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Food of the Banded Newt, *Triturus vittatus ophryticus* (Berthold, 1846), at Different Sites in Trabzon

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Abstract: The diet of the banded newt, *Triturus vittatus ophryticus*, from 3 different sites in northern Turkey was studied based on stomach contents from 180 samples (104 males + 76 females). The banded newt was found to forage on wide variety of prey organisms in the aquatic phase. Benthic invertebrates consistently made the greatest contribution to the diet, both numerically and volumetrically. Nektonic prey also appeared to be of importance in terms of volume but constituted few items. Terrestrial invertebrates contributed very little to the diet. In addition to invertebrates, a few amphibian prey items were found in the stomachs. The number of major prey taxa in the diet was significantly correlated with the seasons (Kruskal-Wallis test, $P < 0.01$). There were proportionally more Ostracods and Chironomids (larvae and pupae) in the diets of banded newts in spring, whereas *Daphnia* sp. were largely consumed in late summer and autumn. Differences in the size of newts seem to cause a corresponding significant difference in the selection of large and small prey ($r_{max} = -0.247$, $P < 0.05$). We also found that *Triturus vittatus ophryticus* consumed similar prey taxa among sites, but that the frequency of the major prey taxa in the diet was significantly different (Tukey's test: $P < 0.05$) due to ecological conditions.

Key Words: *Triturus vittatus ophryticus*, Feeding, Adults, Trabzon

Trabzon'un Farklı Yerlerinde Yaşayan Şeritli Semender, *Triturus vittatus ophryticus* (Berthold, 1846)'un Besini

Özet: Üç faklı yerde yaşayan şeritli semenderin (*Triturus vittatus ophryticus*) besinini belirlemek amacı ile 180 (104 erkek + 76 dişi) örneğin midesi incelenmiştir. Şeritli semenderin su içinde iken değişik organizmalarla beslendiği, bentik omurgasızların hem sayısal hem de hacimsel olarak en fazla yendiği görülmüştür. Yenilen besinler içerisinde nektonik canlılar sayısal olarak az olmasına karşın hacimsel olarak önemli yer tutmaktadırlar. Karasal omurgasızlar ise çok az yenmiştir. Omurgasız hayvanlara ilaveten birkaç kuyruksuz kurbağanın da besin olarak alındığı tespit edilmiştir. Fazla yenen canlı gruplarının sayısının mevsimsel olarak önemli oranda değişiklik gösterdiği görülmüştür (Kruskal-Wallis test, $P < 0,01$). Osracod ve Chironomidler (larva ve pup) daha çok ilkbaharda yenirken, su presi (*Daphnia* sp.)'nın yaz ve sonbaharda yendiği görülmüştür. Diğer taraftan semenderlerin büyüklüğü ile alınan besinin büyüklüğü arasında önemli ilişki bulunmuştur ($r_{max} = -0,247$, $P < 0,05$). Ayrıca, farklı üç yerde yaşayan şeritli semenderin benzer canlılar yediği fakat bu canlıların yenme sıklığının önemli oranda (Tukey test: $P < 0,05$) farklılık gösterdiği görülmüştür.

Anahtar Sözcükler: *Triturus vittatus ophryticus*, Beslenme, Ergin, Trabzon

Introduction

Feeding relationships in amphibian communities have for a long time been studied by herpetologists and ecologists to understand the role that amphibians play in aquatic ecosystems. Many amphibian species occupy an intermediate position in food chains, being important predators on invertebrates and vertebrates (Hirai and Matsui, 1999).

The caucasian banded newt (*Triturus vittatus ophryticus*) occurs near ponds in different types of forests within the Colchis region from the seashore to the subalpine meadows (Tarkhnishvili and Gokhelashvili, 1999). In northern Turkey, the adults of this newt usually stay in the water from early March to late October, and sometimes November depending on climate and altitude (Andrén, 1997; Kutrup et al., 2003 in press). Although many morphological and taxonomic studies have been performed on this subspecies (e.g., Baran and Yılmaz, 1986; Griffiths, 1996; Olgun et al., 1997; Arntzen and Olgun, 2001), there are no studies on feeding ecology.

Numerous dietary studies on aquatic newts have contributed to a much greater understanding not only of their diet (Dolmen, 1981; Dolce and Stoch, 1984; Fasola and Canova, 1992; Joly and Giacoma, 1992), but also of newt prey selection within a habitat (Szymura, 1974; Dolmen and Koksvik, 1983; Griffiths, 1986; Schabetsberger and Jarsabek, 1995; Whiteman et al., 1996; Denoel and Joly, 2001).

These studies demonstrate that much of what is currently known about the feeding ecology of newts is based on the studies of species inhabiting similar localities. They give no information on diet differences among populations with differences in ecological conditions. Our goal in this paper is to analyse the stomach contents of *Triturus vittatus ophryticus* captured during different seasons (spring, summer and autumn) at 3 different sites in northern Turkey.

Materials and methods

The study sites

We studied 3 banded newt breeding sites in Trabzon, a province in Turkey. The highland site of Hidirnebi (45° 35' N, 5° 43' E, 1300 m alt.) is a channel and has a surface area of 45 m^2 (max. depth: 35 cm). The other site, Sinik, (45° 37' N, 5° 46' E, 850 m alt.) is a natural small pond located in a forest with a surface area of 6 m^2 (max. depth: 125 cm), and the pond in Gurbulak (45° 38' N, 5° 54' E, 600 m alt.) has a surface area of 9 m^2 (max. depth: 268 cm). Monthly water temperatures vary between 8 °C and 21 °C in Hidirnebi, 11 °C and 24 °C in Sinik, and 14 °C and 20 °C in Gurbulak. Vegetation is abundant near the shoreline of the sites and consists mostly of *Carex* sp., and their bottoms are mostly open, muddy and sandy, although the pond in Gurbulak shows differences in having large rocks at the bottom. A few water frogs (*Rana ridibunda*) were seen in all of the aquatic sites, and additionally there were many subadult and adult tadpoles belonging to *Rana macrocnemis* in Hidirnebi.

Sampling and analysis

For stomach content analysis, we collected adult newts (104 males + 76 females) by dip-netting and by hand at 3 aquatic sites in the evenings between 11 April and 6 September 2003. To detect seasonal variation, we made monthly collections (30 samples) from 15 April to 15 September for a total of 60 samples for each site. Immediately after capture, we anaesthetized the newts (MS-222) and measured snout-vent length (SVL; to the nearest 0.1 mm), and extracted their stomach contents using a stomach flushing technique described by Griffiths (1986). The stomach contents were individually stored in vials and preserved in 4% formaldehyde for later analysis. Stomach flushed newts were retained for 3 h for observation and then released where they had been captured.

We examined the stomach contents under a stereomicroscope. Food items were counted and classified down to the higher taxonomic level, except for Crustacea and Daphnidae. We measured the maximum length and width of each item (excluding antennae and cerci) to the nearest 0.1 mm, using either callipers or a calibrated ocular micrometer. As described by Griffiths (1986) we calculated volumes of prey items using the formulae $V = 4\pi ab^2/3$ (Ostracoda, Uredela) and $V = 4\pi a^2b/3$ (Cladocera, Hemiptere and Bivalvia) for an ellipsoid. We also used the formulae $V = 0.5(4\pi ab^2/3)$ for hemi-ellipsoid (Copepod, Coleoptera) and $V = 2a(\pi b^2)$ for cylindrical items (larvae and nymphs of insects). For partially digested prey items, we estimated length by measuring widths and then using predetermined length-width regressions from intact prey (Griffiths, 1986; Hirai and Matsui, 1999).

To estimate the relationship between the newt SVL and the volumes of the largest and smallest prey in a stomach, we calculated correlation coefficients. Only those newts with at least 3 prey items in their stomachs were included in this analysis. The Friedman ANOVA was used to determine if the prey sizes had an effect on the frequency of prey items consumed between the sexes. Seasonal fluctuations in the number of prey items were examined using the Kruskal-Wallis test. We also compared frequency of occurrence of different kinds of major prey taxa among 3 sites using Tukey's- test.

Results

Diet composition

We identified 3784 individual prey items extracted from the stomachs of 167 of the 180 newts captured. Average number of prey per stomach was 19.6 ± 54.48 (X ± SD). The remaining 13 newts captured during summer (June and July) had no prey items in their stomachs (Table 1).

Table 1. Diet composition of *Triturus vittatus ophryticus* collected from Gurbulak, Sinik and Hidirnebi from 11 April to 6 September, 2003, grouped ecologically (terrestrial, benthic, zooplankton and nektonic), (l: Larvae, p: Pupae, i: Imago, Total prey: 3784, Total volume: 5199.37 mm ^{3}).

Prey taxa	Common name	Numeric % n	Volumetric % V	Frequency %
Terrestrial				
Cecidomyiidae (i)	Gall midges	0.10	0.22	1.66
Formicidae (i)	Ants	0.26	5.17	3.33
Psyllidae (l)	Suckers	0.21	0.11	2.77
Cicadellidae (i)	Leafhoppers	0.10	0.07	1.66
Isopoda	Woodlice	0.31	2.17	2.22
Diplopoda	Millipedes	0.21	0.69	2.77
Pauropoda	Pauropods	0.05	0.04	1.11
Benthic				
Chironomidae (l)	Midges	3.75	2.33	54.44
(p)		6.07	5.04	19.04
Tipulidae (l)	Crane flies	0.15	0.86	1.11
Simulidae (l)	Black flies	0.52	0.08	7.77
Amphizoidae (l)	Sluggish beetles	0.39	1.30	6.66
(i)		0.05	0.02	1.11
Hydroscaphidae (i)	Water scavengers	0.10	0.05	1.66
Staphylinidae (l)	Rove beetles	0.15	0.09	2.22
Ephemeroprera (l)	Mayflies	2.90	2.71	43.03
Odonata	Dragonflies	0.18	0.09	2.77
Ostracoda				
Cypris sp.	Seed shrimp	65.53	21.22	47.80
Gammarus sp.	Shrimp	0.52	2.10	7.77
Gastropoda	Pond Snail	0.73	10.98	15.03
Bivalvia	Freshwater mussels	2.06	12.82	22.20
Nematoda		1.84	4.10	5.05
Nektonic				
Dytiscidae (l)	Water beetles	0.58	4.19	8.09
Corixidae (i)	Water boatmens	0.58	6.24	10.04
Nepidae (i)	Water scorpions	0.10	3.31	2.22
Saldidae (i)	Shore bugs	0.05	0.72	1.11
Salamandridae				
T. vittatus (l)	Banded newt	0.07	3.77	1.77
Zooplankton				
Daphnia sp.	Water flea	10.30	1.47	21.10
Cyclops sp.	Copepods	0.76	0.05	7.82
Eggs		0.47	0.35	8.36
Unidentified		0.84	7.69	13.31

The main food of this newt was crustaceans, which made up the highest proportion (77.14%) in number as well as in volume (24.85%) of the total prey. *Cypris* sp. were primarily eaten by this newt, in terms of both number and volume. *Daphnia* sp. another prey including water fleas, were also consumed widely in number, but not in volume. Gammarids represented a small proportion in terms of number and volume.

The other modal group was Insecta, which was preferred by this newt, and that made up 19.68% in number and 32.70% in volume of the total prey. Among Insecta, true flies made up the largest proportion in number, followed by mayflies and beetles. In contrast, bugs made up the largest proportion in volume, followed by true flies, beetles, and mayflies. Other flies were a minor component of the diet in both number and volume. Various true fly taxa, such as midges, crane flies, black flies and gall midges were found in the diet composition. The most important components was pupae, which made up 57.02% in number, and the prey of larvae also appears to be of importance (41.78%) in the number of flies. Only 4 adult prey belonging to gall midges were observed. We described various larvae and adults belonging to groups of beetles, such as sluggish beetles, water beetles, water scavengers and rove beetles. In beetles, Amphizoa live under stone, and were also often encountered in the diet in both larval and adult forms. However, all of the prey belonging to bugs were adult, and they made up an important proportion in volume (10.97%) in diet composition, but not in number (0.73%) of the total prey. Among the bugs, water boatmen were more frequently encountered in the stomachs compared with the other bugs.

Unidentified prey items excluding antennae, wing, cerci and other parts, occurred in 0.84% (in number) of stomach contents. In addition, plant materials (vegetation and seeds) and bottom mud were also identified in 28.33% of frog stomachs examined.

Data on the diet of the banded newt were also divided into groups by prey habitat for the purpose of comparing the food items. Benthic invertebrates consistently made up the largest components of stomach contents in number (75.68%) as well as in volume (54.43%). Although zooplankton (11.54%) and nektonic prey (11.7%) appeared to be of similar importance in terms of number their relative contributions to stomach contents in volume were different. Nektonic prey formed a larger part of the diet in terms of volume (27.50%) compared with zooplankton (1.18%). The contribution of terrestrial prey was consistently low during feeding in aquatic conditions. In addition to invertebrates, a few amphibian prey items were found in the stomachs. Three of these were newly metamorphosed newts, *Triturus vittatus ophryticus*, and the others were eggs of this newt (Table 1).

Seasonal variation

We found that small crustaceans had the highest frequency of occurrence in the stomachs examined from April to September (Figure 1). True flies, mayflies and mollusks were also frequently consumed. However, the frequency of these taxa fluctuated over the seasons, and the time of peak frequency differed among prey taxa. Diptera and crustaceans were mostly consumed from April to May (100%), whereas beetles were taken in May (66.6%) and mayflies in August (82.6%). On the other hand, this newt regularly consumed mollusks during all months except for June. While the frequency of occurrence of Coleoptera, Mollusca and Ephemeroptera showed a decrease in September, crustaceans largely occurred (93.3%) in this month, although no diptera were seen in this month.

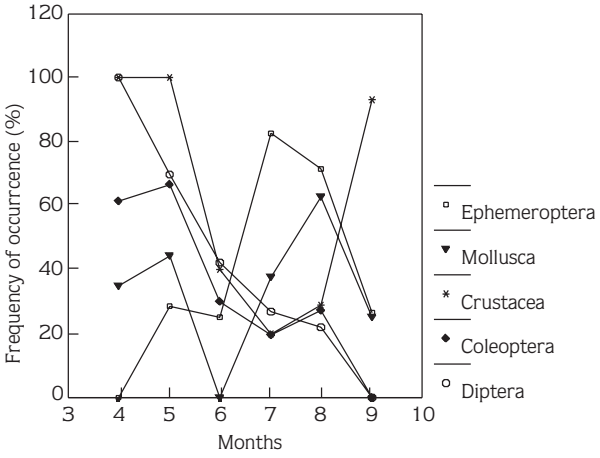

Figure 1. Seasonal variations in frequency of the major prey taxa.

Seasonal variation in number of prey items found in the stomachs of *Triturus vittatus ophryticus* fluctuated over the seasons (Figure 2). This newt consumed significantly more prey items in April and May than it did in other months (Kruskal-Wallis test, $P < 0.01$). Although chironomids (larvae) and ostracods were largely eaten in spring their numbers was decreased sharply in early summer (in June). In July and August newts took more prey items belonging to mayflies. Most of the prey items identified in September were *Daphnia* sp. whereas we did not find any chironomid larvae or pupae in this month.

Diet change

Comparisons of adult newt SVL with minimum and maximum prey volumes revealed that they (46.5-67.8

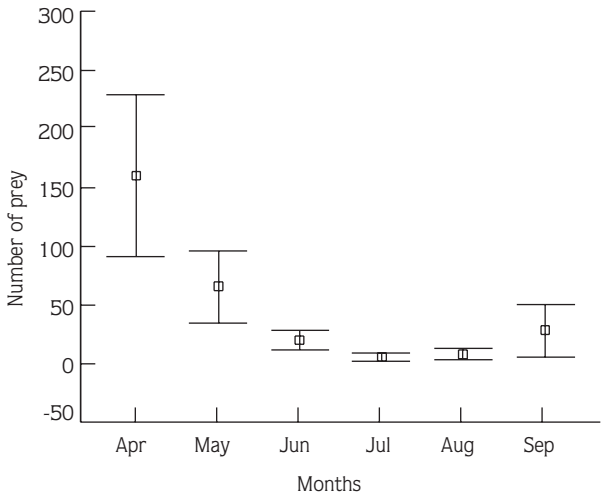

Figure 2. Seasonal variations in number of prey items (mean ± 2 SE) found in stomachs of *Triturus vittatus ophryticus.*

mm SVL) frequently consumed different prey taxa in terms of their sizes. Although large prey such as gastropods (7.1-252.8 mm^3), bugs (13.7-44.2 mm^3), bivalves (4.53-10.6 mm^3) and sluggish beetles (1.80-14.28 mm^3) were significantly (r_{max} = -0.247, $P < 0.05$) consumed by large individuals (>60 mm SVL), other small prey, such as *Cypris* sp. (0.16-0.34 mm^3) and *Daphnia* sp. (0.12-0.39 mm^3) were frequently consumed by all sizes of banded newts (r_{min} = -0.07, $P > 0.05$). Nonetheless, no significant difference was found between the sexes in terms of minimum prey (ANOVA, F: 2.616, df: 118, $P > 0.05$) and maximum prey (F: 0.03, df: 118, $P > 0.05$) consumed during the seasons.

Comparisons of diet composition among the 3 sites showed that *Triturus vittatus ophryticus* consumed similar prey taxa (Table 2), but that the frequency of occurrence of the major prey taxa in the diet of newts was significantly different (Tukey's test: $P < 0.05$). Although crustaceans and diptera were more frequently consumed than the other prey taxa, their numeric proportions and frequency of occurrence differed among the sites. Copepods and water fleas were largely found in Gurbulak, whereas Sinik newts frequently consumed ostracods. Beetles also varied in frequency of occurrence among the sites and were less consumed by the Gurbulak newts (8.3%) than by the others (43.7% in Sinik and 27.8% in Hidirnebi). Freshwater mussels, suckers and water scavengers were largely found from Sinik specimens, while gastropods and mayflies seemed to be mostly eaten by the Gurbulak newts. On the other hand, we described many nematodes, newt eggs and leafhoppers from the Hidirnebi newts. Additionally, a higher proportion of larvae and pupae of insects such as chironomids and beetles were found in the stomachs of the Sinik newts.

Discussion

Analysis of prey items in the stomachs of *Triturus vittatus ophryticus* shows that banded newts forage on a large variety of prey items present in their environment, mainly small crustaceans and other large aquatic insects, together with a small number of terrestrial arthropods that fall into the water.

Table 2. Comparisons of diet composition of 180 newts (for each site: n of newts/n of prey) among the 3 sites (N: numeric proportion (%), F: frequency of occurrence.)

	Sinik (60/2080)		Gurbulak (60/1360)		Hidirnebi (60/344)	
Prey taxa	N	F	N	F	N	F
Crustacea	84.32	100	80.88	76.4	18.89	22.5
Diptera	8.80	82.8	5.82	27.3	45.18	45.2
Coleoptera	0.99	43.7	0.35	8.3	7.80	27.8
Hemiptera	0.19	6.6	1.33	12.6	1.47	8.4
Ephemeraptera	0.50	15.2	3.21	55.3	18.07	19.7
Odonata	0	0	0.22	21.9	1.18	13.4
Gastropoda	0.14	5.0	1.47	33.4	0	0
Bivalvia	2.16	58.3	0.73	8.33	6.68	15.0

Bottom living ostracods were the major components and had a high frequency of occurrence in the stomachs (47.80%). In contrast, Dolce and Stoch (1984) reported that *Ilyocypis gibba* was the major prey for *Triturus vulgaris*. In addition to, Dolmen and Koksvik (1983) found that the major preference of *T. vulgaris* and *T. cristatus* was Cladocera. Planktonic water fleas, *Daphnia* sp. do not make a great contribution to the diet of *T. v. ophryticus*. Total chironomids (benthic larvae and free-swimming pupae) showed the highest frequency (59.34%), but not in terms of number (6.54%). However, Joly and Giacoma (1992) found that chironomids were the major prey in terms of number for *T. italicus*. They also said that *T. alpestris* foraged particularly on terrestrial isopods living in vegetation on the bottom. In this study, the amount of their (4 records) contribution to nutrition was very low (0.31% in number). These results support the hypothesis that the feeding models of newt species are different, as stated by Dolmen (1983).

Body size is an important factor in determining the size of prey consumed (Dolmen and Koksvik, 1983; Griffiths, 1986; Fasola and Canova, 1992; Joly and Giacoma, 1992; Denoel and Schabetsberger, 2003). *Triturus vittatus ophryticus* conformed to these results, as shown by the significant correlation between prey size and SVL. Our results indicate that the largest prey, gastropods (252.8 mm^3), is only eaten by the newts (>63 mm SVL) whereas small prey such as crustaceans, larvae and pupae of dipterae are mostly taken by both small (46.6-56.4 mm SVL) and large newts, which seems to indicate that the difference in size of adult newts causes a corresponding significant difference in the selection of large or small prey.

Fasola and Canova (1992) reported that prey items were consumed in relation to their cycles of availability in the pond, while fluctuating prey were absent. In addition, prey with lower overall electivities showed seasonal effects when the availability of other preferred prey decreased (Measey, 1998). Indeed, certain prey such as small tube-building chironomids and ostracods were consumed by this newt during spring, but their frequency in the diet decreased during summer, and newts consumed other variable prey (pond snails and copepods) instead of tube-building prey in this period. On the other hand, newts caught waterflies in September and mayflies in June. It also seems that seasonal effects may be an important factor in determining what newts eat (Griffiths, 1986; Measey, 1998). However, fewer food items appear to be consumed by this newt in summer (June, July and August) than in the other seasons (spring and autumn). In contrast, Pellantova (1973) observed that the stomachs of *T. vulgaris* are fuller in June than in April.

Diet composition differed among the 3 sites (Sinik, Gurbulak and Hidirnebi). Only the prey taxon Hemiptera (bugs) showed a similar composition in the newt diet among the sites. In general, the prey number found in the stomachs of the newts in Hidirnebi (highest site) was lower than in those the other sites. Hidirnebi is shallower than the other wetland sites (Sinik and Gurbulak), and rocks, which provide shelter during the day, are rare and mud covers most of the bottom. In addition to the possibility of there being less food in Hidirnebi, low temperatures at this site may affect the feeding activity of newts (Griffiths, 1986). These results confirm that the ecological conditions at different breeding sites play an important role in determining the diet composition of *Triturus vittatus ophryticus*. Similar results were reported only for *Triturus alpestris* in 2 lakes in Greece (Denoel and Schabetsberg, 2003). Additionally, a higher proportion of insect larvae and pupae were described in the stomachs of the Sinik newts living in warmer temperatures compared with the other sites. This is similar to the situation observed in the Greek lakes (Denoel, 2001).

Although crustaceans made up the largest proportion of this newt diet in terms of number, insects (larvae and adults) constituted the highest proportion in terms of frequency (90%). This evidence suggests that *T. vittatus ophryticus* is also an insectivore like anurans (Hirai and Matsui, 1999).

We frequently found plant remains in the stomachs of *Triturus vittatus ophryticus*. As stated by Griffiths (1986), such materials might have been accidentally taken as a by-product when consuming small prey among the vegetation. We also found bottom mud in some stomachs examined in spring as described by Dolmen and Koksvik (1983).

Evidence of cannibalism in the diet of newts (Dolmen and Koksvik 1983) was also detected in this study. Newly metamorphosed newts were found in early summer (June), in which the prey items were low compared with the other seasons. It is probable that the number of

newly metamorphosed newts in the diet (3 records) underrepresented the extent to which predation occurred.

Future research that concentrates on the diet of the banded newt in the terrestrial phase may be more profitable in determining the feeding ecology of this newt throughout the course of a year.

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