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Season, body condition and sex variation of ectoparasite abundance in *Tarentola delalandii* (Squamata: Phyllodactylidae) from two ecologically contrasting populations of Tenerife (Canary Islands)

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Abstract:	<p>Individual parasite load depends on several factors as sex, body size or climatic conditions. In turn, parasites may produce several pathologies in the short and long term. In this work analyse ectoparasite load of <i>Geckobia</i> mite in two ecologically contrasting populations (north and south of Tenerife) of the gecko <i>Tarentola delalandii</i>. For this purpose, we performed random transects to capture geckos under stones in each population and counted all mites found in any part of each gecko's body. The results of applying Generalized Linear Models, showed that there were no significant effects on mite abundance of: site, season, sex (within population), condition index or temperature of the refuges where geckos were found. However, there were significant effects of the interactions of season by condition index and of season by sex (nested within population). Parasitism was higher in individuals with lower body index values in Autumn-Winter, than those with higher body condition in Spring-Summer. Moreover, females of the Northern population were more parasitized than males and juveniles in the cooler months of the year. We discuss several potential explanations for these results.</p>

1 **Season, body condition and sex variation of ectoparasite abundance in**
2 ***Tarentola delalandii* (Squamata: Phyllodactylidae) from two**
3 **ecologically contrasting populations of Tenerife (Canary Islands)**

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11 **Abstract.** Individual parasite load depends on several factors such as sex, body size or
12 climatic conditions. In turn, parasites may produce several short and long-term
13 pathologies. Herein, we analyze the ectoparasite load of *Geckobia* mite in two
14 ecologically contrasting populations (North and South of Tenerife) of the gecko
15 *Tarentola delalandii*. For this purpose, we performed random transects to capture
16 geckos under rocks in each population and counted all mites found in any part of each
17 gecko's body. A Generalized Linear Model showed no significant effect on mite
18 abundance of site, season, sex (within population), condition index, or temperature of
19 the refuges. However, there were significant effects of the interactions between season
20 by condition index and season by sex (nested within population). Parasitism was higher
21 in individuals with lower body index values in Autumn-Winter than those with higher
22 body condition in Spring-Summer. Moreover, females of the Northern population were
23 more parasitized than males and juveniles in the year's cooler months. We discuss
24 several potential explanations for these results.

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25 **Keywords.** Ectoparasite load, temporal change, gecko, sex, temperature, condition
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INTRODUCTION

29 Parasitosis in reptiles is one of the main causes of mortality among these animals in
30 captivity; however, in the natural environment, the parasite-host relationship tends to be
31 in equilibrium (García-Zendejas, 2013). Some examples of endoparasites in reptiles are
32 noteworthy as protozoa (amoebas, coccidia, and cryptosporidia) and worms (nematodes,
33 trematodes, and cestodes). Within ectoparasites, mites are common in reptiles and can
34 cause various diseases and weakening; in the wild, ectoparasites should have fitness
35 costs (Huyghe *et al.*, 2010). The main factors that have been described as influential in
36 the degree of parasitism of a specimen are sex, hormonal status, reproductive condition,
37 and behavior (Pollock, 2011). In addition, the ectoparasite abundance can also be
38 influenced by the physical interaction between individuals, such as through sexual
39 contact, fighting, communal nesting, or retirement places (Martínez-Rivera *et al.*, 2003;
40 Bertrand *et al.*, 2013). Lizards are hosts for a wide range of parasites, including mites
41 (Bochkov and Mironov, 2000; Fajfer, 2012).

42 Moreover, environmental conditions such as community composition, temperature,
43 and humidity affect parasite prevalence and load. Consequently, host-parasite dynamics
44 could vary geographically (Merila *et al.*, 1995; Poisot *et al.*, 2017) or with the season
45 (Earle *et al.*, 1992). Some recent papers suggest that lizards with ticks may suffer high
46 water loss and are more prone to dehydration (Megía-Palma *et al.*, 2018; Paranjpe *et al.*,
47 2014; Sannolo *et al.*, 2020; Scholnick *et al.*, 2012).

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48 Further, two hypotheses suggest the selection of parasites on the host preference: that
49 of the “poorly fed host” (Christe *et al.*, 2000) and the “well-fed host” (Christe *et al.*,
50 2003) hypothesis. For example, in rodents, ectoparasites seem to attack younger
51 (weaker) individuals (Hawlena *et al.*, 2006), while in other cases, they prefer well-fed
52 adults (Postawa and Nagy, 2016): larger hosts in good body condition represent a better
53 nutritional resource than smaller hosts in weaker body condition. So, there is still no
54 consensus on the casual relationship between the host's resources, their benefits, and the
55 abundance of ectoparasites.

56 *Tarentola delalandii* Duméril and Bibron, 1836 is a small gecko, predominantly
57 nocturnal, widespread throughout Tenerife and La Palma (Canary Islands). According
58 to phylogeographic analyses populations of this species in Tenerife differentiated on
59 three precursor islands (Anaga, Roque del Conde, and Teno) and subsequently
60 contacted following their junction (Gübitz *et al.*, 2000). This gecko is currently very
61 common in the coastal zone while rarely being seen above 1500 m altitude.

62 The ectoparasites of Canarian lizards were described by Bannert *et al.* (1995), and the
63 mites present in *T. delalandii* are of the genus *Geckobia*, belonging to the family
64 *Pterygosomatidae*. It is widely distributed in southern Europe, around the western
65 Mediterranean basin (Bertrand *et al.*, 2013), and is limited exclusively to geckos, being
66 obligate ectoparasites at all stages of development (Simonsen and Sarda, 1985).

67 *Geckobia* mites have a monoxene cycle, so their transmission is favored by direct
68 contact between infested host individuals, either during reproduction or in territorial
69 disputes (Rivera *et al.*, 2003; Fajfer, 2012; Bertrand *et al.*, 2013). Otherwise, *Tarentola*
70 geckos are very “asocial”; that is, males and females may have a long-term association
71 (even out or reproductive period), but adults are very intolerant to immatures, and even

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72 immatures exclude one each other according to sizes (Pereira *et al.*, 2019; Vasconcelos
73 *et al.*, 2012).

74 Several studies have revealed the presence of different species of this African mite in
75 some species of geckos of the genus *Phyllodactylus* (Hoffman and Morales-Malacara,
76 1985; Floch and Abonnenc, 1944), *Cosymbotus* (Prawasti *et al.*, 2013), *Hemidactylus*
77 (Krantz, 1978; Frenkel and Vargas, 2005) or *Tarentola* (Giroto, 1969; De la Cruz, 1973).
78 Two species of these parasites have been cited for the Tenerife gecko: *G. canariensis*
79 and *G. tinerfensis* (Zapatero-Ramos *et al.*, 1989), whose biological cycles and possible
80 adverse effects on this species are unknown. The majority of ectoparasite mites are
81 located between the scales, in the ear canals, or in joints of the extremities (Fajfer,
82 2012). In *T. delalandii* it has not been quantified if the degree of external parasitism
83 varies between sexes, populations, or seasons of the year. In the gecko *Gymnodactylus*
84 *darwinii* Gray, 1845, *Geckobia* was found much more frequently during the dry season
85 (Cabus-Oitaven *et al.*, 2019), which was also evidenced by Bertrand *et al.* (2013) for
86 *Geckobia sharygini* on *Mediodactylus kotschyi* Strauch, 1887. In addition, abundance of
87 ectoparasites could decreased with elevation (Álvarez-Ruiz *et al.*, 2018).

88 This study aimed to quantify the number of external parasites and analyze their
89 variation between seasons, sexes, and concerning body condition in two selected
90 populations (North and South of the island) having contrasted ecological characteristics.
91 We hypothesized that individuals should have a lower condition after the Summer,
92 especially in the Southern population. Moreover, according to the vulnerable host
93 hypothesis (Christe *et al.*, 2000), individuals with a lower-body condition would be
94 more infested than those with a higher body condition, especially in the Autumn-Winter
95 season after geckos have made a high reproductive effort during the preceding Spring-
96 Summer period. Furthermore, we hypothesized that the number of external parasites

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97 should vary: 1) throughout the months of study, with higher values in Spring-Summer
98 than in Autumn-Winter; 2) between populations, individuals from the Southern
99 population (higher environmental temperatures) could be more parasitized than those of
100 the Northern population. Though the parasite's biological cycle is unknown, the
101 temperature is often considered one of the most important environmental variables
102 affecting parasite distribution, as rising temperatures positively affect development,
103 reproduction, and rate of parasite transmission (Álvarez-Ruiz *et al.*, 2018). Therefore,
104 the climatic conditions of the Southern population could favor *Geckobia* mites more
105 than those of the Northern population.

106 We also hypothesized that males would be more parasitized than females and
107 juveniles. Specifically, in reptiles, the intensity and dominance of ectoparasite
108 infestations tend to be lower in females (Dudek *et al.*, 2016; Llanos-Garrido *et al.*,
109 2017). Male testosterone may have an immunosuppressive effect (Roberts *et al.*, 2004;
110 Grear *et al.*, 2009; Foo *et al.*, 2017) and males who have high testosterone levels tend to
111 have greater mobility, which would imply a higher probability to be exposed to
112 parasites of other congeners - during encounters with females or during fights with other
113 individuals (Amo *et al.*, 2005).

114 MATERIALS AND METHODS

115 *Study areas and sampling times*

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117 Tenerife is affected by a Mediterranean climate and exhibits a great heterogeneity of
118 ecosystems, which oscillates between the semi-desert scrubs of the coasts through the
119 thermophilic forests of Mediterranean affinity, mist forests, pine forests, and summit
120 scrublands. Our work focuses on two contrasting ecosystems on the island, one at a

121 medium latitude in the North, and another at low latitude in the South. We proceed to
122 collect data in two populations: 1) Geneto (San Cristóbal de La Laguna, North of the
123 Island, 28 ° 28'02"N, 16 ° 18'50" E, hereafter Northern population) and 2) El Médano
124 (Granadilla de Abona, in the South, 28 ° 03'06" N, 16 ° 31'51" E, hereafter Southern
125 population). Field sampling was carried out during April to July 2013 and 2015 (Spring-
126 Summer) and October 2014 to January 2015 (Autumn-Winter). It lasted approximately
127 30 hours per month in each area. Fieldwork was performed between 10:00 h and 17:00
128 h when geckos could be inactive under stones. Each locality has a different climate,
129 geology and vegetation, representatives of the Northern and Southern parts of the
130 island. The Northern locality is around 510 m a. s. l., has a humid subtropical climate,
131 and it encompasses an abandoned cultivated area that has potential gecko shelters, such
132 as basaltic rock walls that separate farmland. Mean annual temperature is about 16 ° C.
133 Vegetation is characterized by ruderal species such as *Lavatera cretica*, *Galactites*
134 *tomentosa*, shrubs such as *Spartium junceum*, and *Artemisia thuscula*, and some
135 invasive species such as *Opuntia maxima*, *Tropaeolum majus*, *Agave americana* and
136 species of *Eucalyptus*. On the other hand, the Southern locality is situated at an altitude
137 of 20 m a. s. l. and has an arid subtropical climate (mean annual temperature about 22 °
138 C). The landscape is dominated by light rocks, generally of pyroclastic pumice, and
139 they also contain a bit of hard basalt and some typical minerals, such as trachyte and
140 magnetite. The study zone is located in a ravine, and its surrounding areas have tuff
141 fragments. This area has lower vegetation biomass than that of the Northern zone, and
142 some of the species present are: the more common *Launaea arborescens*, *Zygophyllum*
143 *fontanesii* and *Euphorbia balsamifera*, while *Plocama pendula*, *Tamarix canariensis*,
144 and nitrophilous herbs such as *Heliotropium bacciferum* among others are scarcer.

145 *Sampling procedures and data collection*

146 In both areas, we performed line transects (between 10 and 90 m long and
147 considering 2.5 m on each side) to search most of the ground. We turned all
148 encountered stones along those transects to find the largest number of individuals.
149 Transects were performed by the same person (MdfH) in different places of the habitat,
150 in different directions (randomly selected), and separated at least 30 m to avoid re-
151 sampling individuals. The average transect lasted two hours. The Northern locality had
152 several stone walls that were lacking in the southern locality; therefore, to have a similar
153 ground area covered during transects, we performed a higher number of transects (93)
154 of shorter lengths in the first than in the second locality (36).

155 Most geckos (a total of 538 individuals) were caught by hand and a small proportion
156 with a noose. We recorded the number of external mites on each individual using a
157 magnifying glass. As our main goal was to quantify the global mite load, we did not
158 differentiate between the two described *Geckobia* species; moreover, their biological
159 cycle and possible effects are unknown. Mites were counted on eight areas of the body:
160 eyes, ears, neck, rest of the head, trunk, extremities, tail, and the area of intersection
161 between the body and the extremities. However, given the low number of mites in some
162 of these places, did not permit a comparative analysis. Finally, we considered only the
163 total number of parasites in the body. Further, we determined the sex of geckos, and we
164 used a plastic ruler for measuring their snout-vent length (SVL, ± 0.5 mm precision) and
165 a dynamometer (± 1 g precision) for body mass (BM, considering only individuals with
166 non-regenerated tail). We calculated a condition index (CI) for everyone by obtaining
167 the residuals of log (mass) against log (SVL).

168 After taking measurements and ectoparasite counts, all geckos were immediately
169 released in their original capture site. No gecko or mite were taken for any lab
170 collection.

171 *Data analysis*

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3 172 To detect if geckos differed in body condition between populations, seasons, and sex,
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6 173 and as data did not fulfill parametric requirements, we applied a Generalized Linear
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8 174 Model (GLM) using CI as the dependent variable and population, season, and sex as
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10 175 factors. We ran analyses considering the following models: 1) including the three
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12 176 factors and interactions of order 2; 2) including only the three factors; 3) the same as in
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14 177 model 1 but considering sex nested within population; 4) including only season,
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16 178 population and sex nested within population. For model selection, we used Akaike's
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18 179 information criterion (AIC) and a second order derivative (AIC_c) which contains a bias
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20 180 correction term for small sample sizes that should be used when the number of free
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22 181 parameters, p , exceeds $n/40$ (where n is sample size) (Burnham and Anderson, 2002).
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25 182 We present AIC_c differences ($\Delta AIC_c = AIC_c - AIC_{min}$) for comparing the results of
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27 183 multiple models, and we used a cut-off of $\Delta \leq 2$ to include only those models with
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29 184 substantial support from the data (Burnham *et al.*, 2002). Parallel to this main analysis,
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31 185 we tested if body condition was related to mite abundance, we ran a correlation analysis
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33 186 (Spearman rho) on both variables.
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40 187 As a large proportion of geckos did not present any ectoparasite, these cases were not
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42 188 considered for the following analyses. To discard a possible difference in mite
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44 189 abundance during the Spring-Summer period of 2013 (number of geckos, $n = 109$) and
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46 190 2015 ($n = 89$), we initially applied a U-Mann-Whitney test that proved a non-significant
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48 191 difference ($Z = -0.624$, $p = 0.532$). Once incorporated into computer files, mite
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50 192 abundance data were analyzed using again a GLM (McCullagh and Nelder, 1989;
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52 193 Montgomery, 2013). Taking into account the overdispersion presented by the model,
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54 194 instead of a Poisson, we considered a negative binomial distribution and log link, taking
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56 195 mite abundance as the dependent variable and population, sex (nested within
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196 population), and period of the year (season) as factors, and condition index (CI) and
197 refuge temperature as covariates. We ran analyses considering the following models: 1)
198 including all factors, covariates, sex nested within population and interactions of order
199 2; 2) including only significant interactions appearing in model 1; 3) the same as in
200 model 1 but using data with number of ectoparasites less than 100; 4) including only
201 significant interactions appearing in model 3.

202 RESULTS

203 Table S1 presents the mean SVL and BM (\pm S.E.), minimum, maximum values, and
204 sample size of geckos sampled in each site and season. From 538 individuals sampled,
205 239 (44.4 %) did not have any mite. In Table S2, we present the proportion of infested
206 individuals from each population and sampled period. In Fig. 1 the mean values of
207 ectoparasite numbers in males, females, and juveniles from each population and season
208 sampled. In Fig. 2, we show the evolution of mean retreat temperature in the months
209 sampled, and in Fig. 3 the number of mites on adult males, females, and juveniles in
210 relation to their SVL.

211 There were some more geckos parasitized than expected and fewer geckos non-
212 parasitized than expected in Autumn-Winter of the Northern population and the
213 contrary in Spring-Summer (Table 1a); however, there was no significant association
214 between each gecko category (sex, adult or juvenile) and season (Chi-square = 1.261, df
215 = 1, $p = 0.261$). The contrary occurred in geckos of the Southern population but again
216 there was no significant association (Table 1b, Chi-square = 0.092, df = 1, $p = 0.762$).

217 Generalized Linear Model applied to the condition index of geckos showed that
218 model 2 (Table S3) was the most appropriated (lower AIC). Based on this model, CI
219 mainly differed between seasons, being significantly lower in Autumn-Winter than in

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220 Spring-Summer and between populations (lower in the Southern population). (Table 2
221 and Fig. 3); however, it did not differ between sexes. On the other hand, there was no
222 significant correlation between CI and the number of ectoparasites (Spearman rho =
223 0.005, $p = 0.96$; Fig. 4).

224 Considering the number of ectoparasites as the dependent variable, the values of AIC
225 calculated for different GLM models (Table S4) informed us that the lower value was
226 for the model incorporating only the significant effects of the interactions between
227 season x CI and season x sex (nested within population); therefore, we chose model 4 of
228 that Table. In Table 3, we present the results of GLM analysis for that model showing
229 the interactions of order two that significantly affect ectoparasite numbers in geckos.

230 Within this last model, the analysis showed that: 1) the number of ectoparasites in *T.*
231 *delalandii* is significantly affected by the interaction of season by sex nested in
232 population (Table 3 and Fig. 3), where females were more parasitized than males and
233 juveniles and more in Autumn-Winter than in Spring-Summer; 2) there was also a
234 significant effect of the interaction of season and CI: geckos with lower condition index
235 and in Autumn-Winter were more parasitized than those with higher CI in Spring-
236 Summer (Figs.1 and 3).

237 **DISCUSSION**

238 ***Variations in condition index***

239 We have found that the condition index did not significantly differ between sexes
240 but was significantly lower in Autumn-Winter and the Southern population, which can
241 be understood as in this period of the year geckos have already heavily invested in
242 maintenance and reproductive activities, what could be more costly in the harsh

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243 southern environment. During Spring-Summer, both males and females had better body
244 condition in the Northern than in the Southern population, probably reflecting the
245 broader environmental resources in the first population. In the case of the gecko
246 *Woodworthia* sp., it was suggested that larger individuals living in higher elevations
247 have more significant benefits of keeping energy stores to manage the challenges of
248 reproduction and prolonged inactivity over winter (Penniket, 2012).

249 ***Variations in mite abundance:***

250 ***a) effects of season and condition index***

251 The significant effect on the number of ectoparasites of the interaction of season and
252 gecko's condition index reflects that mites were more frequent in individuals with a
253 lower-body index and in Autumn-Winter than in geckos with a higher body condition
254 in Spring-Summer (see Figs. 3 and 4). This result could reflect the effect of a lower-
255 body condition (in Autumn-Winter, after the reproductive period) and maybe better
256 environmental conditions for mites during that yearly period. This could be explained
257 according to the vulnerable host hypothesis (Christe *et al.*, 2000), as geckos with lower
258 body conditions were more heavily parasitized. If during Autumn-Winter they lack
259 some sources or if they have had high energy costs after reproduction (which occurs in
260 Spring-Summer months), that would compromise their physical state, and then they
261 would be more vulnerable to ectoparasites.

262 ***b) Effect of population***

263 Our study shows that considering all geckos and all sampled periods, the number of
264 *Geckobia* ectoparasites in *T. delalandii* did not differ significantly between the two
265 populations analyzed. This suggests that the very different climatic conditions in both

266 areas seem not to affect the mite infestation rate; however, as the biology of those mites
267 is still unknown, we cannot extract any further conclusion. A study of Atlas day gecko
268 (*Quedenfeldtia trachyblepharus* Boettger, 1874) showed no significant differences in
269 infestation of bloodsucking mites in populations living at different altitudes; several
270 conflicting effects explained their results: environmental conditions changing with
271 elevation, as well as gecko's body condition, population densities, and reptile
272 communities; however, *Quedenfeldtia* is quite different from *Tarentola* in social structure
273 and thermal environment (Blouin-Demers *et al.*, 2013). Moreover, the study of
274 ectoparasite infection levels in the lizard *Gallotia atlantica* Peters and Doria, 1882 from
275 two contrasting habitats (vegetation formed by a sparse xerophytic scrub) of a small
276 islet showed few differences between them, suggesting a low influence of habitat on
277 parasite performance; only prevalence differed between habitats, being higher in the
278 richest and climatically more sheltered site (dominant plant species were *Nicotiana*
279 *glauca*, *Mesembryanthemum crystallinum*, *M. nodiflorum*, *Euphorbia regis-jubae*, and
280 *Salsola vermiculata*), since it may be related to the heliothermic behavior of this lizard,
281 and the resistance of mites to desiccation. (García-Ramírez *et al.*, 2005).

282 ***c) Interaction effect of the season by sex (within population)***

283 The significant effect of this interaction reflects the fact that mites were more
284 frequent in Autumn-Winter than Spring-Summer and that there were differences
285 between the types of individuals. Thus, females (especially in the Northern population)
286 showed a greater number of parasites than males and juveniles in Autumn-Winter;
287 however, males from the southern population had a more significant number of
288 parasites (see Fig.1).

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289 These results are opposed to two of our predictions because we expected to find more
290 parasites during the Spring-Summer season and in males. Some studies suggest that
291 seasonal changes in mite abundance are an essential factor that influences the intensity
292 of lizard infestation (Eisen *et al.*, 2001; Klukowski, 2004). For example, in the case of
293 *G. darwini*, infestation by *Geckobia sp.* was more frequent during the dry season
294 (Cabus-Oitaven *et al.*, 2019), while juveniles of *M. kotschy* showed more significant
295 parasitism than adults in early Spring (Bertrand *et al.*, 2013). Weather conditions, such
296 as temperature and humidity, also influence parasite load; this has been seen to occur in
297 lizards. Those living in moist cool areas have a higher proportion of scales infested with
298 mites (Rubio and Simonetti, 2009) and mite infestation on lizards decreased in August
299 and September during cooler periods (Klukowski, 2004). In *T. delalandii*, a suggestion
300 would be that temperature and humidity affect the number of parasites in the Northern
301 population more than in the Southern population. However, we still need to know the
302 environmental characteristics affecting the biological cycle of *Geckobia*.

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303 Concerning the sex effect on parasite load, males of several lizards had a higher
304 concentration of ectoparasites than females, and those with higher testosterone levels
305 had a higher number of ectoparasites (*Sceloporus*, Pollock, 2011); this author argued
306 that testosterone increased territorial behaviors, which could contribute to males
307 contacting a more significant number of parasites (Pollock, 2011). For the gecko *Q.*
308 *trachyblepharus*, the prevalence was higher in males than in females, but the intensity
309 did not significantly differ with sex (Comas, 2019). One possible reason for a higher
310 male infestation is that testosterone concentrations, higher during the breeding season,
311 make them more vulnerable to ectoparasitism (decreasing their resistance to parasites;
312 see Cox *et al.*, 2007).

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313 Furthermore, males and females of some geckos species have similar degrees of
314 ectoparasites (*Hoplodactylus maculatus* Boulenger, 1885, Todd, 2003; *Hemidactylus*
315 *frenatus* Schlegel, 1836; Obi *et al.*, 2013; *G. darwinii*, Cabus-Oitaven *et al.*, 2019), and
316 juveniles were less infested than adults (Reardon and Norbury, 2004). Adult geckos
317 probably occupy more favorable areas where they come in contact with parasites and
318 their vectors, and juvenile geckos were limited to suboptimal areas by older ones to
319 avoid competition for preys (Obi *et al.*, 2013).

320 Finally, some other studies like ours have shown that females are more parasitized
321 than males. For example, females of *H. frenatus* were more parasitized than males by
322 four groups of endoparasites and the *Geckobia* mite (Mahagedara and Rajakaruna,
323 2012). Our sampling localities are very contrasting, not only in climate (the main
324 difference is in air humidity which is much higher throughout the whole year in the
325 Northern population than in the Southern population), but also in plant productivity and,
326 likely, on insect availability. During Summer, precipitation is practically absent in the
327 Southern region, so adults may be exhausted after the reproduction period (if food and
328 water availability are low), especially in females, which make a high energetic
329 investment in vitellogenesis and egg-laying (Megía-Palma *et al.*, 2018). At mid-altitude
330 (Northern population), conditions are milder and less seasonal. A suggestion would be
331 that air humidity affects the number of parasites in the Northern population more than in
332 the Southern population.

333 Therefore, there is no general rule within geckos related to what sex is more
334 parasitized. In general, it has been detected more frequently that adult geckos have a
335 greater degree of parasitism than juveniles, which is interpreted as that older individuals
336 would have spent more time in contact with the environment and, therefore, had a

337 greater probability of encountering ectoparasites (*T. angustimentalis* Steindachner,
338 1891, Galindo and Martín, 1995).

339 Although our results showed that body condition did not differ between sexes, we
340 suggest that in our case, both female body condition and environmental factors in the
341 Northern population (somewhat higher shelter temperature and humidity for this sex;
342 our unpublished results) could affect *Geckobia*'s degree of parasitization on *T.*
343 *delalandii*. More specific studies on the biological cycle of these mites in each sampled
344 population should be conducted to understand these contrasting results.

345 In conclusion, the number of ectoparasites in *T. delalandii* is mainly influenced by
346 seasonal factors affecting both condition index of individuals and, probably, better or
347 worst environmental factors for parasites present in each population.

348 Further studies should address the environmental characteristics affecting the
349 biological cycle of *Geckobia* and its relation to gecko sex and traits throughout their
350 life, as well as their fitness consequences.

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523 Figure captions:

524 Fig. 1.- Mean (\pm 95% CI) number of parasites for the three categories of individuals in
525 each population and study period.

526 Fig. 2.- Mean refuge temperature where geckos were found in the sampled months of
527 each population.

528 Fig. 3.- Mean (\pm 95% CI) body condition in the three categories of individuals in each
529 population and study period.

530 Fig. 4.- Scatterplot of the total number of ectoparasites in relation to condition index
531 (residuals of BM to SVL) of geckos in each category from each site and season.
532 Vertical line separate individuals with negative and positive residuals.

Table 1.- a) Number of geckos parasitized or not, expected counts and percentages, in each sampled season of the Northern population; b) Southern population.

a)

			Parasites (P)	No parasites (No_P)	Total
Season	Autumn-Winter	Counts	46	38	84
		Expected count	41.8	42.2	84
% within Season		54.8%	45.2%	100%	
% within P - No_P		37.7%	30.9%	34.3%	
Residual		4.2	-4.2		
Spring-Summer	Counts	76	85	161	
	Expected count	80.2	80.8	161	
	% within Season	47.2%	52.8%	100%	
	% within P - No_P	62.3%	69.1%	65.7%	
	Residual	-4.2	4.2		
Total	Counts	122	123	245	
	Expected count	122	123.0	245.0	
	% within Season	49,8%	50.2%	100%	
	% within P - No_P	100%	100%	100%	

b)

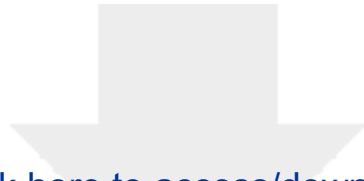
			Parasites (P)	No parasites (No_P)	Total
Season	Autumn-Winter	Counts	55	38	93
		Expected count	56.2	36.8	93
% within Season		59.1%	40.9%	100%	
% within P - No_P		31.1%	32.8%	31.7%	
Residual		-1.2	1.2		
Spring-Summer	Counts	122	78	200	
	Expected count	120.8	79.2	200	
	% within Season	61.0%	39.0%	100%	
	% within P - No_P	68.9%	67.2%	68.3%	
	Residual	1.2	-1.2		
Total	Counts	177	116	293	
	Expected count	177.0	116	293	
	% within Season	60.4%	39.6%	100%	
	% within P - No_P	100%	100%	100%	

Table 2.- Results of GLM analysis applied to condition index of *T. delalandii* using model 2 of Table 4. In bold significant effects of factors.

	Wald's Chi-square	df	p
Intersect	0.042	1	0.838
Population	7.865	1	0.005
Sex	1.873	2	0.392
Season	17.420	1	< 0.001

Table 3.- Results of the generalized linear model analysis applied to ectoparasite numbers of *T. delalandii* using model 4 of Table 6. In bold significant effects of factors and interactions.

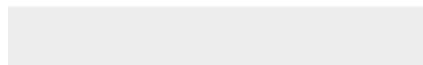
	Wald's Chi-square	df	p
Intersect	627.519	1	0.00
Season * CI	7.44	2	0.024
Season * Sex (Population)	34.87	11	< 0.001



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Cover Letter

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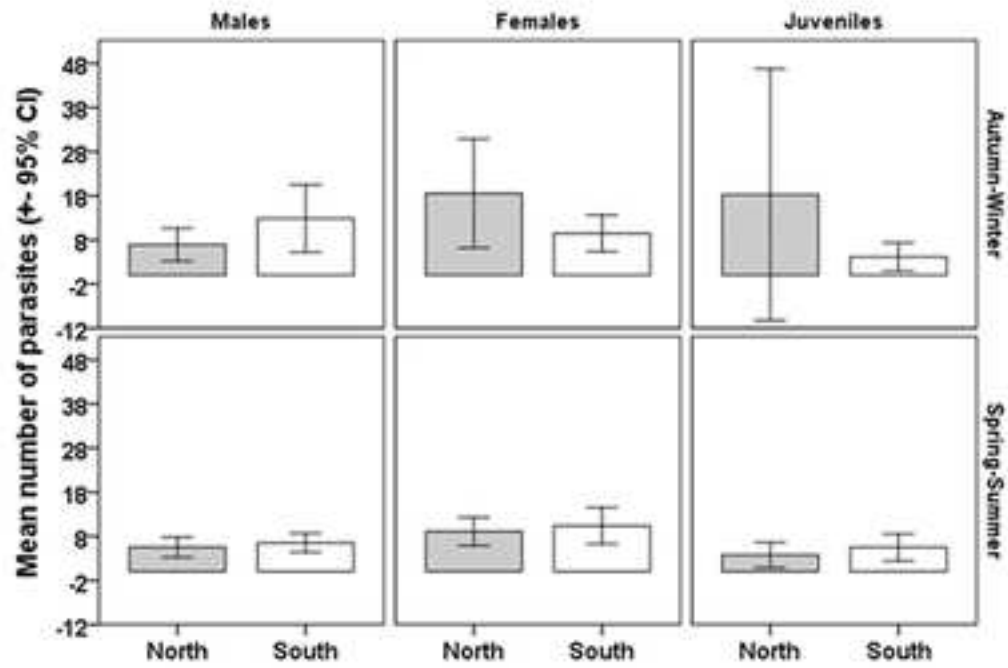


Fig. 1. de Fuentes et al.

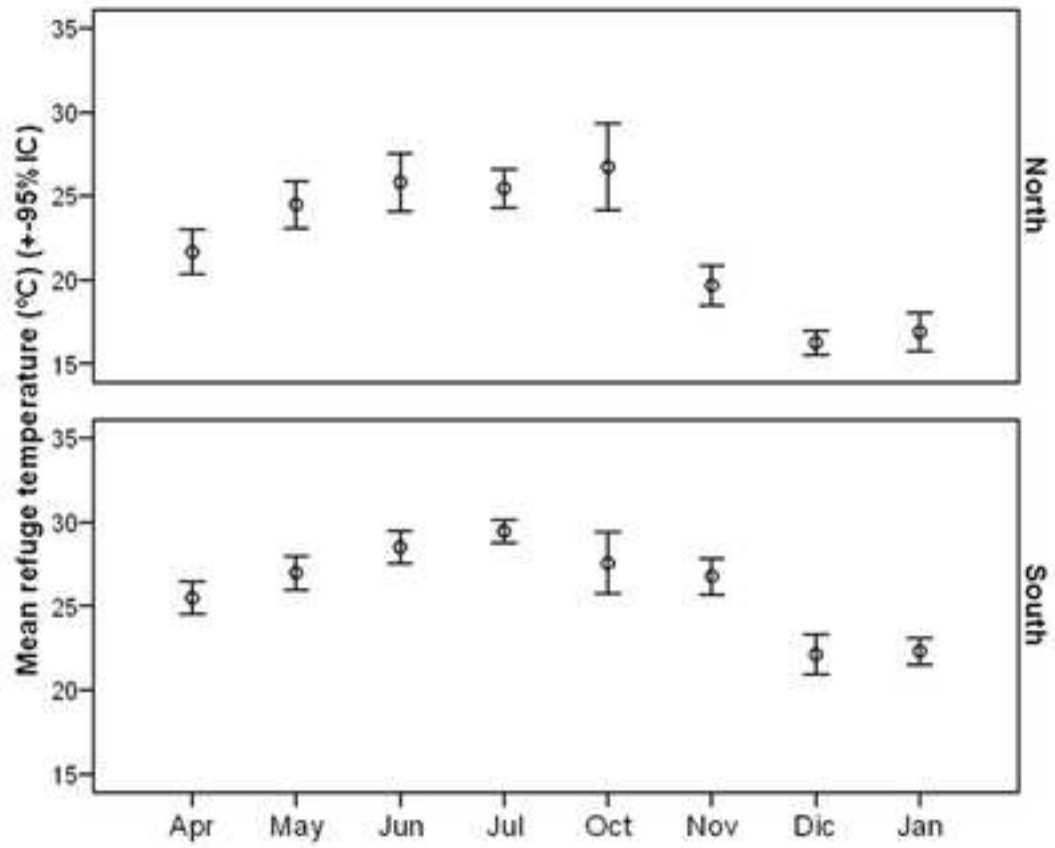


Fig. 2.- de Fuentes et al.

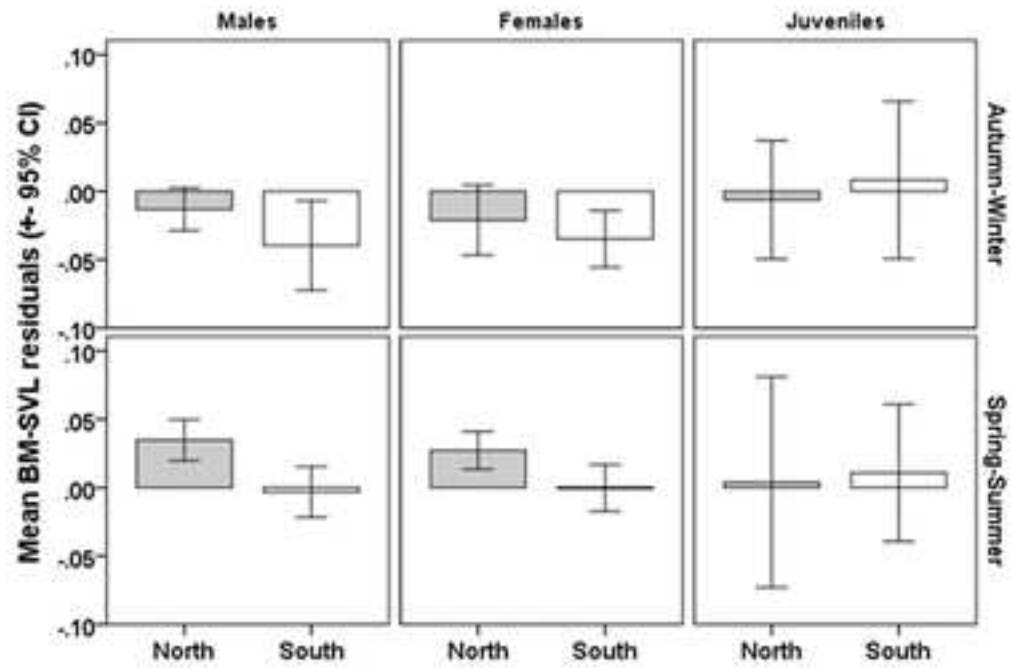


Fig. 3.- de Fuentes et al.

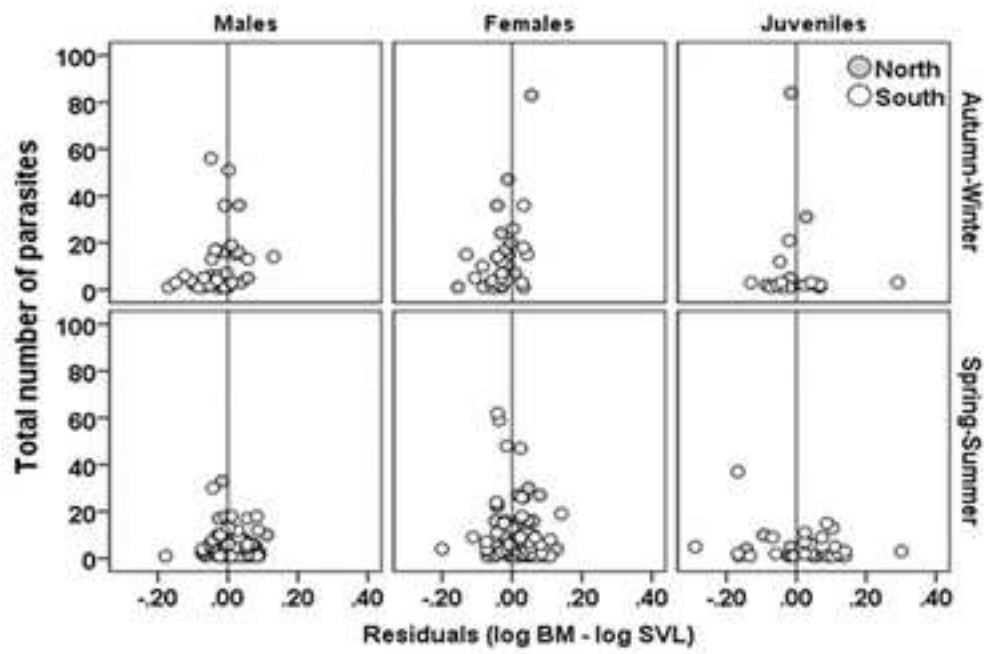


Fig.4.- de Fuentes et al.



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