

## ESCAPE BEHAVIOUR OF THE LACERTID LIZARD *PODARCIS MELISELLENSIS* (SAURIA, LACERTIDAE) IN SOME SMALL ISLANDS OF DALMATIA. PRELIMINARY DATA

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**Abstract.** Anti-predatory behaviour is an important aspect of the ecology of organisms, such as lizards, that occupy an intermediate position in the trophic food chain. Lizards, in fact, frequently experience high predation rates and their behavioural response can be shaped by a number of environmental and physiological factors. We analysed flight initiation distance, distance fled and refuge use frequency in *Podarcis melisellensis* populations inhabiting medium and small sized islands of the eastern coast of the Adriatic Sea. The level of wariness greatly varied among populations of different islands, while the length of the distance fled by lizards was more homogeneous across sites and, in average, it was shorter for lizards that entered a refuge rather than for lizards that did not hide. Most of the recorded variability could be probably

related to differences in habitat structure among islands: lizard wariness, indeed, was higher in poorly vegetated islands, despite these islands did not host ground predator species. Even if this study provides just a preliminary description of *P. melisellensis* anti-predatory behaviour, our results suggest that interesting interactions between strength of predation and habitat complexity occur in shaping lizard escape process in the so called “Vis Archipelago”.

**Keywords:** anti-predatory behaviour, Dalmatia, escape, islands, lizard, *Podarcis melisellensis*.

**Resumen.** El comportamiento anti-depredador es un importante aspecto de la ecología de organismos como los lagartos, que ocupan una posición intermedia en las cadenas tróficas. De he-

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cho, los lagartos sufren frecuentemente elevadas presiones de depredación y sus respuestas comportamentales pueden ser modeladas por toda una serie de factores fisiológicos y ambientales. Analizamos la distancia de inicio de la huída, la distancia de huída y la frecuencia de uso de refugios en poblaciones de *Podarcis melisellensis* que habitan islas de tamaño medio o pequeño en la costa oriental del Adriático. El nivel de precaución antidepredadora varía ampliamente entre las poblaciones de las diferentes islas, mientras que la distancia de huída de las lagartijas era más homogénea entre las diferentes localidades y, en promedio, más corta para lagartijas que entraron en un refugio que para las que no se ocultaron. Buena parte de la variabilidad observada podría estar relacionada con diferencias en la estructura del hábitat entre las islas: de este modo, el grado de precaución de las lagartijas fue mayor en islas con pobre cobertura vegetal, al margen de que en tales islas no existieran depredadores. Si bien este estudio brinda únicamente una descripción preliminar del comportamiento antidepredador de *P. melisellensis*, nuestros resultados sugieren que existe una interesante interacción entre la intensidad de la presión de depredación y la complejidad del hábitat en el denominado "archipiélago de Vis".

**Palabras clave:** comportamiento antidepredador, Dalmacia, huída, islas, lagartija, *Podarcis melisellensis*.

**Resum.** El comportament antipredador és un important aspecte de l'ecologia d'organismes com les

sargantanes, que ocupen una posició intermèdia en les cadenes tròfiques. De fet, les sargantanes sofreixen freqüentment elevades pressions de depredació i les seves respostes comportamentals poden ser modelades per tot un seguit de factors fisiològics i ambientals. Analitzem la distància d'inici de la fugida, la distància de fugida i la freqüència d'ús dels refugis en poblacions de *Podarcis melisellensis* que habiten illes de grandària mitjana o petita a la costa oriental de l'Adriàtic. El nivell de precaució antipredadora varia àmpliament entre les poblacions de les diferents illes, mentre que la distància de fugida de les sargantanes era més homogènia entre les diferents localitats i, en mitjana, més curta per a sargantanes que van entrar en un refugi que para les que no es van ocultar. Bona part de la variabilitat observada podria estar relacionada amb diferències en l'estructura de l'hàbitat entre les illes: d'aquesta manera, el grau de precaució de les sargantanes va ser major en illes amb una pobra cobertura vegetal, al marge que en aquestes illes no existissin depredadors. Si bé aquest estudi brinda únicament una descripció preliminar del comportament antipredador de *P. melisellensis*, els nostres resultats suggereixen que existeix una interessant interacció entre la intensitat de la pressió de depredació i la complexitat de l'hàbitat en el denominat "arxipèlag de Vis".

**Paraules clau.** comportament antipredador, Dalmàcia, fugida, illes, sargantana, *Podarcis melisellensis*.

## INTRODUCTION

Predation is reputed to be one of the major selective forces in the evolution of many behavioural traits (Lima & Dill, 1990), and as such it gains increasing importance in the ecology of species subjected to a high predation pressure. Organisms that occupy an intermediate position in the trophic food chain, such as lizards, frequently experience high predation rates. According to theoretical models about anti-predatory behaviour, individuals should try to balance the costs of escaping (in terms of energy spent or time stolen to other activities, like feeding and mating) with the risks of staying (Ydenberg and Dill, 1986). Typically, the first phase of escape behaviour, dealing with predation risk assessment, is synthesised as a single variable: the flight initiation distance (FID). This is defined as the distance the prey allows the potential predator to approach before starting escaping. The escape process consists of other components too, among which the distance fled by prey while escaping, and above all, the choice of escape tactics. Prey can in fact choose among various escape tactics, such as entering a refuge or running away from the potential predator without hiding. The decision of entering a refuge is probably subject to an evaluation of costs and benefits as complex as the one involving when to flee from the potential predator. Staying inside a shelter, in fact, usually entails the organism experiencing suboptimal environmental conditions, which can have particularly high costs

for ectotherms (Carrascal et al., 1992; Martín and Salvador, 1993; Bulova, 1994; Cooper, 2000; Martín et al., 2003).

A large number of studies have investigated escape behaviour in lizards, and indicate that there are many factors that shape anti-predatory responses of these vertebrates. Among these factors there are, for instance, predation pressure (Stone et al., 1994; Blázquez et al., 1997; Diego-Rasilla, 2003; Delibes and Blázquez, 1998), habitat complexity (Snell et al., 1988; Bulova, 1994; Martín and López, 1995; Rugiero, 1997), and the presence and amount of available food (Martín et al., 2003; Cooper and Pérez-Mellado, 2004). In addition, a number of internal factors can influence lizard escape behaviour, among which general body condition, body temperature, crypsis, and reproductive status (Heatwole 1968; Bauwens and Thoen, 1981; Hertz et al., 1982; Losos, 1988; Snell et al., 1988; Braña, 1993; López et al., 2005).

In this field study we analysed and compared the escape behaviour of some island populations of the Dalmatian lizard *Podarcis melisellensis* (Sauria-Lacertidae). This *Podarcis* species is endemic on many of the medium and small sized islands that characterize the Adriatic Sea off the coast of Dalmatia (Tiedemann and Henle, 1986). Some aspects of the ecology of *P. melisellensis* populations inhabiting the islands involved in this study have already been investigated (Pérez-Mellado et al., 2008), but less is known about their anti-predatory

behaviour. In this paper we provide just a preliminary description of lizard anti-predatory response, from the spotting of the potential predator (level of wariness), to the length of the distance fled while escaping and to the choice of the escape tactic (refuge use frequency). Given the general plasticity of lizard escape behaviour and the different features characterizing the sampled islands, we expected to find some variability among populations.

## MATERIALS AND METHODS

*Podarcis melisellensis* (Braun, 1877) is a relatively small lacertid lizard (in the studied populations, males: SVL=63.14 ± 6.08 mm, n= 42; females: SVL=56.31 ± 3.83 mm, n=39). It is present in the extreme part of North-eastern Italy, along the Slovenian and Croatian coasts, including most of the Istrian, Quarnarian and Dalmatian islands and islets, and along Bosnia-Herzegovina and Montenegro coasts,

south through northern Albania (Tiedemann and Henle, 1986; Sindaco et al., 2006). We sampled five islands of the so called "Vis Archipelago", Central Dalmatia (Adriatic Sea): Vis, the main island, Bisevo, Mali Barjak, Mali Parzanj, that are some of the surrounding islets, and Jabuka (table 1). Samplings were performed in spring 1995.

After spotting an adult lizard we approached it by walking directly towards it at a constant speed, to simulate a predatory attack; during each trial, we recorded the flight initiation distance (FID), and the total distance fled (TDF) by the individual before entering a refuge or stopping running (Bulova, 1994; Cooper, 1997; Diego-Rasilla, 2003). For each lizard we also recorded if it entered a refuge (R) or stopped without hiding (S). In order to minimize the risk of repetitive samplings of the same individual, each island was surveyed in a single day. At each island we walked along linear paths, bypassing previously visited sites. Therefore, we considered data as truly independent.

Island	Island Cod.	Surface (km <sup>2</sup> )	Max. altitude (m a.s.l.)	Sample size	FID (mm) (mean ± SD)	TDF (mm) (mean ± SD)	% of R
Bisevo	Is 1	5.84	239	49	82.041 ± 37.060	49.041 ± 29.948	63.3
Vis	Is 2	90.3	587	46	104.109 ± 39.728	83.261 ± 35.812	34.8
Mali Barjak	Is 3	<0.01	10	31	101.129 ± 35.840	56.064 ± 31.072	16.1
Mali Parzanj	Is 4	0.013	5	13	151.538 ± 35.729	70 ± 43.541	69.2
Jabuka	Is 5	0.01	96	15	147.8 ± 41.141	97.667 ± 57.098	35.7

Table 1. Surveyed islands with some of their features, and descriptive variables of lizard escape behaviour: sample sizes, mean values of FID and TDF and percentages of lizard entering a refuge (R)

On islands with greater sample sizes (Is1, Is2) we checked for differences in FID and TFD between sexes, using a t-test. As we found no differences between sexes in both the variables ( $P > 0.05$  in both of the islands), and also considering that possible differences in the remaining islands would be randomly distributed among populations, without biasing general findings (Cooper et al., 2009), we pooled data from both sexes. We investigated the existence of a possible correlation between FID and TFD through Pearson correlation. In order to detect possible differences among islands, we compared both FID and TDF using ANOVA analyses; Tukey HSD *post-hoc* comparisons were applied. We used t-test to verify if FID and TDF showed

differences in relation to lizard escape tactic. To meet the assumption of normality of data we log-transformed FID and TDF values. We used Statistica 7.0 package for all the analyses.

**RESULTS**

FID and TDF were not significantly correlated ( $n = 154$ ,  $r = 0.111$ ,  $P = 0.169$ ). Both FID and TDF showed a relatively high variability among islands (table 1-2, figure 1). Specifically, FID values in Mali Parzanj and Jabuka were longer than in the other islands; FIDs from Mali Parzanj, in particular, showed significant differences with those recorded in three out of four islands.

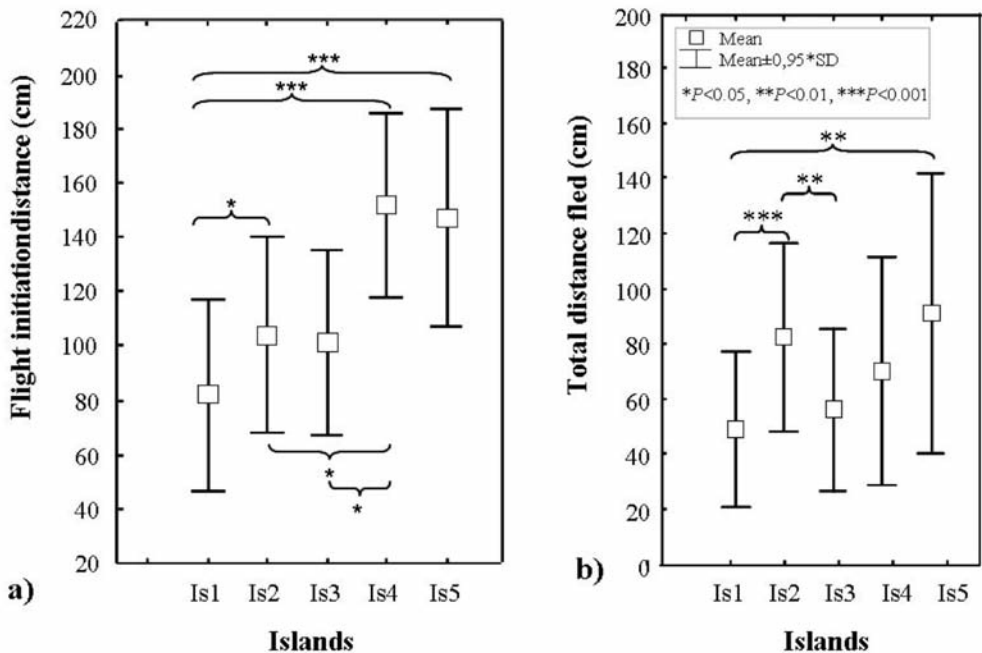


Figure 1. Mean values ( $\pm$ SD) of FID (a) and TDF (b) of *P. melisellensis* in the sampled islands

	Flight initiation distance (FID)			Total distance fled (TDF)		
	F	P	Post hoc comparisons <sup>a</sup>	F	P	Post hoc comparisons <sup>a</sup>
Islands	9.390	<0.001	Is1 < Is2 <sup>†</sup> , Is1 < Is4 <sup>***</sup> , Is1 < Is5 <sup>***</sup> , Is2 < Is4 <sup>†</sup> , Is3 < Is4 <sup>†</sup>	7.576	<0.001	Is1 < Is2 <sup>***</sup> , Is1 < Is5 <sup>**</sup> , Is2 > Is3 <sup>†</sup>

a) <sup>†</sup> $P < 0.05$ ; <sup>\*\*</sup> $P < 0.01$ ; <sup>\*\*\*</sup> $P < 0.001$

Table 2. Comparison of FID and TDF among islands. Results of ANOVA and Tukey HSD *post-hoc* comparisons are reported (n=154)

TDF was relatively more homogeneous among populations; nevertheless, lizards in Vis and Jabuka ran the longest distances. In Bisevo and Mali Parzanj more than 60% of lizards entered a refuge, while in the other islands the majority of individuals did not hide (table 1). T-test revealed that FID did not differ in relation to the escape tactic ( $t=0.586$ ,  $P=0.559$ ,  $n=154$ ). While the same analysis showed significant results for TDF ( $t=4.025$ ,  $P<0.01$ ,  $n=154$ ). Specifically, TDF was shorter for lizards that entered a refuge ( $n=66$ , mean  $\pm$  SD =  $55.045 \pm 36.898$  cm) and was almost twice as long for those that stopped running without hiding ( $n=88$ , mean  $\pm$  SD =  $103.625 \pm 44.906$  cm).

## DISCUSSION

Given the vulnerability that usually characterizes island populations, to increase our knowledge of ecological aspects such as anti-predatory behaviour on islands is particularly important from a conservation perspective. In this study we provided a preliminary description of the escape behaviour of some island populations of *Podarcis melisellensis*, endemic on many islets of Dalmatia.

In the populations that we surveyed, escape behaviour did not seem to vary between sexes (as also observed by Brecko et al., 2008 in *P. melisellensis* island populations). Males and females started escaping at comparable distances from the potential predator and, then, ran comparable long rushes. We found a particularly high variability in FID values, suggesting that populations from different islands are primarily characterized by varying levels of wariness. TDF, on the contrary, was relatively more homogeneous across islands and it was influenced by the choice of the escape tactic: lizards that entered a refuge ran significantly shorter distances than those that did not do so.

In particular, the pattern that we found for FID values seemed to suggest that lizard wariness could be influenced by the habitat structure complexity of the sampled sites, being lizards increasingly tamer in most vegetated islands. Indeed, in Jabuka and Mali Parzanj, individuals escaped at significantly longer distances from the potential predator than in the other islands. Jabuka is a rocky, quite isolated, volcanic islet characterised by very scarce and scattered vegetation, mainly made up of herbaceous species. Mali Parzanj is a flat islet, mainly

covered by herbaceous vegetation, too. On the contrary, in sites with more complex habitat structures, such as Bisevo and Vis, lizards allowed the potential predator to get closer. Studies performed on other lizard species have shown that vegetation cover is a key factor influencing escape behaviour and, consistently with the patterns that we observed, they suggested that in more open habitats lizards tend to be warier (Bulova, 1994; Martín e Lopez, 1995; Snell et al., 1988). Obviously, also predation pressure may represent a driving force influencing escape behaviour. In some lizard species FID increases along with the abundance of predators (Stone et al., 1994; Blázquez et al., 1997). However, this was not the case of our study. Considering the relative closeness of sampled islands, we can suppose they are characterized by the same number of birds of prey (mainly Falconidae). On the contrary, Vis and Bisevo hosted the highest number of terrestrial predator (that is, snakes and mammals), that were completely absent in Mali Barjak, Mali Parzanj and Jabuka (Krystufek & Kletecki, 2007; unpublished data). So, intriguingly, wariness was higher on islands with a minimum predator presence and the simplest habitat structure, thus suggesting an interaction between strength of predation and habitat complexity. As such, being more exposed might mean both being more detectable and having less safe refuges to hide in, which could override the advantage of fewer predators. Overall,

displaying a wary behaviour constitutes a particularly successful strategy for lizards inhabiting open rocky surfaces (Arnold 1987, 1999; Vitt et al., 2002), even if few predators are present.

A complex interaction between habitat structure and predation pressure might be also responsible for the observed patterns of TDF values. The availability of refuges, in particular, probably played a major role in determining the length of lizard rushes as seen by comparing the distances run by individuals that entered a refuge with TDFs of lizards that did not do so. In fact, individuals that hid, ran in average half the distances recorded for lizards that did not hide.

In conclusion, we found that the escape behaviour of *P. melisellensis* varied across islands that, even if quite near each other, differed for size, vegetation cover and number of potential predator species. The detected variability involved all the phases of the escape process, from the decision of the moment to start fleeing to the choice of the escape tactic. From our observations, we can suppose that great part of such variability was probably due to environmental features of the sampled islands, including vegetation structure and refuge availability. However, this study has to be considered as a starting point for further investigations that are needed to better identify the driving forces shaping lizard anti-predatory behaviour in the study areas.

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