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Seasonal changes in the diet of *Rana ridibunda* Pallas, 1771 (Anura: Ranidae) from the Gorele River, Giresun, Turkey

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Abstract. We analyzed the stomach contents of 252 specimens of the marsh frog, *Rana ridibunda,* in the Gorele River habitat of Giresun, Turkey. We found that this species consumed mostly arthropod prey, as well as some prey items belonging to Mollusca, Nematoda and Annelida. Based on prey number, frequency and volume, the most important prey category were insects with beetles, flies and ants predominating. Not only invertebrates but also some vertebrates were found in the stomachs. The highest prey diversity was found in July (62 prey categories) and the lowest in August (38). The highest average prey number was observed in July. Frogs were found to consume large prey items more in June than in the other months. Diet compositions of recaptured individuals varied slightly during the study but confirmed the highest prey number in July. The results of all analyses suggest that the diet of this species varied monthly and correlated with the prey availability.

Introduction

Most anuran species are known to be general predators consuming mainly invertebrates, with some vertebrates being ingested by large frogs (Pough et al., 2001). Since anurans are poikilotherm animals, their activity is related to temperature. In addition, they breed in specific months; therefore, repeating behavioural and ecological observations at different times is important to avoid bias due to daily temperature changes (Houston, 1973). There is also a relationship between the abundance of prey in the environment and in the diet of anurans (Turner, 1959; Houston, 1973).

When studying on the diet composition of any anuran species, the monthly diet variation and the correlation of food composition to prey availability in large sample sizes are important factors. Although there are many records about feeding habits of anurans (e.g., Werner et al., 1995; Ugurtas et al., 2004), only few included these patterns. For example, to detect diet composition of *Rana ridibunda*, Atatur et al. (1993) used only 19 adult specimens; Ruchin and Ryzhov (2002), in a study on this same species, ignored effects of season and prey abundance.

R. ridibunda is distributed in Northern Africa, Middle and Southern Europe and Western Asia (Ozeti and Yilmaz, 1994) and its reproductive season is during the first days of May and the first half of June (Maxwell, 1962). Here we present results of a study on effects of season and prey availability on the diet of *Rana ridibunda* in Turkey.

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Materials and Methods

We selected a population of *R. ridibunda* inhabiting slow flowing water near Giresun, Turkey. The study site (41º02'N, 39º01'E) was near hazelnut and alder trees, and there were no other amphibian species present.

To detect seasonal diet variations, we collected 252 marsh frogs in May (n=40), June (53), July (59), August (52) and September (48) in water or near the water between 09.00 and 16.00 in daylight. After capturing we anesthetized the frogs with diethyl ether as soon as possible and removed stomach contents by flushing method at least three times for each specimen to remove all stomach contents (Legler and Sullivan, 1979). We preserved all contents in 10% buffered formalin for further analysis and measured frogs SVL. After marking frogs individually by toe-clipping, we waited until the anesthetised frogs seemed fine and then released them to their original habitats. On each collecting day, we made sweeps in, on and near the water (up to 0.5 m above) to determine the prey abundance.

We counted all prey items flushed out and identified them to the most practical taxonomic level according to keys by Chu (1949) and Chinery (1993). Larvae and adults of holometablous insects were regarded separately, and empty stomachs were excluded from further analyses. We measured maximum width and length of each item with a calliper (to the nearest 0.1 mm) to estimate their volumes using the formula for an ellipsoid: Volume= 4/3 (Length/2) $(\text{Width}/2)^2$ (Dunham, 1983). For partially digested preys, we used the predetermined length-width regression formulas (Hirai and Matsui, 2001). We calculated the percentages of number, volume and frequency of each prey category. Besides, we recorded the following variables per stomach content: total, average, smallest and largest prey volumes, which were compared using Kruskal-Wallis test (χ^2) and Mann-Whitney U tests.

Table 1. Frog SVL, prey numbers and volumes from the stomach contents of 206 marsh frogs in the population studied.

	SVL (mm)	Prey Number	Total Volume (mm^3)	Minimum Volume (mm^3)	Maximum Volume (mm^3)	Mean Prey Volume (mm^3)
Mean	66.5	9.1	528.7	9.0	258.4	74.1
n	206	206	206	158*	158*	158*
Minimum	19.9	1	0.2	<0.1	0.4	0.3
Maximum	97.6	121	4101	123.2	2330	506.9
SE	1.3	1.1	50.3	1.3	29.4	7.3

* only stomachs with at least three prey items considered

Kendall's rank correlation coefficient (τ) was calculated to detect the relationship between numerical percentage of preys in the environment and percentage of frequency of the same preys in the stomachs. We also used Ivlev's electivity index (Ivlev, 1961) to find out the prey taxa preferred or not preferred by this frog: $E_i=(n_i-r_i)/(n_i+r_i)$ (n_i: relative abundance of prey taxa $_i$, r_i: abundance in the environment; Cogalniceanu et al., 2000). Statistical analyses were conducted with SPSS 10.0 version.

Results

From 206 stomach contents of 252 frogs (46 were empty), 1864 prey items representing 46 prey categories were identified. Mean prey number and volume were, respectively, 9.1 and 528.7 mm^3 per stomachs (table 1). Prey items were belonged into four invertebrate phyla, Arthropoda (having the largest proportions in the diet composition; N%=91.0, F%=98.0 and V%=70.6), Mollusca, Nematoda and Annelida), and one vertebrate taxon (Anura). Insects were the dominant prey (fig. 1). Larval and adult Coleoptera made up the largest fractions in number followed by Diptera, Formicidae and Araneae. In addition to invertebrates, 27 marsh frogs (21 tadpoles and 6 post metamorphic juveniles) were also encountered.

Kruskall-Wallis test showed that prey number, as well as minimum and mean prey volume, changed significantly among months (table 2). For example; we found that more prey items were consumed in July than in the other months, with the highest difference between July and August (*U*-test, z=3.149, P<0.01). The frogs were found to ingest largest prey in June, followed by September, May, August and July. The highest prey diversity was detected in July (62 different taxa identified) and the lowest in August (38).

The most common prey taxa were adult and larval Coleoptera, adult Diptera, Formicidae and Araneae in all months, but in varying proportions. In frequency, number

Months		Prey Number	Total Volume (mm^3)	Minimum Volume (mm^3)	Maximum Volume (mm^3)	Mean Prey Volume (mm^3)
	Mean	8.3	555.6	3.4	346.4	82.8
	n	32	32	25*	25*	25*
May	Minimum	1	0.2	<0.1	8.9	6.4
	Maximum	37	2460.3	21.9	2330.0	437.8
	SE	1.5	121.4	1.1	115.8	22.6
	Mean	5.7	686.0	13.4	338.5	95.3
	n	44	44	36*	36*	36*
June	Minimum	1	0.7	<0.1	11.2	13.1
	Maximum	17	3800.0	62.8	2260.8	407.4
	SE	0.6	131.2	2.6	74.9	14.2
	Mean	19.1	593.7	5.8	180.8	46.5
	n	49	49	41*	41*	41*
July	Minimum	1	0.2	<0.1	0.4	0.3
	Maximum	121	4101.0	91.7	1364.0	506.9
	SE	4.3	123.9	2.3	38.3	12.8
	Mean	4.7	346.3	7.8	196.3	66.8
	n	43	43	29*	29*	29*
August	Minimum	1	3.2	<0.1	1.4	1.1
	Maximum	27	1339.8	36.8	732.4	191.5
	SE	0.7	53.5	1.5	36.2	11.0
	Mean	5.6	446.5	14.4	254.5	87.8
	n	38	38	27*	27*	27*
September	Minimum	1	3.4	0.1	10.1	3.9
	Maximum	18	2959.1	123.2	1099.2	421.9
	SE	0.6	105.2	5.2	54.4	21.4
Kruskall-	χ^2	12.546	4.245	20.411	4.601	14.205
Wallis test	*P*	<0.01	0.374	<0.001	0.331	<0.01

* only stomachs with at least three prey items considered

Table 2. Prey numbers and volumes of marsh frogs in the population studied, separately per month.

and volume, Ephemeroptera, Isopoda, Carabidae, and Adult Diptera had important proportions in May and June whereas they showed a striking decrease in the other months (fig. 2). Orthoptera and Gastropoda were dominating both in frequency and number in August. In July and September, respectively, Scarabaeidae and Oligochaeta were heavily consumed (fig. 3). In insects, larval specimens were seen especially in July. Frogs were consumed in May, June and July (fig. 2) and the volumetric proportion of this prey type was highest in June. According to diet composition of 20 individuals captured more than once, we did not detect any important differences among the five months, but their mean prey number was also highest in July.

The prey types collected in the environment and found in the diet composition were similar but their proportions differed (fig. 4). Although the correlation between the prey availability in the environment and the stomach contents of abundant prey taxa (including 11 categories) was significantly positive (τ=0.514, P<0.05), when larval Lepidoptera and Odonata were excluded from the analysis because of their small fractions in numeric proportions in the environment, the general value of correlation was low and not significant (τ= 0.310, P=0.249). The electivity index calculated suggested that this frog had preferences on some prey types. For example, Heteroptera (E_i=-0.72), Ephemeroptera (-0.91) and Formicidae (-0.56) were apparently avoided by the marsh frogs studied, whereas larval insects (0.52) were preferred to adult insects (-0.23).

Discussion

The results of stomach content analyses of 252 specimens of *R. ridibunda* showed that its diet consisted mainly of Arthropoda followed by some other invertebrate taxa, with an expressed cannibalistic tendency to consume immature individuals of their own species. We found that this species was mostly insectivorous and its foods changed from month to month, weakly correlated with the prey availability except for some prey taxa being not preferred by this frog.

The food types of marsh frogs we detected were similar with those found in ranid frogs in general (Simic et al., 1992; 1995; Cogalniceanu et al., 2000; Ruchin and Ryzhov, 2002), although Atatur et al. (1993) recorded a numeric proportion of insects (97.8%) which was relatively higher than we found (76.1%). The same is true for some other studies (e.g., Ruchin and Ryzhov, 2002). This difference may result from the small sample size (n=19) used by Atatur et al. (1993).

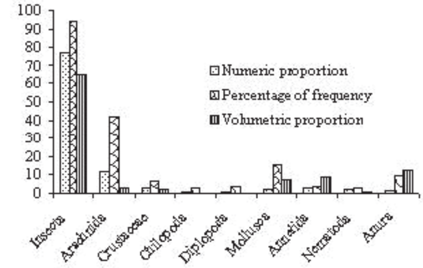

Figure 1. The proportions of the major prey taxa in the diet composition of the marsh frog.

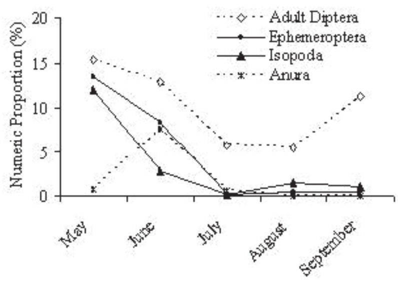

Figure 2. The numeric proportions of some prey taxa especially dominating in May and June.

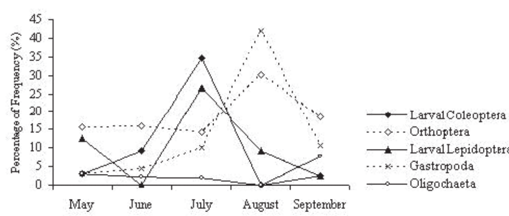

Figure 3. The percentages of frequency of some prey taxa (larval Coleoptera and larval Lepidoptera were dominating in July; Orthoptera and Gastropoda in August; Oligochaeta in September).

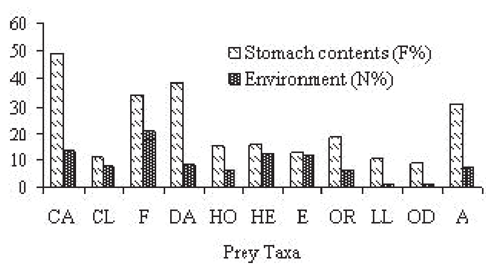

Figure 4. The proportions of some prey taxa in the stomach contents and in the environment (CA, adult Coleoptera; CL, larval Coleoptera; F, Formicidae; DA, adult Diptera; HO, Homoptera; HE, Heteroptera; E, Ephemeroptera; OR, Orthoptera; LL, larval Lepidoptera; OD, Odonta; A, Araneae).

As for example in *Rana catesbeiana* (Smith, 1977), it is known that large frogs occasionally eat vertebrates (Pough et al., 2001). We confirm cannibalism in *R. ridibunda* as reported previously (e.g., Ruchin and Ryzhov, 2002). Rastyatin (1974) and Ruchin and Ryzhov (2002) also found fish and even some mammals such as rats in the stomachs of this species, not detected by us.

In spite of the fact that anuran diets vary monthly (Houston, 1973), there is only one record (Simic et al., 1992) comparing seasonal variations in the diet of marsh frog. There were similarities as well as differences between their results and ours. Similar to our results, prey diversity was highest in July. However, in Simic et al. (1992), Coleoptera and Hymenoptera were dominating in spring and autumn whereas in the population studied here, these prey taxa were dominated in all months with small variations. Crustaceae were found mainly in summer by Simic et al. (1992), whereas we observed this prey mainly in May and June.

Several studies have characterized ranid frogs as general predators, their diets being correlated to prey availability (Turner, 1959; Houston, 1973; Hirai and Matsui, 1999). In contrast, the correlation of these two variables observed in this study was rather weakand several prey taxa were found to be positively or negatively selected by the frogs. For example; the electivity index showed that marsh frog had positive selectivity on larval insects such as larval leaf beetles (Chrysomelidae) whose numeric proportion, in July (N=42.1%), was considerably higher than the results reported so far (Simic et al., 1992; Ruchin and Ryzhov, 2002), indicating a posssibly higher prey electivity in this generalist species in particular populations or seasons.

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