Mites in the Neotropical Lizard *Liolaemus pacha* (Iguania: Liolaemidae): Relation to Body Size, Sex and Season

Author(s): Viviana Juárez Heredia , Natalin Vicente , Cecilia Robles , Monique Halloy
Source: South American Journal of Herpetology, 9(1):14-19. 2014.
Published By: Brazilian Society of Herpetology
DOI: http://dx.doi.org/10.2994/SAJH-D-13-00034.1
URL: http://www.bioone.org/doi/full/10.2994/SAJH-D-13-00034.1

South American Journal of Herpetology, 9(1), 2014, 14–19

Mites in the Neotropical Lizard *Liolaemus pacha* (Iguania: Liolaemidae): Relation to Body Size, Sex and Season

Viviana Juárez Heredia[1,*], Natalin Vicente[1,2], Cecilia Robles[1], Monique Halloy[1]

[1] *Instituto de Herpetología, Fundación Miguel Lillo, Miguel Lillo 251, Tucumán, Argentina.*
[2] *CONICET, Consejo Nacional de Investigaciones Científicas y Técnicas, Buenos Aires, Argentina.*
[*] *Corresponding author. Email: vivianajuarez18@gmail.com*

Abstract. Parasites can significantly influence the health of the host by inhibiting important physiological and behavioral processes. Some factors like body size, age of host, sex, and season can influence parasite load in nature. Mites are ectoparasites that can occur in lizards, possibly having a negative impact on their host. Our goals were to identify the mite that infested the Neotropical lizard *Liolaemus pacha* and describe its anatomical distribution, evaluate if mite intensity affected lizard mass, assess the relationship between lizard body size and mite intensity, and calculate the prevalence and intensity of mites in these lizards, comparing males and females and the reproductive and non-reproductive seasons. We analyzed preserved specimens and also studied lizards in their natural environment. We performed linear regression analyses between the intensity of mite infestation and snout-vent length and between lizard mass and intensity of mite infestation. To compare the intensity of mite infestation between sex and season, we used the Mann-Whitney Test. The mite was identified as a species of *Pterygosoma* Peters, 1849 (Prostigmata: Pterygosomidae). Mite infestation was mainly in the ventral area, particularly in the gular and lateral regions. Lizard body size did not explain the intensity of mite infestation, nor was lizard mass influenced by the intensity of mite infestation. Males in their natural habitat presented, on average, more mites than females, which might be related to differences in behavior. There were no differences between seasons. This study constitutes the second Argentine record of the presence of the ectoparasite *Pterygosoma* sp. in a *Liolaemus* species and the first that explores its relation to ecological parameters.

Keywords. Ectoparasitism; Parasite; *Pterygosoma;* South America; Squamata.

Resumen. Los parásitos pueden afectar significativamente la salud de su hospedador al impedir procesos fisiológicos y comportamentales importantes. Algunos factores como el tamaño corporal, la edad del hospedador, el sexo y la estación, pueden influir en la carga ectoparasitaria en la naturaleza. Los ácaros son ectoparásitos que pueden estar presentes en lagartijas, teniendo un posible impacto negativo sobre su hospedador. Nuestros objetivos fueron: identificar el ácaro presente en la lagartija neotropical *Liolaemus pacha* y definir su distribución corporal; evaluar si las intensidades de infestación de ácaros influyen en el peso de las lagartijas y si el tamaño corporal de las mismas afecta la intensidad ectoparasitaria; y calcular la prevalencia e intensidad de ácaros en estas lagartijas, comparando entre machos y hembras, y entre las estaciones reproductiva y no-reproductiva. Se analizaron ejemplares de colección y se realizó un seguimiento de lagartijas en su ambiente natural. Realizamos un análisis de regresión lineal entre la intensidad de infestación del ácaro y la longitud hocico-cloaca y entre el peso y la intensidad de ácaros. Para comparar las intensidades de ácaros entre sexos y estación, aplicamos el Test de Mann-Whitney. Se identificó al ácaro como una especie de *Pterygosoma* Peters, 1849 (Prostigmata: Pterygosomidae). La mayor infestación fue en la zona ventral, principalmente en las regiones gular y laterales. El tamaño corporal no explicó las intensidades de infestación del ácaro, así como tampoco el peso de las lagartijas fue influido por las intensidades de ácaros. Los machos en su ambiente natural presentaron en promedio más ácaros que las hembras, lo que podría estar asociado a diferencias comportamentales. No hubo diferencias entre las dos estaciones estudiadas. Este trabajo constituye el segundo registro en Argentina de la presencia del ectoparásito *Pterygosoma* sp. en una especie de *Liolaemus* y el primero que explora su relación con variables ecológicas.

INTRODUCTION

The prevalence and intensity of parasite infections in reptiles are not well known in spite of their importance (Amo *et al.*, 2005). Parasites often pose a significant influence in the health of the host by impeding important physiological and behavioral processes (Schall, 1983, 1990; Oppliger *et al.*, 1996; Oppliger and Clobert, 1997), such as spatial distribution (Price, 1980; van Riper *et al.*, 1986), reproductive success, and sexual selection (Hamilton and Zuk, 1982; Møller *et al.*, 1999). Lizards are hosts to a number of parasites including gastrointestinal (Goldberg *et al.*, 2003), skin (Goldberg and Bursey, 1991), and blood parasites (Schall, 1990). Mites are often common in vertebrates and have possible negative effects on the host (Bulté *et al.*, 2009), producing lesions of the skin, inflammation, or even a high parasite load can potentially lead to a decrease in survival (Klukowski, 2004). For example, in *Lacerta vivipara,* it has been reported that survival of offspring was lower when mothers were infested with mites (Sorci *et al.*, 1994). Some factors that influence parasite loads in nature include season, age of host, size, and sex (Klukowski and Nelson, 2001). Larger lizards have more ectoparasites (Cunha-Barros *et al.*, 2003; Carvalho et al, 2006; Rocha *et al.*, 2008; Lumbad *et al.*, 2011), although no differences were found in relation to host weight (García-De La Peña *et al.*, 2004). Many lizards present seasonal shifts in their ectoparasitic load (Lane and Loye, 1989;

Submitted: 05 October 2013
Accepted: 05 March 2014
Handling Editor: Gabriel Costa
doi: 10.2994/SAJH-D-13-00034.1

Schall *et al.*, 2000; Lumbad *et al.*, 2011) and differences between sexes (Tällenklint-Eisen and Eisen, 1999; Lumbad *et al.*, 2011). Nevertheless, these differences are not always clear, depending on lizard species and type of ectoparasite (Schall *et al.*, 2000; Cunha-Barros *et al.*, 2003).

Many studies exist on mite presence in lizards from North America (*e.g.*, Goldberg and Bursey, 1991; Schall *et al.*, 2000; Klukowski, 2004), Europe (*e.g.*, Martin *et al.*, 2008), and South America (*e.g.*, Carothers and Jaksic, 2001; Cunha-Barros *et al.*, 2003; Carvalho et al, 2006; Rocha *et al.*, 2008; Rubio and Simonetti, 2009). However, in Argentina, there exists only one description of a mite species found in a few lizard species of the *Liolaemus* genus, such as *L. buergeri, L. bibronii, L. petrophilus, L. austromendocinus, L. elongatus,* and *L. gracilis* from the southern provinces of Neuquén, Mendoza, Chubut, and Rio Negro (de La Cruz *et al.*, 2004). No evidence, however, is available on how much or how little this parasite may affect the survival of these species or on whether or not there may be sexual or seasonal differences.

The genus *Liolaemus* (Iguania: Liolaemidae; Frost *et al.*, 2001) includes 255 described species (Abdala and Quinteros, 2013) of Neotropical lizards that are found from the Andes of Peru to Tierra del Fuego and present different life styles, reproductive strategies, and feeding modes depending on the season and availability of food items (Cei, 1993; Abdala, 2007). *Liolaemus pacha* is a recently described species (Juárez Heredia *et al.*, 2013) previously known as for *L. quilmes* (Etheridge, 1993). It is found at an altitude of 2,725 m at Los Cardones, province of Tucumán, in northwestern Argentina. The area corresponds to the phytogeographic province of Monte and Prepuna (Cabrera and Willink, 1980; Etheridge, 1993). Its habitat is characterized by a partly sandy substrate, large rocks, sparsely distributed shrubs, and cardones (*Trichocereus pasacana*). The climate is semi-arid with a mean annual rainfall of 180 mm (Cabrera and Willink, 1980).

Liolaemus pacha is diurnal, oviparous, and insectivorous (Ramírez Pinilla 1992; Halloy *et al.*, 2006). Males are slightly larger and more colorful than females (Robles and Halloy, 2009), and during the reproductive season they become more territorial (Halloy, 1996, 2012; Halloy and Robles, 2002; Robles and Halloy, 2009).

Our goals were to (1) identify the mite that infested the neotropical lizard *Liolaemus pacha* and describe its anatomical distribution, (2) evaluate the effect of mite intensity on lizard mass, (3) evaluate the relationship between lizard body size and mite intensity, (4) calculate the prevalence and intensity of mites in these lizards, comparing males and females and the reproductive and non-reproductive seasons.

MATERIALS AND METHODS

We studied a population of *Liolaemus pacha* at a site called "Los Cardones" (26°40'1.5"S, 65°49'5.1"W, datum: WGS84; 2725 m). We made monthly visits of 3 days each to the locality from September 2012 to February 2013. The reproductive period of these lizards coincides with the austral spring (October to December), whereas the post-reproductive season coincides with the austral summer (January to March) (Ramírez Pinilla, 1992; Halloy and Robles, 2003). Lizards were captured by noosing. They were kept in cloth bags, measured, weighed, and marked for identification using a technique described by Fischer and Muth (1989) and applied by Halloy and Robles (2002; see also Robles and Halloy, 2009; Halloy, 2012). When mites were found on a lizard, the number of mites was counted and photographs were taken with a digital camera (Samsung PL 120) to record their distribution on the body of the individuals.

We also analyzed 132 preserved specimens (51 males and 81 females) housed in the collection of the Instituto de Herpetología, Fundación Miguel Lillo (FML; see Appendix) collected 1983–2009. All specimens were measured and data on mass at time of capture was available for female specimens. This information was added to that of lizards captured and weighed in their natural environment. Three specimens were not used for comparison between seasons because they were collected during the winter. To verify the presence of mites, the specimens were observed with a microscope (Wild Heerbrugg, precision 10x/21). The black or dark grey color of mites facilitated detection and counting. The mites were removed from the lizards with a needle and placed in Eppendorf tubes with 70% alcohol. The mites were mounted with polyvinyl alcohol (PVA) and Hoyer solution (Krantz, 1970) for subsequent identification.

To characterize the presence of mites, we used the following three parameters from Bush *et al.* (1997): prevalence (total number of infested lizards with mites divided by the total number of lizards examined), intensity of infestation (number of mites on a lizard), and mean intensity (total number of mites divided by the total number of infested lizards). Values are reported as the mean ± SD.

Both for preserved and living lizards, we used the Mann-Whitney test (Siegel and Castellan, 1988; using Infostat software, Di Rienzo *et al.*, 2012) to compare mite intensities between males and females and between the reproductive and non-reproductive seasons, since the data did not comply with the assumptions of normality and homoscedasticity. To evaluate the relationship between lizard body size and mite intensity, we performed a linear regression analysis between intensity of mite infestation and snout–vent length (SVL). To evaluate if mite intensity affected lizard mass, we performed a linear regression analysis between weight and mite intensity. Because the intensity of mite infestation, SVL, and mass were not normally distributed, we log-transformed all variables (Sokal and Rohlf, 1981).

RESULTS

The mite infesting *Liolaemus pacha* was identified as a species of *Pterygosoma* Peters, 1849 (Acari: Prostigmata: Pterygosomidae). A total of 117 individuals of *L. pacha* (76 males and 41 females) were marked in their natural habitat, of which 18 (males = 12; females = 6) were infested with this mite. This represents a prevalence of 15% with a mean intensity of 32.5 mites (males: $\overline{X}$ = 45.37 ± 49.9, median = 24.5 mites, range = 3–145; females: $\overline{X}$ = 6.66 ± 8.5, $\overline{X}$ = 2.5 mites, range = 1–23).

Among the 132 preserved specimens, prevalence was 21.2% (n = 28) and the mean intensity was 27.9 mites (males: $\overline{X}$ = 17.57 ± 29.46, median = 7; range = 1–84; females: $\overline{X}$ = 31.38 ± 58.37, median = 8; range = 1–201). An analysis of photographs of specimens with mites showed that these were concentrated on the ventral area, particularly in the gular and lateral regions (Fig. 1).

Lizard body size did not explain the intensity of mite infestation neither in females from the FML collection (R^2 = 0.07; $p > 0.05$; n = 18), females observed in their natural habitat (R^2 = 0.24; $p > 0.05$; n = 6), or males in their natural habitat (R^2 = 0.02; $p > 0.05$; n = 12). Lizard mass was also not influenced by the intensity of mite infestation (females from the collection: R^2 = 0.002; $p > 0.05$; n = 18; live females: R^2 = 0.19; $p > 0.05$; n = 6; live males: R^2 = 0.06; $p > 0.05$; n = 12).

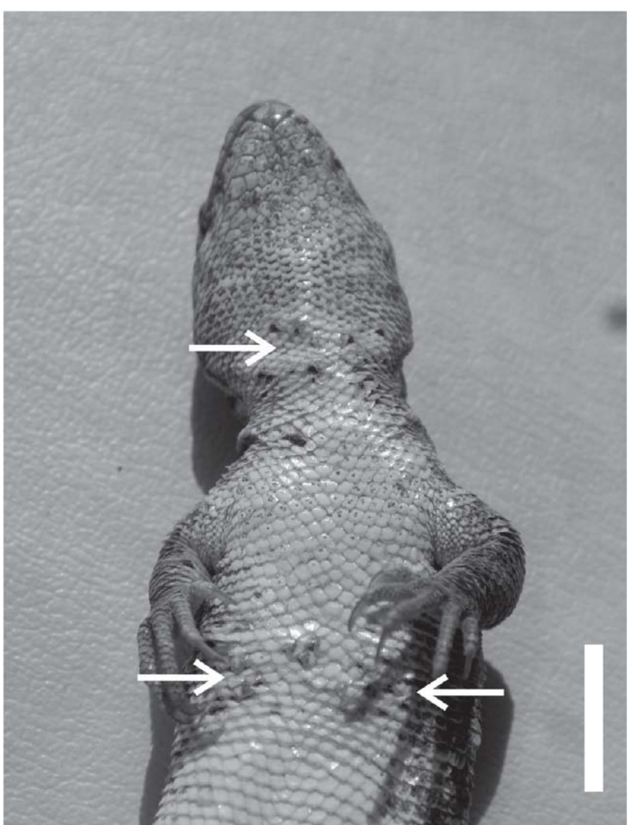

Figure 1. Photograph of an infested *Liolaemus pacha* female, showing the presence of the ectoparasite *Pterygosoma* sp. on its ventral areas (see arrows for examples, photo by NSV). Scale: 1 cm.

Among preserved specimens, no significant differences were found between males and females (Mann-Whitney, W = 99; $p > 0.05$; $n1$ = 21; $n2$ = 7), or between seasons (Mann-Whitney, W = 128.5; $p > 0.05$; $n1$ = 14; $n2$ = 11) with respect to mite intensity. Among live specimens, males had significantly more mites than females (Mann-Whitney, W = 30.50; p = 0.01; $n1$ = 12; $n2$ = 6). With respect to season, we used only males (since there were only 3 live females per season), finding no significant difference (Mann-Whitney, W = 35; $p > 0.05$; $n1$ = 6; $n2$ = 6).

DISCUSSION

Understanding the relationship between ectoparasites, such as mites, and lizards is important from an ecological point of view and the survival of the host (García de la Peña *et al.,* 2010). This study constitutes the second report in Argentina of infestation by the mite *Pterygosoma* sp. in a species of *Liolaemus* and the first to relate infestation to body condition, sex, and season. Pterygosomidae includes nine genera of ectocparasitic mites, *Pterygosoma* being one of the most specialized (Bertrand and Modrý, 2004; Bertrand *et al.,* 2013). This genus presents a number of morphological adaptations for this host, such as finding their way under the host's scales (Bertrand, 2002; Fajfer, 2012). These mites spend the greater part of their life cycle on their host, most species being parthenogenetic. Only the larvae are mobile and colonize new hosts (Bertrand, 2002; Fajfer, 2012).

The presence of the ectoparasite *Pterygosoma* sp. was observed on the ventral area of *Liolaemus pacha,* as has been reported by de La Cruz *et al.* (2004) for other species of *Liolaemus* (see Introduction). Fajfer (2012) mentions that permanent parasites, such as those of Pterygosomidae, are characterized by a low prevalence index, unlike temporary parasites (*e.g.,* trombiculid mites). Considering mite prevalence, we found our results (15–21.2% in *L. pacha*) to be somewhat similar to those reported in other studies of lizards infested by pterygosomid mites: 50% in *Tropidurus hispidus* (Delfino *et al.,* 2011), 29.7% in *Podarcis muralis* (Amo *et al.,* 2005), and 6.1% in *Sceloporus undulatus erythrocheilus* (Ferner, 1976).

According to Poiani (1992), host body size could influence the rates of parasitism for a particular host taxon. Thus, larger hosts tend to have proportionally more infestation sites suitable for parasites than smaller hosts (Cunha-Barros *et al.,* 2003, see references therein). In this study, body size was not a factor that influenced mite infestation. This is consistent with Amo *et al.* (2005) and García De La Peña *et al.* (2004, 2010), but differs from Carvalho *et al.* (2006) and Cunha-Barros *et al.* (2003). Clearly, more studies are needed to investigate the relationship between body size and mite infestation.

Similarly, we did not find a significant relation between lizard mass and mite intensity, suggesting that this ectoparasite does not affect the physical condition of the lizards, at least at the level of infestation reported here. García De La Peña *et al.* (2004) obtained similar results in *Sceloporus couchii*.

Our results show no significant differences between intensity of mites and season, unlike what was reported by other authors (*e.g.,* Ferner, 1976; Lumbad *et al.,* 2011) who observed greater ectoparasite intensity in the spring. In contrast, males in their natural habitat presented more mites on average than females. This result agrees with studies of other taxa, including *Sceloporus occidentalis* (Tälleklint-Eisen and Eisen, 1999; Lumbad *et al.,* 2011), *S. virgatus* (Cox and John-Alder, 2007), *S. undulatus* (Klukowski and Nelson, 2001), *Lacerta agilis* (Olsson *et al.,* 2000), *Podarcis muralis* (Oppliger *et al.,* 2004; Amo *et al.,* 2005), and *Psammodromus algirus* (Veiga *et al.,* 1998). In *Liolaemus pacha,* the difference between sexes might be due to behavioral differences between males and females. Males occupy significantly larger home ranges than females (Halloy and Robles, 2002), which might increase male exposure to these ectoparasites. Moreover, some theories relate the increase in androgens (testosterone) during the reproductive season to a depression of the immune system and greater susceptibility to diseases or new parasites (Hamilton and Zuk, 1982; Folstad and Karter, 1992; Klukowski and Nelson, 2001).

This study opens up several new directions for future research: Does mite intensity affect selection among males? Do males with fewer ectoparasites have greater mating success? Do higher mite intensities modify host physiology (*e.g.,* number of erythrocytes and leukocytes, response of the immune system)? In addition, ecological factors such as microclimatic conditions, precipitation rates, and vegetation should also be considered since they have been shown to favor the presence of these mites (Goldberg and Bursey, 1991).

ACKNOWLEDGMENTS

We are grateful to Hugo Fernández, Leonor Guardia, Analía Autino, Heather Proctor, and Michel Bertrand for their help in mite preparation and identification; Pablo Corrales for field assistance; Esteban Lavilla for allowing us to study specimens from the FML collection and Sonia Kretzschmar and Marta Cánepa for providing assistance whenever needed; permits from Recursos Naturales y Suelos de Tucumán (permits 39498, 952000, and 539RN); and a CIUNT (Ciencia y Técnica, Universidad Nacional de Tucumán) scholarship to the first author.

REFERENCES

Abdala C.S. 2007. Phylogeny of the *boulengeri* group (Iguania: Liolaemidae, *Liolaemus*) based on morphological and molecular characters. *Zootaxa* 1538:1–84.

Abdala C.S., Quinteros A.S. 2014. Los últimos 30 años de la familia de lagartijas más diversa de Argentina. Actualización taxonómica y sistemática de Liolaemidae. *Cuadernos de Herpetología*. In press.

Amo L., López P., Martín J. 2005. Prevalence and intensity of haemogregarine blood parasites and their mite vectors in the common wall lizard, *Podarcis muralis. Parasitology Research* 96:378–381. doi: 10.1007/s00436-005-1354-2

Bertrand M. 2002. Morphologic adaptations to parasitism on reptiles: Pterygosomatidae (Prostigmata: Raphignathina). Pp. 233–240, *in* Bernini F., Nannelli R., Nuzzaci G., de Lillo E. (Eds.), Acarid Phylogeny and Evolution. Adaptations in mites and ticks. Kluwer Academic Publishers, The Netherlands.

Bertrand M., Modrý D. 2004. The role of mite pocket-like structures on *Agama caudospinosa* (Agamidae) infested by *Pterygosoma livingstonei* sp. n. (Acari: Prostigmata: Pterygosomatidae). *Folia Parasitologica* 51:61–66.

Bertrand M., Kukushkin O., Pogrebnya S. 2013. A new species of mites of the genus *Geckobia* (Prostigmata, Pterygosomatidae), parasitic on *Mediodactylus kotschyi* (Reptilia, Gekkota) from Crimea. *Vestnik Zoologii* 47:1–13. doi: 10.2478/vzoo-2013-0009

Bulté G., Plummer A.C., Thibaudeau A., Blouin-Demers G. 2009. Infection of yarrow's spiny lizards (*Sceloporus jarrovii*) by chiggers and malaria in the chiricahua mountains, Arizona. *The Southwestern Naturalist* 54:204–207. doi: 10.1894/PAS-07.1

Bush A.O., Lafferty K.D., Lotz J.M., Shostak A.W. 1997. Parasitology meets ecology on its own terms: Margolis *et al.* revisited. *Journal of Parasitology* 83:575–583. www.jstor.org/stable/3284227

Cabrera A.L., Willink A. 1980. Biogeografía de América Latina, 2nd Edition. Secretaría General de la Organización de los Estados Americanos, Programa Regional de Desarrollo Científico Tecnológico, Washington D.C.

Carothers J.H., Jaksic F.M. 2001. Parasite loads and altitudinal distribution of *Liolaemus* lizards in the central Chilean Andes. *Revista Chilena de Historia Natural* 74:681–686. www.scielo.cl/pdf/rchnat/v74n3/art13.pdf

Carvalho A.L.G., Araújo A.F.B., Silva H.R. 2006. Patterns of parasitism by *Eutrombicula alfreddugesi* (Oudemans) (Acari, Trombiculidae) in three species of *Tropidurus* Wied (Squamata, Tropiduridae) from Cerrado habitat of Central Brazil. *Revista Brasileira de Zoologia* 23:1010–1015. doi: 10.1590/S0101-81752006000400005

Cei J.M. 1993. Reptiles del Noroeste, Nordeste y Este de la Argentina. Monografie XIV. Museo Regionale di Scienze Naturali, Torino.

Cox R.M., John-Alder H.B. 2007. Increased mite parasitism as a cost of testosterone in male striped plateau lizards *Sceloporus virgatus. Functional Ecology* 21:327–334. doi: 10.1111/j.1365-2435.2007.01251.x

Cunha-Barros M., Van Sluys M., Vrcibradic D., Galdino C.A.B., Hatano F.H., Rocha C.F.D. 2003. Patterns of infestation by chigger mites in four diurnal lizard species from a resting habitat (Jurubatiba) of Southeastern Brazil. *Brazilian Journal of Biology* 63:393–399. doi: 10.1590/S1519-69842003000300005

de La Cruz K.D., Morando M., Ávila L. 2004. Description of a new pterygosomatid mite (Acari, Actinedida: Pterygosomatidae) parasitic on *Liolaemus* spp. (Iguania: Liolaemini) from Argentina. *Zootaxa* 521:1–6.

Delfino M.M.S., Ribeiro S.C., Furtado I.P., Anjos L.A., Almeida W.O. 2011. Pterygosomatidae and Trombiculidae mites infesting *Tropidurus hispidus* (Spix, 1825) (Tropiduridae) lizards in northeastern Brazil. *Brazilian Journal of Biology* 71:549–555.

Di Rienzo J.A., Casanoves F., Balzarini M.G., Gonzalez L., Tablada M., Robledo C.W. 2012. InfoStat. Versión 2012. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. Available from: www.infostat.com.ar

Etheridge R. 1993. Lizards of the *Liolaemus darwinii* complex (Squamata: Iguania: Tropiduridae) in Northern Argentina. *Bolletino Museo Regionale di Scienze Naturali* 11:137–199.

Fajfer, M. 2012. Acari (Chelicerata) parasites of reptiles. *Acarina* 20:108–129.

Ferner, J.W. 1976. Notes on natural history and behavior of *Sceloporus undulatus erythrocheilus* in Colorado. *American Midland Naturalist* 96:291–302. www.jstor.org/stable/2424070

Fischer M., Muth A. 1989. A technique for permanently marking lizards. *Herpetological Review* 20:45–46.

Folstad I., Karter A.J. 1992. Parasites, bright males, and the inmunocompetence handicap. *The American Naturalist* 139:603–622. www.jstor.org/stable/2462500

Frost D.R., Etheridge R., Janies D., Titus T.A. 2001. Total evidence, sequence alignment, evolution of polychrotid lizards, and a reclassification of the Iguania (Squamata: Iguania). *American Museum Novitates* 3343:1–38. doi: 10.1206/0003-0082(2001)343<0001:TESAEO>2.0.CO;2

García De La Peña C., Contreras Balderas A., Gamaliel Castañeda G., Lazcano D. 2004. Infestación y distribución corporal de la nigua *Eutrombicula alfreddugesi* (Acari: Trombiculidae) en el lacertilio de las rocas *Sceloporus couchii* (Sauria: Prynosomatidae). *Acta Zoológica Mexicana* 20:159–165.

García De La Peña C., Gadsden H., Salas-Westphal, A. 2010. Carga ectoparasitaria en la lagartija espinosa de yarrow (*Sceloporus jarrovii*) en el cañón de las piedras encimadas, Durango, México. *Interciencia* 35:772–776.

Goldberg S.R., Bursey C.R. 1991. Integumental lesions caused by ectoparasites in a wild population of the side-blotched lizard (*Uta stansburiana*). *Journal of Wildlife Diseases* 27:68–73. doi: 10.7589/0090-3558-27.1.68

Goldberg S.R., Bursey C.R., Camarillo-Rangel J.L. 2003. Gastrointestinal helminths of seven species of sceloporine lizards from Mexico. *Southwestern Naturalist* 48:208–217. www.jstor.org/stable/3672317

Halloy M. 1996. Behavioral patterns in *Liolaemus quilmes* (Tropiduridae), a South American lizard. *Bulletin of the Maryland Herpetological Society* 32:43–57.

Halloy M. 2012. Visual display variations in neotropical lizards, *Liolaemus quilmes* (Iguania: Liolaemidae): relation to sex and season. *Herpetological Journal* 22:265–268.

Halloy M., Robles C. 2002. Spatial distribution in a neotropical lizard, *Liolaemus quilmes* (Liolaemidae): Site fidelity and overlapping among males and females. *Bulletin of the Maryland Herpetolological Society* 38:118–129.

Halloy M., Robles C. 2003. Patrones de actividad y abundancias relativas en un lagarto del noroeste argentino, *Liolaemus quilmes* (Sauria: Liolaemidae). *Cuadernos de Herpetología* 17:67–73.

Halloy M., Robles C., Cuezzo F. 2006. Diet in two syntopic neotropical lizard species of *Liolaemus* (Liolaemidae): interspecific and intersexual differences. *Revista Española de Herpetología* 20:47–56.

Hamilton W.D., Zuk M. 1982. Heritable true fitness and bright birds: a role for parasites? *Science* 218:384–387. doi: 10.1126/science.7123238

Juárez Heredia V., Robles C., Halloy M. 2013. A new species of *Liolaemus* from the *darwinii* group (Iguania: Liolaemidae) Tucumán province, Argentina. *Zootaxa* 3681:524–538.

Klukowski M. 2004. Seasonal changes in abundance of host-seeking chiggers (Acari: Trombiculidae) and infestations on fence lizards, *Sceloporus undulates*. *Journal of Herpetology* 38:141–144. doi: 10.1670/127-03N

Klukowski M., Nelson C.E. 2001. Ectoparasite loads in free-ranging northern fence lizards, *Sceloporus undulatus hyacinthinus:* effects of testosterone and sex. *Behavioral Ecology and Sociobiology* 49:289–295. doi: 10.1007/s002650000298

Krantz G.W. 1970. A Manual of Acarology. Oregon State University Bookstores, Corvallis.

Lane R.S., Loye J.E. 1989. Lyme disease in California: interrelationship of *Ixodes pacificus* (Acari: Ixodidae), the western fence lizard (*Sceloporus occidentalis*), and *Borrelia burgdorferi*. *Journal of Medical Entomology* 26:272–278.

Lumbad A.S., Vredevoe L.K., Taylor E.N. 2011. Season and sex of host affect intensities of ectoparasites in western fence lizards (*Sceloporus occidentalis*) on the central coast of California. *The Southwestern Naturalist* 56:369–377. doi: 10.1894/F10-RW-01.1

Martin J., Amo L., López P. 2008. Parasites and health affect multiple sexual signals in male common wall lizards, *Podarcis muralis*. *Naturwissenschaften* 95:293–300. doi: 10.1007/s00114-007-0328-x

Møller A.P., Christe P., Lux E. 1999. Parasitism, host immune function, and sexual selection. *The Quarterly Review of Biology* 74:3–20. www.jstor.org/stable/2664375.

Olsson M., Wapstra E., Madsen T., Silverin B. 2000. Testosterone, ticks and travels: a test of the immunocompetence-handicap hypothesis in free-ranging male sand lizards. *Proceedings of the Royal Society, Biological Sciences* 267:2339–2343. doi: 10.1098/rspb.2000.1289

Oppliger A., Clobert J. 1997. Reduced tail regeneration in common lizard *Lacerta vivipara* parasitized by blood parasites. *Functional Ecology* 11: 652–655. doi: 10.1046/j.1365-2435.1997.00134.x.

Oppliger A., Celerier M.L., Clobert J. 1996. Physiological and behaviour changes in common lizards parasited by haemogregarines. *Parasitology* 113:433–438. doi: 10.1017/S003118200008149X

Oppliger A., Giorgi M.S., Conelli A., Nembrini M., John-Alder H.B. 2004. Effect of testosterone on immunocompetence, parasite load, and metabolism in the common wall lizard (*Podarcis muralis*). *Canadian Journal of Zoology* 82:1713–1719. doi: 10.1139/z04-152

Poiani A. 1992. Ectoparasitism as a possible cost of social life: a comparative analysis using Australian passerines (Passeriformes). *Oecologia* 92:429–441.

Price P.W. 1980. Evolutionary biology of parasites. Princeton University Press, Princeton.

Ramírez Pinilla M.P. 1992. Ciclos reproductivos y de cuerpos grasos en dos poblaciones de *Liolaemus darwinii* (Reptilia: Sauria: Tropiduridae). *Acta Zoologica Lilloana* 42:41–49.

Robles C., Halloy M. 2009. Home ranges and reproductive strategies in a neotropical lizard, *Liolaemus quilmes* (Iguania: Liolaemidae). *South American Journal of Herpetology* 4:253–258. doi: 10.2994/057.004.0308

Rocha C.F.D., Cunha-Barros M., Menezes V.A., Fontes A.F., Vrcibradic D., Van Sluys M. 2008. Patterns of infestation by the trombiculid mite *Eutrombicula alfreddugesi* in four sympatric lizard species (genus *Tropidurus*) in northeastern Brazil. *Parasite* 15:131–136. doi: 10.1051/parasite/2008152131

Rubio A.V., Simonetti J.A. 2009. Ectoparasitism by *Eutrombicula alfreddugesi* larvae (Acari: Trombiculidae) on *Liolaemus tenuis* lizard in a Chilean fragmented temperate forest. *Journal of Parasitology* 95:244-245. doi: 10.1645/GE-1463.1

Schall J.J. 1983. Lizard malaria: cost to vertebrate host's reproductive success. *Parasitology* 87:1–6. doi: 10.1017/S0031182000052367

Schall J.J. 1990. Virulence of lizard malaria: The evolutionary ecology of an ancient parasite host association. *Parasitology* 100:35–52. doi: 10.1017/S0031182000073005.

Schall J.J., Prenderville H.R., Hanley, K.A. 2000. Prevalence of the tick, *Ixodes pacificus,* on western fence lizards, *Sceloporus occidentalis:* Trends by gender, size, season, site, and mite infestation. *Journal of Herpetology* 34:160–163.

Siegel S., Castellan Jr N.J. 1988. Nonparametric Statistics for the Behavioral Sciences, 2nd Edition. McGraw-Hill, New York.

Sokal R.R., Rohlf F.J. 1999. Biometry. 2nd ed. W.H. Freeman and Company, New York.

Sorci G., Massot M., Clobert J. 1994. Maternal parasite load increases sprint speed and philopatry in female offspring of the common lizard. *The American Naturalist* 144:153–164. www.jstor.org/stable/2462806

Tälleklint-Eisen L., Eisen R. 1999. Abundance of ticks (Acari: Ixodidae) infesting the western fence lizard, *Sceloporus occidentalis,* in relation to environmental factors. *Experimental and Applied Acarology* 23:731–740. doi: 10.1023/A:1006212323760

van Riper C.III, van Riper S.G., Goff M.L., Laird M. 1986. The epizootiology and ecological significance of malaria in Hawaiian land birds. *Ecological Monographs* 56:327–344. doi: 10.2307/1942550.

Veiga J.P, Salvador A., Merino S., Puerta M. 1998. Reproductive effort affects immune response and parasite infection in a lizard: a phenotypic manipulation using testosterone. *Oikos* 81:313–318. www.jstor.org/stable/3546971

APPENDIX

Specimens examined

Liolaemus pacha (*n* = 132): ARGENTINA: **Tucumán Province:** Tafí del Valle Department: Km 98, Ruta Provincial 307 (Los Cardones), 26°40’1.5”S, 65°49’5.1”W, datum: WGS84, 2725 m, collector, O. Pagaburo, 21/04/1990: FML 02448/1 (Holotype), FML 2448/2–4/6–9, FML 18136–39, FML 24790–796, FML 24781–785, FML 15555, FML 02497/2–4/6, FML 22332, FML 22333, FML 22334, FML 22335, FML 22336, FML 22337, FML 22338, FML 22339, FML 22340, FML 02233/1–7, FML 18483–486/488, FML 02475/1–3, FML 02516/1–2, FML 02957/1–2, FML 02449/1–6, FML 02467, FML 02474, FML 02478, FML 02242/1, FML 01428/1–2, FML 17999, FML 16940, FML 18540, FML 18541, FML 18542, FML 18543, FML 18544, FML 18546, FML 18547, FML 18548, FML 18549, FML 18550, FML 18551, FML 18281, FML 18276, FML 18505, FML 18506, FML 18507, FML 18508, FML 18509, FML 18510, FML 18511, FML 18512, FML 18513, FML 18140, FML 18282, FML 18275, FML 18277, FML 18278, FML 18279, FML 18280, FML 19302, FML 19303, FML 02187/1–4, FML 02198/1–3, FML 02206/1–2, FML 02242/2, FML 02272/1–5, FML 02276/1–4, FML 02278/1–3, FML 02382/1–4, FML 02434/1–3.