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Preliminary data on the reproductive characteristics and diet in an insular population of the lacertid lizard *Algyroides nigropunctatus*

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Abstract. We present basic data on the female reproductive traits and diet of the lacertid lizard *Algyroides nigropunctatus* from Bisage island in Lake Skadar (Montenegro) in late spring. Individual females commonly laid clutches of three (range 2 - 5) eggs with an average mass of 0.40 g. At least two clutches were produced in a breeding season. The female body size had no effect on clutch and egg size. There was no evidence of the predicted trade-off between egg size and clutch size. The diet was composed of various types of invertebrates, basically small arthropods, and also small amounts of plant material. Araneae and Coleoptera were the most common and the most important food items.

Key words: Dalmatian *Algyroides*, clutch size, feeding habits, insular habitat, Balkan Peninsula.

Algyroides nigropunctatus (the Dalmatian *Algyroides*) is a Balkan subendemic small lacertid lizard. This diurnal and heliothermic species, usually occupies degraded shrub, semi-shaded, partly overgrown rocky cliff areas, in places associated with the Mediterranean climate along the coastal region of the Adriatic and Ionian seas (Arnold 1987, Chondropoulos 1997). In Montenegro, its range is restricted to the Adriatic region (Džukić 1970, Džukić & Pasuljević 1979), occasionally spreading inland through the canyons along with influences of the Mediterranean climate (Ajtić et al. 2005).

Populations of the Dalmatian *Algyroides* have been included in some phylogenetic analyses (Harris et al. 1999, Podnar & Mayer 2006, Pavličev & Mayer 2009) and studies of sexual size and shape dimorphism of the skull and cephalic scales (Ljubisavljević et al. 2011). The ecology of this species is still little known (Bressi 2004). Although *A. nigropunctatus* is known to eat insects, spiders and other arthropods, worms and caterpillars (Radovanović 1951, Valakos et al. 2008, Kwet 2009, Glandt 2010), a detailed food analysis has not been carried out. Also, available data on the clutch characteristics were based on few individuals (see Bejaković et al. 1996a). Furthermore, complex investigations of lacertid lizards communities from small islands of Lake Skadar in Montenegro conducted during the last decades, considered consequences of an insular environment on morphological, genetic or life-history variation, but have never dealt with dietary aspects of a species ecology (Crnobrnja et al. 1991, Crnobrnja-Isailović et al. 1995, Bejaković et al. 1996b, Crnobrnja-Isailović et al. 2005, Aleksić et al. 2009). Considering these facts, the main aims of our study were to (i) provide basic data about the female reproductive characteristics and (ii) to perform a preliminary analysis of diet composition of males and females of an insular population of *A. nigropunctatus*.

The studied population inhabits the small island (0.028km^2) of Bisage (42°06'N, 19°21'E, 31 m a.s.l.) in the Lake Skadar south archipelago. *A. nigropunctatus* occurs on boulders and stones in proximity of bushy and tree vegetation, sometimes climbing on low tree branches and trunks. Clutch characteristics were investigated on the basis of clutches laid by nine females captured in the first week of June 2008 and the last week of May 2009. The gravid females were kept in individual terraria under the same conditions in the laboratory (located in Podgorica, Montenegro) with exposure to natural and additional artificial light that created a thermal gradient for 12 hours a day from sunrise to sunset. Food consisting of mealworms and insects and water were provided *ad libitum*. The females were inspected daily. Following oviposition, they were measured for snout-vent length (SVL), weighed and released at the study site. Additional data on clutch size came from oviductal eggs of females collected at the same site in the first week of June 2008. Those females were sacrificed immediately after capture for the purpose of diet analysis. Immediately after oviposition, the eggs were weighed and measured (maximum length and width). A digital calliper (0.01 mm precision) was used for linear measurements, while mass measurements were taken with an electronic balance (accuracy 0.01 g). Egg volumes were obtained by approximating the volume of the ellipsoid: $V=4/3\pi a^2b$, a and b being half of the width and length of the egg, respectively (see e.g. Ljubisavljević et al. 2012). The mean clutch size was estimated based on data for nine clutches laid in the laboratory and additional oviductal clutches found in seven autopsied females. Therefore the mean maternal SVL was calculated on 16 gravid specimens. All other measurements were taken on the vivarium-laid eggs. Clutch mass was calculated as the total mass of eggs in a clutch. The relative clutch mass (RCM) was calculated as the ratio of clutch mass to post-oviposition body mass. Descriptive statistics (mean, standard error, range) for all traits were calculated. Correlation analyses were used to analyse interrelationships among reproductive traits. Analysis of variance (ANOVA) and covariance (ANCOVA) were used to analyse differences in clutch characteristics between the two years. Statistical analyses were performed using the computer package Statistica® (STATISTICA for Windows. StatSoft, Inc., Tulsa, OK).

For analysis of diet, we examined 25 adult males and 11 adult females collected during the first week of June 2008. After collection, all animals were sacrificed by quick freezing and then fixed and conserved in 70 % ethanol. Afterwards they were dissected for stomach content analysis. The stomach contents of each specimen and by each sex were examined under stereomicroscope provided with micrometer scale. We identified prey items to the order level and family level in Insecta when possible, while all plant items were included into one category (plants). The calculations were made on order levels, while Insecta families identified were noted within the text. For each measurable prey item found in the stomachs of 20 males and 9 females, we measured its length and width (to the nearest 0,01 mm). Five males and two females had half-digested stomach contents, so we could identify items, but we could not take measurements of their length and width. The volume of each prey was estimated using the same ellipsoid equation as given above for the egg volume (see e.g. Rocha et al. 2004, Montechiaro et al. 2011). We calculated the numerical (N) and volumetric percentages (V) of each prey category, as well as frequency (F) of occurrence (the percentage of stomachs containing a given category of prey). Based on these data we calculated an index of importance Ix= (N% + V% + F%)/3 (Powell et al. 1990) to determine the contribution of each prey category in males and females of *A. nigropunctatus*.

The lizards for this study were collected under permits provided by the Ministry of Tourism and Environmental Protection, Republic of Montenegro (nos. 01-1519/4 and UPI-145/1). Sacrificed animals were deposited in the Herpetological Collection of the Natural History Museum of Montenegro in Podgorica.

Because the preliminary analysis showed no statistical differences in female SVL, clutch size and clutch and egg characteristics between the two years (ANOVA for female SVL, $F_{1,7} = 0.93$, $p = 0.37$; ANCOVA for clutch characteristics with SVL as the covariate, $F_{3,5} = 0.16 – 2.07$, $p > 0.20$ for all variables), we pooled the data in order to achieve a reasonable sample size. Egg and clutch characteristics were presented in Table 1. The simultaneous presence of enlarged vitellogenic follicles and oviductal eggs in some females that were autopsied for the purpose of diet analysis, suggested that at least a proportion of females of the Dalmatian *Algyroides* from the island of Bisage was able to lay at least two clutches per season. The Dalmatian *Algyroides* is generally characterized by small clutch size (Radovanović 1951, Bischoff 1981, Bejaković et al. 1996a, this study). Limited fecundity can be compensated by making more clutches, as revealed in our study. This way, the young could be released into temporally different environments to maximize the chance that some would survive. This could be particularly important in unpredictable insular conditions (Carretero 2006). The northernmost population of this species in northeastern Italy has somewhat greater mean clutch size (4), but produces only one clutch per season (Bressi 2004).

No significant relationship was found between the SVL and clutch and egg characteristics (CS: r = 0.33, $F_{1,14} = 1.74$; CM: $r = 0.39$, $F_{1,7} = 1.29$; RCM: $r = -0.34$, $F_{1,7} = 0.92$; EM: $r = -0.04$, $F_{1,7} = 0.01$; EL: $r = -0.32$, $F_{1,7} = 0.82$; EW: $r = -0.48$, $F_{1,7} = 2.05$; EV: $r = -0.43$, $F_{1,7} = 1.59$; $p > 0.20$ for all variables). Hence, the number of eggs and mean egg sizes for a clutch remained constant with the increase in female SVL. Within lizard species, clutch size generally increases with female size (e.g. Dunham et al. 1988, Braña 1996). However, this relationship is absent in many species with small clutch (e.g. James 1991a, Frankenberg & Werner 1992, Doughty & Thompson 1998, Greenville & Dickman 2005, Li et al. 2006, but see Arribas & Galán 2005), including insular species (Adamopoulou & Valakos 2000, Castilla & Bauwens 2000, Gifford & Powell 2007) and those from Lake Skadar archipelago as well (Bejaković et al. 1995, Bejaković et al. 1996b). A partial correlation analysis showed that there was no significant egg size-clutch size trade-off within individual clutches when holding female SVL constant (EL: $r = -0.42$, EW: $r = 0.05$, EV: $r = -0.22$, $p > 0.05$ in all cases). Also, the mean egg mass for a clutch decreased insignificantly with clutch size when SVL is held constant ($r = -0.65$, $p > 0.05$).

However, the moderate sample size used in this study may impede the statistical detection of some relations among the variables.

Since the species diet varies seasonally (e.g. Pal et al. 2007, Rodriguez et al. 2008), our study

Table 1. Summary of statistics for measurements of reproductive females, clutch and egg size of *A. nigropunctatus*. For egg attributes, the average values for each clutch were used.

Measurement	Abbreviation	Mean ± SE	Range	N
Female SVL (mm)	SVL	59.99 ± 0.86	51.98 – 63.90	16
Clutch size	CS	3.19 ± 0.26	2 – 5	16
Clutch mass (g)	CM	1.45 ± 0.10	1.12 – 1.99	9
Relative clutch mass	RCM	0.40 ± 0.03	0.27– 0.59	9
Egg mass (g)	EM	0.40 ± 0.02	0.28 – 0.50	9
Egg length (mm)	EL	12.62 ± 0.38	11.08 – 14.88	9
Egg width (mm)	EW	7.59 ± 0.15	6.85 – 8.28	9
Egg volume (mm^3)	EV	384.64 ± 25.66	272.67 – 532.57	9

Table 2. Number, frequency of occurrence, volume (in mm^3) and Index of importance (I) for each prey category for *A. nigropunctatus* from Bisage population.

	Males				Females			
	(N=25)	(N=25)	(N=20)	I	(N=11)	(N=11)	(N=9)	I
	Number (%)	Frequency (%)	Volume (%)		Number (%)	Frequency (%)	Volume (%)	
Coleoptera	11 (22)	10 (40)	846.45 (37.6)	33.2	4 (14.8)	4 (36.4)	240.13 (28.5)	26.6
Orthoptera	4 (8)	4 (16)	0.97 (0.04)	8.0	0 (0.0)	0 (0.0)	0 (0.0)	0.0
Diptera	2 (4)	2 (8)	264.67 (11.7)	7.9	1 (3.7)	1 (9.1)	225.02 (26.7)	13.2
Hymenoptera	4 (8)	4 (16)	4.87 (0.2)	8.1	7 (25.9)	2 (18.2)	10.14 (1.2)	15.1
Araneae	17 (34)	15 (60)	880.30 (39.1)	44.44	7 (25.9)	7 (63.6)	77.66 (9.2)	32.9
Isopoda	4 (8)	4 (16)	198.58 (8.8)	10.9	7 (25.9)	5 (45.5)	287.06 (34.0)	35.1
Chilopoda	0 (0)	0 (0)	0 (0.0)	0.0	1 (3.7)	1 (9.1)	3.26 (0.4)	4.4
Decapoda	1 (2)	1 (4)	-	3.0	0 (0.0)	0 (0.0)	0 (0.0)	0.0
Gastropoda	2 (4)	2 (8)	57.28 (2.5)	4.8	0 (0.0)	0 (0.0)	0 (0.0)	0.0
Plant material	5 (10)	5 (20)	-	14.0	0 (0.0)	0 (0.0)	0 (0.0)	0.0
Total	50		2253.12		27		843.27	

presents preliminary data on the trophic habits of the Dalmatian *Algyroides* during the late spring in an insular ecosystem. The diet was found to be composed of ten categories of food items (Table 2). *A. nigropunctatus* consumed a variety of Arthropods similar to other small lacertids in insular conditions of restricted trophic resources (Pérez-Mellado & Corti 1993, Valakos et al. 1997, Adamopoulou et al. 1999). Generally, the main food items were Aranea (spiders) and Coleoptera (beetles), the most frequent arthropods in the open habitats and clearings of the ecosystems of Mediterranean type (Chondropoulos et al. 1993). The terrestrial diet with beetles as predominant food items is characteristic for saxicolous lacertids, such as insular *Podarcis* species (Valakos et al. 1997, Adamopoulou et al. 1999). In males, identified Coleopterans belonged to Coleoptera larvae, Coccinelidae, Carabeidae and Scarabeidae, while females fed on Coleoptera larvae and Elateridae. The greater presence of spiders is also found in the diet of insular *P. taurica* (Chondropoulos et al. 1993) and *P. hispanica* (Pérez-Mellado & Corti 1993). Hymenoptera found in the stomachs were composed of Hymenoptera larvae and Formicidae (ants). The presence of ants as a clumped prey in the diet of small insular lacertids is not unusual (Pérez-Mellado & Corti 1993, Adamopoulou et al. 1999). Myrmecophagy was seen as a good strategy for minimising predation risk and/or searching costs during dry periods when trophic resources are low (Pianka 1986, James 1991b). *A. nigropunctatus* fed on different prey types. In its diet we found sedentary and nocturnal animals (insect larvae, Gastropoda). Therefore the Dalmatian *Algyroides* could be categorized as a widely foraging lizard (Huey & Pianka 1981, Valakos et al. 1997). Different plant parts and fruits were only present in male stomachs, on the third place by importance (Table 2). In small insular lacertids, herbivory occurs as an adaptation to poor food resources in dense populations (Pérez-Mellado & Corti 1993, Herrel et al. 2008), but additional causes have also been suggested (Rodriguez et al. 2008 and references therein). However, plant material may be accidentally consumed together with the prey (e.g. Adamopoulou et al. 1999, Cicort-Lucaciu et al. 2009, Fabricante & Nuneza 2012). The small sample sizes precluded definitive statistical evaluation of dietary differences between males and females and deeper inference of trophic niche partitioning.

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