Food Habits of the Lycian Salamander, *Lyciasalamandra fazilae* (Başoğlu and Atatür, 1974): Preliminary data on Dalyan Population

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Abstract. We analyzed stomach contents of 21 (13 ♂♂, 8 ♀♀) adult Lycian salamanders, *Lyciasalamandra fazilae*, inhabiting Gökbel and İztuzu, south of Dalyan (Köyceğiz, Muğla). Although various terrestrial invertebrates constitute the diet of the salamander, larvae and adult beetles (39.61%), centipedes (16.88%) are the most important food groups. *Lyciasalamandra fazilae* is an active predator capable of changing its feeding regime in proportion to the species richness within its habitat.

Key words: Lycian Salamander, *Lyciasalamandra fazilae*, Food Composition, Turkey

Introduction

Distribution of genus *Lyciasalamandra (Lyciasalamandra luschani, L. atifi, L. antalyana, L. billae, L. fazilae, L. flavimembris* and *L. helverseni*) ranges from Greece to the south and southwest of Turkey as well as some islands including Kastellorizon, Meyisti, Kekova, and Carpathos (Veith & Steinfartz 2004). One of these, *Lyciasalamandra fazilae*, was first described by Başoğlu & Atatür (1974) in the vicinity of Gökçeovacık, Dalyan and Üzümlü (Muğla). Lycian Salamander is restricted to the southern Anatolian coast, Turkey, where it is found from northeast of Fethiye to the western shore of Lake Köyceğiz (range= ~688 km²).

The species is listed as endangered in the Red List Category and Criteria of IUCN because its extent of occurrence is less than 5,000 km², its distribution is severely fragmented, and there is continuing decline in the extent and quality of its habitat (Tok et al. 2006). It is potentially threatened by habitat loss caused by forest fires and over-collection for scientific purposes.

Lycian salamander is mainly terrestrial, inhabits rocky limestone areas usually in pine forests and marquis, and is found sometimes under stone accumulations on hillsides without vegetation (Başoğlu & Özeti 1973, Baran & Atatür 1998). It is found at elevations between 15 and 1025 m and lives in places where mean annual rainfall is less than 1000 mm.

Although age structure (Olgun et al. 2001), breeding (Poylmeni 1994; Özeti 1973, 1979), feeding biology (Polymeni 1989, Düşen et al. 2004) and gregarious behaviour (Gautier et al. 2006) of Mediterranean and Greece populations of *Lyciasalamandra* species have been documented, data on the biology of Lycian salamander are still scarce (Veith et al. 2001).

The aim of the present study is to present the food habits of Lycian salamander in Gökbel and İztuzu populations.

Materials and Methods

The study site is located in Gökbel and İztuzu, (36° 46' N, 28° 40' E, 105 m a.s.l.) south of Dalyan (Köyceğiz, Muğla) southwest Turkey. Dominant plant species in the biotope of individuals inhabiting stony clearings in a pine forest (*Pinus brutia*) include *Asphodelus aestivus* and *Ballota acetabulosa*. These species are accompanied by others such as *Geranium disectum, Picnomon acarna, Scandix pecten-veneris, Crepis sancta, Aucalyptus cameldulensis, Euphorbia egzugea,* and *Delphinium staphystagia*.

We captured salamanders during daytime between 10.00h and 14.00h under stones. The mean temperatures were 17°C during the sampling conducted on March 3, 2006 and 27°C on April 22, 2006. Within half an hour following capture, we anaesthetized individuals in a 1 % solution of MS-222 (methane tricaine sulfonate) in the field and extracted their stomach contents by forced regurgitation with forceps (Hirai & Matsui 2001). We preserved the contents in 70% ethanol for later analysis. We measured snout-vent lengths of all the individuals to the nearest 0.01 mm with a dial calliper. After these procedures, we marked the salamanders by toe-clipping and released them on the spot where they were captured. We collected and observed potential preys of the study area in order to be able to compare stomach contents with environment.

The prey items were identified (Chinery 1992, 1993, Demirsoy 1998, Lodos 1982, 1984, 1989, Roberts 1995, Stoev 2002) to the lowest possible taxon and lengths and widths were measured. Approximate volumes of prey items were calculated using the formula for an ellipsoid (Dunham, 1983):

$V = 4/3\pi\ (L/2)\ (W/2)^2,$

In the formula above, L is length of prey and W is the width of prey.

Plant material found in the stomach contents included mosses, seeds, and small leaves, and was most likely ingested accidentally during foraging. Unidentified arthropods in this study usually consisted of a wing, a leg, or a body segment, which may indicate either the salamander was unable to capture the entire prey item or remaining portion of the prey item was not detected because it had passed through the digestive system at a different rate. The food contents were assessed with respect to frequency of occurrence, numeric proportion and volumetric proportion. Since the distribution of data was significantly different from the normal distribution (Kolmogorov-Smirnov test, $P<0.05$), averages were compared with the non parametric Mann Whitney U test. The significance level was $P\leq 0.05$.

Results

During the study, 21 adult individuals (13 ♂♂ and 8 ♀♀) were captured. The mean snout-vent length (hereafter SVL) (±CI) was determined as 61.12±1.30 (range= 58.03 - 64.97mm) at males, and as 62.38±4.07 (range= 50.97 - 68.53mm) at females. No statistically significant difference was observed between sexes with respect to SVL (Mann-Whitney U test, $P > 0.05$). From the stomach contents of 21 individuals, 154 prey items were extracted with a median (±CI) number of 7.00 ± 5.79. Slight differences were observed between sexes with respect to number of prey items per stomach, frequency of occurrence, numeric and volumetric proportion; nonetheless, these were not statistically significant (Mann-Whitney U test, $P> 0.05$).

Diverse arthropods and molluscs along with plant material and minerals were also encountered. Arthropoda contained six classes (Malacostraca, Diplopoda, Arachnida, Chilopoda and Insecta) and constituted 93.49% of food contents by number. Insecta included 6 orders and made up 55.19% by number, 82.26% by volume of stomach contents.

Among the prey taxa shown in Table 1, coleopteran larvae (71.43%), centipedes (66.67%), spiders (38.09%) and terrestrial snails (33.33%) were frequently consumed by Lycian Salamander (frequency of occurrence >30%). Coleopteran larvae (39.61%) and centipedes (16.88%) (>10%) were numerically the most consumed prey items. Volumetrically, larval coleopterans (82.01%) and centipedes (16.67%) were the most important food items among the preys. Larval preys constituted 31.82% of stomach contents by number and 82.02% by volume. The most diverse orders were Coleoptera (larvae of Carabidae, Elateridae, Tenebrionidae, Coccinellidae, and Curculionidae) and Araneae (Araneidae, Lycosidae, and Salticidae).

Gastropoda was determined as the only class belonging to phylum Mollusca. It made up 6.49% of total preys by number, and 0.10% by volume. Regarding stomach contents, the class was represented by the families Vertiginidae (n%=3.90, v%=0.09) and Polygyridae (n%=2.60, v%<0.01). Furthermore, plants (n%= 3.25, v%<0.01) and minerals (n%=1.95, v%<0.01) were also found in food contents. Highly digested prey items accounted for 2.30% total stomach contents.

Our field studies revealed presence of prey animals in the biotope

Table no.1 Food composition (in %) of *Lyciasalamandra fazilae* (154 preys from 21 stomachs, total volume 4824.58mm^3).
f%= frequency of occurrence, n%= numeric proportion, v%= volumetric proportion.

Prey Taxa	**f%**	**n%**	**v%**
Insecta	95.24	55.19	82.26
Orthophtera	4.76	1.30	<0.01
Hemiptera	4.76	1.30	<0.01
Lygaeidae	4.76	1.30	<0.01
Homoptera	4.76	2.60	<0.01
Coleoptera	85.71	39.61	82.09
larvae	71.43	28.57	82.01
Carabidae	14.29	3.25	0.02
Elateridae	4.76	1.30	<0.01
Tenebrionidae	4.76	3.25	0.05
Coccinellidae	4.76	0.65	<0.01
Curculionidae	4.76	1.30	<0.01
Diptera	19.05	5.20	0.02
larvae	4.76	1.95	<0.01
Culicidae	9.52	2.60	0.01
Lepidoptera	9.52	1.30	0.01
larvae	9.52	1.30	0.01
Hymenoptera	14.29	1.95	<0.01
Formicidae	14.29	1.95	<0.01
Arachnida	38.09	8.44	0.29
Araneae	38.09	8.44	0.29
Araneidae	14.29	1.95	0.01
Lycosidae	28.57	4.54	0.23
Salticidae	14.29	1.95	0.05
Malacostraca	23.81	5.19	0.13
Isopoda	23.81	5.19	0.13
Oniscidae	19.05	4.54	0.13
Chilopoda	66.67	16.88	16.67
Lithobiomorpha	14.29	3.25	0.10
Geophilomorpha	42.86	13.64	16.58
Diplopoda	28.57	7.79	0.55
Julida	9.52	1.95	<0.01
Gastropoda	33.33	6.49	0.10
Stylommatophora	33.33	6.49	0.10
Vertiginidae	23.81	3.90	0.09
Columella sp.	23.81	3.90	0.09
Polygyridae	14.29	2.60	<0.01
Cryptomastix sp.	14.29	2.60	<0.01
Plant	19.05	3.25	<0.01
Mineral	14.29	1.95	<0.01
Unidentified	19.05	2.30	<0.01

belonging to orders such as Stylommatophora, Chilopoda, Diplopoda, Isopoda, Arachnida, Formicidae, Diptera, and Coleoptera. Considered potential food in the environment, all of these prey groups were encountered in the stomach contents in varying proportions.

Discussion

The present study revealed that Lycian salamander feeds on a variety of invertebrates, and particularly, terrestrial arthropods constitute an important part of its diet. The previous studies on other salamander species showed that feeding habits of individuals were strongly affected by habitat conditions such as soil moisture, season and prey availability (e.g. Gunzburger 1999, Jaeger 1972, Martof & Scott 1957). Various other studies related to *Lyciasalamandra* species also mentioned that the individuals in the biotope consumed available prey (Düşen et al. 2004, Polymeni 1989), meaning that the salamanders are an opportunistic feeder in that habitat. The present study also confirms the findings of other studies on this species, namely that the Lycian salamander is an opportunistic predator.

Our study indicates that Lycian Salamander prefers beetles, spiders, centipedes, millipedes and terrestrial gastropods as food. Especially larval coleopterans and centipedes are the most important food items in its diet. The earlier studies reported that larval and adult insects were predominantly consumed preys, and the other groups included gastropods, millipedes, pill bugs and sow bugs. (Baran & Atatür 1998, Polymeni 1989). Düşen et al. (2004)'s findings suggested that adult coleopterans (33.04%) were the main prey of *Lyciasalamandra luschani*, *L. atifi*, *L. antalyana*, *L. billae*, *L. fazilae* and *L. flavimembris* whereas gastropods (19.59%) and spiders (10.82%) were other important preys. European Fire Salamander, *Salamandra salamandra*, also consumes Gastropoda, Miriapoda, and Araneae most frequently (Covaciu-Macrov et al. 2002).

Considering the variety of food groups found in the stomach contents, it could be stated that *Lyciasalamandra fazilae* has a wide range of prey in its diet. The finding that especially larval preys have a considerable volume in the food contents shows that the individuals need to have a sophisticated sense of sight in order to be able to detect and catch such slow-moving prey animals. Eyes are the primary sensory organs for feeding and movements of the prey trigger a response for eating (Duellman & Trueb 1986, Pough & Magnusson 1992, Stebbins & Cohen 1995). Moreover, adult insects provide less energy compared to larvae because their bodies are covered with chitin. Preference of larvae by the individuals is most probably due to the urge for consuming the calories they need in a shorter period of time (Jager & Rubin, 1982). Yet another possibility could be the fact that larval preys can be captured much easier than adult insects.

Considering the variety of prey groups observed in the area, the percentages of preys in the stomach contents were expected to be different than what we determined; however, prey groups such as coleopteran larvae, centipedes, spiders and isopods were seen to be consumed more compared to other prey groups. This is probably associated with the potentiality of prey capture by the individuals. The high percentage of other prey groups such as spiders, centipedes and terrestrial gastropods is connected with the large possibility of their occurrence under stones. This largely increases the likelihood of these preys to be used as food by predators. Furthermore, a widely distributed prey animal in the biotope like Formicidae (ants) is rarely encountered in the food content, indicating that the individuals could exhibit fussy behaviour during foraging. The findings in limited amount of flying *Insecta* groups such as dipterans, lepidopterans, hymenopterans, hemipterans, homopterans and orthopterans in the food content stem from the fact that possibility of capture by the individuals is rather low. The predator should than choose its diet relative to the abundance, or availability, of the most profitable prey type (Krebs, 1978). Poor-flying or non-flying prey abundant under stones were observed in the stomach contents of the population we have examined, indicating that the Lycian salamander is an active predator (sensu Huey & Pianka 1981).

Despite small differences in percentages, no statistically significant difference was found between the sexes with respect to food contents. Sexual dimorphism is generally lower in urodeles (61%) (Shine 1979). In Lycian salamander, no statistically significant difference was observed between sexes with respect to SVL. This stems from the fact that females and males use the same microhabitat during foraging. In addition, Düşen et al. (2004) stated that there are no difference stomach contents between sexes.

In conclusion, *Lyciasalamandra fazilae* is an active predator usually feeding on poor-flying or non-flying terrestrial preys, and its food composition can change in proportion to the species richness of the habitat it lives in. The fact that salamanders, such as Lycian salamander, inhabiting forest biotopes feed on terrestrial invertebrates from that particular biotope is a clear indication of the significant role they play in balancing the populations of these prey groups. We firmly believe that the data we have obtained will contribute to the little-known biology of this species, and detailed studies to be conducted on different populations of this endangered species will shed light on researchers for successful implementation of measures to be taken.

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