Haematozoans, mites and body condition in the oceanic island lizard *Gallotia atlantica* (Peters and Doria, 1882) (Reptilia: Lacertidae)

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Abstract

We studied relationships among blood haemogregarines (Apicomplexa), ectoparasitic mites (*Ophyonissus*; Acari: Trombiculidae) and an endemic lizard host (*Gallotia atlantica*, Lacertidae) on an oceanic islet (Alegranza, Canary Islands). We asked whether blood infection, mite load and body condition were related in lizard subpopulations at two contrasting habitats. Both haemogregarine prevalence (100%) and intensity of parasitism (>1) were strikingly higher than values found for congeneric lizards from the other Canary Islands. There were few differences between habitats in infection levels, suggesting low influence of habitat on parasite performance. Both mite prevalence and intensity were very high, though only prevalence differed between habitats (higher in the richest and climatically more sheltered site). Body condition in lizards did not differ significantly between habitats. We found no association among blood parasite load, mite infection and lizard body condition. Results are discussed in the context of parasite-host relationships on small islands as compared to larger areas such as continents.

Keywords: **Body condition, Gallotia atlantica, haemogregarines, lizards, mite vector, oceanic islet, Ophyonissus, parasites**

Introduction

Parasites are able to affect both behaviour and physiology of the host, leading to a general decrease in fitness and numerous life history trade-offs, particularly with reproduction costs, habitat use and predation risk (Poinar 1991; Wiehn et al. 1999). Parasite prevalence and infection intensity may vary with body size (Blower and Roughgarden 1988), age (Earle et al. 1992), sex (Schall 1986; Fedynich and Rhodes 1995) and reproductive effort (Korpimaki et al. 1993, 1995; Norris et al. 1994). Extrinsic factors such as the geographic
region (Merila et al. 1995; Super and Van Riper 1995), season or year (Earle et al. 1992; Weatherhead and Bennett 1992) may also affect parasitic loads.

Small oceanic islands are vantage points in the study of host-parasite interactions because they shelter small host populations on relatively simple ecosystems (with few hosts of the same species or and few species to be parasitized). In the Canarian archipelago, the small islets north of Lanzarote allow ideal conditions to study a simple system formed by an endemic lizard, *Gallotia atlantica* (Peters and Doria, 1882), and its parasites. Relationships among blood parasites, lizards and mites have been studied mainly in continental systems. Haemogregarines are the most common protozoan blood parasites in lizards, presenting a complex life cycle in which, as definitive and intermediate hosts, a haematophagous invertebrate and the lizard are respectively involved (Manwell 1977; Oppliger et al. 1999). Other haematozoans have also been described from endangered island birds (Peirce et al. 2003). The haemogregarine life history is not well known, but trombiculid Acari (Prostigmata: Parasitengona) are suspected as potential vectors (Reichenow 1913; Svahn 1974), and sexual reproduction in haemogregarines takes place in the mite. In the endemic Canarian lizards of the genus *Gallotia*, *Ophionyssus* acari may be involved in the transmission of these haematozoans (Bannert et al. 1995). Taxonomic classification of lacertid haemogregarines is based on the life cycle occurring in the vector. However, the relationships between vectors and protozoan parasites in island lizards need more research and thus haemogregarine taxonomy remains uncertain (Bannert et al. 1995, and references therein).

To gain insight into this system, we studied the associations between parasites and body condition, and the effect of contrasting habitat on parasitism by both mites and haemogregarines in the lizard *G. atlantica*. The study is steered by the hypothesis that lizards with higher levels of mite infestation will also show poor body condition associated with higher haemogregarine infection.

**Study area and species**

We analyzed prevalence and intensity of infection by haemogregarine and trombiculid larvae (the adults are soil dwellers) in the lizards living in different habitats on the Alegranza islet (Canary Islands, 27°37′–29°25′ N and 13°20′–29°25′ W). This volcanic islet is 110 km off the Atlantic coast of Africa (Cabo Jubi) and 17 km north of Lanzarote. With ca. 12 km² in area and a maximum elevation of 289 m (La Caldera volcano), its climate is subdesertic with dry summers, a mean temperature of 21°C and an average rainfall of 250 mm per year (Nogales et al. 1998). The island is uninhabited and belongs to a protected preserve with important marine bird colonies, though it receives a few occasional human visits. The vegetation is formed by a sparse xerophytic scrub dominated by *Salsola vermiculata* L., *Suaeda vera* Forssk. ex J. F. Gmel., *Chenoleoides tomentosa* (Lowe) Botsch., *Mesembryanthemum* spp., *Nicotiana glauca* R. C. Graham, *Euphorbia regis-jubae* Webb & Berthel. and *Lycium intricatum* Boiss.

Only two reptile species live on the islet, *G. atlantica* (Lacertidae), and *Tarentola angustimentalis* Steindachner, 1891 (Gekkonidae). *Gallotia atlantica* is the smallest lacertid lizard of the Canaries [mean ± SD; snout-vent length, SVL: 62.31 ± 4.54 mm, n=17 (Nogales et al. 1998); weight: 5.95 ± 1.7 g, n=34, present work]. It inhabits the islands of Lanzarote, Fuerteventura, the eastern islets, and there is a small introduced population on the east of Gran Canaria.
Field work was conducted between 29 April and 3 May 1996. Lizard sampling was performed at two sites with contrasting exposure to sun and wind, moisture regimes, plant cover and substratum type. The sheltered site was at the bottom of the crater of La Caldera volcano (~800 m in diameter). The exposed site was at a northern lava field (Los Hornitos). La Caldera bottom is an earthy plain with interspersed rocky areas, being relatively protected from dominant Trade winds. Dominant plant species were *Nicotiana glauca*, *Mesembryanthemum crystallinum* L., *M. nodiflorum* L., *Euphorbia regis-jubae* and *Salsola vermiculata*. Los Hornitos is characterized by rough, recent lava fields (*malpais*) interspersed with sandy areas exposed to sun, wind, and sea spray. Dominant plants were *Lycium intricatum*, *Patellifolia patellaris* (Moq.) A. J. Scott, Ford-Lloyd & J. F. Williams, *Chenoleoides tomentosa*, *E. balsamifera* Aiton and *M. nodiflorum*.

**Methods**

We captured lizards with 30 × 15 × 10 aluminum oil cans baited with tomatoes as fall traps. In all, we captured 34 lizards from both sites (n=17 per site). Lizards living on lavas are larger and heavier that those from other areas (Castroviejo et al. 1985; López-Jurado and Mateo 1992). The relationship between body weight and SVL for *G. atlantica* in Alegranza responded to the following regression model: body weight = −13.25 + 0.32 SVL (R² = 0.667, p < 0.001, n=34). Also, there is a positive but moderate allometric relationship between lizard size (SVL) and several osteological variables (Nogales and Valido 1999). Hence, only specimens with a SVL between 54.6–70.2 mm were used in the analysis to avoid influence of weight variation in SVL variation. This resulted in younger and older individuals being excluded from the analysis. Only lizards with an entire tail were considered, due to the bias that tail autotomy may introduce in the estimation of body condition.

For each specimen weight and SVL were recorded. Blood samples were taken from the postorbital sinus using heparinized capillars. Blood smear preparations were fixed with methanol for 5 min and stained with Giemsa solution (concentration 1:10, pH = 7.0). Haemogregarine prevalence was estimated as percent infected lizards (Margolis et al. 1982). Parasitism intensity by haemogregarines was calculated for each infected host as percent infected blood cells per 1000 cells inspected in 5 min visual searches. For each lizard we counted the number of mites and calculated prevalence and intensity. Parasite load was compared between the two sites by the Mann-Whitney U test for both haemogregarines and mites. For mites, prevalence was compared with the Chi-square test. Body condition was estimated as the residual of the regression of SVL on body mass (Dunlap and Mathies 1993; Christian and Bedford 1995). A Student’s t-test was used to compare body condition between the two sites. Spearman (non-parametric) and Pearson (parametric) correlation analysis were applied to study association between these parameters. Previous to parametric tests, we verified the requisites of lineality, normality and homocedasticity.

**Results and discussion**

Total trombiculid prevalence in *G. atlantica* was 53.3%, with an average intensity of 6.25 (1–28) (Table I). Mite prevalence was significantly higher in La Caldera (78.6%) than in Los Hornitos (25%) (χ² = 4.3; p < 0.05) but mean intensity of infestation did not differ significantly between sites (p > 0.05) (Table I). Haemogregarine prevalence was 100%, with an average intensity of 1.41, with no difference between sites. Intensity of haemogregarine
parasitism was not significantly different between La Caldera (mean ± SD = 1.21 ± 0.81; n = 14) and Los Hornitos (mean ± 1SD = 1.58 ± 1.04; n = 16) (F = −1.101; p = 0.28) (Table I).

Body condition was also similar between the two study sites (F = −0.738; p = 0.466) and there was no overall significant association between intensity of haematozoan infection and body condition (r = 0.267; p = 0.153; figure 1). Both parameters were not correlated for La Caldera (r = −0.82; p = 0.71) and Los Hornitos (r = 0.455; p = 0.146). Mite parasitism intensity was not related to body condition for both sites pooled (r = 0.305; p = 0.193) or considered apart (La Caldera: r = 0.437; p = 0.179; Los Hornitos: r = 0.447; p = 0.45).

Body weight of lizards was not related to haematozoan infection (overall: r = 0.235; p = 0.212; La Caldera: r = 0.215; p = 0.441; Los Hornitos: r = 0.191; p = 0.613). Snout-vent length and haemogregarine infection intensity were also uncorrelated (overall: r = 0.036; p = 0.849; La Caldera: r = 0.315; p = 0.252; Los Hornitos: r = −0.129; p = 0.633). The relationship between intensity of haematozoan infection and mite parasitism was not significant (overall: r = 0.038; p = 0.889; La Caldera: r = 0.064; p = 0.853; Los Hornitos: r = 0.795; p = 0.108).

Infection levels were relatively high (>1% parasitized blood cells) and all lizards examined were parasitized by haemogregarines. Although our results are not conclusive, relationship between body condition of these island lizards and both blood and mite parasites seems not positive. Body condition was apparently similar between two habitats

Table I. Mean intensity, range and prevalence of infestation by trombiculid mites (Ophyonissus) and haemogregarines in the lizard Gallotia atlantica on the Alegranza islet (Canary Islands).

| Trombiculid mites | Haemogregarines |
|-------------------|-----------------|
| Mean intensity    | Range | Prevalence | Mean intensity | Range | Prevalence |
| Los Hornitos      | 4,8   | 1–10       | 31,2           | 1,58  | 0,09–3,81  | 100         |
| La Caldera        | 6,91  | 1–28       | 78,6           | 1,21  | 0,08–3,43  | 100         |
| Overall           | 6,25  | 1–28       | 53,3           | 1,41  | 0,08–3,81  | 100         |

Figure 1. Relationship between body condition and percent haematozoan (haemogregarine) infestation in the lizard Gallotia atlantica in the Alegranza islet (n = 34 lizards). The equation is a parametric regression (line) between the two parameters, showing the multiple correlation coefficient R-squared (not significant).
contrasting in microclimate, vegetation and substratum at the islet scale. In addition, body condition was not related to levels of blood or skin parasites. Haemogregarine prevalence and intensity of parasitism found in G. atlantica on Alegranza was much higher than those of G. galloti in the larger islands Tenerife and La Gomera (prevalence range: 17.8–20%, compared to 100% in G. atlantica; intensity: <1%, compared to 1.41% in G. atlantica) (Oppliger et al. 1999). In G. atlantica, intermediate age classes (young adults and subadults) show the highest prevalences, as occurs in other lacertids (e.g. Lacerta vivipara Van Jacquin, 1787; Sorci 1996).

Only the larvae of trombiculid mites (Prostigmata: Parasitengona: Trombiculidae) were detected as potential vectors for haemogregarines. However, presence of both larvae and adults of Ophionyssus mites has been reported on the endemic Canarian lizards G. galloti (Oudart, 1839) and G. stehlini (Schenkel, 1901) (Astasio-Arbiza et al. 1982; Bannert et al. 1995, 2000). Differences in trombiculid infection between the two study sites may be associated to differences in environmental traits related to the heliothermic behaviour of G. atlantica, and to the resistance of mites to desiccation. La Caldera is more humid and the bottom of the crater is less exposed to moisture and thermal stress. The desiccation risk for mites at Los Hornitos is contrasting higher due to the dryness, the higher salt input from sea spray and more direct sun exposure. Susceptibility to ectoparazites (Salvador et al. 1996) or haemogregarines (Veiga et al. 1998) increases in the reproductive season, when testosterone levels diminish body condition in male lizards of some species (Marler and Moore 1988). The males of Tiliqua rugosa Gray infected by Hemolivia mariae Smallridge & Paperna, 1997, experience a decline in body condition during the reproductive season (Smallridge and Bull 2000). In our case, neither ecto- nor endoparasites seemed to affect body condition of G. atlantica in the study season.

Parasite prevalence is often associated with habitat characters (Eisen and Wright 2001). In small oceanic islands, the habitat mosaic is less diverse and environmental conditions more homogeneous. The identical prevalence of haemogregarines in G. atlantica on contrasting areas in Alegranza suggests low influence of the environment on parasitism risk and parasite reproductive constraints. Also, it may indicate that lizard habitat preferences are wider than expected. Similar effects of both blood parasites and their vectors on lizard body condition between such contrasting habitats are likely in the case of enough habitat connectivity within this small islet. On the other hand, the paucity of vertebrate hosts due to area restriction or isolation, or both, may be causes for increased prevalence and intensity of the parasites. For other endoparasite groups, relatively high parasite loads have been recently found in a Lanzarote subpopulation of G. atlantica (i.e. digenean trematodes; Roca 2003). Haematozoon interactions with other endoparasite taxa and total parasitic load (i.e. all ecto- plus endoparasite species) may partially influence the body condition in this lizard. In other vertebrate host species, elevated haematozoan infections are a probable cause of declines in body condition (i.e. breeding success in passerines; Valkiunas et al. 2003). A more integrative approach is clearly needed in the study of endoparasite complexes, especially haematozoans, in island lizards.

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