

Dietary shifts in the Western Whip Snake *Coluber viridiflavus* LACÉPÈDE, 1789, of the small Mediterranean island of Ustica (Squamata: Serpentes: Colubridae)

Ernährungswandel bei *Coluber viridiflavus* LACÉPÈDE, 1789
von der kleinen Mittelmeerinsel Ustica
(Squamata: Serpentes: Colubridae)

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KURZFASSUNG

Wir untersuchten die taxonomische Zusammensetzung der Nahrung von *Coluber viridiflavus* LACÉPÈDE, 1789 aus verschiedenen Lebensräumen (mediterrane Macchie, landwirtschaftlich genutztes Gebiet, Kiefernwald, Felsküste) der kleinen Insel Ustica vor der Nordküste Siziliens (Italien). Zumindest im Lebensraum "landwirtschaftlich genutztes Gebiet" wurde ein teilweiser Wandel in den Ernährungsgewohnheiten von *C. viridiflavus* hinsichtlich der Art der Beutetiere festgestellt, indem die Nahrung der Schlange hier hauptsächlich aus Amphibien (Wechselkröten) und Nagetieren besteht. Vermutlich entwickelte *C. viridiflavus* auf Ustica diese ungewöhnliche Eigenart als Reaktion auf die schlechte Verfügbarkeit der üblichen Beutetiere (Eidechsen und Nager) und die hohe Dichte an Wechselkröten im landwirtschaftlich genutzten Gebiet dieser mediterranen Insel.

ABSTRACT

We studied the taxonomic diet composition of *Coluber viridiflavus* LACÉPÈDE, 1789, collected from various habitat types (Mediterranean macchia, cultivated lands, pinewood, rocky coastline) of the small Island of Ustica, off the northern coast of Sicily (Italy). Our study documents a partial shift in *C. viridiflavus* feeding habits in terms of prey type at least in one habitat type (cultivated lands), where the diet of the snakes consisted mainly of amphibians (Green Toads) and rodents. We suggest that *C. viridiflavus* from Ustica developed such unusual traits in response to low availability levels of usual prey (lizards and rodents) and high abundance of Green Toads in the cultivated lands of this Mediterranean island.

KEYWORDS

Reptilia: Squamata: Serpentes: Colubridae: *Coluber viridiflavus*, food habits, diet, feeding ecology, Mediterranean environment, Ustica Island, southern Italy

INTRODUCTION

There is considerable evidence showing that snake populations inhabiting small islands show some shifts or specific adaptations in dietary habits when compared to mainland populations. For instance, the exclusively insular Milos Viper *Macrovipera schweizeri* (WERNER, 1935) seems to be specialized in foraging upon migrating birds (NILSON et al. 1999), whereas mainland congeners - e.g., *M. lebetina* (LINNAEUS, 1758) from Jordan - are known to forage mainly on rodents (DISI et al. 2001). As a consequence of insular adaptation in dietary habits, island populations of the elapid Australian tigersnake *Notechis ater* (KREFFT, 1866) prey on endothermic vertebrates more

frequently than mainland populations (SHINE 1987), and island populations of *Coluber hippocrepis* LINNAEUS, 1758 tend to forage on carrions more often than is usual in mainland populations (e.g., compare data in PLEGUEZUELOS & MORENO 1990 with data in CAPULA & al. 1997a).

From the above mentioned examples it seems to be evident that reduced availability of the usual specific food resources in the island habitats may be the primary cause of dietary shifts of insular snake populations (CAPULA et al. 1997a).

The most common and widespread snake of mainland and insular Italy, *Coluber viridiflavus* LACÉPÈDE, 1789, also shows

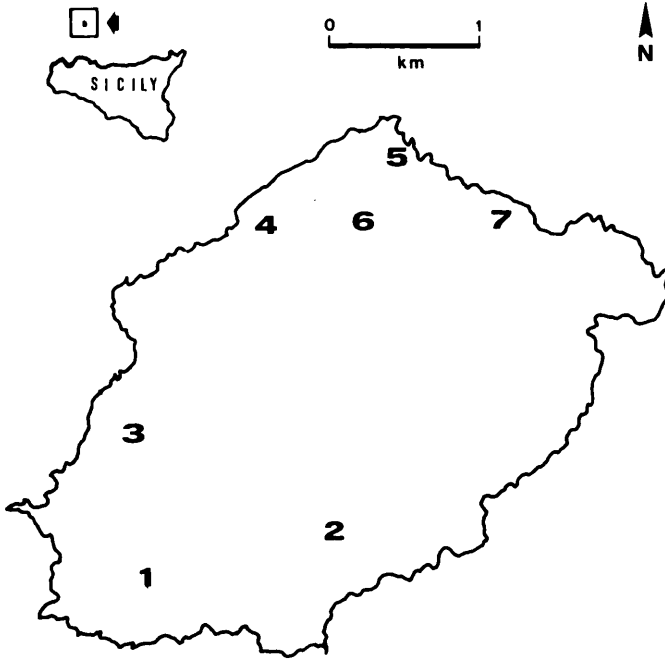


Fig. 1: Map of Ustica Island (Tyrrhenian Sea, Italy; insert shows location of the island), with the capture localities of 42 specimens of *Coluber viridiflavus* LACÉPÈDE, 1789.

Abb. 1: Die Insel Ustica (Tyrrhenisches Meer, Italien; das Insert zeigt die Lage der Insel) mit den Fundorten der 42 untersuchten Individuen von *Coluber viridiflavus* LACÉPÈDE, 1789.

- 1 - Case Gostel along the "Mezzogiorno" path; 2 - Timpone Basile; 3 - Spalmatore; 4 - Piano Madonna; 5 - Villaggio Preistorico; 6 - Località "Giuffrida"; 7 - Contrada Madonna di Pompei.

some dietary shift in insular habitats. In mainland Italy this species is known to feed mainly upon lizards and rodents (CAPIZZI & al. 1995; RUGIERO & LUISELLI 1995; CAPIZZI & LUISELLI 1996; CAPULA & al. 1997b; RUGIERO et al. 2002), but on Montecristo Island (Tuscan Archipelago, Tyrrhenian Sea) it was frequently recorded foraging on

the Tyrrhenian Painted Frog, *Discoglossus sardus* TSCHUDI, 1837 (ZUFFI 2001).

In this paper we examined the taxonomic composition of the prey in *C. viridiflavus* from Ustica, a small island off the northern coast of Sicily, for possible dietary shifts as found in the Montecristo Island population (ZUFFI 2001) and in other insular snakes.

STUDY AREA AND METHODS

Field investigations were carried out on Ustica, a volcanic island situated about 55 km off the northern coast of Sicily, (Tyrrhenian Sea) (fig. 1). Ustica Island, currently about 9 km² in size, is part of a larger volcanic complex emerged from the Tyrrhenian Sea at the beginning of the Quaternary, and

then submerged again. The general landscape is characterized by the rocky indented coastline and the presence of three hills, with elevations between 157 m a.s.l. and 250 m a.s.l. The island lacks any permanent superficial water body, and is characterized by wide olive, almond and vine cultivations,

hedges of *Opuntia ficus-indica* and patches of evergreen scrubs (Mediterranean 'macchia' with *Pistacia lentiscus*, *Spartium junceum*, *Cistus* spp., *Rosmarinus officinalis*). Great parts of the hills are covered with *Pinus* sp. plantations.

Fourty two snakes were captured at seven sites (fig. 1): 1 - Case Gostel along the "Mezzogiorno" path (S side of Ustica); 2 - Timpone Basile (S side of Ustica); 3 - Spalmatore (SW side of Ustica); 4 - Piano Madonna (NW side of Ustica); 5 - Villaggio Preistorico (N side of Ustica); 6 - Località "Giuffrida" (N side of Ustica); 7 - Contrada Madonna di Pompei (NE side of Ustica). All adults were melanistic.

Thirty-three days were spent in the field (23 - 30 July 2001, 24 - 30 June 2002, 17 August - 3 September 2002). Fieldwork was conducted along standardized routes in the various micro-habitats under all climatic conditions, from 7 a.m. to 12 a.m., and from 4 p.m. to 8 p.m. and suspended during the hottest hours of the day, when high ambient temperatures (> 30°C) would have prevented snakes from being active.

Each snake was measured for snout-vent length (SVL, to the nearest ± 0.1 cm) and body mass (to the nearest ± 0.1 g with

an electronic balance), sexed by examining the morphology of the cloacal region, and individually marked by ventral scale clipping for future identification. Then, the snakes were palpated in the abdomen until regurgitation of ingested food or defecation occurred. In addition, specimens found dead during our surveys (i.e., those killed by cars, etc.) were dissected to determine if prey items were present. We identified them to the lowest taxonomic level practicable in this study. We estimated the mass of the prey by weighing those items ($n = 12$) which were in perfectly preserved condition (LUISELLI & AGRIMI 1991). This was not possible in faecal prey residues which generally consisted of reptile scales and mammalian hair.

According to the place of capture, the snake records which included prey items were assigned to one of the following habitat categories: (i) Mediterranean "macchia"; (ii) cultivated land; (iii) pinewood; (iv) rocky coastline.

All statistical tests were two-tailed, with alpha set at 5%. Means are followed by ± 1 standard deviation (SD). Data were processed using Statistica® (version 4.5 for Windows®) and Prism 3.0® (GraphPad® Software, San Diego) PC+ packages.

RESULTS

A total of 42 specimens of *Coluber viridiflavus* were captured (18 males, 21 females, 3 juveniles). Adult sex ratio was 0.86 (males : females) and did not deviate significantly from equality (binomial test, $P > 0.5$). The mean encounter rate was 1.27 specimens per day. The mean SVL of males (mean = 74.4 ± 5.5 cm, $n = 18$) was significantly higher than that of females (mean = 71.6 ± 2.7 cm, $n = 21$; inter-sample difference: one-way ANOVA: $F_{1,37} = 10.526$, $P = 0.0025$). SVL of the juveniles measured 24.3, 34.8, and 39.6 cm, respectively.

Thirteen males (72.2% of the male sample), twelve females (57.1%), and two juveniles (66.7%) contained food in the stomach or gut. In total, 64.3% of the whole snake sample ($n = 42$) had eaten identifiable food. Dietary data collected from the free-ranging specimens are presented in table 1. In adult snakes ($n = 39$),

rodents and Green Toads *Bufo viridis* LAURENTI, 1768, accounted for 31% of the prey items each, and the lizard *Podarcis sicula* (RAFINESQUE, 1810), for 38% (total number of prey items = 29). Two prey items (both *P. sicula*) were found in the juvenile snakes. Most of the specimens that had fed had a single prey item in the stomach or gut; however, two males and one female had two lizards each, and one male had two Green Toads (see table 1). No snake contained more than one prey category in the stomach or gut. There were apparent differences in prey types among snakes captured in the four habitat types: Green Toads were preyed upon only by snakes from cultivated lands ($n = 9$); lizards were found in snakes collected in Mediterranean "macchia" ($n = 8$), as well as in cultivated lands ($n = 3$) and rocky coastline ($n = 2$); rodents were found in

Table 1: Summary of the prey items collected from 42 *Coluber viridiflavus* LACÉPÈDE, 1789 individuals on Ustica Island (Tyrrhenian Sea, Italy). Number of snake specimens examined (containing prey): 18 (13) males, 21 (12) females, 3 (2) juveniles. The numbers of individuals containing prey are indicated in parentheses.

Tab. 1: Zusammenstellung der Beutetiere, die in 42 *Coluber viridiflavus* LACÉPÈDE, 1789 Individuen der Insel Ustica (Tyrrhenisches Meer, Italien) gefunden wurden. Untersucht wurden (bzw. enthielten Beutetiere) 18 (13) Männchen, 21 (12) Weibchen und 3 (2) Jungtiere. In Klammern die Anzahl der Schlangen, die Beute beinhalteten.

| Prey / Beutetier | Number of prey items / Anzahl Beuteobjekte | | | Σ |
|------------------------|--------------------------------------------|---------------------------|-------------------------------|---------|
| | in Males in Männchen | in Females in Weibchen | in Juveniles in Jungtieren | |
| Mammalia | | | | |
| <i>Rattus</i> sp. | 3 (3) | 3 (3) | | 6 (6) |
| <i>Mus musculus</i> | | 1 (1) | | 1 (1) |
| Rodentia indet. | 1 (1) | 1 (1) | | 2 (2) |
| Reptilia | | | | |
| <i>Podarcis sicula</i> | 7 (6) | 4 (2) | 2 (2) | 13 (10) |
| Amphibia | | | | |
| <i>Bufo viridis</i> | 3 (3) | 6 (5) | | 9 (8) |
| Σ | 14 (13) | 15 (12) | 2 (2) | 31 (27) |

snakes living in cultivated lands ($n = 6$) and in Mediterranean "macchia" ($n = 3$).

Neither green frogs - *Rana bergeri* GÜNTHER, 1986, *R. hispanica* BONAPARTE, 1839 - nor geckos - *Hemidactylus turcicus* (LINNAEUS, 1758), *Tarentola mauritanica* (LINNAEUS, 1758) - were preyed upon by snakes, although they are known to occur on Ustica (TURRISI & VACCARO 1998; LO VALVO & LONGO 2001).

The correlation between snake size (body mass) and prey size (body mass) was positive ($r = 0.588$, $n = 12$, $P < 0.03$), and the slope is significantly different from zero ($F = 7.340$, $n = 12$, $P < 0.05$). The total weight of 12 prey items ranged from 5.3 % to 32.1 % (mean = 22.4 ± 7.8 % of snake mass) of the weight of the snakes that had ingested them.

DISCUSSION

The taxonomic composition of the diet of *Coluber viridiflavus* has been studied intensively in some areas of mainland Italy, and, independent of the habitat type of the snakes, it has always been shown that anuran amphibians do not account for a substantial portion of the snake's diet (see table 2 for a summary of these data). In particular, toads were never recorded as prey of mainland *C. viridiflavus* while island *C. viridiflavus* preyed increasingly upon anurans (see table 2), both *Discoglossus* on Montecristo (ZUFFI 2001) and *Bufo* on Ustica (this study). No anuran was ever found to be taken by mainland *C. viridiflavus* in agricultural areas (see table 2, and compare this study with data presented in RUGIERO &

LUISELLI 1995) while Green Toads were a common prey for Ustica snakes in this type of habitat. Therefore, our study documents a partial shift in feeding habits of the population of *C. viridiflavus* from Ustica Island in terms of prey type (towards amphibians). Similar shifts were also observed in the boid *Corallus caninus* (LINNAEUS, 1758) (PENDLEBURY 1974) and the crotalid *Agkistrodon piscivorus* (LACÉPÈDE, 1789) (WHARTON 1969). In the above mentioned cases these shifts can be considered responses to differences in prey availability. Although our study was not properly designed to investigate the proximate and ultimate causes of snake dietary shifts, the most parsimonious assumption is that local responses to prey

Table 2: Summary of the literature data available on the percent frequency of anurans in the diet of *Coluber viridiflavus* LACÉPÈDE, 1789 from mainland and island populations in Italy, in relation to habitat types. The anuran species eaten and their numbers are presented in parentheses.

Tab. 2: Zusammenstellung von Literaturdaten über den zahlenmäßigen Anteil (%) von Froschlurchen an den Beuteobjekten italienischer Festland- und Inselpopulationen von *Coluber viridiflavus* LACÉPÈDE, 1789 in verschiedenen Lebensräumen. In Klammern die erbeuteten Anurenarten und ihre Stückzahlen.

| Study Region / Untersuchungsgebiet | Habitat Type / Habitattyp | Percent of Anurans in all prey items / Anteil (%) der Anuren an allen Beutetieren | Total number of prey items / Gesamtzahl der Beutetiere | Reference / Quelle |
|-----------------------------------------------------|--------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------|
| Mainland Populations / Festlandspopulationen | | | | |
| Latium, Central Italy | Oak forest | 0.47 ($n = 1$; <i>Rana italica</i>) | 211 | RUGIERO et al. 2002 |
| Latium, Central Italy | Agro-forest | 0.00 | 115 | CAPIZZI & LUISELLI 1996 |
| Latium, Central Italy | Mediterranean/ Agricultural | 0.00 | 52 | RUGIERO & LUISELLI 1995 |
| Σ Mainland / Festland | | 0.26 | 378 | |
| Island Populations / Inselpopulationen | | | | |
| Montecristo Island | Mediterranean vegetation | 40.0 ($n = 4$; <i>Disco- glossus sardus</i>) | 10 | ZUFFI 2001 |
| Ustica Island | Mediterranean/ Agricultural | 29.0 ($n = 9$; <i>Bufo viridis</i>) | 31 | This study diese Arbeit |
| Σ Islands / Inseln | | 31.71 | 41 | |
| Average / Mittel | | 3.34 | 419 | |

availability may force island *C. viridiflavus* to prey on anurans on both the islands of Montecristo and Ustica. Assuming that the above suggestion is correct, then it may be suggested that *C. viridiflavus* from Ustica developed such unusual traits in response to low level of usual prey availability (lizards and rodents) and high abundance of Green Toads, at least in the cultivated lands of this Mediterranean island. It is in fact well known that snakes inhabiting areas with low availability levels of the usual food type may develop unusual feeding habits and foraging modes (e.g., POUGH & GROVES 1983; SCHWANER & SARRE 1988, 1990; CAPULA et al. 1997a; LUISELLI et al. 2001; PEARSON et al. 2002). Other amphibians occurring on Ustica Island, i.e. *Rana bergeri* and *R. hispanica*, were not taken by *C. viridiflavus*; this is probably because the green frogs are very localized and strictly aquatic, while *B. viridis* has more terrestrial habits and thus is more easily encountered and preyed by the snake.

It is to be stressed that all dietary data given here were recorded during summertime. Thus, it is likely that the higher proportion of fed specimens in comparison with other diet studies of *C. viridiflavus* (e.g., RUGIERO & LUISELLI 1995) may merely reflect increased foraging activity at this season due to the increased ambient temperatures. The positive correlation between prey and predator size is consistent with most snake data available in the literature (e.g., FORSMAN 1991, 1993) as well as with data on mainland *C. viridiflavus* (CAPIZZI & LUISELLI 1996; RUGIERO et al. 2002). The relative prey size was considerably higher in Ustica snakes than in mainland conspecifics (e.g., see RUGIERO et al. 2002). However, this latter result may depend merely on the smaller sample size of the Ustica snakes rather than on actual differences between mainland and island snakes, or, perhaps, on the fact that the body mass of a toad is considerably bigger than of a lizard.

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