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Helminths of the Atlantic lizard, *Gallotia atlantica* (Reptilia, Lacertidae), in the Canary Islands (Eastern Atlantic): Composition and structure of component communities

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Abstract
A survey of helminth communities of *Gallotia atlantica* (Peters et Doria, 1882), from Lanzarote and Fuerteventura islands, in the Canary Archipelago, Spain, was conducted in order to determine the prevalence, intensity, and diversity of parasites of these lacertid lizards. Larval cestodes were found in the body cavity of hosts from Lanzarote. *Spauligodon atlanticus* was the only core species in the helminth component community of *G. atlantica*. Helminth infracommunities of both host populations were depauperate and isolationist.

Key words
Helminth communities, *Gallotia atlantica*, lacertid lizards, Canary Islands

Introduction

Studies on the community ecology of parasites in European reptiles have increased in the last decade (Biserkov and Kostadinova 1998, Sanchis *et al*. 2000, Sharpilo *et al*. 2001). This has increased our knowledge of the composition and structure of infracommunities as well as component communities of helminths parasitizing different reptile species. Islands have received less attention in this context, although some studies have been made on helminth communities of insular reptiles (Roca and Hornero 1994, Martin and Roca 2004a).

Gallotia atlantica (Peters et Doria, 1882) is a small to medium-sized lacertid lizard, endemic of two islands of the Canary Archipelago (East Atlantic). Atlantic lizards occur in arid habitats as well as in coastal sandy, rocky and inhabited areas (García-Márquez and Mateo 2002). Characteristic plants of these xeric zones are *Launaea arborescens* (Compositae), *Salsola vermiculata* (Chenopodiaceae) and *Lycium intricatum* (Solanaceae) (Valido and Nogales 2003). The insular distribution of Atlantic lizards makes this species a particularly useful and relevant host for detailed studies of the community ecology of parasites.

In this paper, we report on the helminth fauna of the Atlantic lizard, *G. atlantica*, from Lanzarote and Fuerteventura islands. Our approach was to analyse for the first time the prevalence, intensity, and diversity of helminths from this host, specifically addressing the following aims: (1) characterization of helminth community richness and diversity; (2) characterization of helminths as either specialists or generalists; (3) characterization of the helminths as core, secondary or satellite species; and (4) comparison of the helminth fauna of *G. atlantica* with other Canarian lizards.

Materials and methods

The study area was Lanzarote and Fuerteventura islands, Canarian Archipelago, located off the north west coast of Africa, at 27°37´–29°24´N and 13°37´–8°10´W. Both are volcanic islands, with an eastern peripheral position in the Canarian Archipelago (Fig. 1). Lanzarote has a surface of 807 km^2 and 670 m of maximum elevation; Fuerteventura has 1,655 km^2 and 807 m of altitude (Fernández-Palacios and Martín 2001).

In total, 70 lizards were caught in Lanzarote: 21 in Nazaret (locality 1), 31 in Yaiza (2), 18 in Orzola (3), and 42 lizards were collected in Fuerteventura: 25 in Lajares (4), 17 in La Pared (5) (Fig. 1). All lizards were captured during July 1996.

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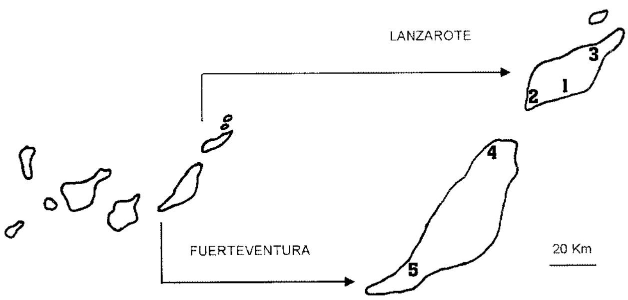

Fig. 1. Localization of Lanzarote and Fuerteventura islands in the Canary Archipelago, and prospected localities from both islands (see the text)

Samples are homogeneous since hosts from each locality were collected within 1 day and all were caught in typical habitats on both islands; habitats dominated by volcanic and scattered bushes called “malpaíses” (badlands). Hosts were examined for parasites using standard techniques and each helminth infracommunity was fully censused. All parasites were identified and counted. Voucher material is deposited in the collection of the Department of Zoology, University of Valencia, Spain.

The use of descriptive ecological terms follows Bush *et al.* (1997). Prevalence of 10% was adopted as the lowest limit in identifying satellite species (Kennedy and Bakke 1989). Species with prevalences 10%<*P*<30% were assigned as secondary species (Hanski 1982, Roca 1993). Species with prevalences of 30% or higher were considered as core species (Roca 1993). Criteria of Edwards and Bush (1989) and Roca and Hornero (1994) were used in the consideration of the helminth species as specialists or generalists. Brillouin’s index was used for calculating diversity according to Magurran (2004).

Results

Helminth fauna of G. atlantica

Eight species of helminths were recorded from the total sample size of 112 lizards (one trematode, three cestodes and four nematodes). Five of the helminth species were recorded as adults and three (all the cestode species) as larval stages. These cestode species, *Diplopylidium acanthotetra*, *Dipylidium* sp. and *Mesocestoides* sp., were located in the body cavity, whereas the remaining helminths were found in the digestive tract.

Table I. Infection parameters of the helminths parasitizing *Gallotia atlantica* from Lanzarote

Helminth species	Site of infection	Prevalence*	Intensity of infection		Mean abundance
			range	$\bar{x}$	
Cestoda					
Diplopylidium acanthotetra (larvae)	body cavity	4 (5.7)	(1–16)	14 ± 12.9	0.8 ± 4.2
Dipylidium sp. (larvae)	body cavity	4 (5.7)	(3–61)	27.8 ± 27.3	1.6 ± 8.6
Mesocestoides sp. (larvae)	body cavity	1 (1.4)	–	–	–
Trematoda					
Pseudoparadistomum yaizaensis	small intestine	4 (5.7)	(6–49)	24.8 ± 19	1.4 ± 6.9
Nematoda					
Parapharyngodon micipsae	caecum	8 (11.4)	(1–13)	5.3 ± 4.5	0.6 ± 2.2
Parapharyngodon echinatus	caecum	28 (40)	(1–61)	14.5 ± 14.1	5.8 ± 11.4
Spauligodon atlanticus	caecum	31 (44.3)	(1–110)	30.1 ± 32	13.3 ± 25.9

*Number of hosts parasitized divided by the number of hosts sampled (N = 70). Values in parentheses are percentages.

Table II. Infection parameters of the helminths parasitizing *Gallotia atlantica* from Fuerteventura

Helminth species	Site of infection	Prevalence*	Intensity of infection		Mean abundance
			range	$\bar{x}$	
Nematoda					
Parapharyngodon micipsae	caecum	10 (23.8)	(1–4)	2.2 ± 1	0.5 ± 1.1
Parapharyngodon echinatus	caecum	11 (26.2)	(1–19)	6.2 ± 5.9	1.6 ± 4
Spauligodon atlanticus	caecum	7 (16.7)	(4–43)	15.4 ± 12.9	2.6 ± 7.6
Skrjabinelazia hoffmanni	intestine	6 (14.3)	(1–28)	6.7 ± 10.5	1 ± 4.4

*Number of hosts parasitized divided by the number of hosts sampled (N = 42). Values in parentheses are percentages.

Table III. Overall diversity parameters of helminth infracommunities from both host populations

Host	N	Species richness*	Helminth abundance*	Diversity*	Proportion of sample with 0 or 1 helminth species
G. atlantica (Lanzarote)	70	1.1 ± 0.8 (0–4)	23.6 ± 31.2 (0–156)	0.14 ± 0.24 (0–0.89)	0.7
G. atlantica (Fuerteventura)	42	0.8 ± 0.7 (0–2)	5.7 ± 10.2 (0–47)	0.09 ± 0.19 (0–0.63)	0.8

*Values are given as the mean ± SD, with the range in parentheses.

Helminth communities in G. atlantica *from Lanzarote and Fuerteventura islands*

The total number of parasite species and the infection parameters for the hosts in each island are shown in Tables I and II. The overall prevalence of infection in *G. atlantica* from Lanzarote was 78.6% and 62% in *G. atlantica* from Fuerteventura.

Although seven helminth species were recorded in *G. atlantica* from Lanzarote and four from Fuerteventura, the average number per lizard never exceeded 1.1 and 0.8, respectively, and the maximum number of helminth species found in any individual lizard was four and two, respectively (Table III). The total number of helminth species in both samples exceeded both the average and the maximum number of species per individual lizard.

Insular variations in community structure and composition

Table III shows the diversity parameters for helminth infracommunities in both host populations. Helminth richness and abundance, and Brillouin's index (diversity) were slightly higher in host sample from Lanzarote than those from Fuerteventura. The low values of Brillouin's index for both hosts emphasize the low diversity of their helminth infracommunities.

Proportion of lizards with 0 or 1 helminth species, were similar in both hosts (Table III). A substantial insular variation was detected in the absence of cestode larval forms in *G. atlantica* from Fuerteventura. Moreover, *Pseudoparadistomum yaizaensis* seems to be an endemic species for Lanzarote as it has been only found in one of the prospected localities (Yaiza). *Skrjabinelazia hoffmanni* was found in Fuerteventura but not in Lanzarote island.

Discussion

Overall prevalence of infection in *G. atlantica* from Lanzarote agrees with the range (78% to 100%) of global prevalences showed by Canarian lacertid lizards. High values of prevalence are probably due to high host population densities and physiography of islands (Martin and Roca 2004a). It seems that the increase of prevalence is higher on oceanic islands, e.g., Canary Islands, than on continental or "land bridge" islands (Martin and Roca 2004a). Nevertheless, hosts from Fuerteventura are out of the mentioned prevalence range, being in accordance with lower densities of *G. atlantica* at this island (García-Márquez and Acosta 2003).

Although Fuerteventura was not extensively sampled for lizards and considering the homogeneity of habitats on the island, the eight helminth species found, almost certainly represent the majority of the helminth fauna of *G. atlantica* in its distribution area (Lanzarote and Fuerteventura islands). In a former study on *G. atlantica* from Fuerteventura, Chicharro (1996) found three of the four nematode species recorded in this study: *Parapharyngodon echinatus*, *P. micipsae* and *S. atlanticus*. Our results therefore confirm that the Atlantic lizard harbours, altogether with *Gallotia galloti*, the poorest helminth fauna among the Canarian lacertid lizards (Martin and Roca 2004a, b; Roca *et al*. 2004).

The most specialist parasite was *P. yaizaensis*, found only in *G. atlantica. S. atlanticus* can be considered as *Gallotia* specialist, but not for other European lizards. *S. hoffmanni* can be considered as lizard specialist. *P. micipsae* and *P. echinatus* appear to be generalist species since they have been found in several families of reptiles.

Most helminth species occurred at low prevalence. In fact, only *S. atlanticus* from hosts of Lanzarote can be considered as a core species (see Materials and methods). *P. echinatus* from both samples is secondary species. The remaining helminths are satellite species. *S. atlanticus*, is a core species in the component community of *G. atlantica* from Lanzarote (P = 44.3%), but only a satellite species in Fuerteventura island (P = 16.7%). The only secondary species, *P. echinatus*, shows different prevalence in both host populations (see Tables I and II).

Gallotia atlantica serves as paratenic or intermediate host for three cestode species. It is consistent with earlier reports of Martin and Roca (2004a) who described a similar situation for *Gallotia caesaris* in El Hierro island. But there are substantial differences between lizards from Lanzarote and Fuerteventura, since larval forms have not been found in lizards from Fuerteventura. Feral cats are the most probable definitive hosts for these cestode larval forms (Martin and Roca 2004a) and, since the presence, diversity and abundance of larval helminths depend on overlap in the host range with definitive hosts that support the species in the region (Sharpilo *et al*. 2001), we can conclude that the presence of mammalian parasites is linked to the greater availability of host mammals (feral cats) in Lanzarote compared with Fuerteventura island. It is in accordance with results from García-Márquez and Acosta (2003) showing low densities of feral cats in arid habitats of Fuerteventura.

A strictly endemic and specialist helminth species was the trematode *P. yaizaensis*, described by Roca (2003) from lizards of the locality of Yaiza, in Lanzarote. Its restricted distribution area may be linked to the presence of the appropriate intermediate hosts, probably a terrestrial mollusc and an isopod or an insect (Timon-David and Timon-David 1967), as well as with the particularly poor environmental conditions of insular ecosystems (Roca and Hornero 1991). Insularity may also be the cause of endemisms such as a case of *S. atlanticus* that we have found in Canarian lacertid lizards and that could be originated as a consequence of allopatric processes of speciation.

The low values of prevalences and mean intensities of infection (Tables I and II) indicate that many members of the helminth infracommunities occurred only irregularly and occasionally. This agrees with the typical pattern of helminth infection in many reptiles, i.e., few species occur frequently, few species occur with moderate prevalence, and many species are rare (Aho 1990, Roca and Hornero 1994).

Since the total number of helminth species in the populations of *G. atlantica* from both islands, greatly exceeded both the average and the maximum number of species per individual lizard, no single infracommunity included all species locally available. This upper limit on species richness is not usually realized (Poulin 1998). This agrees with the results obtained for *G. galloti* (Roca *et al*. 2004) and *G. caesaris* (Martin and Roca 2004a), and seems to be a typical pattern of many lacertid lizards (Roca and Hornero 1994, Roca 1999).

Although samples of hosts from the two islands were heterogeneous with respect to sample sizes, we suggest that helminth component communities of *G. atlantica* from both islands are very similar. The most common helminths (*P. micipsae*, *P. echinatus* and *S. atlanticus*) were present on both islands, as have been found in other similar archipelagos (Dobson *et al*. 1992, Roca and Hornero 1994). *G. atlantica* from Lanzarote and Fuerteventura islands have similar diversity patterns of helminth infracommunities (Table III). Higher abundance and species richness in hosts from Lanzarote are mainly due to high values of diversity parameters of the nematodes *S. atlanticus* and *P. echinatus* (Tables I and II), and to the presence of larval forms of cestodes. Diversity is also similar to those of other Canarian lacertid lizards. Thus, *G. caesaris* from El Hierro island and *G. caesaris* from La Gomera island, showed Brillouin's diversity index values of $\bar{x}$ H = 0.2; range 0–1.1 and $\bar{x}$ H = 0.3; range 0–1, respectively (Martin and Roca 2004a). *G. galloti* from Tenerife island, showed values of $\bar{x}$ H = 0.2, range 0–0.9 (Roca *et al*. 2004). Such low diversity values agree with the ones observed in many saurian reptiles (see Roca 1999) and suggest that the helminth infracommunities of these Canarian lacertid lizards are depauperate and isolationist, a pattern probably widespread among these reptiles. Some characteristics of the reptile hosts, i.e., ectothermy, simplicity of the alimentary canal, and low vagility (Kennedy *et al.* 1986, Roca and Hornero 1994), may be responsible for this pattern.

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References

Aho J.M. 1990. Helminth communities of amphibians and reptiles: Comparative approaches to understanding patterns and processes. In: *Parasite communities*: *patterns and processes* (Eds. G. Esch, A. Bush and J. Aho). Chapman and Hall, London, 157–195.

Biserkov V., Kostadinova A. 1998. Intestinal helminth communities in the green lizard, *Lacerta viridis*, from Bulgaria. *Journal of Helminthology*, 72, 267–271.

Bush A.O., Laferty K.D., Loft J.M., Shostak A.W. 1997. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. *Journal of Parasitology*, 83, 575–583.

Chicharro G. 1996. Parasitofauna de *Tarentola delalandii*, *T. gomerensis*, *T. angustimentalis* y *Gallotia atlantica* de las Islas Canarias. PhD Thesis, Universidad Complutense de Madrid, Madrid.

Dobson A.P., Pacala S.W., Rougharden J.D., Carper E.R., Harris E.A. 1992. The parasites of *Anolis* lizards in the northern Lesser Antilles. I. Patterns of distribution and abundance. *Oecologia*, 91, 110–117.

Edwards D.D., Bush A.O. 1989. Helminth communities in avocets: Importance of compound community. *Journal of Parasitology*, 98, 439–445.

Fernández-Palacios J.M., Martín J.L. 2001. Las islas como experimento de laboratorio. In: *Naturaleza de las Islas Canarias*: *Naturaleza y conservación* (Eds. J.M. Fernández-Palacios and J.L. Martín). Santa Cruz de Tenerife, Turquesa, 39–44.

García-Márquez M., Acosta J.M. 2003. Distribución y estado de conservación de la lisneja (*Chalcides simonyi*). In: *Memoria final AHE-Vicenconsejería de Medio ambiente del Gobierno de Canarias*. Santa Cruz de Tenerife, AHE-GOBCAN, 1–109.

García-Márquez M., Mateo J.A. 2002. *Gallotia atlantica*. In: *Atlas y Libro Rojo de los anfibios y reptiles de España* (Eds. J.M. Pleguezuelos, R. Márquez and M. Lizana). Dirección General de Conservación de la Naturaleza, Madrid, 196–197.

Hanski I. 1982. Dynamics of regional distribution: the core and satellite species hypothesis. *Oikos*, 38, 210–221.

Kennedy C.R., Bakke T.A. 1989. Diversity patterns in helminth communities in common gulls, *Larus canus*. *Parasitology*, 98, 431–445.

Kennedy C.R., Bush A.O., Aho J.M. 1986. Patterns in helminth communities: Why are birds and fish different? *Parasitology*, 93, 205–215.

Magurran A.E. 2004. Measuring biological diversity. Blackwell Publishing, Malden.

Martin J.E., Roca V. 2004a. Helminth infracommunities of *Gallotia caesaris caesaris* and *Gallotia caesaris gomerae* (Sauria: Lacertidae) from the Canary Islands (Eastern Atlantic). *Journal of Parasitology*, 90, 266–270.

Martin J.E., Roca V. 2004b. Helminth infracommunities of a population of the Gran Canaria giant lizard *Gallotia stehlini* (Sauria: Lacertidae). *Journal of Helminthology*, 78, 319–322.

Poulin R. 1998. Evolutionary ecology of parasites. Chapman & Hall, London.

Roca V. 1993. Helmintofauna dels reptils. *Monografies de la Societat, d'Història Natural de les Balears*, 2, 273–292.

Roca V. 1999. Relación entre las faunas endoparásitas de reptiles y su tipo de alimentación. *Revista Española de Herpetología*, 13, 101–121.

Roca V. 2003. A new genus of Dicrocoeliidae (Digenea) from the lizard *Gallotia atlantica* (Sauria: Lacertidae) from the Canary Islands (Spain). *Journal of Natural History*, 37, 1401–1406.

Roca V., Hornero M.J. 1991. Helmintofauna de *Podarcis pityusensis* (Boscá, 1883) (Sauria: Lacertidae). *Revista Española de Herpetología*, 5, 77–87.

Roca V., Hornero M.J. 1994. Helminth infracommunities of *Podarcis pityusensis* and *Podarcis lilfordi* (Sauria: Lacertidae) from the Balearic Islands (western Mediterranean Basin). *Canadian Journal of Zoology*, 72, 658–664.

Roca V., Carretero M.A., Llorente G.A., Montori A., Martín J.E. 2004. Helminth communities of two lizard populations (Lacertidae) from Canary Islands (Spain). Host diet-parasite relationships. *Amphibia-Reptilia*, in press.

Sanchis V., Roig J.M., Carretero M.A., Roca V., Llorente G.A. 2000. Host-parasite relationships of *Zootoca vivipara* (Sauria: Lacertidae) in the Pyrenees (North Spain). *Folia Parasitologica*, 47, 118–122.

Sharpilo V.P., Biserkov V., Kostadinova A., Behnke J.M., Kuzmin Y.I. 2001. Helminths of the sand lizard, *Lacerta agilis* (Reptilia, Lacertidae), in the Palaearctic: faunal diversity and spatial patterns of variation in the composition and structure of component communities. *Parasitology*, 123, 389–400.

Timon-David J., Timon-David P. 1967. Recherches éxperimentales sur le cycle vital de *Paradistomum mutabile* (Molin) parasite de la vésicule biliaire de *Lacerta muralis* (Laurenti). *Annales de Parasitologie Humaine et Comparée*, 42, 187–206.

Valido A., Nogales M. 2003. Digestive ecology of two omnivorous Canarian lizard species (*Gallotia*, Lacertidae). *Amphibia-Reptilia*, 24, 331–344.

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