THE FOOD OF FOUR *SALAMANDRA SALAMANDRA* POPULATIONS FROM DEFILEUL JIULUI NATIONAL PARK (GORJ COUNTY)

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Abstract. *We have analyzed 111 Salamandra salamandra specimens belonging to four different habitats from Defileul Jiului National Park. Our field studies were done between 9 and 10 of September, 2007, using the stomach irrigation method. Though vegetal fragments, shed-skin, minerals, and Gastropod's eggs were identified in the stomach contents, the main part of the food was represented by Invertebrates, mostly land animals. We noticed a high preference for preys with larger size and lower speed (Diplopoda, Araneida, Lumbricidae, Lepidoptera larva, etc), along with these, flying insects were also present (Lepidopterans). Salamandra salamandra is a polyphagous animal, going for the most accessible preys from its habitat.*

Keywords: *Salamandra salamandra, trophic spectrum, habitats, polyphagous.*

Rezumat. Hrana a patru populaţii de *Salamandra Salamandra* din Parcul Naţional Defileul Jiului (Judeţul Gorj). *Am analizat 111 exemplare de Salamandra salamandra preluate din patru habitate diferite din Parcul Naţional Defileul Jiului. Prelevarea probelor s-a făcut în perioada 9 şi 10 septembrie 2007, folosind metoda spălăturii stomacale. În conţinuturile stomacale am identificat fragmente de vegetale, de exuvie, minerale şi pontă de Gastropode. Cele mai importante conţinuturi stomacale sunt reprezentate de nevertebrate, mai ales de cele de provenienţă terestră. S-a observat un consum ridicat al prăzilor de talie mai mare şi de mobilitate redusă (Diplopode, Araneide, Lumbricide, larve de lepidoptere etc.), dar am constatat în acelaşi timp şi prezenţa insectelor zburătoare (lepidoptere). Salamandra salamandra este un prădător polifag, care consumă prăzile cele mai accesibile în habitatul pe care îl populează.*

Cuvinte cheie: *Salamandra salamandra, spectrul trofic, habitate, polifag.*

INTRODUCTION

Salamandra salamandra is wide-spread in Europe, and also in the Central-East and North-Western regions of Africa (JOLY 1968). This species entered Romania's territories in the post-glacial periods (STUGREN, 1957), nowadays being encountered at altitudes starting with 200 m (COGĂLNICEANU et al., 2000). Most recently it was found even at 150m altitude, in Satu Mare County (COVACIU MARCOV et al., 2007). *Salamandra salamandra* is an exclusively terrestrial species, which cannot tolerate dryness, this is the reason why it can be found during the daytime only in rainy periods, or right before raining, when the atmosphere's humidity is high (COVACIU MARCOV, 2002a).

There were many researches done and many studies published about this species (e.g. EGEA SERRANO et al., 2006, UTZERI et al., 2004, COVACIU MARCOV et al., 2007, DOPAZO et al., 1998, DOPAZO & KORENBLUM, 2000, KUZMIN, 1994, SCHMIDT et al., 2005, 2007, EITAM et al., 2005 etc.). But there are only two researches done on the trophic spectrum of this species (COVACIU MARCOV et al., 2002a, CICORT LUCACIU et al., 2007a).

The species of *Salamandra salamandra* is protected by the Bern Convention, and it is there on the red list of many European countries, like Ukraine (KUZMIN, 2000). In Romania it is considered to be vulnerable (COGĂLNICEANU et al., 2000). It is very necessary to have knowledge about the biological and ecological necessities of a species in the purpose of protecting and preserving it (ANCONA & CAPIETTI, 1995). Studies done on the trophic spectrum of Amphibians reveal information about the way the natural food resources are used by this species (BELLOCQ et al., 2000).

MATERIALS AND METHODS

We have analyzed the trophic spectrum of four *Salamandra salamandra* populations from Defileul Jiului National Park. The habitats from which the specimens were captured are quite insulated, but still presenting apparently similar characteristics. The differences can be observed only in the trophic spectrum of the captured specimens, this being an indicator of the environmental aspects (BELLOCQ et al., 2000). The first three studied habitats (Chitu Valley, Lainici Convent, and Trântoru Valley) are valleys of cold and rocky streamlets, located in very dense forests with extremely steep valleys. Bratcu Valley is completely different form the previous ones. It is a very grassy, open valley. This forest is less dense, there is a road crossing it. This seems to be the cause of the fact that we could capture only very few specimens in this habitat.

The stomach contents were obtained using the stomach irrigation method (LEGLER & SULLIVAN, 1979, LECLERC & COURTOIS, 1993, GRIFFITS, 1986), avoiding the slaughtering of the studied specimens (BULAKHOV, 1976). In order to collect the contents, we used syringes fitted with a drainage tube (COGĂLNICEANU, 1997). The probes were collected in test tubes, and preserved using a 4% formalin dilution. We have identified the preys from the stomach contents using speciality text books (RADU & RADU, 1967, IONESCU & LĂCĂTUŞU, 1971, CRIŞAN & MUREŞAN, 1999).

Because of Amphibians are known for their rapid digestion (CALDWELL, 1996), we reduced as much as

possible the time between capturing the specimens and obtaining the samples, in order to ensure the accuracy of the research. Furthermore, the specimens were released in their natural habitats immediately after stomach irrigation.

The results of the study were statistically processed, considering parameters like the taxonomic affiliation of preys, feeding rate, the provenance, abundance, and frequency of preys, feeding intensity and variations of the diversity of feeding. It was not possible for us to identify the sex of the captured specimens. We have analyzed the results considering the habitat of provenance. For the specimens habiting in Chitu Valley, we have also considered the ontogenesis, identifying adult and juvenile forms.

RESULTS AND DISCUSSIONS

We have analyzed 94 specimens of *Salamandra salamandra* captured in four different habitats. Out of this, 40 were captured in Chitu Valley, represented by 33 adults and 7 juveniles. 37 specimens were captured from the valley nearby Lainici Convent, 24 from Trântoru Valley, and the rest of 10 specimens from Bratcu Valley.

In the stomach contents we identified animal kind preys, vegetal fragments, shed-skin fragments, and Gastropod eggs. We found 3 specimens with empty stomachs, this way the feeding rate's value in this study is 96,81%.

The understanding of the Amphibians' feeding means understanding of the way these animals are using the trophic resources from the environment (BELLOCQ et al., 2000). These animals spend the most of their time foraging (PERRY et al., 1997). The insignificant number of empty stomachs found shows that the biotope had optimal conditions for feeding, commensurate temperature and humidity not only for the prey species, but also for *Salamandra salamandra* in the period in which the research was done. Similar conditions were described as well for salamanders (GUERRERO et al., 1990, COVACIU MARCOV et al., 2002a, etc), as for other Amphibian species (GHIURCĂ & ZAHARIA, 2006, SAS et al., 2003, CICORT LUCACIU et al., 2007b).

Regarding the intensity of feeding, we focused on the maximum number of preys/specimen and the average number of preys/specimen. Considering the habitats, the highest recorded number of preys/ specimen was found in Chitu Valley, represented by 19. The value we have found in the other habitats is 9. The highest average number of preys/specimen, with a value of 5.4, was noticed in Bratcu Valley. Specimens from Chitu Valley have an average number of preys/specimen of 4.47, in Trântoru Valley this value was 3.5, and nearby Lainici Convent, 3.37. There are remarkable differences considering the ontogenesis. The highest value of the maximum number of preys/specimen we have found in juvenile forms. The maximum number of preys/ specimen recorded in the case of adults from Chitu Valley was 10. The average number of preys/specimen is also considerably higher in the case of juveniles, having a value of 7.14, compared with 3.9 for adults.

Concerning the provenance of prey taxa, they are all terrestrial, except one aquatic prey (*Gammarus* sp.). The abundance of terrestrial preys is 99.73%.

Alongside animal kind preys, we identified vegetal fragments in the stomach contents. The highest value we recorded with specimens from the population from Bratcu Valley, 80%. In Trântoru Valley this value was 58.33%, nearby Lainici Convent 51.35%, and in Chitu Valley 42.5%. There are no significant differences considering the ontogenesis of the studied specimens.

The higher frequency of vegetal fragments in stomach contents from Trantoru Valley and Bratcu Valley are due to the characteristics of these two habitats. Here the vegetation is much more abundant compared to the other two habitats, increasing this way the possibility of feeding with vegetal. The active consumption of vegetal food is clearly present in larva forms (e.g. DE SOUSA FILHO et al., 2007). But usually, adults do not actively feed with vegetal, these fragments being swallowed alongside with mobile preys (WHITAKER et al., 1977), excepting very few Amphibian species which feed on vegetal (e.g. ULTSCH, 1973). The accidental consumption of vegetal fragments along with other preys was reported as well in other *Salamandra salamandra* populations (COVACIU MARCOV et al., 2002a, CICORT LUCACIU et al., 2007a), as with *Lyciasalamandra luschani fazilae* species (CICEK et al., 2007), or with *Salamandrina terdigitata* (UTZERI et al., 2004).

During this research, we have noticed a positive correlation between the frequency of feeding on shed-skin and vegetal fragments, the values of frequency being higher in Trantoru Valley and the highest in Bratcu Valley. In spite of this, we noticed a negative correlation between the consumption of vegetal fragments and the intensity of feeding, and a positive correlation between the consumption of minerals and the intensity of feeding. This only led us to the conclusion that rocky valleys with less dense grassy vegetation were more favorable than Bratcu Valley, which is more open and more abundant in sunlight. This conclusion is strengthened by the fact that we could capture only very few individuals in the latter valley.

We noticed the occurrence of dermatophagy only in the contents of adult individuals' stomach. The highest frequency for shed-skin present in stomach contents, 25%, is found in specimens from Trântoru Valley; in Bratcu Valley it is 20%, 10% in Chitu Valley and 5.41% nearby Lainici Convent. These fragments are actually pieces from the individuals' own skin.

The presence of shed-skin was not mentioned before in any scientific work. This phenomenon is well known for species which hunt in water, being explained as a way of recycling epidermal protein (WELDON et al., 1993). Generally, the abundance of Amphibians in a certain habitat has positive effects on the consumption of shed-skin. But, analyzing the salamanders, this is not the situation of a high abundance in the biotope, these animals being used to live

at relatively big distances one from another. This is why we consider that the shed-skin present in the stomach contents actually represent the own exuvia, probably being swallowed while capturing preys. A similar case is the phenomenon of keratophagy, commonly found with reptiles, which live at big distances one from another, and consuming fragments from their own skin (MITCHELL et al., 2006).

Eating eggs was revealed in our research in the case of one specimen only, representing 2.70% from the population nearby Lainici Convent. It was possible for us to identify the prey taxon, it is belonging to the Gastropods.

The presence of eggs was mentioned in only one individual's stomach content. Eggs were identified as Gastropod`s eggs. These are mentioned to be present in other Amphibians' feeding also, such as *Triturus cristatus* (CICORT LUCACIU et al., 2007b). Some scientists state that this clearly indicates the character of being an opportunist predator of these animals (COVACIU MARCOV et al., 2002b).

Swallowing mineral particles was observed in two habitats only, in Chitu Valley (7.5%), and nearby Lainici Convent (27.03%). There are differences considering ontogenesis, the frequency noted with juvenile forms (14.28%) is more than double compared to the adults (6.06%). These mineral particles consist of stones and sand.

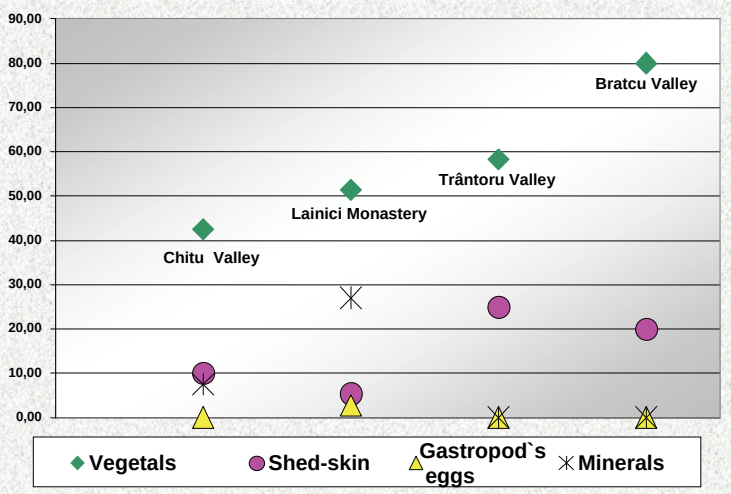

Fig. 1. The frequency of vegetal fragments, shed-skins, Gastropodas eggs, and minerals.
Fig.1. Frecvența fragmentelor de vegetale, exuvie, ponta de gasteropode şi minerale.

We have identified 373 kind of preys belonging to 31 taxa, all of them Invertebrates. The abundance of prey taxa shows variations depending on the habitat (Table 1). Considering the population with the habitat in Chitu Valley, the highest abundance is recorded for Diplopoda, followed by Limacidae and Lumbricidae. We registered a significant abundance also for terrestrial Gastropods with shell, and for Araneida species. Nearby Lainici Covent, Limax species has the highest abundance, followed by Araneida and Diplopoda, and on the third rank are Lepidopterae larva. In the top of the list of preys from Trântoru Valley, there are Araneida and Diplopoda species. Just like in the other habitats, a lower value for abundance is registered for Limacidae, Gastropods with shell, Chilopoda and Lepidoptera. The most relevant taxa found in the stomach contents of *Salamandra salamandra* habiting in Bratcu Valley are Opiliones, but there are also Limax-Gastropods and Diplopoda. We noticed relevant differences considering ontogenesis of *Salamandra salamandra* specimens. In the case of adult forms, Diplopoda are prevailing in the stomach contents, while in juvenile forms Limax species has a higher abundance. Second place is reverse for both forms, meaning that adults prefer Limacidae and juveniles have a preference for Diplopoda species. Adults also go for Araneida, terrestrial Gasteropods with shell, and Lumbricida. Juveniles also forage for Lepidoptera larva.

The frequency of preys is determined by the presence of certain taxa in the stomach contents of the studied specimens. This is why there are certain differences between the frequency and abundance. In the specimens captured in Chitu Valley, Diplopoda species have the highest frequency, followed by Lumbricida, Limax species and Araneida.

From frequency point of view, in the habitat nearby Lainici Convent, Diplopoda species are found in statistics only on the fourth place, the most frequent being Limax, Araneida, and Lepidoptera species. In the Trântoru Valley habitat samples, Araneida, Diplopoda and terrestrial Gastropods species are most frequent. Opiliones and Lepidoptera larva have the highest frequency in Bratcu Valley. Moreover, there are differences based on the ontogenesis of *Salamandra salamandra* individuals. Myriapods are present with the highest frequency in the stomach contents of both males and females, but juvenile forms have a preference for Lumbricids, which appear only on the second place in the frequency of adult forms. Juvenile forms also prefer terrestrial Gastropods, Limacidae, Araneida, and Chilopoda species. With lowest frequency we have identified Isopoda and terrestrial Heteroptera species, along with Brachycera forms and Lepidoptera larva. In the case of adult forms, it is worth mentioning the presence of Limacidae and Araneida species in the stomach contents.

The diversity of food registers insignificant differences in the four habitats, and also regarding the ontogenesis of *Salamandra salamandra* from these habitats. In Chitu Valley H=2.41 in the case of adults, and H=2.28 for juveniles, in this habitat final H=2.45. Nearby Lainici Convent H=2.40, in Trântoru Valley H=2.36, and in Bratcu Valley H=2.59.

Table 1. The ponderosity (P) and frequency (F) of prey taxa.
Tabel 1. Ponderea (P) și frecvența (F) taxonilor pradă.

	Chitu Valley		Lainici Convent		Trantoru Valley		Bratcu Valley	
	P	**F**	**P**	**F**	**P**	**F**	**P**	**F**
Vegetal fragments		42.5		51.35		58.33		80
Shed-skin		10		5.41		25.00		0
Gastropod`s eggs		0		2.70		0		0
Minerals		7.5		27.03		0		20
Lumbricidae	12.29	40	1.6	5.41	2.38	8.33	3.7	20
Gasteropods (t.)	10.61	32.5	5.6	16.22	9.52	33.33	3.7	20
Gastropods-Limax	15.08	35	23.2	40.54	11.9	25.00	11.11	20
Araneida	10.06	35	14.4	37.84	21.43	50.00	0	0
Opiliones	7.26	27.5	6.4	21.62	0	0	18.52	40
Izopoda(t)	2.23	10	1.6	5.41	2.38	8.33	3.70	20
Gammaridae	0	0	0	0	0	0	3.70	20
Diplopoda	19.55	62.5	14.4	27.03	16.67	41.67	11.11	40
Chilopoda	5.59	20	5.6	18.92	7.14	25.00	3.70	20
Ortoptera	0	0	0	0	4.76	16.67	0	0
Homoptera Cicadinae	0	0	0	8.11	0	0	0	0
Colembola	0.56	2.5	0	0	0	0	0	0
Heteroptera(t)	2.23	10	4.8	3.51	2.38	8.33	3.7	20
Coleoptera(t)	3.91	17.5	3.2	8.11	4.76	16.67	3.7	20
Carabidae	0.56	2.5	0	0	4.76	16.67	0	0
Stafilinidae	0.56	2.5	0	0	0	0	0	0
Elateridae	0.56	2.5	0	0	0	0	0	0
Scarabeidae	0.56	2.5	1.6	5.41	0	0	0	0
Coccinelidae	0.56	2.5	0	0	0	0	3.7	20
Cerambicidae	0	0	0.8	2.70	0	0	0	0
Curculionidae	0	0	0	0	0	0	3.7	20
Neuroptere	0	0	0.8	2.70	0	0	0	0
Lepidoptera-larva	3.35	10	9.6	32.43	2.38	8.33	7.41	40
Lepidoptera	0	0	0	0	7.14	25.00	0	0
Trichoptera	0	0	0.8	2.70	0	0	3.7	20
Culicidae	0	0	2.4	8.11	0	0	7.41	20
Typulidae	0.56	2.5	0	0	0	0	0	0
Brachyc. larva(t)	2.79	12.5	0	0	0	0	7.41	20
Muscidae	0	0	0	0	2.38	8.33	0	0
Hymenopterae	0.56	2.5	0	0	0	0	0	0
Hymenopterae-Formicidae	0.56	2.5	0.8	2.70	0	0	0	0

While doing our research on *Salamandra salamandra*, a negative selectivity was noticed for small-sized preys (KUZMIN, 1994). A positive selectivity is present towards the large-sized preys including those with high mobility or the flying ones, like Lepidoptera species (KUSHNIRUK, 1971). It is interesting to consider this, because salamanders have lower mobility and would feed on preys with lower mobility (LUTHARD & ROTH, 1979). Though, if we take into account the fact that we have captured the specimens after rain, when the wet air had its effects upon the mobility of flying insects (SZABO, 1962), our results are correct. The presence of high mobility preys was mentioned even in other *Salamandra salamandra* populations (COVACIU MARCOV et al., 2002a, CICORT LUCACIU et al., 2007a).

Text books specify that ontogenesis can have remarkable effects on the feeding of salamanders (HILL, 1950). Considering the intensity of feeding, we found huge differences depending on the habitat, but not between the two stages, adults and juveniles, where differences in our research was insignificant. Salamander larva do not present big changes in their trophic spectrum during ontogenesis (REILLY, 1995). On the other hand, we noticed a great influence and interdependence between the salamanders' behavior and the environment's changes (EGEA-SERRANO et al., 2006). Our results imply that changes in the environment have a greater influence upon the feeding behavior, while the ontogenesis has effects which are not worth mentioning. Compared to Anura species, salamanders have a very stereotype (LAUDER & REILLY, 1994), and "hard wired" behavior when it comes to capturing their preys. The insignificant differences noted between the trophic spectrum of adults and juveniles, prove that this feeding behavior does not change during the ontogenesis, but it remains fixed (REILLY, 1995). Also, living in the same habitat, adults and juveniles have access to the same preys. This fact is proven also by the very small differences between the diversity of food for juveniles and adults. These very small differences also indicate that the environmental factors were same or similar, salamanders using the most accessible preys from this environment. Salamanders are thought to have a great role in controlling the populations of Invertebrates in their habitat (COVACIU MARCOV et al., 2002a).

Salamandra salamandra is a polyphagous predator, hunting for the most accessible preys from its habitat (COVACIU MARCOV et al., 2002a). When analyzing the abundance of the prey taxa, we notice that preys connected to the forest environment (Araneida, Opiliones, Diplopoda) are predominant, but there are also to be found preys characteristic to wet lands (Limax, Diplopoda, Gastropods with shell). This is due to the environment they live in, using the most accessible food resources from this environment. The consumption of forest preys was mentioned about other *Salamandra salamandra* populations as well (CICORT LUCACIU et al., 2007a). Moreover, terrestrial Gastropods represent a key element of the trophic spectrum for salamanders (ZAKRZEWSKI & KEPA, 1981, COVACIU MARCOV et al., 2002a, CICORT LUCACIU et al., 2007a).

Among the Myriapods, it is worth taking a look at the highest abundance of Diplopoda species. These animals are slower than Chilopoda species, being this way much easier captured by salamanders. In the same time, they represent a good source of potential energy because of their large size.

Taking a final look at the ontogenesis of preys, we can mention a high rate of consumption for Brachycera larva and Lepidoptera larva. In this case, the selectivity can be strengthened by the fact that holometabola insect larva have a high content in lipids, and thus are very nutritive (BROOKS et al., 1996).

CONCLUSIONS

The insignificant number of empty stomachs found shows that the biotope had optimal conditions for feeding, commensurate temperature and humidity not only for the prey species, but also for *Salamandra salamandra* in the period in which the research was done.

The shed-skin present in the stomach contents actually represent the own exuvia, probably being swallowed while capturing preys.

Salamanders have lower mobility and would feed on preys with lower mobility (LUTHARD & ROTH, 1979).

There are very small differences between the diversity of food for juveniles and adults. These very small differences also indicate that the environmental factors were same or similar, salamanders using the most accessible preys from this environment.

Salamandra salamandra is a polyphagous predator, hunting for the most accessible preys from its habitat (COVACIU MARCOV et al., 2002a).

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