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DATA UPON THE FEEDING OF SOME NEWT POPULATIONS (*Triturus cristatus* AND *Lissotriton Vulgaris*) FROM ALMĂŞ-AGRIJ DEPRESSION, SĂLAJ COUNTY, ROMANIA

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Abstract. *In the spring of 2009, we studied the stomach contents of 164 Lissotriton vulgaris individuals and 90 Triturus cristatus individuals, originating from four habitats from Almăş-Agrij Depression, Sălaj County. The differences between their feeding are determined by the size of the newts and the trophic strategy that they use. Thus, T. cristatus uses a ,,sit and wait" technique, consuming fewer large-sized preys, while L. vulgaris uses an ,,active foraging" type of strategy, feeding with a larger number of small preys. The habitat creates important feeding differences within the same species. The trophic offer, as well as the morphologic particularities of the habitats, highly influence the feeding of the newts. The particularities of some habitats make the feeding of the newts to be difficult. On a whole, the two species consumed 1598 preys, belonging to 21 prey taxa. Beside the animal preys, the stomach contents also contained vegetal, mineral and shed-skin fragments, amphibian egglayings. The differences between the two sexes seem to be less emphasized than the ones between the species or the ones determined by the habitats, their variation being probably accidental.*

Key words: *feeding, prey taxa, newt, Triturus cristatus, Lissotriton vulgaris, Romania*

INTRODUCTION

Five newt species inhabit Romania (Cogălniceanu et al. 2000), from which only three are present in Almăş-Agrij Depression, Sălaj County (Covaciu-Marcov et al. 2009). Only two of these (*Triturus cristatus* and *Lissotriton vulgaris*) are widely distributed in the territory, the third species *Mesotriton* *alpestris*, being exclusively limited to the higher and forested sectors (Covaciu-Marcov et al. 2009). Newts are amphibians with a dual activity, oscillating between the aquatic and terrestrial environment. Thus, in the reproduction period during spring, they are present in different aquatic habitat types, while during summer and autumn, once with the egglaying, they occupy the terrestrial medium (Fuhn 1960). As a result of this life style, they can operate in both environments. Meanwhile, newts are important amphibians regarding a conservative point, in Romania *T. cristatus* being a vulnerable species, while *L. vulgaris* is an almost threatened one (Iftime 2005). Therefore it is very important to know the ecology of the two species and the parameters of the habitats which they occupy. In this respect, the feeding studies hold a special position, food being considered the main connection between an animal and its environment (Kenett & Tory 1996). The food composition can be regarded as a quality indicator of the environment in which different populations live (Kovács et al. 2007). Newts represent important predators in their habitats, being predator forms, both as adults and larvae. Generally, amphibians are situated towards the top of the trophic pyramid (Cogălniceanu et al. 2000).

Despite the importance of the studies referring to the feeding of the amphibians, such analyses have not been performed up to now in Sălaj County. Studies regarding the feeding of the newts are a recently approached direction in Romania, this type of research lacking from the literature older than one decade. These studies begin to be published only after the year 2000, first in the north-western part of the country (eg: Covaciu-Marcov et al. 2002a,b,c,d, 2003, 2010, Cicort-Lucaciu et al. 2004, 2005a,b, 2006a,b,c, 2007, 2009, David et al. 2007, 2008a,b, Ferenți et al. 2008a, 2009a) and afterwards, more poorly represented in other parts of the country (Dobre et al 2007, David et al 2009). All of these studies were performed in the aquatic period of the newts and unfortunately, only few of them compared the feeding of several species (Cicort-Lucaciu et al. 2007, David et al. 2009, Covaciu-Marcov et al. 2010).

Consequently, our study aimed to investigate the trophic spectrum of two newt species, respectively *T. cristatus* and *L. vulgaris*, in a premier for Sălaj County. The objectives of our study were the followings:

1. determining the food composition of the two species.
2. establishing the differences between the two sexes, and where it was possible between the sexes of each species.
3. establishing the origin of the medium of the consumed preys.
4. identifying the trophic strategies used by the two species.

MATERIAL AND METHODS

We realised the feeding study upon the two newt species from Almăş-Agrij Depression, Sălaj County, in the spring of 2009. On a whole, we investigated the stomach contents of 254 newts. From these, 164 belonged to the smaller species, *L. vulgaris*, while 90 belonged to the larger species, *T. cristatus*. In the situation in which the number of captured newts was high enough, we realised the feeding analysis separately depending on the sex of the animals (Table 1). This fact was mainly possible in the case of *L. vulgaris*, species which, due to its smaller size, usually presents higher population effectives even in the smaller habitats. Regarding *T. cristatus* species, the separate feeding analysis depending on the sex was possible only in one habitat.

Table 1.

The number of analyzed individuals. The frequency of occurance of the empty stomachs, of the stomachs with vegetal remains, shad skin, amphibian spawn and mineral. The number of consumed prey items. The mean and maximum number of preys / individuals. The percentage abundance of the aquatic and terrestrial preys. The feeding diversity according to the Shannon-Wiener H. (Lv – *Lissotriton vulgaris*, Tc – *Triturus cristatus*, M- males, F- females, T- total).

Locality	Mesteacănu				Gâlgău Almaşului		
Data	22.04.2009				22.04.2009		
Species	L. v.			T. c.	L .v		
Sex	M	F	T		M	F	T
No. of analyzed individuals	29	28	57	18	24	24	48
%Empty stomach	3.44	7.14	5.26	-	16.66	25	20.83
% vegetal remains	24.1	71.4	47.4	55.6	41.7	50	45.8
% stomachs with shed skin	41.4	32.1	36.8	-	41.7	29.2	35.4
% stomachs with spawn	10.3	-	5.26	88.9	-	-	-
% stomachs with mineral	-	-	-	-	4.17	4.17	4.17
Total no. of prey	57	67	124	158	13	19	32
Max. no. of prey/individual	8	6	8	17	2	3	3
Average no. of prey /individual	1.96	2.39	2.17	8.77	1.84	1.26	0.66
% terrestrial prey	5.27	1.5	2.42	3.8	61.54	12.5	25
% aquatic prey	94.73	98.5	97.58	96.2	38.46	87.5	75
Feeding diversity (H)	1.48	1.55	1.61	0.78	1.67	1.73	1.91
%Empty stomach	3.44	7.14	5.26	-	16.66	25	20.83

Table 1. (continued)

Locality	Şoimuş				Jebuc			Total	
Data	23.04.2009				27.06.2009				
Species	L. v			T. c	T. c			L.v.	T.c.
Sex	M	F	T		M	F	T		
No. of analyzed individuals	29	30	59	24	26	22	48	164	90
%Empty stomach	-	-	-	-	-	9.09	4.16	7.92	2.22
% vegetal remains	48.3	50	49.2	25	53.8	45.5	50	47.6	44.4
% stomachs with shed skin	3.45	23.3	13.6	-	23.1	9.09	16.7	28	8.89
% stomachs with spawn	-	3.33	1.69	-	7.69	72.7	37.5	2.44	37.8
% stomachs with mineral	-	-	-	-	7.69	9.09	8.33	1.22	4.44
Total no. of prey	392	356	748	298	110	128	238	904	694
Max. no. of prey/individual	38	27	38	37	14	39	39	38	39
Average no. of prey /individual	13.51	11.86	12.7	12.41	4.23	5.81	4.96	5.51	7.71
% terrestrial prey	0.52	7.59	1.48	45.5	56.37	34.38	45.54	2.44	16.72
% aquatic prey	99.4	92.41	98.5	98.32	43.63	65.62	55.46	97.56	83.2
Feeding diversity (H)	1	1.22	1.41	1.5	1.23	1.55	1.12	1.79	1.91
%Empty stomach	-	-	-	-	-	9.09	4.16	7.92	2.22

The samples were collected at the end of April and June. This particularity of the study represents a consequence of the climatic level registered at the beginning of the warm season of 2009. Our initial intention was to follow the seasonal variation of the newts' feeding during the reproduction period, following the pattern of other similar studies (Covaciu-Marcov et al. 2002b, 2010, Cicort-Lucaciu et al. 2005a,b, 2006b,c). Thus, we started in April to collect samples from several habitats, with the intention to continue the process in the following months. But the habitats from which we had already collected the samples had dried out in May, therefore we could not continue the study. The fact was a result of the extremely hot spring from 2009. Afterwards, a rainy period was recorded in June, situation which allowed the rebuilding of some aquatic habitats, thus being possible the collecting of samples from June.

The studied newts come from 4 localities situated on the entire surface of Almăş-Agrij Depression, both in the higher areas of it and in the lower sectors neighbouring the meadows of Someş River. The newts were captured from the populated aquatic habitats, generally from the shore using a round net with a 2m long metallic handle. In the wider habitats, but with a low water depth, we entered in the water with rubber boots, the newts being captured with the help of a rectangular dredger. After we had captured them, we determined the animals and collected them in buckets with water depending on the species. We collected the stomach contents at an interval of maximum 2 hours after the capturing, the extending of this period could have led to the degradation of the preys, the amphibians' digestion being a quick one (Caldwell 1996). The samples were obtained using the stomach flushing method (Solé et al 2005). After the collecting of the samples, all of the newts were released in their habitats of origin. The stomach contents were stored in air tight test tubes and preserved with formaldehyde. The preys were determined in the laboratory, at the magnifying glass, with regards to the specific scientific literature. We analysed the amount of the preys and their frequency of consumption by the newts. The food diversity was established using the Shannon-Wiener (H) diversity index (1949).

The aspect of the habitats

The morphology of the habitats occupied by newts and in general by amphibians is very important for their feeding. Cases were signalled in which, during the same period, the feeding was different between populations situated in different habitats (Cicort-Lucaciu et al 2006c). The newts that we studied come from 4 habitats.

The first habitat lies in the vicinity of Mesteacănu locality, at an altitude of 508 m. The habitat is situated in the area of Meseş Mountain, in the hydrographic basin of Almăş. It is represented by a bogging area situated on the side of a steep slope, at approximately 150 m from a compact beech forest. The bogging area has approximately 20 m^2, while the water depth does not surpass 0.5 m. During the study, the water surface was reduced due to the low precipitation level. Numerous thick bulrush bushes were found near the shores. The habitat is poorly affected by man, due to the distance between the important localities; sometimes the animals drink water from here.

The second one is situated near Gâlgăul Almaşului locality, at 250 m altitude. The habitat is represented by a bogging area formed at the level of a stream with a low flow. It is located in a narrow meadow, surrounded on both sides by oak forests and pine plantations. The water depth reaches one metre. The bogging area has approximately 15 m in length and at most 5 m in width, on the shores being present some willows and a lot of bulrush.

The third habitat is found at the edge of Jibou town, being situated at the lowest altitude from all of the studied habitats, at only 180 m. It is represented by a relatively large puddle, being positioned between the slope of a hill and a country road. It is supplied by a spring with a low flow, the water excess being taken over by a ditch from the road margin. The hilly slope is covered by an oak forest, on the edge facing the water being present several willows. On the opposite shore, facing the road, there are present several bunches of bulrush. The water depth surpasses one metre, the substratum presenting silt. Due to the closeness to a larger locality, the anthropogenic impact is high. Thus, different wastes and even cadavers of domestic animals are thrown in the water.

The last habitat is located near Jebucu locality. It is situated at the border between Sălaj and Cluj County, at an altitude of 557 m. The habitat is represented by a system of 5 temporary puddles, situated on a pasture, on the margin of a country road, near the railroad. The water depth reaches 0.75 m in the largest puddle, but generally it does not surpass 30 cm. Due to the temporary character, the vegetation is poorly represented, only bulrush being present on the shores.

RESULTS AND DISCUSSIONS

Not all of the studied newts fed prior to the capturing. We identified individuals without stomach contents at both newt species and in 3 of the 4 studied habitats. All of the individuals presented stomach contents in only one habitat, at Jibou. The identification of certain amphibians that have not fed in a specific period usually indicates the existence of unfavourable environmental conditions in the respective period. Situations, in which a part of the population had fed, have been sometimes signalled at different amphibian species (Houston 1973, Cogălniceanu et al. 1998, Covaciu-Marcov et al. 2005a), although there are numerous cases in which all of the samples presented food (Toth et al. 2007, David et al. 2008c, Hodişan et al. 2009a). The last occasion is associated with the existence of favourable feeding conditions (Sas et al. 2004, 2009). The presence of animals without food has also been recorded in the case of some newt species from Romania, including the two studied ones (Cicort-Lucaciu et al. 2005a, Covaciu-Marcov et al. 2010).

Generally the frequency of the amphibians without stomach contents is higher at the beginning of the activity period (Hirai & Matsui 2000, Covaciu-Marcov et al. 2010). The respective fact is determined by the thermal regime, the low temperatures affecting both the amphibians and especially the potential preys (Guidali et al. 1999, Yu et al. 2009). Individuals without food are also registered mainly on the first date of sample-collecting, in April, in the case of the populations from Almăş-Agrij depression, strengthening the validity of the rule established by the authors mentioned above. These data prove once more the stereotype of the newts' feeding and its dependence upon the cyclic meteorological factors. However, in the only habitat in which the newts without food lacked, the samples were also collected in April, while newts without food are registered even in June. A second period, in which individuals without food appear, was registered in the case of the newts. This is localised at the end of the aquatic period, when the animals lose their adaptation to the aquatic medium (Cicort-Lucaciu et al. 2006b). Even if according to the calendar, this period can be overlapped with the end of June, when we collected the samples from Jebucu, the crested newts from here were not preparing to leave the water. Their reproduction period was affected by the drought from the spring of 2009, in June these newts being in a full process of egglaying. Therefore, at least the appearance of the newts without food from Jebucu must not be associated with the existence of some unfavourable thermal conditions or with the preparation of the newts to leave the water. Eventually, it should be connected to a higher poverty of the trophic offer, characteristic to a temporary habitat. It could also be possible that the reduced trophic offer could be the collateral result of the drought from the interval, which affected the water level and thus the aquatic invertebrates.

The only habitat in which we did not register empty stomachs, the one from Jibou, is also the largest one. Thus, the trophic offer can be more diverse and quantitatively richer concerning a larger habitat, allowing the satisfaction of the trophic needs of both newt species. Meanwhile, the habitat is protected by the hilly forested slope, therefore the thermal spring variations did not affect it as much as it did the smaller habitats situated on opened pastures, thus highly more exposed. In addition, the higher water level probably stopped the low spring frosts to disperse in depth. The fact can also be deduced by the appearance and the high consumption amount of the microcrustacean (ostracoda and cladocera) in this habitat. These preys, even if are sometimes considered as casual ones for newts (Cicort-Lucaciu et al. 2007), can be very important in some situations and replace the absence of other preys (Covaciu-Marcov et al. 2002d). The same fact also happened at Jibou, where the microcrustacean registered high amounts and were consumed by most of the individuals of the two newt species, contributing to the absence of empty stomachs.

The newts without food register the highest frequency at Gâlgăul Almaşului, where 20.83% of the population did not feed prior to the study. This fact is relatively difficult to explain, because in the same day, in the habitat from Mesteacănu the frequency of the animals without food was much lower (only 5.26%). Moreover, the habitat from Gâlgăul Almaşului is more protected than the one from Mesteacănu. Probably, certain local factors determined the high frequency of empty stomachs. The water is colder here, being a flowing one, represented by a stream with deeper areas, while previously to our activity the water was disturbed by the domestic animals that stressed the newts.

The differences between the frequencies of the two newt species without food between are important. Thus, their frequency is much higher at *L. vulgaris*. The difference can be a consequence of the fact that *L. vulgaris* was studied only in April, thus towards the beginning of the activity period. The frequency of empty stomachs is actually determined by the fact that only common newts were captured at Gâlgăul Almaşului. Therefore, the high frequency of the animals without food at that population also affected the total of the species.

Regarding the sex differences, the frequency of empty stomachs is always higher at the females. Only the females did not feed from *T. cristatus* species. The fact can appear somehow surprising, because usually the females' feeding is more intense (Juncá & Eterovick 2007, Balint et al. 2008). This is due to the higher energetic consumption necessary for the forming and depositing of the egglaying (Hasumi 1996, Radu et al. 2007). It is also possible that in the present case, during the collecting of the samples, the actual nuptial parade had ended, therefore the males were not preoccupied by it. Meanwhile, it is likely that the females were found during the egglaying and thus could not feed properly. The fact can be plausible, because generally during the nuptial parade, the males are more preoccupied with this activity than with their feeding (Ranta et al 1987).

A great part of the analysed newts presented vegetal fragments in their stomach contents. These were mainly represented by fragments of aquatic plants or algae, but also terrestrial parts, especially pewter. The vegetal debris was present in the stomach contents of both newt species, having close frequencies (Table 1). This type of stomach content category was often identified by other authors at the two species (Cicort-Lucaciu et al. 2007, David et al. 2009, Covaciu-Marcov et al. 2010), being also generally present at the amphibians (Szeibel et al. 2007, Groza et al. 2008, Lima et al. 2010).

In most of the cases the vegetal parts were present alongside different animal preys. This fact confirms the supposition of their accidental consumption, the vegetal fragments being consumed together with the followed preys (Whitaker et al. 1977). However, there are other authors that consider their consumption to have a certain value for amphibians, being intentionally performed, either to fragment the exo-skeleton of some insects, or to eliminate some intestinal parasites (Evans & Lampo 1996). At least the first option is harder to accept in case of the newts, which generally, and also in our case, consume non-chitinous preys (Cicort-Lucaciu et al. 2007, 2009).

However, we encountered 2 individuals that exclusively consumed vegetal parts. Both samples belonged to the populations from Gâlgăul Almaşului, where the frequency of empty stomachs was the highest. Although there were recorded amphibian species that voluntarily consume vegetal parts (Das 1996, Silva & Britto-Pereira 2006), it is difficult to accept that newts swallowed plants for feeding. In this case, probably the trophic offer of the habitat was very reduced, thus the hungry animals ingested vegetal parts either resulting from a confusion with a potential prey, or from a failed attack upon the prey. Otherwise the first explanation had been previously invoked in the case of the amphibian from the thermal waters, therefore also involving conditions with a poor trophic offer and with starved amphibians (Covaciu-Marcov et al. 2005b).

The differences between the sexes are not relevant at either of the species. At *L. vulgaris* the frequency of the vegetal parts is higher in the case of the females, while at *T. cristatus* the situation is reversed.

Another category of frequently consumed trophic elements is represented by shed-skin. These were represented by newt shed-skin in all of the cases, although in the past there were signaled situations in which newts consumed the shed-skin of other species (Cicort-Lucaciu et al. 2005a). The consumed shed-skin is probably their own, or the one of other individuals from the population. If we verify the hypothesis regarding the consumption of shed-skin resulting from a confusion between it and a potential prey due to the movements of the animal that sheds (Sas et al. 2005), it is about the shed-skin of other samples that newts cannot swallow and thus ingest only their shed-skin. If it concerns the recycling of the epidermal proteins (Weldon et al. 1993), due to the lack of other trophic resources, it can be their own shed-skin.

The highest frequencies of shed-skin consumption are registered in the habitats with poor feeding, where the frequency of empty stomachs was maximum, at Gâlgăul Almaşului and Mesteacănu. This indicates that shed-skin represents an important trophic resource in the habitats in which lack other trophic elements, compensating their absence. Once with the increase of the feeding intensity, the frequency of shed-skin consumption decreases, although their consumption remains high at some populations regardless of the trophic offer and period (Hodişan et al. 2009b). We identified a common newt that consumed exclusively shed-skin in the habitat from Gâlgăul Almaşului. This case, connected to the fact that in the respective habitat also appeared newts that exclusively consumed vegetal parts, which related to the maximum frequency of empty stomachs, highlight the difficult feeding from the specified habitat, at least during the study period. Moreover, it underlines that fact that the exclusive consumption of vegetal or shed-skin fragments is associated or determined by the existence of difficult feeding conditions.

L. vulgaris consumed much more frequently shed-skin that the larger species. The difference can indicate that shed-skin consumption is not necessarily the result of an unsuccessful attack, because *T. cristatus* hunts and consumes on many occasions individuals of *L. vulgaris* (Cicort-Lucaciu et al. 2005a, 2006c). Meanwhile, *T. cristatus*, a larger and faster species, can capture even in difficult habitats other types of trophic elements, and thus is not constrained to swallow shed-skin.

Amphibian egglaying was consumed in 3 of the 4 studied habitats. This type of stomach contents completely lacked only from the stomach contents of the *L. vulgaris* population from Gâlgăul Almaşului. The fact is not necessarily connected to the more difficult feeding of this population, but to the fact that in the respective habitat no amphibian species reproduced during the study period, thus the newts had no egglaying to consume.

Normally, at the beginning of the study period, the frequency of egglaying consumption is higher, decreasing afterwards as it approaches the warm season (Covaciu-Marcov et al. 2002c, Cicort-Lucaciu et al. 2005a). However, in our case we cannot observe such an evolution. Generally, at the beginning of the activity period, the high egglaying frequency is determined by the presence of brown ranide egglaying (Covaciu-Marcov et al. 2010). In our case, on the first date of collecting, the reproduction period of the brown ranide had already ended, thus their egglaying were no longer present in the habitats. At Jibou, the frequency of egglaying consumption was very low. The fact can be determined by the large dimensions of the habitat, where thus the contact of the newts with these trophic resources is harder. Newts identify egglaying by smell (Joly 1981), which can be even more difficult in a large habitat, than in a small one. High frequencies can be recorded at Mesteacănu and Jebucu, smaller habitats, where the contact with egglaying was more easily realised. Meanwhile, the egglaying, being large and easy to consume, can compensate the lack of other trophic elements and thus replace a poorer trophic offer.

If we compare the two species, it can be noted that *T. cristatus* registered higher frequencies of egglaying consumption than the other species. Numerous egglaying were consumed by other populations of this species (Covaciu-Marcov et al. 2002b, David et al. 2009). The fact can be a consequence of the lifestyle of the crested newts, but also of the different trophic strategy. Thus, *T. cristatus* is mainly a benthonic form, unlike *L. vulgaris* which is much more nektonic (Dolmen & Koksvik 1983). Consequently, *T. cristatus* can much more easily reach the egglaying than *L. vulgaris*. The egglaying are either deposited at the bottom of the water, or are fixed on different submersible supports (Fuhn 1960), either way they are more accessible to the benthonic forms. Meanwhile, *T. cristatus*, having larger dimensions, probably prefers to save energy during the feeding process, avoiding the consumption of small preys, when nourishing and easily-to-consume trophic elements are available.

The situation is not very clear regarding the differences between the sexes in the case of egglaying consumption. Thus, at the *T. cristatus* females the consumption frequency was 10 times higher than in the case of the males. The fact can be expectable. On the one hand, the females do not have a dorsal crest, therefore are slower in the water than the males and more obviously stationed at the level of the substratum (Cicort-Lucaciu et al. 2005b). Meanwhile, during the reproduction period, the energetic consumption involving the egglaying is high, and thus the females are centred around this abundant and easy to consume trophic resource. At the *L. vulgaris* population from Jibou only the females consumed egglaying, which is in concordance with the above mentioned. But at Mesteacănu only the males fed with egglaying, which underlines the random character of the consumption of these trophic elements, depending on the opportunity to encounter them. Being more mobile, the males occupy a larger surface of the habitat, thus they encounter and consume egglaying more easily.

Another category of identified stomach contents was the inorganic elements. These were consumed by both species, in two of the habitats (Table 1). These elements, obviously lacking nutritive value, were however signalled in the stomach contents of numerous amphibian species (Hodar et al. 1990, Dobre et al. 2007, Ferenți et al. 2008b). Their presence has been explained as being accidental, being swallowed together with the aimed preys (Covaciu-Marcov et al. 2006). However, considering that the vegetal parts might serve to crush the exo-skeleton of some invertebrates

(Evans & Lampo 1996), it could not be excluded that this should be the case of the inorganic elements. The presence and the relatively high frequency of inorganic elements from Gâlgăul Almaşului is a consequence of the consumption of benthonic preys in the respective habitat. Thus, numerous plecoptera larvae, benthonic forms, were consumed here. Meanwhile, worms were consumed at Jebucu by almost all of the studied individuals. Thus, together with the benthonic preys or with the ones from the soil level, the newts also swallowed different inorganic fragments. In conclusion, our results confirm the theory regarding the accidental consumption of these stomach contents.

On a whole, the two species consumed 1598 preys. From these, *L. vulgaris*, a smaller species, consumed a larger number of preys, 904, while *T. cristatus*, although larger, consumed only 694 preys. The difference is a consequence of the fact that, although the larger species consumed fewer preys, these had larger dimensions. The fewest preys were consumed at the habitat from Gâlgăul Almaşului, while the most preys were consumed at the habitat from Jibou. These data underline once again the scarcity of the feeding of the population from Gâlgăul Almaşului. At Jibou the large number of preys was determined by the consumption of numerous microcrustacean (ostracoda and cladocera).

Regarding the maximum number of preys per individual, the differences between the two species are very low. At *T. cristatus* the maximum number was of 39 preys / individual, while at *L. vulgaris* of 38 preys / individual. In the case of *L. vulgaris* this high number was determined by the microcrustacean, while in the case of *T. cristatus* by the Diptera Nematocera larvae. Therefore, in the habitats where the microcrustacean lack, or are less important regarding their quantity (Mesteacănu and Gâlgăul Almaşului) the feeding intensity is lower. This fact does not necessarily represent a poorer feeding regarding the quantity, because the microcrustacean can be compensated through the consumption of larger preys, but in a smaller number. The lowest maximum number of preys per individual was recorded in the habitat from Gâlgăul Almaşului, being of only 3 preys / individual. This value is extremely low in comparison to most of the ones registered in the case of other common newt populations (Cicort-Lucaciu et al. 2006b, David et al. 2009). Concerning the differences between the sexes, these seem to be random, existing cases in which the males consumed more preys, but also cases in which the situation is reversed.

The differences between the two species are also reduced in the case of the medium number of preys per individual (Table 1). The highest values are also registered at Jibou, being a consequence of the microcrustacean presence. Their abundance during the interval was probably determined by the position of the habitat at the lowest altitude. Thus, the habitat from Jibou benefited from a gentler climate, which allowed the development in high numbers of these types of preys. Also in the case of this parameter, the lowest values are registered at Gâlgăul Almaşului. The resemblance between the position occupied by the populations regarding the maximum and average number of preys per individual indicates the homogeneity of the resources from the studied habitats.

All of the studied newt populations consumed mainly aquatic preys. The fact is expectable, because during our study the newts were found in the aquatic medium. In the case of other studies realised in the same interval, the aquatic preys also had the highest amounts (Cicort-Lucaciu et al. 2005a, Ovlachi et al. 2007, Ferenți et al. 2008a). However, terrestrial preys were identified in the stomach contents of both species and sexes from all habitats. Their amount was usually low.

We also encountered habitats in which the amount of the terrestrial preys reached important values. For example, at the habitat from Jebucu, the amount of the terrestrial preys reached 45.54% from the total. The explanation for this situation is offered by the temporary character of the puddle system, where the trophic offer is reduced, fact which constrains the newts to hunt for terrestrial preys. In this case, the abundance of the worms from near the habitat is very helpful for the newts. The worms were present in the area due to the rain from the night previous to the sample collecting, being a trophic resource easy to capture and quantitatively important. Similar situations were previously recorded, being explained either by the reduced trophic offer from the aquatic habitat, either by the very abundant offer from the neighbouring terrestrial habitat (Covaciu-Marcov et al. 2002c, Cicort-Lucaciu et al. 2007). Also in the situation described in the literature, in the case of a reduced trophic offer, the newts consumed numerous worms (Covaciu-Marcov et al. 2002c). Thus the restriction of the aquatic trophic resources determined the newts to guide themselves towards such preys. Although found in the water, they can hunt in the moist periods from the shores of the habitats (Covaciu-Marcov et al. 2010), similar situations being described at other species (Kuzmin 1990). Although it is stated that sometimes the terrestrial preys consumed by newts accidentally reached the water (Kutrup et al. 2005), the high amount of the worms indicates that newts are the ones that go for hunting on the ground, activity performed after the reproduction period.

The highest food diversity is registered at the crested newts. The fact is plausible, the larger dimensions of *T. cristatus* allowing it to consume a higher prey diversity, from which the larger ones are not accessible to *L.*

vulgaris. Differences regarding the food diversity also exist between the two species, between the two sexes, but also between the populations from different habitats. Somehow surprising, the lowest diversity is not recorded at the habitat from Gâlgăul Almaşului, but at the one from Mesteacănu, although there the feeding intensity was higher. The fact is a consequence of the number of prey taxa consumed by the two populations, which is lower at the *T. cristatus* population from Mesteacănu than at the *L. vulgaris* one from Gâlgăul Almaşului. Moreover, the situation is also generated by the prey number from different categories / individual. Thus, although the *T. cristatus* population from Mesteacănu feeds more intensely and better satisfies its trophic necessities, it has a lower trophic diversity. The respective crested newts feed well, but homogenous.

On a whole, the two newt species fed with preys belonging to 21 prey taxa. Where it was necessary, we separated the larvae of some taxa from their adults, due to the fact that they have a different mobility and thus imply different capturing techniques. The larvae are numerous in the stomach contents, being a profitable trophic category regarding the energy, due to the high lipid content (Brooks et al. 1996). From the 21 prey taxa, *L. vulgaris* consumed 19, while *T. cristatus* fed with fewer ones, consuming only 14. Although it has smaller dimensions, *L. vulgaris* captured more prey taxa, which explains the more diverse feeding of this species. The prey taxa consumed additionally by *L. vulgaris* are not necessarily of small dimensions. Some of these (Plecoptera or ephemera larvae) have large sizes, thus can be easily captured and consumed by *T. cristatus*, but probably lack from its habitat. Other additional taxa consumed by *L. vulgaris*, such as spiders, have low amounts, being accidentally consumed after they had randomly reached the newts' habitat. The number of consumed prey taxa has always been higher at *L. vulgaris* in the habitats in which the two newt species appear together.

In the case of both species, there are differences between the number of prey taxa consumed in different habitats. Differences between the food composition at the newts originated from different habitats have been previously signalled (Covaciu-Marcov et al. 2002c, Kutrup et al. 2005). In the case of both species the highest number of prey taxa was consumed in the habitat from Jibou. The fact underlines the importance of the microcrustacean in the feeding of the newts and the importance of the habitat's characteristics in satisfying their trophic needs. At *T. cristatus*, only 7 prey taxa were consumed in the 2 studied habitats. Although 2 months separate them, the number of prey taxa is identical. Generally, once with the approaching of the warm season the number of prey taxa consumed by the amphibians increases, new taxa appearing in their food (Covaciu-

Marcov et al. 2000, 2004). In our case, this fact is not registered due to the temporary character of the habitat from Jebucu, which restrains its trophic offer. At *L. vulgaris* the lowest number of prey taxa is recorded at Gâlgăul Almaşului, underlining the difficult feeding of the respective population.

There are prey taxa that were consumed in only some habitats at both newt species. The presence of the respective taxa represents a consequence of the ecological particularities from the level of the habitats. Thus, bivalves were consumed only at Jibou. The fact is a result of the features of the habitat from Jibou, which is the largest from the studied ones. Being a quasi-permanent one, it allows the survival of the shells. The most homogenous consumed prey taxon is represented by the Nematocera Diptera larvae, which were consumed in all of the studied habitats. The fact is a general one, the mosquito larvae being in the case of many newt populations a fundamental trophic resource (Cicort-Lucaciu et al. 2005a, Dobre et al. 2007).

The differences between the sexes are not relevant. Thus, in two of the habitats the males consumed more prey taxa, while in the other two habitats the females consumed more prey taxa. As up to now, the differences between the sexes seem to be random, while the feeding differences between the habitats or between the two species seem obvious and explainable.

In the case of *L. vulgaris* the highest amount from the consumed food was recorded by the microcrustacean, the ostracoda occupying first place and the cladocera second place (Table 2). Unlike the common newts, at *T. cristatus* the most consumed preys were the amphibian larvae, while the Nematocera Diptera larvae occupied second place. Thus, the medium-sized preys registered the highest amounts at the larger species, while the smallest species consumed mainly reduced-sized preys. The fact underlines that at least for *T. cristatus* the consumption of microcrustacean is an additional solution, being used in the absence of other more quantitatively important preys (Cicort-Lucaciu et al. 2007). The tadpole consumption has been frequently recorded at the crested newts (Cicort-Lucaciu et al. 2005b, Covaciu-Marcov et al. 2010), registering high amounts in many cases (Covaciu-Marcov et al. 2002a,d). The fact is a result of the high number of tadpoles present in certain periods in the newts' habitats.

Both newt species consumed tadpoles in all of the four studied habitats, but they registered high amounts only at *T. cristatus*. Although the microcrustacean represent additional solutions, at Jibou the crested newts also consumed numerous cladocera and ostracoda. The fact can be a consequence of the scarcity of other preys, but also of the larger dimensions of the habitat that allows the more mobile preys to avoid predators. Thus, it can also be explained the lack from the crested newts' stomach contents of some individuals from the smaller species, *L. vulgaris*, although it was signalled in other cases (Cicort-Lucaciu et al. 2005a). On the contrary, however, the microcrustacean are slow, while the daphnia at least form important agglomerations in certain areas of the puddle, in sectors with low and warmer waters, being accessible to the newts.

Table 2.

The percentage abundance (%A) and the frequency of occurrence (%f) of the consumed prey items by the *L. vulgaris* individuals. (l.- larvae, a.- aquatic, t.- terrestrial)

	Mesteacănu 22.04.2009		Gâlgău Almaşului 22.04.2009		Jibou 23.04.2009		Total	
	A%	F%	A%	F%	A%	F%	A%	F%
Nematoda	-	-	-	-	4.01	15.3	3.32	5.49
Annelida – Oligochaeta	-	-	-	-	0.4	5.08	0.33	1.83
Gastropoda (a.)	0.81	1.75	-	-	-	-	0.11	0.61
Bivalvia	-	-	-	-	0.4	5.08	0.33	1.83
Arachnida – Araneae	-	-	6.25	4.17	-	-	0.22	1.22
Crustacea – Cladocera	1.61	1.75	-	-	32	37.3	26.7	14
Crustacea – Ostracoda	-	-	-	-	48.3	89.8	39.9	32.3
Crustacea – Copepoda	-	-	9.38	2.08	-	-	0.33	0.61
Ephemeroptera (l.)	0.81	1.75	-	-	0.4	5.08	0.44	2.44
Plecoptera (l.)	-	-	18.8	10.4	0.13	1.69	0.77	3.66
Homoptera – Aphidinea	-	-	3.13	2.08	-	-	0.11	0.61
Coleoptera- Dytiscidae	0.81	1.75	-	-	2.41	16.9	2.1	6.71
Coleoptera- Dytiscidae (l.)	15.3	24.6	3.13	2.08	1.2	8.47	3.21	12.2
Coleoptera (t.)	0.81	1.75	12.5	8.33	-	-	0.55	3.05
Diptera - Nematocere (l.)	18.5	28.1	31.3	12.5	6.95	52.5	9.4	32.3
Diptera - Nematocera	0.81	1.75	-	-	0.94	1.69	0.88	1.22
Diptera – Brachycera	-	-	3.13	2.08	-	-	0.11	0.61
Lepidoptera (l.)	0.81	1.75	-	-	0.13	1.69	0.22	1.22
Trichoptera (l.)	24.2	43.9	-	-	0.94	11.9	4.09	19.5
Anura (l.)	35.5	49.1	12.5	6.25	1.87	15.3	6.86	24.4

In the case of the two studied newt species there are large differences between the amount of the main prey taxa regarding the habitat (Table 2 and 3). However, the microcrustacean occupy first place at Jibou concerning both species. The differences appear from the second place, which is occupied by the tadpoles at *T. cristatus* and by the Nematocera larvae at *L. vulgaris*. In the case of the *T. cristatus* population from Jebucu, although the Nematocera larvae occupy first place, the worms hold second place, representing 36.1% from the total preys consumed by this population. The fact indicates the importance of the terrestrial preys for this population.

Table 3.
The percentage abundance (%A) and the frequency of occurrence (%f) of the consumed prey items by the *T. cristatus* individuals. (l- larvae, a- aquatic, t-terrestrial, undet.- undetermined)

	Mesteacănu 22.04.2009		Gâlgăul Almaşului 22.04.2009		Jibou 23.04.2009		Total	
	A%	F%	A%	F%	A%	F%	A%	F%
Annelida – Oligochaeta	-	-	-	-	36.1	93.8	12.4	48.9
Gastropoda (t.)	1.27	11.1	-	-	0.84	4.17	0.58	4.44
Bivalvia	-	-	1.34	16.7	-	-	0.58	4.44
Crustacea – Cladocera	-	-	44.3	33.3	-	-	19	8.89
Crustacea – Ostracoda	-	-	16.8	66.7	-	-	7.2	17.8
Coleoptera- Dytiscidae (l.)	3.8	22.2	-	-	3.36	12.5	2.02	11.1
Coleoptera- Dytiscidae	-	-	0.67	8.33	-	-	0.29	2.22
Coleoptera – Carabidae	1.27	11.1	-	-	-	-	0.29	2.22
Coleoptera (t.)	1.27	11.1	-	-	0.84	4.17	0.58	4.44
Coleoptera (undet.)	-	-	-	-	1.68	8.33	0.58	4.44
Diptera - Nematocera (l.)	6.33	44.4	4.7	33.3	52.1	25	21.3	31.1
Diptera – Brachycera	-	-	0.67	8.33	-	-	0.29	2.22
Lepidoptera (l.)	-	-	0.67	8.33	5.04	25	2.02	15.6
Trichoptera (l.)	5.06	22.2	8.05	66.7	-	-	4.61	22.2
Anura (l.)	81	77.8	22.8	83.3	-	-	28.2	37.8

The differences between the sexes are usually not very obvious in the case of the amount of the prey taxa. Generally, in the case of both sexes the same prey taxa occupy first places regarding the amount. There are however differences, but these are low, affecting only some habitats and not all of the prey taxa (Table 4). Beside the fact that there are certain differences of the amount of some prey taxa, there are taxa consumed by only one of the sexes. Thus, at Gâlgăul Almaşului the aphida were consumed only by the females, having even relatively high amounts. These preys are terrestrial, probably reaching the water accidentally, where they were more accessible to the females, which lacking the dorsal crest, stayed more towards the shores. Otherwise, the positioning of the common newts towards the shores of the populated aquatic basins, in areas with lower and warmer water, has been previously signalled (Covaciu-Marcov et al 2010).

Table 4.

The percentage abundance (%A) of the consumed prey items by the males and females of *L. vulgaris* and *T. cristatus* (M– males, F– females, l- larvae, a- aquatic, t- terrestrial, undet.- undetermined)

	Mesteacănu 22.04.2009		Gâlgăul Almaşului 22.04.2009		Jibou 23.04.2009		Jebuc 27.06.2009	
	L. vulgaris		*L. vulgaris*		*L. vulgaris*		*T. cristatus*	
	M	F	M	F	M	F	M	F
Nematoda	-	-	-	-	-	8.43	-	-
Annelida – Oligochaeta	-	-	-	-	0.26	0.56	45.5	28.1
Gastropoda (t.)	-	-	-	-	-	-	-	1.56
Gastropoda (a.)	1.75	-	-	-	-	-	-	-
Bivalvia	-	-	-	-	-	0.84	-	-
Arachnida – Araneae	-	-	15.4	-	-	-	-	-
Crustacea – Cladocera	-	2.99	-	-	61	-	-	-
Crustacea – Ostracoda	-	-	-	-	30.1	68.3	-	-
Crustacea – Copepoda	-	-	-	15.8	-	-	-	-
Ephemeroptera (l.)	-	1.49	-	-	0.51	0.28	-	-
Plecoptera (l.)	-	-	30.8	10.5	-	0.28	-	-
Homoptera - Aphidinea	-	-	-	5.26	-	-	-	-
Coleoptera- Dytiscidae (l.)	14	16.4	-	5.26	1.28	1.12	5.45	1.56
Coleoptera- Dytiscidae	0	1.49	-	-	0.26	4.78	-	-
Coleoptera (t.)	1.75	-	15.4	10.5	-	-	1.82	-
Coleoptera (undet.)	-	-	-	-	-	-	3.64	-
Diptera - Nematocera (l.)	19.3	17.9	23.1	36.8	4.85	9.27	38.2	64.1
Diptera - Nematocera	1.75	-	-	-	-	1.97	-	-
Diptera - Brachycera	-	-	7.69	-	-	-	-	-
Lepidoptera (l.)	1.75	-	-	-	-	0.28	5.45	4.69
Trichoptera (l.)	22.8	25.4	-	-	1.02	0.84	-	-
Anura (l.)	36.8	34.3	7.69	15.8	0.77	3.09	-	-

In some cases there are important differences between the amount and frequency of consumption of certain prey taxa (Table 2 and 3). Thus, in the case of *T. cristatus* the worms occupied first place regarding the frequency, while occupying only 3rd place concerning the amount. This fact indicates that the worms are the most important prey taxa for the crested newts during the study. Although the crested newts consumed a smaller number of worms than Nematocera larvae or tadpoles, the worms were consumed by more newts. Almost half of the crested newts fed with worms, therefore these trophic resources were more homogenously distributed in the environment, being more accessible to a larger number of newts. Meanwhile, worms are slow preys and have large dimensions, which can satisfy the trophic necessities of the newts in smaller numbers. At this species, the tadpoles occupied second place regarding the frequency, preys which occupied first place regarding the amount. Tadpoles are also relatively large and nutritive preys.

Differences between the position held by a prey taxa regarding the amount and frequency of consumption are also registered at *L. vulgaris* species. Thus, the ostracoda crustacean and Nematocera larvae record first place concerning the frequency. From these, the last one occupied third place in the case of the amount. The tadpoles are found in second place regarding the frequency and fourth place after the amount. The larger preys hold better positions after the frequency of consumption than after the amount. The situation is a general one, both species consuming smaller preys, which influence the total amount. But, due to the smaller dimensions, the respective preys barely satisfy the trophic necessities of the newts. Thus, they guide themselves towards larger preys, which are consumed in smaller numbers because of their size, thus have low amounts and high frequencies. The preys with high consumption frequencies are important for the whole population (Ferenți et al. 2009b). These were consumed by a large number of newts, thus have a high value for the entire population. The preys with high amounts but low frequencies have been consumed by only some individuals from the population, for which they have a high importance. Another example is the one given by the *T. cristatus* population from Jibou where the Trihoptera larvae were consumed by 66.7 % of the newts, but represented only 8.05 % from the total preys. These preys have large dimensions, thus high nutritive value, not being necessary the consumption of a higher number of individuals.

The differences between the frequency of the prey taxa regarding the sex of the newts (Table 5) are similar to the ones registered in the case of the amount; a clear rule cannot be drawn concerning their variation. Thus, at some populations there are differences between the frequency of consumption of some taxa between the two sexes, while at other populations the same prey taxa occupy the same positions at both sexes.

Table 5.
The frequency of occurrence (%f) of the consumed prey items by the males and females of *L. vulgaris* and *T. cristatus* (M– males, F– females, l- larvae, a- aquatic, t- terrestrial, undet.- undetermined)

	Mesteacănu 22.04.2009		Gâlgăul Almaşului 22.04.2009		Jibou 23.04.2009		Jebuc 27.06.2009	
	L. vulgaris		*L. vulgaris*		*L. vulgaris*		*T. cristatus*	
	M	F	M	F	M	F	M	F
Nematoda					-	30	-	-
Annelida - Oligochaeta					3.45	6.67	92.3	90.9
Gastropoda (t.)					-	-	-	9.09
Gastropoda (a.)	3.45	-	-	-				
Bivalvia					-	10	-	-
Arachnida - Araneae	-	-	8.33	-				
Crustacea - Cladocera	-	3.57	-	-	75.9	-	-	-
Crustacea - Ostracoda					93.1	86.7	-	-
Crustacea - Copepoda	-	-	-	4.17				
Ephemeroptera (l.)	-	3.57	-	-	6.9	3.33	-	-
Plecoptera (l.)	-	-	12.5	8.33	-	3.33	-	-
Homoptera - Aphidinea	-	-	-	4.17				
Trichoptera (l.)	37.9	50	-	-	13.8	10	-	-
Lepidoptera (l.)	3.45	-	-	-	-	3.33	23.1	27.3
Coleoptera- Dytiscidae (l.)	24.1	25	-	4.17	6.9	10	15.4	9.09
Coleoptera- Dytiscidae	0	3.57	-	-	3.45	30	-	-
Coleoptera (t.)	3.45	-	8.33	8.33	-	-	7.69	-
Coleoptera (undet.)					-	-	15.4	-
Diptera - Nematocera (l.)	24.1	32.1	8.33	16.7	37.9	66.7	30.8	18.2
Diptera - Nematocera	3.45	-	-	-	-	3.33	-	-
Diptera - Brachycera	-	-	4.17	-	-	-	-	-
Anura (l.)	55.2	42.9	4.17	8.33	6.9	23.3	-	-

In the habitats where both studied newt species are present there does not seem to exist a competition between them. In these situations, *L. vulgaris* guides itself towards the consumption of small-sized preys, which it consumes in high quantities. On the contrary, *T. cristatus* focuses on feeding with larger preys, from which consumes fewer individuals. This portioning of the habitat decreases the competition between the two species. The fact is probably eased in a larger habitat, such as the one from Jibou, where the large surface of the aquatic basin allows a better distribution and utilisation of the trophic resources. The low competition can also be a consequence of the two species' preferences towards other areas of the habitat.

The above mentioned differences can also indicate the usage of different trophic resources by the two studied newt species. Generally, two types of trophic strategies have been observed at the amphibians,,sit and wait" and ,,active (widely) foraging" techniques (Toft 1980, Huey & Pianka 1981). In the case of *L. vulgaris*, the consumption of small preys indicates the existence of an active foraging type of strategy. It involves actively searching for preys, and thus spending a higher amount of energy in this process (Anderson & Karasov 1981). The crested newts seem to use, the sit and wait" technique, saving energy and attacking the larger preys with which they come into contact. Moreover, the crested newts register higher values regarding the frequency of the egglaying in comparison to the common newts. Being an active predator, *L. vulgaris* consumed both a high number of prey taxa and many preys from the respective taxa. Thus, the common newt has high chances to meet several prey taxa, connected to certain microhabitates. However, in the case of the crested newts the preference for larger preys does not necessarily indicate avoiding the smaller ones, because when they are present in the habitat they will be massively consumed by *T. cristatus*. Meanwhile, the crested newts are not satisfied to wait for the larger preys to pass through their vicinity, but they actively search for them, thus modifying their trophic strategy. The fact is demonstrated by the consumption of worms, which were hunted at the limit of the populated aquatic habitat.

CONCLUSIONS

In the stomach contents of the two studied newt species we identified vegetal fragments, newt shed-skin matter, amphibian egglaying, inorganic elements and animal preys. These belonged to 21 prey taxa. Nematocera larvae were constantly consumed in all four habitats. Not all of the analysed newts presented stomach contents, the frequency of individuals without food being much higher in the habitat from Gâlgâul Almaşului. The highest number of prey taxa was consumed by *L. vulgaris*. In the case of this species, the highest amount was recorded by the crustacean ostracoda, followed by the crustacean cladocera, while in the case of the frequency the crustacean ostracoda and Nematocera larvae occupied first place, followed by the tadpoles. At *T. cristatus* the tadpoles and Nematocera larvae held the highest amounts while the worms and tadpoles registered the highest frequencies. Most of the preys consumed by the two species are represented by aquatic invertebrates. However, terrestrial preys appear in the stomach contents of both species and in all habitats. In the case of some habitats with low trophic offer, the terrestrial preys hold important amounts.

There are differences between the feeding of the newts from the four studied habitats. We encountered habitats in which the newts' feeding is poor, such as the one from Gâlgăul Almaşului. In the respective habitat, we registered a high number of animals without food, the exclusive consumption of vegetal parts and a low number of preys / individual. In other habitats, the feeding intensity is much higher due to the consumption of small preys, such as microcrustacean. The particularities of the habitats in which the newts are present greatly influence their feeding.

The differences that exist between the feeding of the two newt species are very important. Thus, *T. cristatus* consumed fewer preys than *L. vulgaris*, but the respective preys had larger dimensions. On the contrary, *L. vulgaris* consumed a high number of small preys, having a more intense feeding. These differences can be determined by the different size of the two species, but also represent a consequence of the utilisation of different trophic strategies. Thus, *L. vulgaris* uses the ,,active foraging" type of technique, while *T. cristatus* uses the ,,sit and wait" strategy. Due to the portioning of the habitat and to the different trophic strategies, the two species do not compete for food. The differences between the two sexes are, in case of both species, slightly pronounced, their variation being probably accidental.

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