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# Nature-based tourism as a form of predation risk affects body condition and health state of *Podarcis muralis* lizards

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## ABSTRACT

Nature-based tourism has experienced a greater increase, and, even although it might have deleterious effects for many wildlife species, its consequences remains little explored. Many lizard species are endangered and tourism has been proposed as a potential factor responsible of the decline of several lizards' populations, but no study has examined the effect of tourism on lizards' behaviour, body condition and health state. Many lizards respond to people as if they were predators, by readily escaping to refuges. However, an increase in the frequency of these antipredatory strategies can lead to a loss of body condition, which may have important consequences for short and long term fitness. We analysed the effects of tourism on escape behaviour of common wall lizards, *Podarcis muralis*, as well as on their body condition and health state (ectoparasites, blood parasites, and cell mediated immune response). Results showed that lizards did not modify their escape behaviour in response to tourism. Lizards had similar approach and flight distances, and escape strategies regardless of the level of tourism pressure. However, lizards inhabiting areas with high tourism levels, where they presumably needed to perform antipredatory behaviours more often, showed higher intensity of infection by ticks and lower body condition at the end of the breeding period. Moreover, lizards with poorer body condition had lower cell mediated immune responses. Therefore, tourism seems to have deleterious effects on body condition and on host–parasite relationships in this lizard species. These effects should be taking into account when designing walking paths in protected areas. Our study reports evidence that regardless lizards showed similar escape behaviour in tourist than in natural areas, their body condition and health state should be also examined to accurately assess the actual effects of tourism on lizards' populations.

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## 1. Introduction

Ecotourism is largely perceived to safeguard natural areas and thereby to contribute to the conservation of biodiversity (Munn, 1992; Ceballos-Lascuráin, 1996; Gössling, 1999; Tisdell and Wilson, 2002; Lindsey et al., 2005; but see López-Espinosa de los Monteros, 2002). However, in the last decades, nature-

based tourism, often claimed as ecotourism, has experienced a greater increase, but its consequences for many taxa have not been so rapidly assessed (see Frid and Dill, 2002; Buckley, 2004; for a general review). Changes in behaviours such as modifications of the escape responses have often been considered the most sensitive measure of the effects of human disturbance on animals, and it has frequently used as an

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index of disturbance effects (Carney and Sydeman, 1999). Thus, it has been assumed that an increased avoidance response of animals to human presence in tourist areas means a deleterious effect of tourism on those animal populations (see for example, Ikuta and Blumstein, 2003). This may be true because antipredatory behaviours are costly in terms of losing time for other activities such as foraging (Koivula et al., 1995; Dill and Fraser, 1997; Martín et al., 2003a; Cooper and Perez-Mellado, 2004) or reproduction (Sih et al., 1990; Crowley et al., 1991; Martín et al., 2003b). Moreover, predator avoidance can also lead to physiological costs for prey such as a decrease in body condition (Martín and López, 1999a; Pérez-Tris et al., 2004).

However, measuring escape responses may be not enough for assessing the effects of nature-based tourism on wildlife (Higham, 1998). On one hand, if animals inhabiting areas with high tourism pressure do not respond differently to the current approach of a human from those inhabiting areas with no tourism pressure, the conclusion could be that those individuals are not affected by tourism. However, animals often may not move from disturbed areas because they may not have a suitable habitat nearby where to go, and thus, they may be forced to stay (Gill et al., 2001). Furthermore, if animals inhabiting tourist areas perform these antipredatory behaviours with the same characteristics but more frequently, they may suffer the costs of these behaviours as for example a loss of time to perform other activities (Lima and Dill, 1990) and/or a decrease in body condition (Martín and López, 1999a; Pérez-Tris et al., 2004). On the other hand, antipredatory behaviour seems to be dependent on body condition of animals (Beale and Monaghan, 2004). Therefore, animals may not differ in their escape response because animals that inhabit areas with high tourism pressure might have poor body condition for different reasons, and thus they might not be able to afford the costs of these behaviours. This is because, although predation is a major selective force, prey should optimize their antipredatory response by balancing antipredatory demands with other requirements (Lima and Dill, 1990; Lima, 1998). Hence, prey may wait to perform an escape response until costs of not responding are higher than costs of such response (Ydenberg and Dill, 1986; Dill and Houtman, 1989; Bonenfant and Kramer, 1996) to cope with risk without incurring excessive costs (Sih, 1992, 1997; Dill and Fraser, 1997; Martín and López, 1999b, 2003).

A decrease of body condition may have important consequences for short and long term fitness of individuals. For example, the loss of body condition could lead to a decrease in the ability to invest in defence against parasites as the nutritional status can affect the capacity of a lizard to mount an immune response to infection (Cooper et al., 1985; Smallridge and Bull, 2000). This may influence host–parasites relationships, and may increase the negative effects of parasites on their host, which, in turn, can affect the maintenance of animals' populations.

Nature-based tourism may have deleterious effects on reptiles because many species respond to humans as if they were potential predators, by readily escaping to refuges (e.g. Martín and López, 1999a,b; Amo et al., 2003), and an increase in antipredatory behaviours may be costly for lizards (Martín and López, 1999a; Pérez-Tris et al., 2004). However, deleterious

effects of tourism have only been described for sea turtles (see Wilson and Tisdell, 2001 and references therein) and Galápagos marine iguanas (*Amblyrhynchus cristatus*) (Romero and Wikelski, 2002). Therefore, much more research is needed to examine the effect of tourism on reptiles' populations. This effect may be especially important because in the last decades many populations of several lizards' species are in decline in Europe, and, for some species, increased tourism has been suggested as possible factor of this decline (Corbett, 1989; Pleguezuelos, 1997; Pleguezuelos et al., 2002). However, no studies have analysed the effect of tourism on body and health condition of lizards.

Here, we analysed the effects of nature-based tourism on common wall lizards, *Podarcis muralis*, taking into account not only the escape behaviour but also the body condition and health state of lizards. Concretely, we examined in areas with different level of tourism pressure within the same habitat whether lizards differed in: (a) the distance to the nearest refuge, (b) the escape strategy used when attacked by a simulated predator, (c) approach and flight distances, (d) body condition, and (e) health state (immune response, and ectoparasite and blood parasite load). Since lizards are known to accurately assess the risk of predation and respond accordingly, we expected that lizards might not show differences in antipredatory behaviour if they responded to the current level of predation risk of each attack (Martín and López, 2005) regardless of the average levels of risk in an area. Hence, lizards in areas with high tourism pressure might suffer the costs associated to perform antipredatory behaviours more frequently, with the subsequent deleterious effects for their body and health condition. Furthermore, lizards with decreased body condition might not be able to allocate resources to parasite defence, and, therefore, the deleterious effects of parasitemia should be more evident in tourist areas. Alternatively, lizards submitted to a higher predation pressure might be able to modify their escape behaviour to cope with the average predation risk of the area without incurring excessive costs of antipredatory behaviours. Therefore, if they had shorter distances to refuges, and shorter approach and flight distances, we should not expect differences between areas with different tourism pressure in the body condition and health state of lizards.

## 2. Methods

### 2.1. Study area and species

The study was performed during spring and summer 2003 at a large pine forest area ("Valle de La Fuenfria") in the Guadarrama mountains (40°44'N, 4°02'W; Madrid province, Spain). The dominant vegetation consists of *Pinus sylvestris* forest, with shrubs such as *Juniperus communis* and *Cytisus scoparius*. These mountains are the traditional recreational area of Madrid City, and hence, they suffer a high level of tourism, with a great number of pedestrians, especially during the weekends and during the period of activity of lizards (i.e., in spring and summer). During spring (April, May and June), the mean estimated number of people visiting the particular forest where we did the study was 340 people per day (unpublished data from the Visitor Center of this forest). This number increased

during the weekends (700 people per day) and decreased during the week days (160 people per day). During summer (July–August), the mean estimated number of people was 500 people per day (740 people per day during weekends and 380 people per day during week days). The influence of pedestrians was limited to a few paths, as people usually did not cross-country walk through this rough habitat (personal observation). Therefore, there were patently differences in the number of tourism pressure between areas.

For this study, we classified sampling areas according to two levels of tourism pressure: (1) areas with 'high' level of tourism, located close (within 5 m) to frequently transited walking paths, or in recreational and picnic areas, and (2) areas with 'low' level of tourism, far from walking paths (more than 30 m), and where people was rarely observed. Except for the presence of walking paths, both types of areas were similar respect to microhabitat or microclimate characteristics.

The wall lizard, *Podarcis muralis*, is a small lacertid lizard (60–76 mm adult snout-to-vent length, SVL) widespread in central Europe, although in the Iberian Peninsula it is restricted to mountainous areas of the northern half, where it occupies soil dwellings, talus and walls in shaded zones in forests (Martin-Vallejo et al., 1995). In the study area, lizards mate in April–May and produce a single clutch in June–July (Pérez-Mellado, 1998).

## 2.2. Escape behaviour

During April we simulated predatory attacks to adult lizards ( $n = 70$ ), recording their escape behaviour in areas with different level of tourism within the study area. We walked haphazardly in days with favourable climate conditions (warm sunny days) and between 09:00 and 13:00 h GMT until an adult lizard was sighted with binoculars, whereupon we attempted to approach it directly. The same person performed all approaches, walking at the same moderate speed (about 40 m/min) and wearing the same clothing, to avoid confounding effects that may have affected lizards' risk perception (e.g., Burger and Gochfeld, 1993; Cooper, 1997; Martín and López, 2005). For each approach we noted: (a) the distance at which the lizard was detected, (b) the distance from the initial location of the lizard to the nearest available refuge, (c) the 'approach distance' as the distance between the lizard and the observer when the lizard first moved (a straight line measured to the nearest 0.1 m), (d) the 'escape strategy' used, distinguishing between lizards that remained stationary without hiding, lizards that fled to hide in the nearest refuge, and lizards that fled without hiding (Amo et al., 2003), and (e) the 'flight distance' as the distance that the lizard ran during an episode of escape until it hid or stopped for first time.

Given the high lizard density, and because we avoided sampling the same area twice, the probability of repeated measurements on the same individual was low. We therefore treated all measurements as independent. We used two-way analyses of variance (ANOVAs) to compare detection distance or distance to the nearest refuge (dependent variables) between areas with different levels of tourism, and between sexes of lizards, including the interaction between sex and level of tourism. We used two-way analyses of covariance

(ANCOVAs) to compare approach or flight distances (dependent variables) between areas with different levels of tourism, and between sexes, and their interaction, with the distance to the nearest refuge as a covariant.

We used generalized non lineal models (GLZ) to assess the effect of level of tourism and distance to the nearest refuge on the type of escape strategy used by lizards as a dependent variable following a multinomial distribution classifying lizards that did not flee, lizards that hid in the nearest refuge, and lizards that fled without hiding. As there were some cases where there were no data for both sexes, we could not perform the analysis including the sex in the model. For example, no male escaped by fleeing without using refuges in tourist areas, and no female used refuges in non-tourist areas. Although results of a previous study did not show sexual differences in the escape strategy of wall lizards (Amo et al., 2003), we used Chi-squared tests to compare the frequencies of each type of escape strategy between males and females and between tourist and non-tourist areas.

## 2.3. Body condition, health state, and parasite load of lizards

We captured by noosing 78 adult lizards to examine their body condition, health state, and parasite load in areas with different level of tourism in two seasons, spring (during the mating period, June) and summer (after the mating period had finished, July–August). We weighed lizards, measured their snout-vent-length (SVL), and noted the number of ectoparasites (ticks) observed on their body immediately after capture. Then, we took captured lizards for data collection (see below) to "El Ventorrillo" Field Station, 5 km from the capture site. Lizards were individually housed in 60 × 40 cm PVC outdoor terraria. They were fed mealworm larvae (*Tenebrio molitor*), and water was provided ad libitum. The photoperiod and ambient temperature were that of the surrounding region. All lizards were healthy and were returned to their exact capture site 48 h after capturing. The measurements were taken under license from the Consejería del Medio Ambiente de la Comunidad de Madrid (Spain).

To assess blood parasite load, we made a smear on a microscope slide from blood taken from the postorbital sinus by using one 9  $\mu$ l heparinized hematocrit tube. Blood smears were air-dried, fixed in absolute methanol for 10 min and then stained in Giemsa diluted 1:9 with phosphate buffer (pH 7.2) for 40 min before their examination for parasites. On mounted slides, half a smear, chosen at random, was scanned entirely at 200 $\times$  along the longitudinal of slide, looking for extraerythrocytic protozoa (Merino and Potti, 1995; Amo et al., 2004, 2005). Number of intraerythrocytic parasites (haemogregarines) was estimated at 400 $\times$  by counting the number of parasites per 2000 erythrocytes.

We measured cell mediated immune responsiveness (CMI) of lizards captured in summer by using a delayed-type hypersensitivity test. We estimated CMI on the basis of quantification of the swelling response to intradermally injected phytohaemagglutinin (Smits et al., 1999). The phytohaemagglutinin (PHA) skin test is a reliable measure of non-specific cellular immunity in vivo (Lochmiller et al., 1993), and it has been used in many studies of animals including lizards

(Merino et al., 1999; Svensson et al., 2001; Belliure et al., 2004). The PHA test requires 24 h to reach the maximum intensity of swelling, although a previous study in birds has shown that the maximum swelling happens 6 h before injection and it's similar to that obtained 24 h before injection (Navarro et al., 2003). We injected the lizard's footpad of the right hind limb with 0.02 ml of phytohaemagglutinin solution (PHA-P, Sigma), and measured the swelling with a pressure sensitive spessimeter (to the nearest 0.01 mm) before and 24 h after the injection (Smits et al., 1999). The PHA response involves proliferation of T cells, but the PHA also attracts other immune cells, including basophils and heterophils, to the injection site and causes inflammation (Smits et al., 1999; Mauck et al., 2005). Therefore, the swelling during the first 24 h is a good method to asses the innate immune system that is the first line of defense of an organism to control parasite infections. Results of previous studies showed that repeatability of this measure, calculated as the intraclass correlation coefficient (Lessells and Boag, 1987) was high ( $r > 0.95$ , L. Amo, unpublished data).

We used backward general lineal models (GLM) to analyze differences in intensity of ticks' infection (dependent variable) in relation to sex, size, season (spring vs. summer) and level of tourism of the area, including the interactions between these variables in the initial model. Similar backward GLMs were used to analyse differences in blood parasite load (dependent variable) in relation to all the above independent variables plus the intensity of ticks' infection, and to analyze differences in body mass (dependent variable) in relation to all the above variables plus ectoparasite and blood parasite loads. Finally, we also used backward GLMs to analyze differences in CMI response (dependent variable) in relation to the sex, size, mass and level of tourism, and ectoparasite and blood parasite loads.

### 3. Results

#### 3.1. Escape behaviour

The distance of detection did not differ between areas with different levels of tourism (ANOVA,  $F_{1,65} = 0.47$ ,  $p = 0.49$ ) or between sexes ( $F_{1,65} = 1.42$ ,  $p = 0.24$ ), and the interaction was not significant ( $F_{1,65} = 2.29$ ,  $p = 0.14$ ) (Table 1). There were neither significant differences in the distance to the nearest refuge at which lizards were located before the attack between levels of tourism (ANOVA,  $F_{1,66} = 0.01$ ,  $p = 0.98$ ) nor between sexes

( $F_{1,66} = 0.56$ ,  $p = 0.46$ ), and the interaction was not significant ( $F_{1,66} = 0.38$ ,  $p = 0.54$ ) (Table 1).

Approach distances were not related to the distance to the nearest refuge (ANCOVA,  $F_{1,65} = 1.28$ ,  $p = 0.26$ ), did not differ significantly between levels of tourism ( $F_{1,65} = 0.44$ ,  $p = 0.51$ ), or between sexes ( $F_{1,65} = 1.80$ ,  $p = 0.18$ ), and the interaction was not significant ( $F_{1,65} = 0.10$ ,  $p = 0.75$ ) (Table 1). Similarly, flight distances were not related to the distance to the nearest refuge (ANCOVA,  $F_{1,64} = 0.60$ ,  $p = 0.44$ ), there were no significant differences between levels of tourism ( $F_{1,64} = 0.93$ ,  $p = 0.34$ ), or between sexes ( $F_{1,64} = 1.36$ ,  $p = 0.25$ ), and the interaction was not significant ( $F_{1,64} = 0.48$ ,  $p = 0.49$ ) (Table 1).

The escape strategy of lizards was not related to the distance to the nearest refuge (Wald's  $\chi^2 = 3.43$ ,  $df = 2$ ,  $p = 0.18$ ) nor to the level of tourism of the area (Wald's  $\chi^2 = 1.96$ ,  $df = 2$ ,  $p = 0.37$ ). There were no significant differences between males and females when comparing each type of escape strategy in tourist or non tourist areas (Chi-squared test,  $\chi^2 < 1.05$ ,  $df = 1$ ,  $p > 0.30$  in all cases; Table 1), neither there were significant differences between tourist or non tourist areas when comparing each type of escape strategy in males or females (Chi-squared test,  $\chi^2 < 2.30$ ,  $df = 1$ ,  $p > 0.13$  in all cases; Table 1).

#### 3.2. Parasite load, body condition, and health state of lizards

The intensity of infection by ticks (GLM,  $R^2 = 0.15$ ,  $F_{2,71} = 6.51$ ,  $p = 0.003$ ) was higher in males than in females ( $F_{1,71} = 5.50$ ,  $p = 0.02$ ; Fig. 1), and higher in areas with high level of tourism ( $F_{1,71} = 8.27$ ,  $p = 0.005$ ; Fig. 1). Other variables and interactions were not significant and were removed from the final model.

Blood parasite load (GLM,  $R^2 = 0.16$ ,  $F_{5,68} = 2.59$ ,  $p = 0.03$ ) did not change in the course of seasons in areas with low level of tourism, whereas it decreased in areas with high level of tourism (season  $\times$  tourism level:  $F_{1,68} = 8.78$ ,  $p = 0.004$ ). The interaction between season, level of tourism and size of lizards was significant ( $F_{1,68} = 8.38$ ,  $p = 0.005$ ). Thus, during the breeding period there was no relationship between body size and intensity of haemogregarines' infection in any area. However, after the breeding period the relationship between body size and intensity of blood parasites was negative in areas with low tourism but positive in areas with high tourism pressure. Other variables and interactions were not significant and were removed from the final model.

**Table 1 – Mean ( $\pm$ SE) of variables describing escape behaviour of male and female *Podarcis muralis* lizards in areas with low or high level of tourism**

|  | Low level of tourism |                  | High level of tourism |                  |
|--|----------------------|------------------|-----------------------|------------------|
|  | Males (N = 18)       | Females (N = 13) | Males (N = 20)        | Females (N = 19) |
| Distance to the nearest refuge (cm)      | 31 $\pm$ 16          | 16 $\pm$ 3       | 24 $\pm$ 10           | 23 $\pm$ 7       |
| Distance of detection (cm)               | 389 $\pm$ 36         | 400 $\pm$ 43     | 418 $\pm$ 36          | 324 $\pm$ 22     |
| Approach distance (cm)                   | 81 $\pm$ 31          | 38 $\pm$ 27      | 112 $\pm$ 44          | 53 $\pm$ 24      |
| Flight distance (cm)                     | 6 $\pm$ 3            | 0 $\pm$ 0        | 20 $\pm$ 15           | 3 $\pm$ 3        |
| Number of lizards stationary             | 12                   | 11               | 11                    | 13               |
| Number of lizards fleeing without hiding | 1                    | 2                | 0                     | 3                |
| Number of lizards hiding in a refuge     | 5                    | 0                | 9                     | 3                |

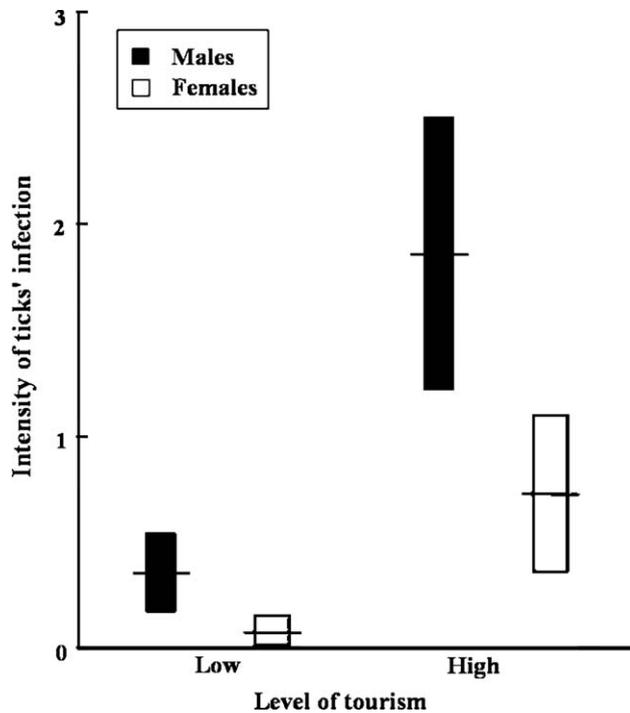


Fig. 1 – Mean ( $\pm$ SE) intensity of infection by ticks (number of ticks per individual) in male (black bars) and female (open bars) *Podarcis muralis* lizards in areas with low and high level of tourism.

Body mass of lizards (GLM,  $R^2 = 0.83$ ,  $F_{6,67} = 53.10$ ,  $p < 0.0001$ ) was positively correlated with their SVL ( $F_{1,67} = 118.49$ ,  $p < 0.0001$ ). Males were significantly heavier than females of equivalent body size (sex  $\times$  size:  $F_{1,67} = 5.26$ ,  $p = 0.02$ ). Lizards had relative lower body mass in areas with high level of tourism ( $F_{1,67} = 9.29$ ,  $p = 0.003$ ), but this relation-

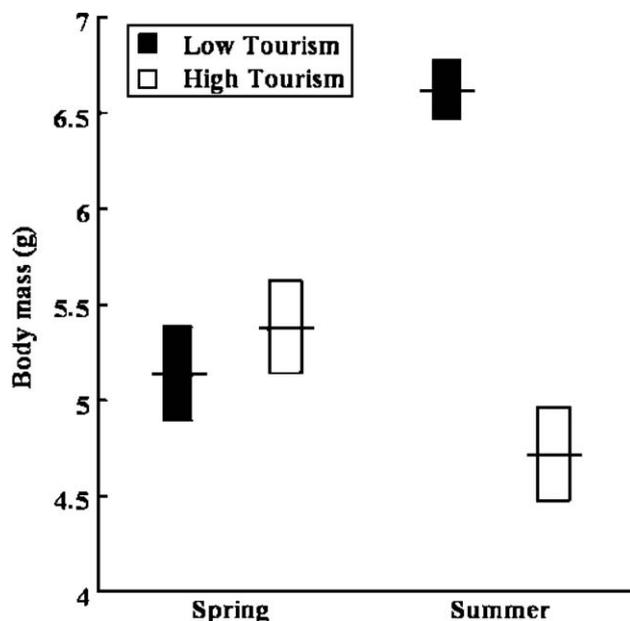
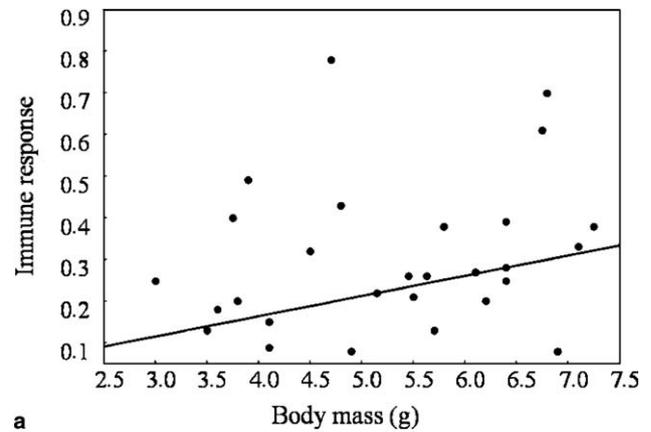
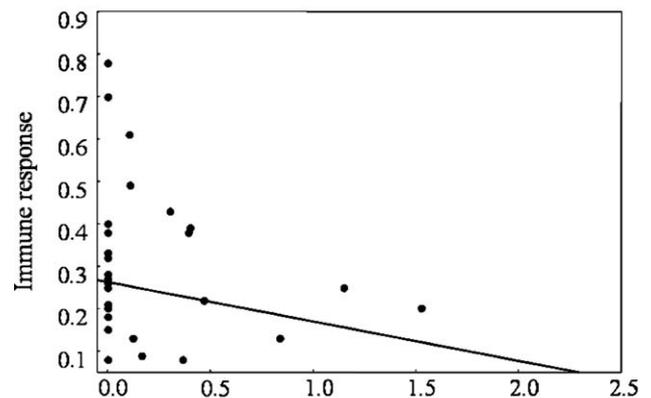


Fig. 2 – Mean ( $\pm$ SE) body mass (g) of *Podarcis muralis* lizards in areas with low (black bars) and high level of tourism (open bars) in spring and summer.



a



b

Fig. 3 – Relationship between cell mediated immune response and (a) body mass (g), or (b) intensity of haemogregarines' infection (log-transformed) in *Podarcis muralis* lizards.

ship varied between seasons (tourism  $\times$  season:  $F_{1,67} = 6.01$ ,  $p = 0.02$ ; Fig. 2), being significant only after the mating period (Tukey's test,  $p = 0.0002$ ), but not during the mating period ( $p = 0.47$ ). Ectoparasite and blood parasite loads did not affect body mass, and were removed from the model.

Lizards with higher CMI showed greater body mass (GLM,  $R^2 = 0.27$ , model:  $F_{2,37} = 6.73$ ,  $p = 0.003$ ; body mass:  $\beta = 0.31$ ,  $F_{1,37} = 4.89$ ,  $p = 0.03$ ; Fig. 3a) and lower blood parasite load ( $\beta = -0.41$ ,  $F_{1,37} = 8.38$ ,  $p = 0.006$ ; Fig. 3b). The ectoparasite load, sex and level of tourism were not related to the CMI response and were removed from the model.

#### 4. Discussion

Our results suggest that common wall lizards responded to the current level of predation risk rather than to the average risk of predation in an area. Hence, although the risk of capture is higher for prey that are farther from the refuge (Bulova, 1994; Cooper, 1997), there were no differences in their initial distance to the nearest refuge in relation to the level of tourism pressure of the area. Moreover, distance of detection of lizards was also similar in both areas. Thus, our results suggest that lizards did not modify their microhabitat use in order to locate themselves closer to refuges or be more cryptic in relation to the average risk of predation in an area, which

agrees with previous results with this species (Diego-Rasilla, 2003).

Furthermore, when attacked, lizards showed similar anti-predatory behavior regardless of the tourist pressure of the area. Lizards began to escape at similar approach distances from the experimenter and had similar flight distances. Neither the type of escape strategy used differed in relation to the level of tourism, although it was related to the distance to the nearest refuge. Lizards that fled from the predator were at higher distances from the nearest refuge than lizards that remained stationary or those that hid in the refuge, as observed previously (Amo et al., 2003). Previous results also showed that wall lizards adjusted continuously their escape decisions to the level of risk posed by the predator in each attack (Amo et al., 2003; Martín and López, 2005). On contrast, results of a previous study suggested that *P. muralis* lizards of a population submitted to a high predation pressure had greater approach distances and greater use of refuges compared with individuals of a low predation pressure population (Diego-Rasilla, 2003). However, the study populations that differed in the pressure of tourism also differed in altitude, with possible differences in ambient temperatures. Thus, in that study an increase in the use of refuges in the high predation pressure population (but also placed at low altitude) could be due not only to the high risk but also to the higher refuge temperature and, hence, lower costs of refuge use (Amo et al., 2003).

However, antipredatory strategies are costly in term of body condition for this lizard (Martín and López, 1999a), and our results suggest that lizards inhabiting areas with high tourism pressure showed lower body condition than lizards inhabiting less visited areas, especially in summer. This is probably due to the increased cumulative frequency of anti-predatory behaviours that lizards should have performed in response to human disturbance during all their activity period. Alternatively, lizards in worse body condition might not be able to perform the expected greater response to humans in tourist areas if they were not able to afford the costs of anti-predatory behaviour (Beale and Monaghan, 2004). However, our explanation agrees with a previous study that showed that wall lizards submitted to a high frequency of approaches by a simulated predator increased refuge use and, as a consequence, suffered a loss of body mass (Martín and López, 1999a). This loss of body mass may have important consequences because reproductive activities can also decrease body mass during the mating period (Amo et al., 2004; but see also Amo et al., 2005), and if antipredatory behaviour prevents lizards to increase their body mass at the end of the mating period, lizards may not be able to adequately afford the hibernation period, with the subsequent increase in mortality.

Furthermore, our results also suggest that CMI is positively correlated to body condition of lizards. CMI constitutes one of the main components of immunity in vertebrates (Roitt et al., 1989; Wakelin, 1996) and it constitutes a generalized short-term response to grafts, allergens and wounds (Belliure et al., 2004). Our results show that the CMI was negatively correlated with blood parasite load. Therefore, if a loss of body mass implied a loss of immunocompetence (but see Viney et al., 2005), lizards may be exposed to the

deleterious effects of parasites. An interesting result is that larger lizards support higher levels of haemogregarines' infection in tourist areas than in natural areas during summer, whereas there were not such differences in spring. This result can be explained because in natural areas larger, and thus, probably older lizards, may have good body condition to perform an adequate response to infection and decrease its intensity, whereas in areas with high level of tourism, the loss of body condition may imply a lower immune response and thus, higher blood parasite loads. This effect may also be enhanced because, in areas with high levels of tourism, lizards may be exposed to infection more frequently than in natural areas due to the higher intensity of haemogregarines' vectors (i.e., ticks).

Our results do not show any effect of ticks on body mass of wall lizards, as previously observed in this (Amo et al., 2005) and other lizard species (Bull and Burzacott, 1993; Olson et al., 2000; but see also Dunlap and Mathies, 1993; Main and Bull, 2000). Also our results show that males supported higher intensity of ticks' infection than females, as previously observed (Salvador et al., 1999; Amo et al., 2005). This sexual difference in tick infestation may be due to immunosuppressive effects of testosterone (Salvador et al., 1996; Olson et al., 2000), which also makes males increase their movement rate with the subsequent increase in exposure to ticks of infected conspecifics (Salvador et al., 1996; Veiga et al., 1998).

On conclusion, regardless of average levels of tourism pressure (i.e. predation risk), lizards responded similarly to the current approach of a human by usually fleeing to hide in refuges. However, lizards inhabiting areas with high tourism pressure, which must escape and hide in refuges more often, probably suffered the costs associated to this cumulative high frequency of antipredatory behaviours, showing lower body condition. Furthermore, lizards with poor body condition had low CMI, which may aggravate the deleterious effects of antipredatory behaviour on body condition. Therefore, tourism could be affecting the maintenance of lizards' populations because, for example, female lizards in poor body condition produced offspring of small size (Shine and Downes, 1999), and body size of neonate lizards can affect their probability of survival (e.g. Ferguson and Fox, 1984; Sinnero et al., 1992). Furthermore, females parasitized by blood parasites also showed reduced fat stores and produced smaller clutches (Schall, 1983). These effects should be considered when designing walking paths in protected areas to conserve lizards' biodiversity. Similar recommendations have been proposed to protect other taxa from the effects of tourism, such as hoatzin chicks *Opisthocomus hoazin* (Müller et al., 2004) and Iberian frogs *Rana iberica* (Rodríguez-Prieto and Fernández-Juricic, 2005). Furthermore, our study reports evidence that regardless lizards showed similar escape behaviour in tourist and tourist-free areas, their body condition also need to be examined to accurately assess the actual effects of tourism on lizards' populations. Nevertheless, although this study suggests a deleterious effect of tourism on lizards' populations, long-term studies are needed to better understand the effects of tourism on reptile populations, as previously observed in birds (Higham, 1998).

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