O_{forest, subalpine}$= 0.55). When considering forest and subalpine populations (Shannon's index, *H*), we recorded a close food niche breadth between the sexes ($H_{\text{forest m}}$ = 2.37, $H_{\text{forest f}}$ = 2.08, $H_{\text{forest j}}$ = 2.24; $H_{\text{subalpine m}}$ = 2.14, $H_{\text{subalpine f}}$ = 2.24, $H_{\text{subalpine j}}$ = 2.03). Furthermore, depending on elevation, the individuals inhabiting the forest area had a partially wider food niche breadth (H_{forest}= 2.34, $H_{\text{subalpine}}$=2.16). According to the results of Vanderploeg and Scavia's electivity index (E^*), E^* value ranged from -0.71 to 0.96: Coleoptera (E^*= 0.96), Arenea (0.91), and terrestrial insect larvae (0.88) had the highest values (Table 4). This result also indicates that the food contents of the species vary partially according to the availability of the surrounding prey items.

DISCUSSION

Our study revealed that Uludağ frog, *R. macrocnemis,* feeds largely on various invertebrates and predominantly on the Insecta. The food content consists mainly of Coleoptera, Diptera and Hymenoptera. In previous studies on the species, Arachnida (Araneae), Opiliones, Chilopoda, Diplopoda, Insecta, Gastropoda, Oligocheta, Malacostraca (Isopoda) and Amphibia groups were determined in the food content (Khonyakina, 1973; Velia, 1977; Tertyshnikov et al., 1979; Ushakov and Tusnolobova, 1986; Kuzmin and Tarkhnishvili, 1997; Meschersky, 1997; Kuzmin, 1999; Tarkhnishvili and Gokhelashvili, 1999; Uğurtaş et al., 2004).

It was found that in Caucasian populations, the food content of the species consisted largely of Coleoptera (30–46%), predominantly the Carabidae family (10.0–54.2%) (Khonyakina, 1973; Velia, 1977; Tertyshnikov et al., 1979; Ushakov and Tusnolobova, 1986; Kuzmin and Tarkhnishvili, 1997; Meschersky, 1997; Kuzmin, 1999; Tarkhnishvili and Gokhelashvili, 1999). The other important prey groups that were observed were Diptera and Araneae (Kuzmin, 1999; Tarkhnishvili and Gokhelashvili, 1999). Furthermore, in the study performed in Uludağ, Uğurtaş et al. (2004) encountered preys included in the Insecta group at the rate of 68.0% in the food content of the species and stated that Coleoptera (36.1%), Plecoptera (19.2%), and Diptera (22.1%) were the most significant prey groups. This result also supports the previous studies. Nevertheless, it is noteworthy that the rate of aquatic preys was small in previous studies (e.g. Kuzmin, 1999; Tarkhnishvili and Gokhelashvili, 1999; Uğurtaş et al., 2004). In this study, it was found that the species feeds on both aquatic and terrestrial prey items. Therefore, this shows that it forages both in water and on land. Especially the individuals in the subalpine belt feed on aquatic preys at a higher rate. It is striking that the species observed in the food of the species consist largely of nocturnal prey items. It was also previously reported that the night activity of the species is higher (Ushakov and Tusnolobova, 1986; Çiçek, 2009).

Insects, and particularly Coleoptera, also have a significant place in the food of brown frogs such as *R. arvalis* (Aszalós et al., 2005; Dobenkov et al., 2005; Sas et al., 2005, Stoyanova and Mollov, 2008), *R. dalmatina* (Aszalós et al., 2005; Kovács et al., 2010) and *R. temporaria* (Houston, 1973; Drobenkov et al., 2005, Stoyanova and Mollov, 2008). On the

Table 4. Percentages of potential preys in the environments and Vanderploeg and Scavia's electivity index (*E**) for prey taxa.

Prey Taxa	Prey abundance			E*		
	Fir Forest	Subalpine belt	Overall	Fir Forest	Subalpine belt	Overall
ARANEA	2.62	1.28	1.92	0.951	0.743	0.913
CHILOPODA	1.36	1.05	1.20	0.744	0.609	0.684
DIPLOPODA	0.97	0.83	0.90	-	0.448	0.282
Terrestial larvae	2.70	1.35	2.00	0.713	0.923	0.877
ODONATA	3.00	0.69	1.80	0.395	0.891	0.723
PLECOPTERA	3.23	2.42	2.81	0.482	0.383	0.439
HETEROPTERA	6.74	7.73	7.26	0.464	0.542	0.558
HOMOPTERA	7.20	6.14	6.65	-0.515	-0.700	-0.612
HYMENOPTERA	12.59	15.48	14.09	0.864	0.806	0.844
COLEOPTERA	20.91	25.06	23.07	0.943	0.956	0.958
DIPTERA	18.63	21.97	20.37	0.871	0.806	0.846
TRICOPTERA	6.67	5.96	6.30	0.882	0.662	0.805
LEPIDOPTERA	5.90	4.54	5.20	0.773	0.482	0.662
COLEMBOLLA	2.54	1.56	2.03	-	0.162	-0.119
GASTROPODA	1.63	1.61	1.62	0.171	-	-0.340
OLIGOCHETA	2.36	1.39	1.86	0.708	-0.125	0.501
MALACOSTRACA	0.94	0.93	0.94	0.662	-	0.262

other hand, flying insects play a noticeable role in the feeding of *R. temporaria* (Houston, 1973; Drobenkov et al., 2005).

Besides the invertebrate prey items, one tadpole and one juvenile *R. macrocnemis* were also observed in the food content. It was also previously reported that the species displays cannibalistic behavior (Meschersky, 1997; Kuzmin, 1999; Tarkhnishvili and Gokhelashvili, 1999; Uğurtaş et al., 2004). As competition for food among individuals increases, cannibalism is a mechanism that increases the survival rate (Polis, 1981).

It was also previously reported that the food compositions of ranids are associated with the surrounding prey items (Hirai and Matsui, 2000, 2001; Sas et al., 2005). According to the obtained results, the food habit of the species varies largely by the abundance of the surrounding prey items. However, it does not totally depend on abundance. Particularly in the breeding period, a quite high number of culicid larvae are available in Kirazlıyayla and Sarıalan. Nevertheless, this is barely reflected on the food content. It was also previously reported that no complete relationship was available between food composition of amphibians and the surrounding prey availability (e.g. Cogălniceanu et al., 2000). Generally, no difference was observed among the food contents of females, males and juveniles. The overlapping of the food composition indicates that it does not vary by sex and age and that individuals use the same microhabitat in order to forage (e.g. Hirai and Matsui, 2000, 2001; Parker and Goldstein, 2004). However, differences in terms of abundance of prey items in the forest and subalpine areas also affect the feeding regimes of individuals. Widely-foraging predators encounter and consume mostly non-moving types of prey items (Pianka, 1966). The availability of generally slow-moving prey items in the food content of *R. macrocnemis* shows that the species is an opportunistic widely-foraging predator, like many ranids (e.g. Duellman and Trueb, 1986; Cogălniceanu et al., 2000; Parker and Goldstein, 2004; Sas et al., 2005).

In conclusion, the food habit of *R. macrocnemis* generally varies by the availability of surrounding prey items (Table 4), and it is an opportunistic widely-foraging predator, the food of which consists largely of Coleoptera (mainly Carabidae and Dytiscidae), Diptera and Hymenoptera (mainly Formicidae).

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REFERENCES

Amphibiaweb, (2009): Information on amphibian biology and conservation. <http://amphibiaweb.org/>. Downloaded on 9 September 2009.

Aszalós, L., Bogdan, H., Kovács, É.H. & Peter, V.I. (2005): Food composition of two *Rana* species on a forest habitat (Livada Plain, Romania). North-West. J. Zool. **1**: 25-30.

Başoğlu, M., Özeti, N. (1973): Türkiye amfibileri (The amphibians of Turkey; taxonomic list, distrubution, key for identification pp. 127-138). E. Ü. Fen Fakültesi, Kitaplar Serisi No: 151, Bornova/İzmir. (in Turkish)

Burton, T., Likens, G. (1975): Energy flow and nutrient cycling in salamander populations in the Hubbard brook experimental, New Hampshire. Ecology **56**: 1068-1080.

Cogălniceanu, D., Aioanei, F., Ciubuc, C., Vădineanu, A. (1998): Food and feeding habits in a population of common spadefoot toads (*Pelobates fuscus*) from an island in the lower Danube foodplain. Alytes **15**: 145-157.

Cogălniceanu, D., Palmer, M.W., Ciubuc, C. (2000): Feeding in anuran communities on islands in the Danube floodplain. Amphibia-Reptilia **22**: 1-19.

Çiçek, K. (2009): Uludağ (Bursa)'da yaşayan, *Rana macrocnemis* Boulenger, 1885 (Anura: Ranidae)'in populasyon dinamiği. Unpublished doctoral dissertation, Ege University, Izmir. (in Turkish).

Drobenkov, S.M., Novitsky, R.V., Kosova, L.V., Ryzhevich, K.K., Pikulik, M.M. (2006): The amphibians of Belarus (Advances in Amphibian Research, Vol. 10). Pensoft Publishers, Sofia-Moscow.

Duellman, W. E., Trueb, L. (1986): Biology of amphibians. The Johns Hopkins University Press, London.

Eken, G., Bozdoğan, M., İsfendiyaroğlu, S., Kılıç, D.T., Lise, Y. (2006): Türkiye'nin önemli doğa alanları. Doğa Derneği, Ankara. (in Turkish)

Gotelli, N.J., Entsminger, G.L. (2010): EcoSim: Null models software for ecology. Vers. 7. Acquired Intelligence Inc. & Kesey-Bear. Jericho, <http://garyentsminger.com/ecosim.htm> Downloaded on 6 September 2009.

Hirai, T., Matsui, M. (2001): Food habits of an endangered Japanese frog, *Rana porosa brevipoda*. Ecol. Res. **16**: 737-743.

Houston, W.W.K. (1973): Food of common frog, *Rana temporaria*, on high moorland in northern England. J. Zool. **171**: 153-165.

Khonyakina, Z.P. (1973): On the biology of tailless amphibians of Daghestan. In: Problems of Herpetology, p. 196-197. Nauka, Leningrad. (in Russian)

Kovács I., David, A., Ferenți, S., Dimancea, N. (2010): The food composition of two brown frog populations (*Rana dalmatina* and *Rana temporaria*) from Sălaj County, Romania. Biharean Biologist **4**: 7-14.

Kovács, É.H., Sas, I., Covaciu-Marcov, S.D., Hartel, T., Cupsa, D., Groza, M. (2007): Seasonal variation in the diet of a population of *Hyla arborea* from Romania. Amphibia-Reptilia 28: 485-491.

Krebs, C.J. (1989): Ecological Methodology, Harper and Row, New York.

Kuzmin S.L. (1999): The amphibians of the former Soviet Union. Pensoft, Sofia-Moscow.

Kuzmin, S., Tarkhnishvili, D.N., Ishchenko, V.I., Ananjeva, N., Orlov, N., Tuniyev, B., Sparreboom, M., Uğurtaş, İ.H., Rastegar-Pouyani, N., Papenfuss, T., Anderson, S., Eken, G., Kılıç, D.T., Gem, E., Kaya, U. (2008): *Rana macrocnemis*. In: IUCN 2009, IUCN Red List of Threatened Species, Version 2009.1. <www.iucnredlist.org>. Downloaded on 9 September 2009.

Kuzmin, S.L., Tarkhnisivili, D.N. (1997): Food niche dimensions in a Caucasian amphibian assemblage. In: Advance in Amhibian Research in the Former Soviet Union 2, p. 117-129. Kuzmin, S.L., Dodd, C.K., Eds, Pensoft Publishers, Sofia-Moscow.

Lima, J.E. de P. Rödder, D., Solé, M. (2010): Diet of two sympatric *Phyllomedusa* (Anura: Hylidae) species from a cacao plantation in southern Bahia, Brazil. North-Western Journal of Zoology 6(1): 13-24.
Meschersky, G.I. (1997): The food habits of the Iranian Long - Legged Frog (*Rana macrocnemis*) in North Ossetia. In: Advance in Amhibian Research in the Former Soviet Union 2, p. 111-116. Kuzmin, S.L., Dodd, C.K., Eds, Pensoft Publishers, Sofia-Moscow.
Parker, M.L., Goldstein, M.I. (2004): Diet of the Rio Granade Leopard Frog (*Rana berlandieri*) in Texas. J. Herpetol. **38**: 127-130.
Pianka, E.R. (1966): Convexity, desert lizards, and spatial heterogeneity. Ecology **47**: 1055-1059.
Pianka, E.R. (1973): The structure of lizard communities. Annu. Rev. Ecol. Syst. **4**: 53-74.
Polis, G.A. (1981): The evolution and dynamics of intraspecific predation. Annu. Rev. Ecol. Syst. **12**: 225-251.
Sas, I., Covaciu-Marcov, S.D., Cupsa, D., Cicort-Lucaciu, A. St., Antal, B. (2005): Food habits of *Rana lessonae* and *Rana arvalis* in Covasna County (Romania). Environ. Prog. **4**: 359-365.
Shannon, C.E. (1948): A mathematical theory of communication. AT&T. Tech. J. **27**: 379-423.
Stoyanova, A., Mollov, I. (2008): Diet and trophic niche overlap of the Moor frog (*Rana arvalis* Nilsson, 1842) and the Common frog (*Rana temporaria* L., 1758) from Poland. In: Anniversary Scientific Conference of Ecology, Proceedings, p. 181-190. Velcheva I., Tsekov, A., Eds.. 1 November 2008, Plovdiv, Bulgaria.
Tarkhnishvili, D.N., Gokhelashvili, R.K. (1999): The amphibians of the Caucasus (Advances in Amphibian Research in the Former Soviet Union 4). Pensoft Publications, Sofia.
Tertyshnikov, M.F., Logachova, L.P., Kutenkov, A.P. (1979). On the distribution and ecology of the Caucasian frog (*Rana macrocnemis* Boul.) in the central part of the northern Caucasus. Vestnik Zoologii **1979**: 44-48. (in Russian)
Uğurtaş, İ.H, Yıldırımhan, H.S., Kalkan, M. (2004): The feeding biology of the *Rana macrocnemis* Boulenger, 1885 (Anura: Ranidae), collected in Uludağ, Bursa, Turkey. A. H. R. **10**: 215-216.
Ushakov, V.A., Tusnolobova, T.P. (1986): On ecology of the Caucasian frog (*Rana macrocnemis*) in the Kabardino-Balkarsky Mountain reserve. In: Herpetological Investigation in the Caucasus, p. 170-176. Borkin, L.J., Eds, Proceedings of the Zoological Institute of Leningrad Vol.158, Leningrad. (in Russian)
Vanderploeg, H.A., Scavia, D. (1979): Calculation and use of selective feeding coefficients: zooplankton grazing. Ecol. Model. **7**:135-150.
Veith, M., Kosuch, J., Vences, M. (2003): Climatic oscillations triggered post-Messinian speciation of Western Palearctic brown frogs (Amphibia, Ranidae). Mol. Phylogenet. Evol. **26**: 310-327.
Velieva, Z.D. (1977): Ecology of the Caucasian Brown frog in the biocenoses of Azerbaijan. In: Voprosi Gerpetologii (Abstr. of 4th General Meeting of the Soviet Herpetological Society), p. 55-56. Darevsky, I.S., Eds, Nauka, Leningrad. (in Russian).