

Diet Composition of the Dice Snake (*Natrix tessellata* Laurenti, 1768) (Reptilia: Colubridae) in the Danube River Catchment Area

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Abstract: *Natrix tessellata* (Laurenti, 1768) is a diurnal piscivorous Eurasian snake species with a large distribution area. The Danube River is a main aquatic corridor and its floodplain is an important habitat for this species. *Natrix tessellata* lives in countries all along the river, owing to its good adaptability to different climate, altitude and even human activities, enabling it to live in human-dominated landscape as well. The aim of this paper is to give an overview on the feeding spectrum of *N. tessellata* in countries along the Danube River and to compare its feeding preferences in the different stretches of the river. The detailed analysis of the diet of *N. tessellata* is based on species level data from ten countries from the Danube River Basin (Austria, Bulgaria, Croatia, Czech Republic, Slovakia, Hungary, Romania, Serbia, Slovenia and Ukraine). On the basis of our own data and the special literature, we found that *N. tessellata* fed on 38 fish and six amphibian taxa in the region. The feeding spectrum changed characteristically along the Danube River with differences among the Lower Danubian (e.g. Bulgaria, Romania), Middle Danubian (e.g. Hungary) and Upper Danubian (e.g. Austria) countries.

Keywords: *Natrix tessellata*, Reptilia, feeding spectrum

Introduction

Natrix tessellata is a Eurasian snake species strongly bound to aquatic habitats (GASC *et al.* 1997). It inhabits different water types along the Danube River, such as different floodplain sections, tributaries and standing water bodies (GAEBELE *et al.* 2013). It is listed in Annex II of the Bern Convention (1999) and it appears also in Annex IV of the Habitat Directive of the European Union (92/43/ECC) but owing to its wide distribution and presumably large population size, it is categorised as least concern by IUCN (2012). However, it is considered to be threatened in a number of Western and Central European states with low genetic variation in some populations (GAUTSCHI *et al.* 2002, GUICKING *et al.* 2004), in addition its world population has been assessed as declining (IUCN 2012). As such, conservation

measures should still be undertaken for this species. Habitat destruction, pollution, road traffic, collection and persecution are listed as possible threats (e.g. KAMMEL, MEBERT 2011).

The dice snake has a large distribution and it occurs in different habitats, which would imply the species can adapt well to local conditions, presumably by adopting a wide feeding spectrum. However, it is generally considered to be a diurnal piscivorous snake (GASC *et al.* 1997) despite the available information showing that it also eats non-fish prey items (e.g. BESHKOV, DUSHKOV 1981).

Natrix tessellata was found to live along the Danube River and the connected habitats at several stretches, and its diet was also investigated at several sites there. Due to its excellent swimming

and diving abilities and association to freshwater habitats, *N. tessellata* is generally considered to be a strictly piscivorous fish species (LAŇKA 1978, KREINER 2007), however, no comparative study has been conducted so far. In this paper we present the first overview of the feeding spectrum of *N. tessellata* in the countries from the Danube River Basin and analyse the geographical differences among them.

Material and Methods

Information was gathered on the diet of the dice snake from its whole Danubian range. The countries from the Danube River Basin with information only from populations outside the Danube catchment, *i.e.* the small German populations from the Nahe River and Lahn River, as well as the Swiss populations from Geneva Lake were not included in the analysis. Information from papers only mentioning large, collective groups such as „insects”, „fish” or „frogs” as food items, without giving species (or at least genus) level information, may be discussed in the article but has not been included in the database, even if their addition would have added new items to the list such as insect, mice or shrews (RADOVANOVIC 1951, 1964). No time limit was applied and available reports from the first half of 20th century were used as well. Besides published records and our own observations, citizen science data were also collected by approaching international and national internet databases for photographic evidence of dice snake predation on a given taxa (*e.g.* www.varangy.hu, www.herpetozoa.at, www.shdmr.org). Prey species were determined according to ARNOLD, OVENDEN (2002), HARKA, SALLAI (2004), KOTTELAT, FREYHOF (2007), PINTÉR (2002) and a public fish database in the internet (www.fishbase.us).

Association analysis with the presence-absence data of the prey taxa of the dice snake was used in non-metric cluster analysis (GOODALL 1953, PODANI 1997, 2001, WILLIAMS, LAMBERT 1960) to elucidate zoogeographical differences among ten Danube River catchment countries, from where appropriate information could be collected. Statistical analysis was made using SYN-TAX 2000 (PODANI 2001). Results were plotted using MS Office 2010 and SYN-TAX 2000 (PODANI 2001).

Results and Discussion

Species, and in some cases genus, level data on the feeding spectrum of the dice snake were collected from ten countries in the Danube River catchment area. Altogether 44 animal taxa have been listed as prey for the dice snake belonging to two classes: Pisces and Amphibia. The ratio of classes among the taxa is 14% Amphibia and 86% Pisces (Table 1).

The highest number of prey taxa eaten was found in studies conducted in Hungary (19), Austria (15) and Serbia (13), while the lowest were from Croatia and Slovenia (six for both countries). Fish were recorded in the diet of the *N. tessellata* in all countries in the Danube River catchment area (Fig. 1.) and they comprised the highest number of taxa eaten in each of them. In spite of the high ratio of fishes among prey items, in 50% of the countries (Bulgaria, Czech Republic, Romania, Serbia, Slovenia) amphibians were also detected as prey of the dice snake.

The detailed analysis of the diet of *N. tessellata*, based on species level data from ten countries (Austria, Bulgaria, Croatia, Czech Republic, Slovakia, Hungary, Romania, Serbia, Slovenia, Ukraine), proved that *N. tessellata* feeds on at least 44 prey taxa from two classes in the Danube River catchment (Table 1.). Earlier evaluations generally considered *N. tessellata* as a strictly piscivorous snake species (KREINER 2007, LAŇKA 1978), regardless of the fact that it had been described to hunt even in terrestrial habitats at night (GRUSCHWITZ *et al.* 1999, LAŇKA 1978). A key factor determining the actual species composition in the diet of *N. tessellata* is that it remains in the immediate vicinity of surface waters at a distance of less than 20 metres to the water edge under normal conditions during the active season (NEUMANN, MEBERT 2011, VELENSKY *et al.* 2011). As a result, it predominantly feeds on aquatic and/or water-bound animals, with fish being the most important prey organisms.

There is a clear relationship between fish species preyed upon and the size of the water bodies. In the main arm of the Danube River the dice snake mostly eats benthic fish (*Neogobius* sp., *Ponticola* sp.) and/or fish species hidden in aquatic vegetation stands (*Cyprinidae* sp., *Alburnus alburnus*, juvenile *Chondrostoma nasus* and *Leuciscus idus*) (GAEBELE *et al.* 2013). Along tributaries, streams, densely ve-

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Table 1. Prey spectrum of the dice snake (*Natrix tessellata*) in the Danube River catchment area. Country codes: AUT: Austria, BUL: Bulgaria, CRO: Croatia, CZE: Czech Republic, HUN: Hungary, ROU: Romania, SLO: Slovenia, SRB: Serbia, SVK: Slovakia, UKR: Ukraine

Classes	Species/ Genus	Countries										
		AUT	CZE	SVK	HUN	SLO	CRO	SRB	ROU	BUL	UKR	
Pisces	<i>Alburnoides bipunctatus</i>	+										
	<i>Alburnus albidus</i>						+					
	<i>Alburnus alburnus</i>	+	+	+	+	+	+	+	+	+	+	
	<i>Barbatula barbatula</i>	+										
	<i>Barbus barbatus</i>	+										
	<i>Carassius auratus</i>		+								+	
	<i>Carassius gibelio</i>				+				+			
	<i>Chondrostoma nasus</i>	+			+							
	<i>Cobitis taenia</i>	+			+							
	<i>Cottus gobio</i>	+					+					
	<i>Cyprinus carpio</i>		+									
	<i>Esox lucius</i>		+									
	<i>Gambusia affinis</i>							+	+		+	
	<i>Gobio gobio</i>	+	+	+								
	<i>Gymnocephalus schraetser</i>				+							
	<i>Knipowitschia caucasica</i>									+	+	+
	<i>Knipowitschia</i> sp.							+		+	+	+
	<i>Lepomis gibbosus</i>				+					+		
	<i>Leuciscus idus</i>			+	+							
	<i>Leuciscus leuciscus</i>				+							
	<i>Leuciscus</i> sp.						+					
	<i>Neogobius fluviatilis</i>				+				+	+	+	+
	<i>Neogobius melanostomus</i>				+				+	+	+	+
	<i>Neogobius ratan</i>									+		
	<i>Neogobius</i> sp.				+				+	+	+	+
	<i>Oncorhynchus mykiss</i>	+										
	<i>Perca fluviatilis</i>	+	+		+							
	<i>Ponticola eurycephalus</i>									+		
	<i>Ponticola kessleri</i>				+					+	+	
	<i>Ponticola syrman</i>									+		
	<i>Pseudorasbora parva</i>	+		+	+				+			+
	<i>Rhodeus sericeus</i>				+				+			
<i>Rutilus rutilus</i>	+	+	+	+				+	+	+	+	
<i>Salmo trutta</i>	+					+						
<i>Sander volgensis</i>				+								
<i>Scardinius erythrophthalmus</i>		+	+	+				+				
<i>Squalius cephalus</i>	+	+	+	+	+	+	+	+				
<i>Thymallus thymallus</i>	+											
Amphibia	<i>Bombina variegata</i>									+		
	<i>Pelophylax kl. esculentus</i>		+									
	<i>Pelophylax ridibundus</i> (tadpoles and juveniles)		+						+	+		
	<i>Pseudepidalea viridis/variabilis</i> (tadpoles and juveniles)		+									
	<i>Rana</i> sp. (tadpoles)					+		+				
	<i>Rana temporaria</i>					+		+				

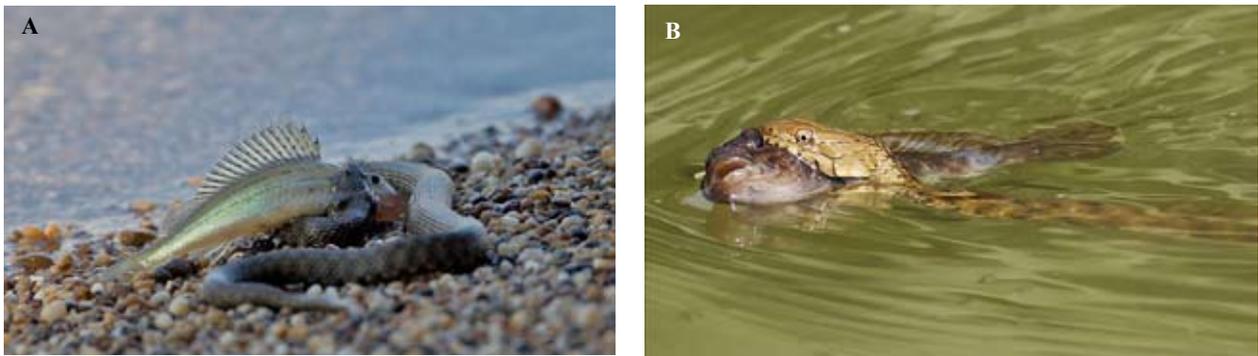


Fig. 1. Rare (A: *Gymnocephalus schraetser*) and common (B: *Neogobius melanostomus*) prey species of the dice snake along the Middle Danube River (Hungary). Larger fish or those that are difficult to handle, are carried on land and swallowed after the prey becomes weak due to oxygen shortage. (Photo: A: Ádám Selmeczi Kovács, B: Gábor Tírpák)

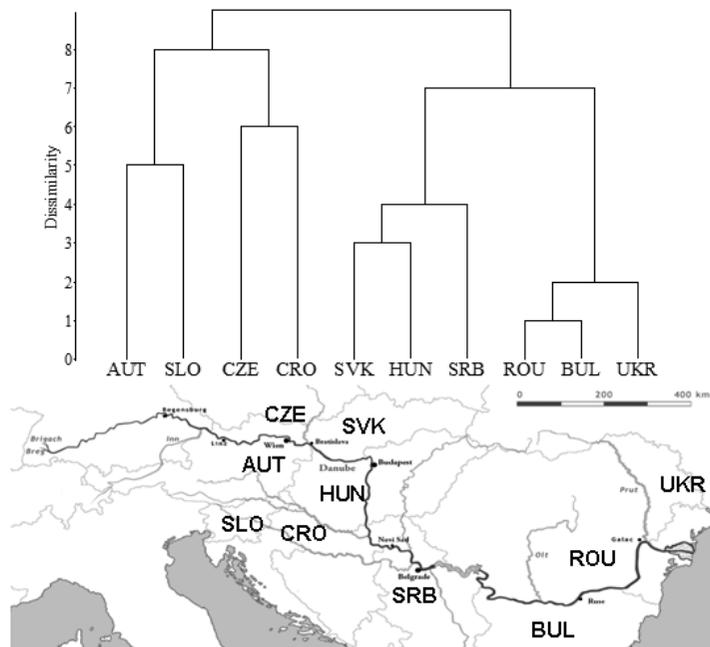


Fig. 2. Similarity of the feeding spectrum of the dice snake (*N. tessellata*) in ten countries in the Danube River catchment area. Country codes: AUT: Austria, BUL: Bulgaria, CRO: Croatia, CZE: Czech Republic, HUN: Hungary, ROU: Romania, SLO: Slovenia, SRB: Serbia, SVK: Slovakia, UKR: Ukraine

getated water courses, lakes and ponds, dice snake hunts fish (mainly *Cyprinidae* sp., *Gambusia affinis*, *Lepomis gibbosus* and *Perca fluviatilis*), as well as amphibian larvae and adults (mainly *Pelophylax* and *Rana* sp.) near the bank (GAEBELE *et al.* 2013, SLOBODA *et al.* 2010, VLČEK *et al.* 2010, ZIMMERMAN, FACHBACH 1996). With decreasing water body size, the feeding spectrum of the dice snake changes considerably to include terrestrial species, besides fish and amphibians (ŽAGAR *et al.* 2011). Populations in high mountains (over 1000 m a.s.l.) may specialise on eating larval and adult amphibians as predominant food (CAFUTA, KROFEL 2007, ŽAGAR *et al.* 2011).

Other prey items were also present occasionally, which indicated the good adaptability of the species to different conditions.

The feeding spectrum of the dice snake differs among different regions in the Danubian catchment. The analysis of the results revealed three main groups (Fig. 2.). The first group in the cluster includes the Lower Danubian countries with the highest number of Ponto-Caspian gobiid species (*e.g.* *Neogobius* sp., *Knipowitschia* sp. and *Ponticola* sp.), common *Cyprinidae* species (*Alburnus alburnus*, *Rutilus rutilus*) and two non-native species (*Lepomis gibbosus* and *Pseudorasbora parva*). Amphibian predation

was also recorded in all countries of the Ukrainian – Bulgarian – Romanian branch (Table 1) (BESHKOV, DUSHKOV 1981, CARLSSON *et al.* 2011, KARVEMO *et al.* 2011, NEKRASOVA *et al.* 2013, SCHÜLTER 2006, SLOBODA *et al.* 2010, VELIKOV 2011). During extremely hot summers the dice snake was also observed to hunt at night in this area, as well as far away from surface waters, which furthers the potential feeding spectrum of this snake (see *e.g.* MÖLLER 1990, who observed over a period of several weeks a large dice snake which “unusually” hunted geckos at night in a man-made environment).

Countries from the Middle Danubian River Basin, except for Croatia, formed the next group (Serbia – Hungary – Slovakia). There were several fish with very large distribution areas among the prey species there, such as *Alburnus alburnus*, *Leuciscus idus*, *Pseudorasbora parva*, *Rhodeus sericeus*, *Rutilus rutilus*, *Squalius cephalus* (GAEBELE *et al.* 2013, own data), (Table 1). Amphibian predation for the group is known only from a photographic evidence from Serbia, while RADOVANOVIĆ (1951, 1964) also reported amphibian and small mammal predation from the former Yugoslavia but without giving species-specific information.

The Austrian – Slovenian – Croatian – Czech branch includes countries with limited amphibian consumption (CAFUTA, KROFEL 2007, HUTINEC, MEBERT 2011, MUSILOVÁ, ZAVADIL 2011, REHAK 1992, ŠVAB 2003, VLČEK *et al.* 2010, ŽAGAR *et al.* 2011) and (for Austria, Croatia, Slovenia) characteristic local mountain fish species (HUTINEC, MEBERT 2011, ŽAGAR *et al.* 2011, ZIMMERMAN, FACHBACH 1996) in the diet of the dice snake. Countries in which the dice snake also feeds on amphibians are on a separate sub-branch (Table 1).

The analysis of the diet of the dice snake in the Danube River catchment proved that the population of the snake in the Danube River Basin has got a diverse feeding spectrum. It feeds primarily on fish, while amphibian larvae, juveniles and adults are of secondary importance at the catchment level. Some data also indicate occasional predation on reptiles and mammals. The large number of taxa in the diet indicates a good adaptability to different potential prey species (GHIRA *et al.* 2009) and the flexibility of the dice snake to reaching the appropriate resources (RESHETNIKOV *et al.* 2013) also by switching its foraging strategy from ambush to active search or back along the whole Danubian catchment.

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