THE DIET OF TWO *Salamandra salamandra* (AMPHIBIA) POPULATIONS FROM THE DOMOGLED - VALEA CERNEI NATIONAL PARK, ROMANIA

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Abstract. On 25 October 2020 we studied the diet of two *Salamandra salamandra* populations from Domogled - Valea Cernei National Park. Totally, we collected 37 individuals from two habitats, one situated near a brook, and another without a permanent water course. The number of prey taxa consumed in those two habitats was equal (18), as the prey taxa were generally the same in both habitats. The highest percentage abundance and frequency of occurrence was registered by Gastopoda Limacidae. Near the brook, prey taxa related with humidity were dominant. Unlike these, in the other habitat, fire salamanders consumed more preys not related with humidity, smaller in size, with a hard and more chitinous body, fact which increased the number of preys / individual and food diversity. This indicates that habitat differences (even if both are favourable for *S. salamandra*) modify the species` food composition, which, being opportunistic, feeds with the more accessible preys in each habitat. Although the study was performed at the end of October, all fire salamanders had stomach contents, and the prey taxa were generally the same consumed in other periods and regions from the country.

Keywords: habitats, differences, food composition, fire salamanders, preys.

Rezumat. Hrănirea a două populații de *Salamandra salamandra* (Amphibia) din Parcul Național Domogled - Valea Cernei, România. În 25 octombrie 2020 am studiat hrănirea a două populații de *Salamandra salamandra* din Parcul Național Domogled - Valea Cernei. Am colectat în total 37 de indivizi din două habitate, unul situat lângă un pârâu, iar celălalt fără o sursă de apă permanentă. Numărul taxonilor pradă consumați în cele două habitate a fost egal (18), taxonii pradă fiind în general aceiași în ambele habitate. Ponderea și frecvența cea mai mare a fost înregistrată de Gastropoda Limacidae. Lângă pârâu taxonii pradă legați de umiditate au fost dominanți. Spre deosebire de aceasta, în celălalt habitat salamandrele au consumat mai multe prăzi fără legătură cu umiditatea, de dimensiuni mai mici, cu un corp mai dur și chitinos, fapt care a crescut numărul de prăzi / individ și diversitatea hranei. Acest fapt sugerează că diferențele dintre habitate (chiar dacă ambele au fost favorabile pentru *S. salamandra*) modifică compoziția hranei acestei specii, care fiind oportunistă se hrănește cu cele mai accesibile prăzi din fiecare habitat. Chiar dacă studiul a fost realizat la sfârșitul lunii octombrie, toate salamandrele au avut conținut stomacal, taxonii pradă fiind în mare aceiași cu cei consumați în alte perioade și regiuni din țară.

Cuvinte cheie: habitate, diferențe, compoziția hranei, salamandre, prăzi.

INTRODUCTION

Differences in the salamanders' feeding in the Carpathians were considered a consequence of habitat differences rather than disparities determined by geography (BALAGOVÁ et al., 2015). The feeding of *Salamandra salamandra* (Linnaeus, 1758) has been studied in various locations in the Carpathian Mountains, many of these areas being located in southwestern and western Romania (see in: BALAGOVÁ et al., 2015). Many studies from Romania analysed the feeding of single populations (COVACIU-MARCOV et al., 2002; CICORT-LUCACIU, 2009; CICORT-LUCACIU et al., 2007; FERENȚI et al., 2010a; MAIER et al., 2020). However, there are also studies which compare the salamanders' diet from more habitats located in the same geographical area (FERENȚI et al., 2008, 2010b; LEZĂU et al., 2010), emphasizing some differences between them (FERENȚI et al., 2010b). Some previous data from the country come from natural protected areas of southwestern Romania (FERENȚI et al., 2008, 2010a; LEZĂU et al., 2010; MAIER et al., 2020), where the intensive feeding of salamanders proved the optimal trophic conditions in these protected areas (MAIER et al., 2020). One of the protected areas from southwestern Romania, where studies on the feeding of salamanders were not carried out, is the Domogled - Valea Cernei National Park (DVCNP), even if fire salamanders are well represented in the region (IFTIME, 2005). DVCNP is a protected area which shelters a high number of important species for conservation (ROZYLOWICZ et al., 2019). Recent data also showed the presence of a remarkable diversity in other groups, like terrestrial isopods from Băile Herculane area (POP et al., 2019), crustaceans which are often consumed by salamanders (e.g. CICORT-LUCACIU et al., 2007; FERENȚI et al., 2010b; LEZĂU et al., 2010; MAIER et al., 2020). Moreover, in DVCNP there is a strictly endemic terrestrial isopod species linked to humid forests from rocky or gorge areas (TOMESCU et al., 2015; POP et al., 2019; FERENȚI et al., 2020). Thus, because *S. salamandra* is also linked to forested habitats (e.g. FUHN, 1960), and considering that in other cases salamanders consumed terrestrial isopods (e.g. CICORT-LUCACIU et al., 2007; FERENȚI et al., 2010b; LEZAU et al., 2010; MAIER et al., 2020), we supposed that they will also consume this endemic isopod. Therefore, in the autumn of the year 2020 we set out to analyse the diet of some *S. salamandra* populations in DVCNP, with a focus on the food composition of the species from this protected area.

MATERIALS AND METHODS

The field study was undertaken on 25 October 2020, on a rainy and gloomy autumn day (after a rainy night) with an 8ºC - 10ºC air temperature. During the same day, with a difference of one hour, in similar meteorological conditions, we studied the feeding of two *S. salamandra* populations from DVCNP, a region where the species is wildly distributed (IFTIME, 2005). Both populations were situated in the surroundings of the Cerna River, upstream of Băile Herculane. The first population was collected from the Cheile Țâșnei area, on the right bank of the Cerna River. The second population was located at approximately 25 km upstream from the previous sampling point, before the Cerna Sat locality. Thus, because, along the Cerna valley, one of the populations was situated upstream, and the other downstream, they were named accordingly. The downstream population, near Cheile Țâșnei, was situated along a permanent water course, surrounded with relatively steep slopes, in a humid and shaded area, covered by a dense beech forest. Salamanders were captured at a distance of some centimeters and 10 meters of the water. The upstream habitat was also situated in a dense old-growth beech forest. But unlike the previous habitat, the upstream habitat is situated at a distance of 40-50 meters of the Cerna river, without a permanent watercourse, represented by a slightly sloping area. Salamanders were collected directly by hand, 22 individuals from downstream, and 15 individuals from the upstream area. The stomach content sampling was realised by the stomach flushing method (e.g. SOLÉ et al., 2005), a practice previously applied on this species (e.g. CICORT-LUCACIU et al., 2007; FERENȚI et al., 2008, 2010a,b; LEZĂU et al., 2010; MAIER et al., 2020). Afterwards, salamanders were released in their habitats. The stomach contents were identified in the laboratory, at a taxonomic level similar to other studies on the salamanders' diet (e.g. CICORT-LUCACIU et al., 2007; FERENȚI et al., 2008, 2010a,b; LEZĂU et al., 2010). The only preys identified to species level were terrestrial isopods, just like in other cases (MAIER et al., 2020). Subsequently we calculated the percentage abundance and frequency of occurrence of each prey taxa and estimated the taxa diversity with the Shannon index.

RESULTS

All individuals of the two *S. salamandra* populations from DVCNP had stomach contents. The number of prey taxa was similar between the two populations (18 prey taxa). In addition to prey taxa, both populations consumed vegetal fragments and shed skin fragments; the downstream populations consumed some inorganic elements too, represented by sand granules (Table 1).

Table 1. Percentage abundance (P%) and frequency of occurrence (f%) of preys consumed by the two *S. salamandra* populations from the Domogled-Valea Cernei National Park.

	Upstream		**Downstream**	
	P %	**f %**	**P %**	**f %**
Shed skins	-	13.33	-	18.18
Vegetal remains	-	66.67	-	81.82
Inorganic elements	-	-	-	13.64
Lumbricidae	2.08	13.33	7.14	31.82
Gastropoda Limacidae	22.92	60.00	55.36	90.91
Araneida	12.50	46.67	1.79	9.09
Opilionida	8.33	33.33	-	-
Terrestrial Isopoda	2.08	13.33	3.57	18.18
Diplopoda	21.88	66.67	5.36	13.64
Chilopoda	9.38	46.67	3.57	13.64
Colembola	-	-	8.04	31.82
Thysanura	1.04	6.67	1.79	9.09
Orthoptera	-	-	1.79	9.09
Heteroptera	-	-	0.89	4.55
Homoptera	1.04	6.67	-	-
Coleoptera Carabidae	2.08	13.33	0.89	4.55
Coleoptera Chrysomelidae	-	-	0.89	4.55
Coleoptera Lampyridae	3.13	20.00	0.89	4.55
Coleoptera Elateridae	1.04	6.67	-	-
Coleoptera larva	1.04	6.67	0.89	4.55
Coleoptera undetermined	1.04	6.67	-	-
Trichoptera	2.08	13.33	2.68	13.64
Lepidoptera larva	2.08	13.33	-	-
Diptera Brachycera	3.13	13.33	0.89	4.55
Diptera Brachycera larva	3.13	13.33	2.68	13.64
Hymenoptera	-	-	0.89	4.55
Number of preys	96		112	
Preys/individual average number	6,4		5,09	
Preys/individual maximum number	13		9	

In the food of both *S. salamandra* populations, Gastropoda Limacidae had the highest percentage abundance and frequency of occurrence (Table 1). However, in terms of the next positions, important differences were recorded between the two populations (Table 1). Disparity between the two populations was also registered in the case of food diversity, which was H=1.82 in the case of the downstream population, and H=2.32 in the case of the upstream population. Even if the number of prey taxa was the same, the average and maximum number of preys / individuals was different, as higher values were registered upstream (Table 1). Regarding terrestrial isopods, in the upstream habitat the two individuals consumed by salamanders belonged to one species, *Protracheoniscus politus*. Unlike this, the four terrestrial isopod individuals consumed by salamanders in the downstream population belonged to four species (*Ligidium* sp., *Hyloniscus dacicus*, *Trachelipus arcuatus*, *Cylisticus convexus*). All preys consumed by the salamanders from DVCNP were terrestrial animals, most of them flightless and only a few were flying taxa.

DISCUSSIONS

The feeding of *S. salamandra* populations from DVCNP was relatively uniform, as salamanders consume broadly the same prey taxa. Thus, not only that the number of prey taxa was the same, but their food has 13 prey taxa in common. Moreover, the same prey taxa, Gastropoda Limacidae, had the highest percentage abundance and frequency of occurrence in both populations. Therefore, the uniform conditions of the study area, characterised by a humid, rainy, and cold day are reflected in the salamanders' trophic spectrum, as it contains broadly the same taxa, active in the rainy season with low temperatures. However, the differences between the feeding of the two populations are noticeable. Thus, downstream salamanders consumed more slugs, earthworms and terrestrial isopods linked to wet areas, as the habitat is located close to a permanent watercourse. Even the fact that this population had mineral elements in their stomach content is a consequence of the stream's vicinity. In other cases, *S. salamandra* populations from near watercourses ingested inorganic elements accidentally together with animal preys (FERENȚI et al., 2010a). In the upstream habitat, the forested slopes are situated at a certain distance from the water, thus the salamanders consumed isopods from the forest and animals independent from water, like spiders, millipedes, etc. This fact suggests that despite the uniform meteorological conditions, the diet of salamanders is obviously influenced by habitat characteristics, as in the case of other amphibians (e.g. COVACIU-MARCOV et al., 2010; LÓPEZ et al., 2015; PLITSI et al., 2016; MAGESKI et al., 2019; MOLLOV et al., 2020). Due to the presence of the stream, the downstream population consumed more preys linked to wet areas, which in our case had larger sizes. Because of this, the number of preys/individuals was smaller in the case of this population. Unlike this, the upstream population located in an area without any permanent water source consumed preys which do not depend so much on humidity, and which in this case had smaller dimensions and a hard exoskeleton, therefore they were consumed in larger numbers, fact which made the number of preys/individual higher. This confirms that the food composition of amphibians is influenced on the one hand by meteorological conditions, which determine the activity of some preys (e.g. ASZALÓS et al., 2005; YU et al., 2009; BOGDAN et al., 2013; SUCEA et al., 2014), but also by habitat conditions which permit the existence of preys in those habitats (e.g. COVACIU-MARCOV et al., 2011; BOGDAN et al., 2013; PLITSI et al., 2016). In fact, the differences between the two habitats confirm the trophic opportunism of salamanders (e.g. ANDREONE et al., 1990; FERENȚI et al., 2008; BALAGOVÁ et al., 2015). At the same time, it is known that the density of salamanders is higher in habitats crossed by watercourses (BURGSTALLER et al., 2021), and this fact could be linked to the different feeding conditions of different habitat types.

Even if the number of taxa consumed in DVCNP was similar with other studies, the number of preys / individuals and implicitly the feeding intensity was lower (CICORT-LUCACIU et al., 2007; LEZĂU et al., 2010; MAIER et al., 2020). Apparently, this fact could be a consequence of the late study period (end of October), as previously in September in another zone of Romania the feeding intensity was similar or even lower (FERENȚI et al., 2008). However, in other regions of southwestern Europe the species has its peak activity in October-November (VELO-ANTÓN et al., 2021), as salamanders are more active at lower temperatures, when they have an increased metabolism (CATENAZZI, 2016). A recent study from Romania performed at the beginning of March shows a normal feeding (MAIER et al., 2020), as the feeding intensity was almost double compared with the one registered in DVCNP. There is a possibility that the colder climate from Băile Herculane compared to the Danube Gorge (STOENESCU et al., 1966; MÂNDRUȚ, 2006), where the previous study was made (MAIER et al., 2020), affects both the salamanders' feeding and prey activity. However, some preys could be absent by chance from the food of the populations from DVCNP. For example, in March salamanders consumed scorpions (MAIER et al., 2020), but this prey was not part of the studied populations' diet, although scorpions are present in the Băile Herculane area (e.g. BUNESCU, 1959; FET et al., 2002; GHERGHEL et al., 2016).

In DVCNP *S. salamandra* consumes broadly the same prey taxa as in other regions of the country (CICORT-LUCACIU, 2009; CICORT-LUCACIU et al., 2007; FERENȚI et al., 2010a,b; LEZĂU et al., 2010; MAIER et al., 2020), or eastern Europe (KUZMIN, 1990; BALAGOVÁ et al., 2015). Even the isopods consumed by salamanders show that differences in the feeding of these species in the Carpathians are probably determined by habitat differences (BALAGOVÁ et al., 2015). Thus, on the forested slope the sylvan terrestrial isopod, *Protracheoniscus politus* (e.g. RADU, 1985; TOMESCU et al., 2011) was consumed, but *Ligidium* sp., *Hyloniscus dacicus*, *Trachelipus arcuatus* were consumed near the stream, which are species linked to wet areas or humid forests (RADU, 1983, 1985;

TOMESCU et al., 2011, 2015). However, salamanders consumed only some of the isopod species present in the region (POP et al., 2019; FERENȚI et al., 2020), as most of the species have different habitat requirements, and they are not present with salamanders. Therefore, salamanders did not consume the endemic isopod *Trachelipus trilobatus*, because this species is not present in the habitat used by salamanders, as it is linked to areas with vertical limestone slopes or gorges from forested areas (TOMESCU et al., 2015; FERENȚI et al., 2020). Still, because *T. trilobatus* is linked to forested habitats (TOMESCU et al., 2015; FERENȚI et al., 2020) which are also characteristic for salamanders (e.g. FUHN, 1960) in perspective it would be worth seeing if salamanders consume this species in these areas. Compared at least with Romanian scientific data (CICORT-LUCACIU, 2009; CICORT-LUCACIU et al., 2007; FERENȚI et al., 2008, 2010a,b; LEZĂU et al. 2010; MAIER et al., 2020), the feeding of *S. salamandra* from DVCNP is adequate.

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