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Inter and intra specific cannibalism and aggressiveness within the *Triturus cristatus* superspecies: hungry or crowded?

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Abstract. The authors focused their observations on the agresivity behavior of great crested newts from an urban population within the Municipality of Bucharest. The investigations intended to elucidate whether the aggresive behavior is generated by feeding-related features or by reasons of population dynamics, in the form of density regulation or territoriality. Nevertheless, observations regarding the attack on other species of newts (alpine newts – *Triturus alpestris*) or on the occurence of attacks within age cathegories and differrent biological periods (aquatic larvae, aquatic juveniles, aquatic reproductive adults, terrestrial active adults, terrestrial hibernating adults) were concerned.
Key Words: *Triturus cristatus* superspecies, newts, cannibalism, inter/intraspecific aggresive behavior.

Résume. Les auteurs ont concentre leurs efforts en observant le comportement d'agressivité chez les tritons crêtes d'une population urbaine appartenant au Municipe de Bucarest. Les recherches concernent en élucider la nature du comportement d'agressivité et s'il est génère par des aspects liées au l'activité de nutrition ou par des raisons concernant la dynamique de la population, soit-il régulation de la densité populationnelle ou divers aspects de territorialité. Au même temps, ont a accorde d'importance aux aspects liées a l'agressivité contre autres espèces de tritons (tritons alpins) ou aux aspects concernant les attaques pari des différentes catégories d'age et périodes biologiques (des larves aquatiques, des juvéniles aquatiques, des adultes aquatiques reproducteurs, des adultes terrestres actives, des adultes terrestres en procès de hibernation).
Mots clés: *Triturus cristatus* superspecies, triton, cannibalisme, comportement agressif inter et intra spécifique.

Rezumat. Autorii si-au concentrat eforturile asupra observării comportamentului de agresivitate la tritonii cu creastă aparţinând unei populaţii urbane din perimetrul Municipiului Bucureşti. Cercetările au avut scopul de a elucida natura comportamentului de agresivitate, mai exact, dacă acesta este generat de aspecte legate de hrănire sau de motivaţii care ţin de dinamica populaţională, fie că este vorba de reglarea densităţii populaţionale sau de aspecte legate de teritorialitate. Totodată, s-a acordat importanţă şi aspectelor legate de atacul asupra altor specii de tritoni (tritoni de munte) sau aspectelor privind semnalarea frecvenţei atacurilor în cadrul diferitelor categorii de vârstă sau perioade biologice (larve acvatice, subadulţi acvatici, adulţi acvatici reproducători, adulţi tereştrii activi, adulţi tereştrii în hibernare).
Cuvinte cheie: *Triturus cristatus* superspecies, tritoni, canibalism, comportament agresiv inter şi intraspecific.

Introduction. Previous studies on feeding behavior that directly or indirectly approach cannibalism and aggresivity in amphibians in general (Cicek & Mermer 2006; Cicort-Lucaciu et al 2006; Groza et al 2008; Balint et al 2008; Kovacs & Sas 2009; Sas et al 2009) and newts in particular (David et al 2007; David et al 2008) from Romania and other countries have allready been achieved to a large scale, including such forms as consumption of eggs, shedded skins, aquatic larvae or even small size metamorphs of the same species or even other species. The most frequent observations refer mainly to

shedded skins or egg consumption, as a mean to regulate the population dynamics or to recycle available proteins from shedded skin, in what concerns the cannibalistic behavior (Cicort-Lucaciu et al 2006; Groza et al 2008), and to aggresive behavior by means of intimidation postures involved in courtship and mating behavior (Jalba 2008). Although studies regarding urban *Triturus* species do not lack (Jehle et al 1995; Jehle & Arntzen 2000; Thonke et al 1994), and some refer to a large extent to the phenomenon of skin and egg ingestion in adult newts, attempting as well to ellucidate the reasons for which this type of feeding behavior occurs, research papers involving aggresive behavior of newts are less frequent.

Urban populations of amphibians within the Municipality of Bucharest originate either in the form of old populations which were separated from the periurban or other urban populations due to habitat fragmentation, and formed local assemblages arround diverse waterbodies as parts of parks, which is the most common possibility in the case of central populations, or in the form of larger or smaller numbers of individuals that immigrated to newly created favourable spots such as recently constructed parks (that included waterbodies) due to either destruction/alteration of their original habitat (the case of periurban amphibian populations) or simply territory expansion, due to favorable factors presented by newly created habitats (which represents the least frequent case). Thus, amphibian populations from the parks within the central area of the Bucharest Municipality represent a valuable model to study the behavioral modifications of long term isolated populations of amphibians, in general and newts in particular.

Considering these, we attempted to research the occurence of individual-orriented cannibalistic/aggresive behavior in a population of urban newts, both on site and in laboratory conditions (aquarium) and attempt to correlate the frequency of the upper-mentioned behavior with the age cathegories of the species.

Material and Method

Study location. The crested/Danube newt population interested in the present study is located in a central park (The Cişmigiu Garden) within the Municipality of Bucharest (Figure 1 and Figure 2). The park is frequented by visitors during the whole year, being both an attraction and a recreation spot in the central part of the city, having in this respect a various number of peisagistic architecture arrangements, among which a main waterbody, represented by a central lake of small size and several smaller concrete basins, in which we identified the population of crested newts interested in the study (sites 1, 2 and 3, see Figure 3). The pools are situated at Lat. = 44°26'14,07" N, Long.= 26°05'27,85" E and elevation 76m for site 1, Lat.= 44°26'13,34" N, Long.=26°05'26,29" E and elevation 75m for site 2 and Lat. =44°26'14,15" N, Long. = 26°05'25,85"E and elevation of 75m for site 3. The three sites are sittuated at a relatively small distance one from the other, the average distance being of 25m. The average depth of the studied pools is 0,8m, and the average distance to the main waterbody is of 50m.

While the lake is provided with springs that ensure the necessary water over the year, the smaller pools, represented by the concrete bassins, are provided with water from the lake, by means of water pump systems. The concrete pools are emptied periodically (once every year, from the beggining of December to the end of March) for cleaning activities and maintenance. During the empty period, the bottom of the bassins is swept clean, removing every trace of vegetal matter that could provide shelter for amphibians or other aquatic fauna, excepting pulmonate snails (Gastropoda:Pulmonata) and earthworms (Oligochaeta). These aspects lead to a very rapid dynamic of food, once the pools are filled with water and the amphibians enter them for reproduction. Since there is no other food available in water, both subadults and reproducing adults recurse to cannibalism in order to ensure necessary energy for life.

Period of study. The study lasted from August 2008 to the first week of April 2009, when regular visits (at least twice every month) were made to the study site.

Contention and maintenance. The newts were collected by means of a dip-fishing net, a part of them being studied on location (check for wounds, measurements) and released on site, while another part (a number of 14 exemplaries: 3 adults, 8 subadults and 3

aquatic larvae) were taken into the laboratory and maintained in aquarium tanks for further observation. The transport of the exemplaries from the collecting site to the laboratory (approximatively 1,5 km) employed special plastic contention/transport boxes of variable sizes, depending on the dimmensions and number of the individuals, for subadults and adults, while larvae were transported in large glass Petri dishes. The laboratory aquarium tanks varied in size from 120 to 30 liters, being provided with water areas and refuge places (branches, rocks and moss patches). The enclosures for aquatic branchiated larvae were provided with a larger quantity of water (a large ammount of water was taken from the original pools in order to prevent chemical adaptation shock), aquatic plant species and refuge places as with adults and subadults, as well as with filtrating and aerating devices. Suplimentary refuge areas above water were achieved by means of emerging rocks and roots, as well as by a layer of floating aquatic vegetation (*Pistia sp.*). All age cathegories were fed with Chironomid larvae and *Tubifex sp*., available from the aquaristic commerce, as well as with earthworms of adequate size and high protein fish feed (Tetra Diskus, Tetra Pro).

Species identification. Diagnosis of the species was achieved according to criteria presented in literature (Gherghel & Iftime 2009; Fuhn 1960; Arntzen & Wallis 1999; Maletzky et al 2008), considering as relevant the following aspects: the value of the Wolterstorff index (the ratio between the length of the front limb X100, divided by the value of the distance between the insertion points of the limbs), the number of the rib-bearing vertebrae (RBV) and specific cromatic features, represented by the gular and abdominal coloration, aspect of the dorsal crest in reproductive males, white vermiculation on neck and flanks, aspect of abdominal coloration. Results of the diagnosis were presented in three tables (Table 1, Table 2 and Table 3).

Figure 1. Location of the studied area on the hydrographic map of Romania. (Global Mapper v.10.02)

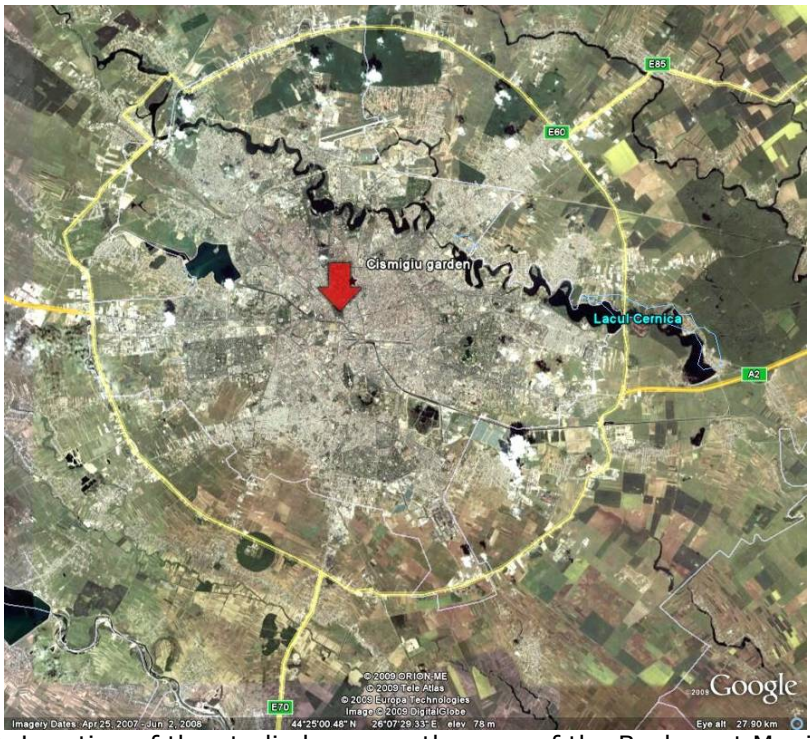


Figure 2. Location of the studied area on the map of the Bucharest Municipality. (Google Earth 5.0.11337.1968 (beta)).

Figure 3. Location of the research sites in the Cişmigiu Garden territory. (Google Earth 5.0.11337.1968 (beta)).

Table 1

Metric diagnosis

Sex	Observed Wolterstorff index value	Wolterstorff index value for *Triturus cristatus* (Arntzen & Wallis 1999)	Wolterstorff index value for *Triturus cristatus* (Fuhn 1960)	Wolterstorff index value for *Triturus dobrogicus* (Arntzen & Wallis 1999)	Wolterstorff index value for *Triturus dobrogicus* (Fuhn 1960)	Wolterstorff index value for *Triturus cristatus* > *Triturus dobrogicus* (Fuhn 1960)	Wolterstorff index value for *Triturus cristatus* (Maletzky et al 2008)
Male	51.85851	54.0 – 63.69	74 % (65 %) 52 %	<54.0	44 % (49 %) 57 %	64 % (56 %) 51 %	51.3 %-66.7 %
	51.62791						
Female	38.57988	46.2 – 53.89	36 % (51 %) 62 %	<46.2	36 % (44 % 50 %	26 % (46 %) 60 %	44.0 %-65.9 %
subadult	45.28986						
	43.05556						
	53.71179						
	61.58618						
	55.07745						
	65.70066						
	47.21442						
	48.28711						
	44.11878						
	52.77973						
	60.15561						

Observations were made periodically, especially during feeding times, reproductive period, end of metamorphosis and at different moments of the day (morning, noon, evening).

At a moment in time, four adult alpine newts (*Triturus alpestris*) and one adult *Triturus cristatus* superspecies were added to the aquatic larvae tank and to the tank with the subadults that preferred to remain a longer period in water. There were noted attempts to attack the two introduced species.

The observations focused on the types of aggresion involved (attempt to eat an individual or assumption of aggresive postures that later may denaturate in physical attacks), on the age cathegory of both the aggressor and the aggressed individuals (several other caracters were also monitored, such as color and size), on the body part towards which aggresive acts are orriented, on the occurence of limitating the aggresive/cannibalistic behavior to the representants of the same species or, in opposition, manifesting such a behavior towards other species as well. Observed aspects were synthetised under the form of a table (Table 4) and several graphic representations which employed a DAFOR scale in order to illustrate various aspects of newt aggresive behavior (Figures 5, 6, 7, 8, 9, 10, 11 and 12).

Fotography. Interested aspects were photographed by means of a Petri dish in which newts were placed and exposed from below, to observe the chromatic patterns and from above, versus a ruller. Photographies taken from above were then processed by means of measurement software (SnakeMeasurer) and measurements were noted. Sample photographs for each individual were presented in Table 3.

Statistical and graphical interpretation was achieved by means of Microsoft Excel with XLStat patch and Statistica 6 software.

Results and Discussion. As Table 1 demonstrates, the values for the Wolterstorff index of the two adult males and the female fit into the limits of the values provided by both Fuhn (1960) and Arntzen & Wallis (1999), for the species *Triturus dobrogicus*, but also into those offered by Fuhn 1960 for *Triturus cristatus* > *Triturus dobrogicus*, who has also analysed the Bucharest populations. Upon the presented data, we considered that the most probable hypotesys is that the studied population belongs to the *Triturus dobrogicus* species, having also a great chance to be hybridized to a whatever extent with the *Triturus cristatus* species, upon the measurements of the female specimen. Nevertheless, Fuhn (1960) remarks the presence of hybrid populations of crested newts in Bucharest. Also, the values of the two adult males fit in the intervals offered by Maletzky et al (2008) for the *Triturus cristatus* species, but the one for the female does not. The values for the 11 subadults varied on a large scale, as presented in Figure 4. Still, chromatic diagnosis (Table 3) proved that there is no exemplary with pure chromatic aspect of either *T. cristatus* or *T. dobrogicus*.

Table 2

Merristic diagnosis: RBV *for Triturus cristatus* and *T. dobrogicus* (modified after Arntzen & Wallis 1999)

Species	*Herre 1932*	*Lanza et al 1991*	Arntzen & Wallis 1999	Present study
T. dobrogicus	17	17.6	17.5	
T. cristatus	16	16.0	16.0	16

In what concerns the Rib Bearing Vertebrae count (RBV), three aquatic subadults found dead were interested. The result was of 16 RBV for all three exemplaries, which, according to the speciality literature (Arntzen & Wallis 1999), is a representative caracter for *Triturus cristatus* (Table 2).

An obvious conclusion would be that the individuals analysed belong from the metric point of view to the *T. dobrogicus* species, but merristically (RBV) to the *T. cristatus* species.

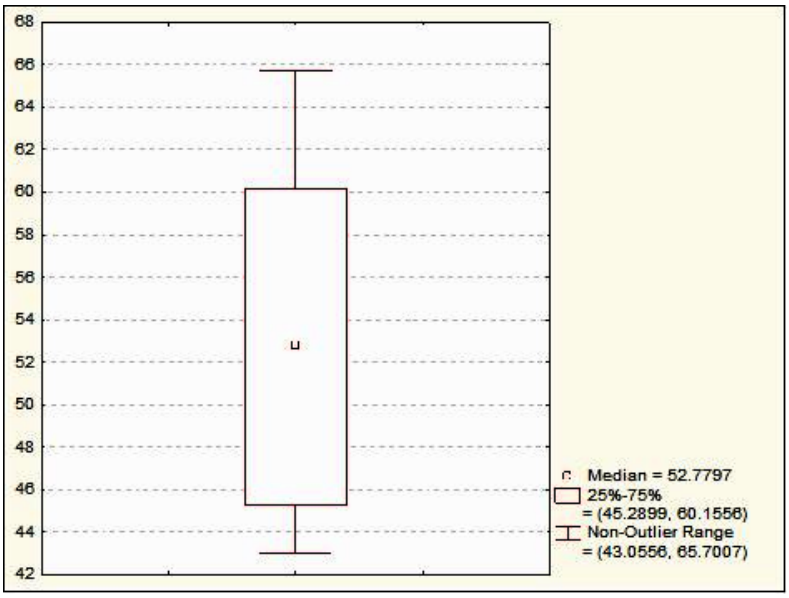


Figure 4. Variation of Wolterstorff index in unsexed subadults of *Triturus cristatus* superspecies.

From the chromatic point of view, the following caracters (Fuhn 1960; Gheghel & Iftime 2009) were observed:

- the aspect of the dorsal crest (tall and highly serrated in *T. dobrogicus*, smaller and less serrated in *T. cristatus*);
- the chromatics of the gular zone (yellow with black and white spots in hybrids, black with white spots in *T. dobrogicus* and grey with black and white spots in *T. cristatus*);
- ventral dark spots (confluent in *T. dobrogicus*, separated in hybrids and *T. cristatus*);
- white vermiculations present in the gular zone and on the flanks (strong in *T. cristatus*; weak/absent in hybrids, *T. dobrogicus*);

Table 3

Chromatic diagnosis

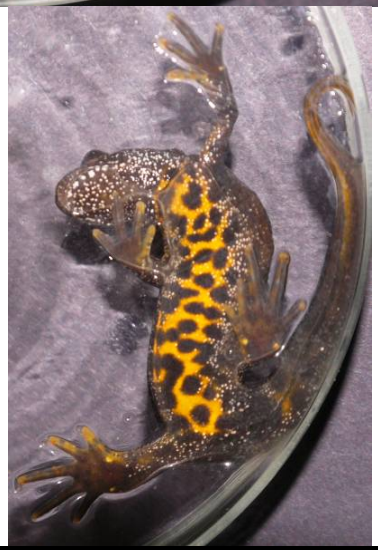
Nr. individual / *Present study observations*	*Dorsal crest* (tall and highly serrated=*T. dobrogicus*, hybrids; smaller and less serrated = *T. cristatus*)	*Gular zone chromatics* (yellow with black and white spots = hybrids, black with white spots = *T. dobrogicus*, grey with black and white spots = *T. cristatus*)	Ventral dark spots (confluent = *T. dobrogicus*, separated = hybrids/*T. cristatus*)	White vermiculations on gular zone and lateral sides of head and body (strong= *T. cristatus*; weak/absent= hybrids, *T. dobrogicus*)	Diagnosis	Foto
1	subadult	yellow with black and white spots (h)	confluent (d)	weak/absent (h/d)	Hybrid/ T. dobrogicus	

2	subadult	grey with black and white spots (c)	confluent (d)	weak/absent (h/d)	T. dobrogicus/ T. cristatus	
3	subadult	grey with black and white spots (c)	separated (h/c)	strong (c)	T. cristatus/ Hybrid	

4	subadult	grey with black and white spots (c)	confluent (d)	strong (c)	T. cristatus/ T. dobrogicus	
5	subadult	yellow with black and white spots (h)	confluent (d)	strong (c)	Hybrid	

6	tall and highly serrated (d)	yellow with black and white spots (h)	confluent (d)	strong (c)	Hybrid	
7	female	yellow with black and white spots (h)	confluent (d)	strong (c)	Hybrid	

8	smaller and less serrated (d)	yellow with black and white spots (h)	confluent (d)	strong (c)	Hybrid	
9	subadult	yellow with black and white spots (h)	separated (c)	strong (c)	hybrid/*T. cristatus*	

10	subadult	yellow with black and white spots (h)	confluent (d)	strong (c)	Hybrid	
11	subadult	black with white spots (d)	confluent (d)	strong (c)	*T. dobrogicus/ T. cristatus*	

12	subadult	yellow with black and white spots (h)	separated (c)	strong (c)	Hybrid/*T. cristatus*	
13	subadult	grey with black and white spots (c)	confluent (d)	strong (c)	*T. cristatus*/ *T. dobrogicus*	

14	subadult	grey with black and white spots (c)	confluent (d)	strong (c)	*T. cristatus/ T. dobrogicus*	

Employed notions in the present research paper were defined as follows:

Aggresive behavior types

- *cannibalism*: intentionate act of eating or attempting to eat an individual of the same species;
- *predatorism*: intentionate act of eating or attempting to eat an individual of another related species (in the present case, another species of newt);
- *intraspecific aggresivity*: act of aggresion on an exemplary of the same species without the obvious intention of eating it, but mainly of removing/blocking the access of the respective individual to a certain area or resource;
- *interspecific aggresivity*: act of aggresion on an exemplary of another closely related species (in the present case, another species of newt) without the obvious intention of eating it, but mainly of removing/blocking the access of the respective individual to a certain area or resource;
- *reproductive aggressivity*: the act of attempting to remove/block acces of an exemplary of the same sex and species to reproduction with another exemplary of the same species and opposite sex.

The body parts affected in the aggresive behavior instances refer to those parts of the newt body towards which intentionate aggression acts are orriented.

The reason for which the aggressive behavior is triggered represents the main motivation (obvious or most probable) that leads to the expression of the respective aggressive instance.

Injuring degrees employed were defined on a DAFOR scale and vary as follows:

- 4 = *severe, death* (severe wounds, that might involve removing of the attacked body part and usually degenerate in the death of the attacked individual);
- 3 = *severe* (severe wounds, that might involve removing of the attacked body part and may degenerate in the death of the attacked individual);
- 2 = *moderate* (wounds that might involve partial or total removal of the attacked body part; usually do not involve death of the attacked individual);
- 1 = *less severe* (refer mainly to hits and bites and less to real wounds, that might involve removal of the attacked body part, or mimicry of aggressive behavior without physical contact);
- 0 = *absent* (no wounds or hits were observed, neither aggressive stances).

Active/passive aggression refers to either individuals that act as aggressors (active) or individuals that are aggressed (passive).

Age categories define moments in the life cycle of newts as follows:

- a*quatic larvae* refers to the first stage of development in newts, that present branchiated larvae;
- a*quatic metamorphs* refers to larvae that have metamorphosed into non-branchiated young individuals but still inhabit the aquatic environment;
- a*quatic phase of subadults* refers to non-reproductive adults (subadults that have not reached the reproductive age but inhabit the aquatic environment);
- *terrestrial phase of subadults* refers to non-reproductive adults (subadults that have not reached the reproductive age but inhabit the terrestrial environment);
- *non-reproductive adults in aquatic phase* refers to adults that have reached the appropriate age for reproduction but inhabit the aquatic environment in other period than reproductive;
- a*quatic reproductive adults* refers to adults that enter the aquatic environment for reproduction;
- t*errestrial adults* refers to adults that have reached the adequate age for reproduction but are inhabiting the terrestrial environment (outside of reproduction period).

Table 4

Observed patterns of aggresiveness and cannibalism in the studied population of newts

Observed behavior	*Body part affected*	*Reason*	*Injure type*	*Frequency*	*Age cathegory within which the respective active behavior was observed*	*Age cathegory within which the respective passive behavior was observed*
Cannibalism	Tail; Limbs; Flank; Whole organism; Rarely head;	Feeding/ Population dynamics regulation.	Severe, usually involve death or loss of affected part;	Very frequent	Aquatic metamorphs; Aquatic phase of subadults; Non-reproductive adults in aquatic phase.	Aquatic larvae; Aquatic metamorphs; Aquatic phase of subadults;
Predatorism	Whole organism; Tail; Limbs.	Feeding	Severe, involves death.	Frequent	Aquatic metamorphs; Aquatic phase of subadults; Terrestrial subadults; Non-reproductive adults in aquatic phase; Terrestrial adults.	Aquatic larvae; Aquatic metamorphs; Aquatic phase of subadults; Terrestrial subadults.
Intraspecific aggresivity	Tail; Head.	Feeding?/ Territoriality; Population density regulation.	Light, but may degenerate to severe injuring, even death.	Frequent	Aquatic metamorphs; Aquatic phase of subadults; Terrestrial subadults; Non-reproductive adults in aquatic phase; Terrestrial adults	Aquatic larvae; Aquatic metamorphs; Aquatic phase of subadults; Terrestrial subadults; Non-reproductive adults in aquatic phase; Terrestrial adults
Interspecific aggresivity	Tail; Head.	Feeding/ Territoriality	Medium, but may degenerate in severe wounds, even consumption of whole organism, in aquatic subadults	Moderate	Aquatic metamorphs; Aquatic phase of subadults; Non-reproductive adults in aquatic phase; Terrestrial adults.	Aquatic larvae; Aquatic metamorphs; Aquatic phase of subadults; Terrestrial subadults; Aquatic adults; Terrestrial adults. Aquatic reproductive adults.
Reproduction aggresivity	Head; Flank.	Reproductive concurence/ territoriality	Light, generally do not degenerate into physical contact.	Less frequent	Aquatic reproductive adults.	Aquatic reproductive adults.

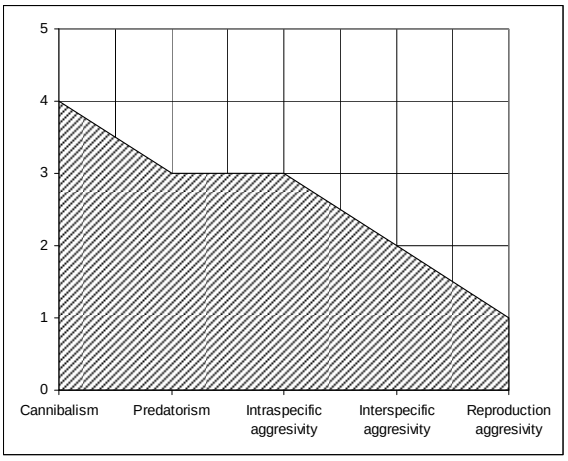


Figure 5. Frequency ranks of aggressive behavior types (frequency ranks as follows: 4=very frequent; 3=frequent; 2=moderate; 1=less frequent; 0=absent.)

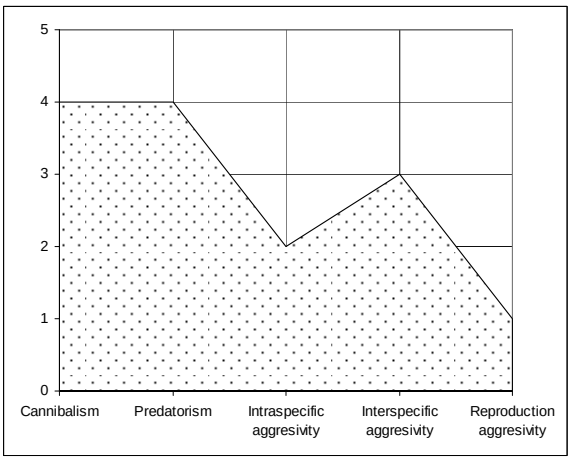


Figure 6. Injuring degree ranks of aggressive behavior types (injuring degree as follows: 4=severe, death; 3= severe; 2=moderate; 1=less severe; 0=absent.)

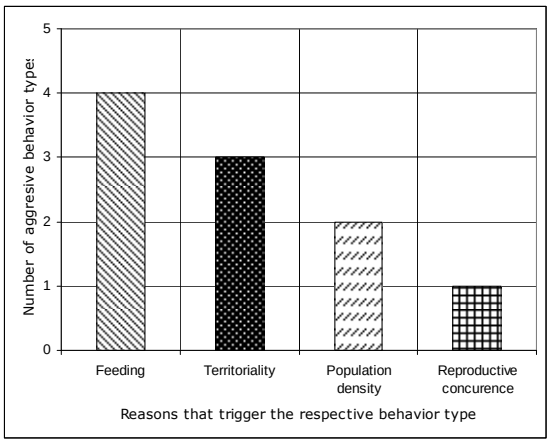


Figure 7. Number of aggressive behavior types involved in reason categories.

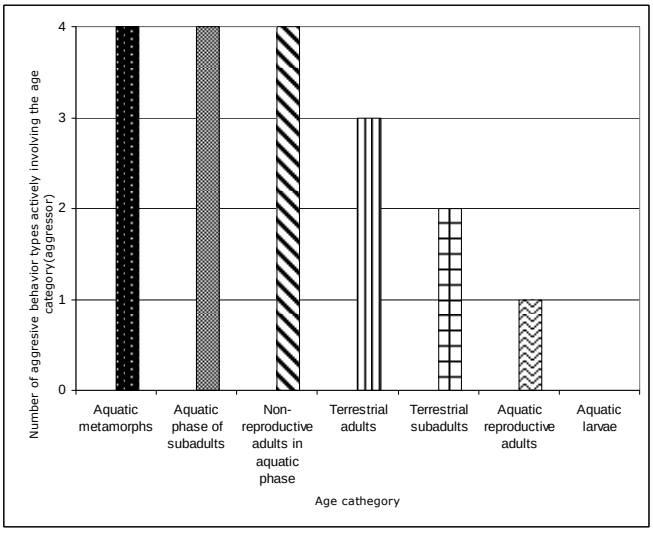


Figure 8. Degree of active aggressive involvement (aggressor) by age categories.

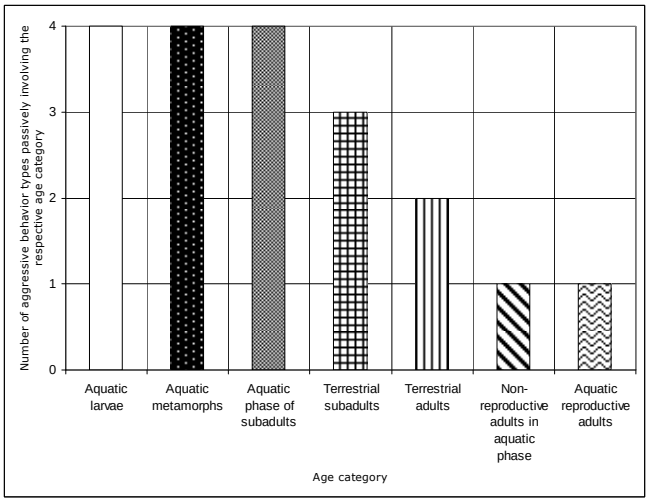


Figure 9. Degree of passive aggressive involvement (aggressed) by age categories.

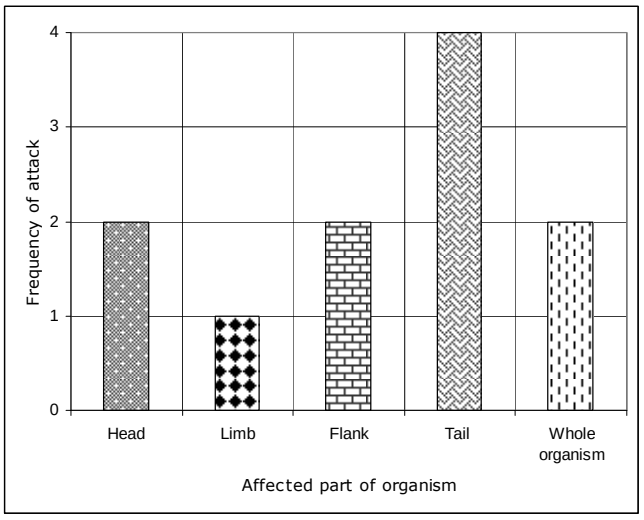


Figure 10. The most affected parts of organism.

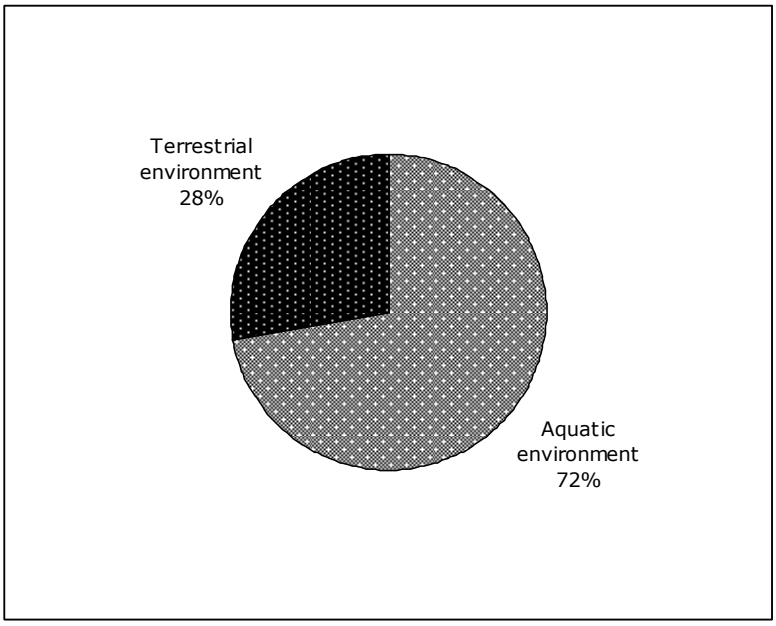


Figure 11.Occurence of active aggressivity behavior per environment type.

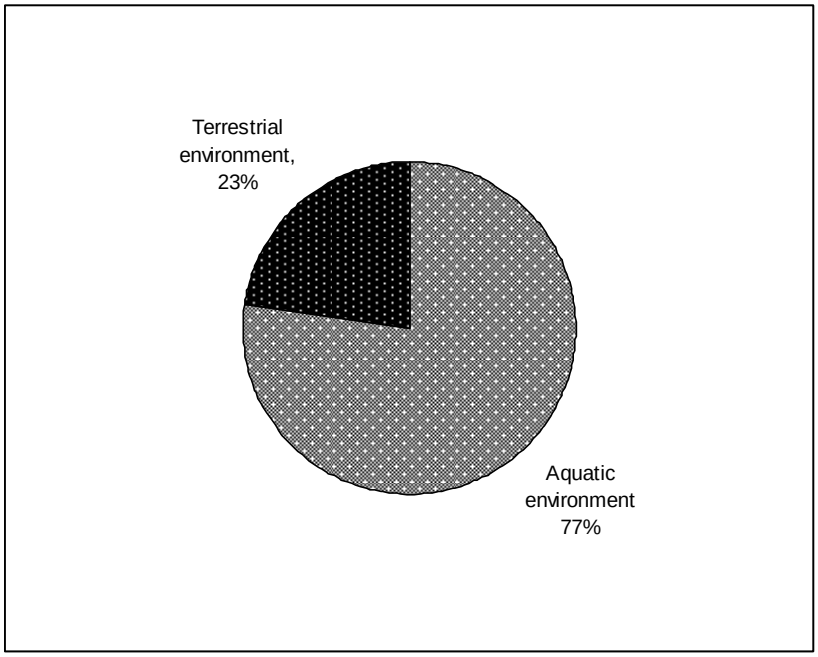


Figure 12. Occurrence of passive aggressivity behavior per environment type.

Conclusions. As literature (Fuhn 1960) and presented data argument, the newt population from the Cişmigiu Garden is a hybrid population (since the two species hybridize frequently in the areas where their areals overlap (Mikulicek et al 2004)) of *Triturus cristatus* and *Triturus dobrogicus*, where characters vary within a wide interval of values for the criteria taken into account. If from the metric approach, the individuals analysed belong to *Triturus dobrogicus* according to some authors (Arntzen & Wallis 1999, Fuhn 1960, Maletzky et al 2008), from the meristic (RBV) point of view, the species presents caracters belonging to *Triturus cristatus* (16 rib bearing vertebrae in *Triturus cristatus* versus 17 in *Triturus dobrogicus*). The chromatic analysis shows no individual with pure chromatic aspect of either one or another species.

From both the passive and active attitude versus aggressive behavior, the most important environment appears to be by far the aquatic one.

Most of the life stage categories attack and are attacked while in aquatic phase, as results from the presented graphics. This aspect underlines the importance of preserving in good conditions the aquatic environment (Calhoun et al 2005) for the temporary water breeding amphibians in general and for *Triturus cristatus* superspecies newts in particular.

In an urban environment, aquatic resources such as food and shelter are more scarce than in a natural environment, posing thus the problem of a higher concurence for these resources within the newt or other amphibian population (Schabetsberger et al 2004, Faragher & Jaeger 1998).

The most affected part of the body in attacks is represented by the tail (Figure 13), due to the fact that usually, when attacking for food, newts follow prey and tend to attack from behind, after a certain attempt to discretely approach prey, in almost all age stages (observed aspects). This fact arguments that the most frequent reason for attacking newts of other species or of the same species is feeding.

Considering the aspect that in the urban environment food resources are scarce, the most available resource of food for certain moments becomes the representatives of the same species. Nevertheless, other attack types with less severe implications aim towards different parts of the body, such as head, limbs or flanks in reproductive aggressivity, which has rather a ritual implication, seldom leading to killing or injuring the adversary. Another similar instance is represented by concurrence aggressivity: when several newts met at a feeding place, short fights under the form of frontal or lateral hits and light bites might occur, but without serious damage to the involved individuals. Usually, after such a fight, the weaker individual leaves and searches for food in a further place. Observations proved a more frequent aggressive behavior in darker specimens versus lighter ones. Adult females were observed only in cannibalistic and predatory instances; they do not participate in ritual reproduction aggression acts.

Figure 13. A subadult in terrestrial phase with the tip of the tail bitten by another subadult from the same generation.

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