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Road edge effect on the abundance of the lizard *Gallotia galloti* (Sauria: Lacertidae) in two Canary Islands forests

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Abstract. Transportation infrastructure is a main cause of environmental change in forest landscapes worldwide. In the Canary Islands, a dense road system fragment the native Canarian pine and laurel forests causing potential changes in population densities of endemic lacertid lizards (genus *Gallotia*). Our aim was to assess road edge effects on relative abundance patterns of the endemic *Gallotia galloti* in both forests. We also explored the species–habitat relationships in this road-fragmentation context. We found that lizard relative density in relation to road edges differed between forests. Lizards were more abundant along edges and leeward interior, but virtually absent from the interior of the windward laurel forest. In the pine forest, lizards were present at three distances from edge, with a net decrease in abundance from edge to interior. These patterns may be explained partly by differences in vegetation structure regarding road proximity in each forest that potentially affect the helio- and thigmothermic character of *G. galloti*, and thus its habitat use. A general suggestion of this study is that road margins create corridors that may be used by native lizards for dispersal through inhospitable forest matrix. The high road density in Tenerife may have negative implications for the conservation of the genetic variability of *G. galloti*. At the island scale, increased communication between lizard populations through road corridors might increase homogenization of the gene pool. Ecological processes in which this lizard plays important roles may also experience changes along road edges.

Introduction

Transportation infrastructure is globally recognized as a main source of ecological fragmentation and disturbance in forest landscapes (Forman et al. 2002). Roads produce loss of forest area, divide the ecosystem with artificial linear gaps, generate abrupt edges and shape landscape patterns in the surroundings (Forman and Alexander 1998). Roads also operate as corridors, through and across which species and disturbances move, penetrating variable distances into the habitat remnants (Forman 1998). In addition, road edges are habitat for many species (Spellerberg 1998).

Amongst vertebrates, birds and mammals have received the bulk of research effort regarding road disturbance and edge effects (see reviews in Bennet 1991a; Forman et al. 2002). Comparatively, less information exists about road edge effects on reptiles, especially on island ecosystems. Roads have been reported as habitat for reptiles (Way 1977; Yanes et al. 1995; Driscoll 2004; Shine et al. 2004), but they also function as a mortality sink due to vehicle traffic (Vestjens 1973; Bennet 1991a; González-Prieto et al. 1993; Rosen and Lowe 1994; Bonnet et al. 1999). A scarcely investigated topic of corridor use by animals is the role of roadsides in favouring penetration of some species, not only exotic invaders, but also native generalists, into habitats otherwise inappropriate for dwelling (Bennet 1991b; Downes et al. 1997). Other researchers have addressed the importance of habitat fragmentation, including roads as connecting as well as dividing elements, in promoting enhance or decline of different reptile species, and related these processes to changes in habitat quality of the remnants (e.g. Driscoll 2004). There are few published reports on native lizard species exploiting opportunistically the habitat provided by forest roads or other forest edges (e.g., Sartorius et al. 1999; Driscoll 2004). Particularly, the Canarian lizards are endemic lacertid species whose presence and abundance patterns in relation to the road net are still unknown.

Here we compare the use of road corridors by an endemic lacertid lizard (*Gallotia galloti*) in two forest ecosystems of the Canary Islands. The specific goals of this work were (i) to evaluate changes in relative population density of lizards on a gradient running from roadsides (edge habitats) to respective laurel and pine forest interiors, and (ii) to assess the relationships between vegetation structure and lizard abundance to examine its distribution in relation to road edges in these fragmented island forests.

Methods

Study species

Gallotia galloti (Oudart 1839) (Sauria: Lacertidae) is endemic to the Canary Islands, and its genus is represented by, at least, seven living species, two of them discovered within the last decade on isolated areas of Tenerife and La Gomera (Nogales et al. 2001). *G. galloti* is represented by three subspecies in Tenerife and one subspecies in La Palma. It is an abundant, medium-sized lizard of 130–145 mm snout-vent length (Salvador 1985; Díaz 1994) and it occupies all the altitudinal vegetation belts, from the coastal scrub to the summit scrubland (over 3000 m a.s.l.). However, it is somewhat less abundant in laurel and pine forest formations (Klemmer 1976; Bischoff 1982). Densities of up to 500 lizards per hectare have been recorded in Tenerife (Castanet and Báez 1988). *G. galloti* is omnivorous, selects areas with low shrub cover (Valido and Nogales 1994) and uses orchard walls, rocky outcrops and road verges for basking. This lizard can regulate body temperature by exposure to sun radiation and by contact with warm ground, showing some thermal independence with respect to air and substrate (Báez 1985). The activity level of *G. galloti* has been reported to reach a maximum at body temperatures ranging from 26.7–34.8 °C in spring and from 28–35.9 °C in summer (Báez 1985; Díaz 1994). At least in summer, its daily activity is maximum between 800 and 1400 h (Báez 1985; Díaz 1994).

Study areas

The field work was carried out at two laurel forest sites and two pine forest sites in Tenerife, Canary Islands (Figure 1). Site elevations ranged from 800 to 900 m in the laurel forest (Anaga massif, NE Tenerife) and 1000 to 1150 m in the pine forest (Corona Forestal Natural Park). The laurel forest is a relict formation derived from the Tertiary Mediterranean flora, formed by a rich and dense canopy (up to 10 tree species, ca. 80–90% cover) dominated by *Laurus azorica*, *Ilex canariensis*, *Myrica faya*, *Erica arborea*, *Prunus lusitanica* and *Viburnum tinus*. Laurel forest asphalt and unpaved roads were located at El Moquinal on the windward or north slope (800 m elevation). A nearby laurel forest preserve, Aguirre, was selected as continuous forest on the leeward or south-facing slope (distant 500–1000 m from any road, 800–900 m elevation) (Figure 1). The tree canopy in Aguirre was dominated by *L. azorica*, *M. faya*, *I. canariensis*, *E. arborea*, *Apollonias barbujana* and *Picconia excelsa*, with an understory dominated by *V. tinus* and tree saplings. We included this area to relate lizard abundance to vegetation structure in conditions of preserved laurel forest, due to virtual absence of lizards in forest interior at the windward slope after preliminary field observations. We could not locate roads (either paved or unpaved) in leeward slope for comparison (there were only impoverished and partially cleared *Myrica–Erica* remnants).

The Canarian pine forest is mostly a monospecific tree formation of *Pinus canariensis*, with an understory of *Chamaecytisus proliferus*, *Cistus symphytifolius*, *Daphne gnidium*, *M. faya and E. arborea*, with *Asphodelus aestivus* and some grasses (Poaceae) in the herb layer. In the pine forest, two unpaved road segments were studied in La Esperanza (1150 m elevation, southeast-facing) and La Guancha (1050 m elevation, north-facing) sites (Figure 1).

Sampling design

Each lizard census transect was 100 m in length. In the laurel forest we established 23 transects on roadsides on the windward slope, 11 transects 50 m from roads on the windward slope, and 10 transects more than 500 m from roads on the leeward slope (Aguirre) (Figure 1). In the pine forest 36 transects were realized in roadsides, and 32 transects at 50 and 150 m running parallel to the road edge. The 100 m transects were adjacent (i.e., consecutive) within sites

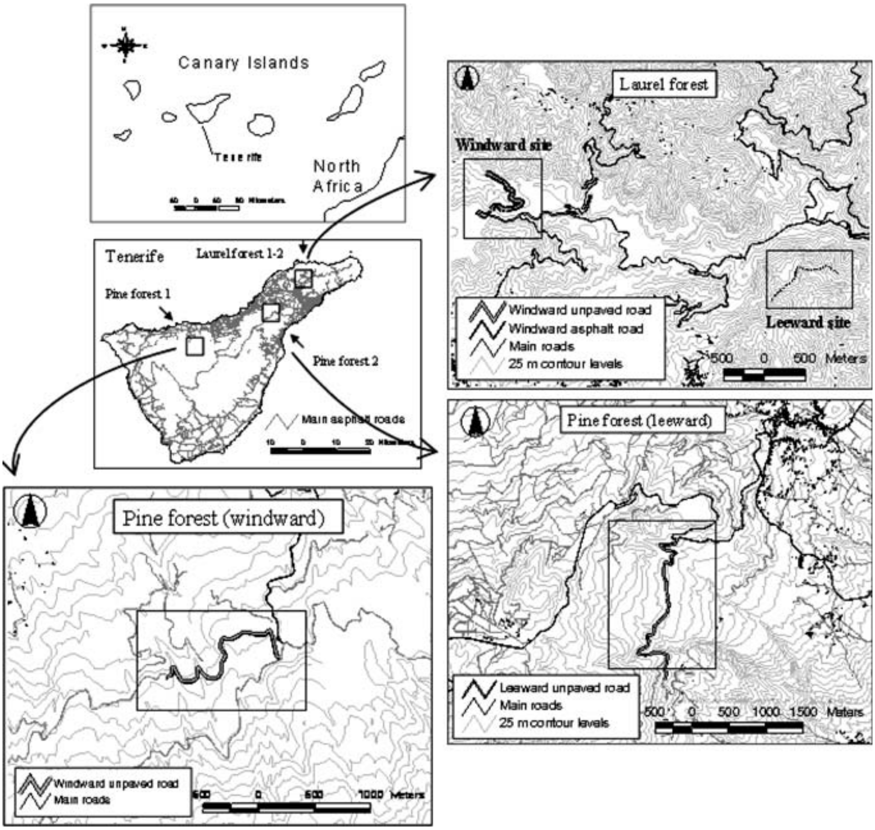

Figure 1. Location map of the study sites and transects in laurel and pine forests.

and hence there was a probability that census units were not independent. We tested for serial independence of transects with a runs test, using the mean as the reference value (the result did not differ if the median was used) (Siegel and Castellan 1988). Runs tests were applied separately for different transect situations (road or interior) and forest (laurel or pine). The significance level was set at $\alpha = 0.05$. Runs test indicated that the lizards were distributed at random between adjacent transects and that census units were thus independent: laurel forest: windward unpaved road ($Z = 0.899$, $p = 0.369$); windward asphalt road ($Z = 1.406$, $p = 0.160$); leeward interior ($Z = 1.006$, $p = 0.314$); pine forest: leeward unpaved road ($Z = 1.934$, $p = 0.053$); windward unpaved road ($Z = -0.488$, $p = 0.626$).

The location and selection of transects was directed by the availability of asphalt or unpaved road segments in suitable habitats. In the laurel forest, the windward slopes, and especially the forest ridges, are less suitable for lizard populations due to high frequency and intensity of fresh and humid trade winds and to higher canopy concealing compared to leeward slopes. In addition, vegetation concealing prevented efficient walking and visibility in dense laurel forest on the windward slope. However, the pine forest interior in our study areas is less dense, allowing higher visibility and easier walking for lizard census purposes. All the paved and unpaved roads studied were relatively narrow and similar in width (~6–7 m) so we considered corridor width a negligible source of bias. We established transects at least 100 m from overlapping linear infrastructures (other roads, trails or firebreaks) to avoid their potential influence on lizard density.

Lizard census

Lizard counts were performed during the summer between 3 August and 3 September 1998, between 1030 and 1430 h, under clear sky and absence of strong wind. In the late spring and summer season lizards are abundant and active along road gaps in the Canarian forests. All lizards seen or flushed within a 5 m width band on each side of the observer's progression line were counted by walking in each transect (Díaz and Carrascal 1991; Castilla and Bauwens 1992). This method provides a relative measure of lizard density (lizards per 0.1 ha) and allows reliable comparison between habitats (Martín and López 2002).

Habitat description and analysis

As predictor of lizard density, habitat structure was assessed along census transects at regular intervals. Every 50 m, and within a circle centred on the census band (radius = 5 m, area = 78.5 m^2), we estimated the following variables: canopy height (CANO); percentage cover of grass ≤ 30 cm height (GRAS) and > 30 cm height (GRA2; not included in the laurel forest); cover of shrubs ≤ 2 m height (SHR1) and > 2 m height (SHR2); leaf litter cover (LITT), compound of aciculae in the pine forest, evergreen leaves in laurel forest; cover of the rocky substrata for rocks > 10 cm diameter (ROCK), potentially used as a refuge and basking support by lizards; and number of tree stems per class of diameter at breast height (dbh): laurel forest: ≤ 10, 10–20, 20–30 and > 30 cm (TR10, TR20, TR30 and TR30+); pine forest: ≤ 20, 20–60 and > 60 cm (TR20, TR60 and TR60+).

We applied non-parametric procedures (Mann–Whitney's U and Kruskal–Wallis tests) to evaluate differences in lizard relative density and habitat structure between road edge and forest interior. Principal component analysis (PCA) was used to reduce the number of independent variables (habitat descriptors) to a non-redundant combination of explanatory variables. The validity of the analysis was assessed with the Kaiser–Meyer–Olkin (KMO) sampling adequacy test (KMO > 0.7) and the sphericity test ($p < 0.001$)

(Kaiser 1974). Only factors with eigenvalues higher than one were selected, and Varimax rotation was applied for a better interpretation of axes. The associations between each principal component (PCA factors) and total lizard density per transect unit were studied with Spearman rank correlation analysis. We used non-metric multidimensional scaling (MDS) analysis to represent the spatial variation in habitat structure in relation to road edges in both forests. The Proxscal procedure was selected and the squared Euclidean distance was used as a measure of dissimilarity for the scaling solution. The S-Stress was used as an index of adjustment. All statistical analyses were performed in SPSS 12.0.

Results

A total of 288 and 91 lizards were counted in laurel and pine forest respectively. Average lizard densities per transect unit were significantly higher in the laurel forest (mean ± SD = 5.54 ± 6.24, range = 0–26 lizards, $n = 44$ census units) than in the pine forest (1.44 ± 1.52, range = 0–7 lizards, $n = 100$ census units) (Mann–Whitney's U = 741.5, $p = 0.012$).

In the laurel forest, mean lizard density was significantly higher along road edges (6 ± 4.36, range = 0–16 lizards) than at forest interior (1.85 ± 3.05, range = 0–10 lizards) (U = 99, $p < 0.001$) (Figure 2).

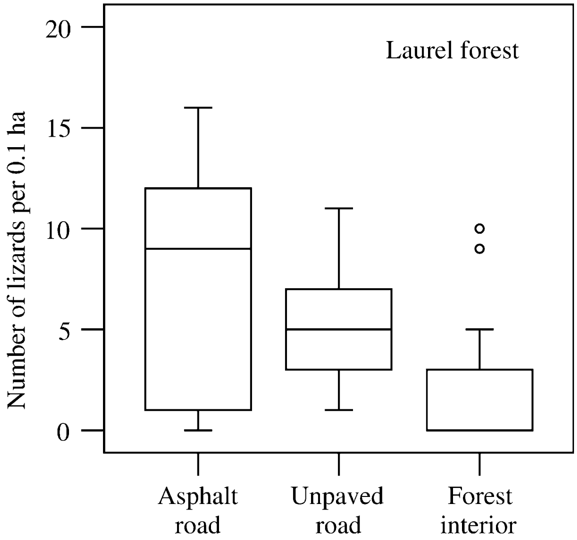

Figure 2. Differences in relative population density of *G. galloti* between edge of asphalt roads, unpaved roads, and interior (> 50 m from the edge) of the laurel forest. Shown are mean, first, and third quartiles, upper and lower values and outliers (open circles).

No lizards were found at laurel forest interior in the El Moquinal site (windward slope). However, in the leeward laurel forest (Aguirre) lizards were relatively abundant (3.7 ± 3.47, range = 0–10 lizards) (Figure 2). There were not significant differences between lizard densities along asphalt and unpaved road edges in laurel forest (U = 58, $p = 0.317$) (Figure 2).

In the pine forest, lizard density decreased significantly between unpaved road edge (2.39 ± 2.03, range = 0–7), and interior at 150 m (0.67 ± 0.78, range = 0–2) (Kruskal–Wallis test = 7.26, $p = 0.026$) (Figure 3). However, these differences were significant only between 5 and 150 m (U = 50, $p = 0.011$), but neither between 50 and 150 m (U = 62, $p = 0.098$), nor between 5 and 50 m (U = 104, $p = 0.164$) (Figure 3).

For the laurel forest, the PCA analysis on habitat descriptors extracted four factors with eigenvalues > 1, accounting for ca. 73% of the variance in the data (Table 1). In this forest, we found a modest negative association between relative lizard density and the first PC ($r_s = -0.611, p < 0.001$) (Table 2). This first component had high loadings for the variables related with mature forest with dense and tall canopy (CANO, LITT, TR20) and tall understory shrub cover (SHR2) (Table 1). Also, there was a significant but moderate, positive relationship between lizard density and the third PC ($r_s = 0.49, p = 0.001$). This factor scored high for low shrub understory (SHR1), and cover of low grass (GRAS). No significant associations were found between lizard density and the second and fourth PCs ($p > 0.05$, Table 2), which had high loadings

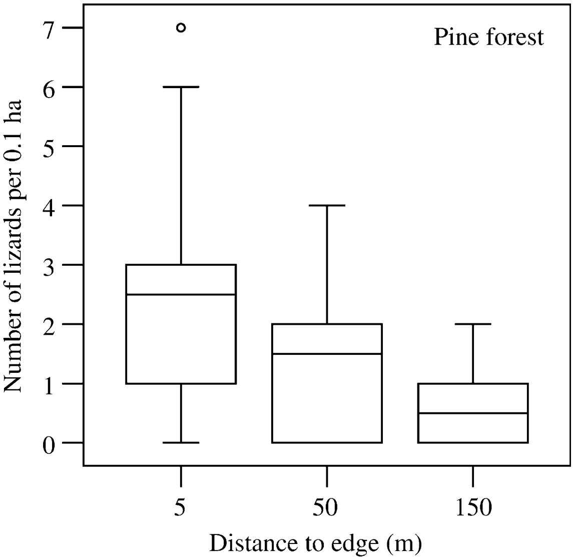

Figure 3. Differences in relative population density of *G. galloti* along the road edge-interior gradient in the pine forest. Shown are mean, first, and third quartiles, upper and lower values and outliers (open circle).

Table 1. Principal components analysis of lizard's habitat descriptors in laurel and pine forests.

Laurel forest	PC1	PC2	PC3	PC4	Pine forest	PC1	PC2	PC3
LITT	**0.87**	0.23	0.00	0.13	ROCK	−**0.79**	0.38	0.23
CANO	**0.80**	0.23	−0.45	0.05	GRA2	**0.77**	0.22	0.22
TR20	**0.74**	0.31	−0.32	0.11	LITT	**0.77**	−0.43	−0.20
SHR2	−**0.67**	0.31	−0.23	0.15	GRAS	**0.63**	0.05	0.45
TR10	0.05	**0.88**	0.02	−0.08	SHR2	−**0.60**	0.18	0.20
TR30	0.33	**0.68**	−0.16	0.27	SHR1	−0.12	**0.86**	−0.02
GRAS	0.04	−0.16	**0.77**	0.08	TR60+	0.09	−**0.71**	0.24
SHR1	−0.41	0.20	**0.68**	−0.25	TR20	0.18	0.28	−**0.75**
ROCK	0.03	−0.08	0.11	**0.86**	TR60	0.06	−0.07	−**0.64**
TR30+	0.06	0.35	−0.35	**0.63**	CANO	0.18	−0.45	**0.60**
Eigenvalue	3.58	1.51	1.20	1.04	Eigenvalue	3.11	1.95	1.27
CVar (%)	35.77	50.85	62.81	73.20	CVar (%)	31.12	50.63	63.33

Shown are varimax rotated factor loadings, eigenvalues, and cumulative variance (CVar) of principal components (PC). Significant higher factor loadings (> 0.5, in absolute value) are shown for each variable and used in the interpretation of axes. Variable codes in main text (Methods).

for density of both thin and thick stems (T10, T30, T30+) and cover of rocks (ROCK) (Table 1). Canopy height (CANO) was the individual habitat variable showing the strongest correlation with lizard density ($r_s = -0.857$, $p < 0.001$), whereas the strongest positive correlation was found with cover of low shrubs (SHR1) ($r_s = 0.442$, $p = 0.002$).

In the pine forest, the PCA extracted three factors with eigenvalues > 1 which explained 63% of the variance in the data (Table 1). Lizard density showed a moderate positive association with the first factor ($r_s = 0.409$, $p = 0.006$), which scored high for cover of rocks (ROCK), needle litter (LITT), grass cover (GRAS, GRA2) and tall understory shrub (SHR2). No significant correlations were detected between lizard density and the second and third PCs (Table 2), which described the structure of more mature pine stands with low shrub cover in the understory (CANO, TR20, TR60, TR60+, SHR1) (Table 1). The original habitat variable more strongly associated with lizard density was the cover of tall grass (GRA2) ($r_s = 0.434$, $p = 0.003$).

Table 2. Spearman rank correlations (r_s) between principal components describing habitat, and lizard relative density in laurel and pine forests (habitat data pooled regardless edge proximity).

Principal components	Laurel forest		Pine forest	
	r_s	p	r_s	p
PC1	−**0.61**	<0.001	**0.41**	0.006
PC2	−0.20	0.190	0.11	0.480
PC3	**0.49**	0.001	−0.09	0.548
PC4	0.25	0.100		

Significant correlations ($p < 0.05$) are shown in boldface.

The multi-dimensional scaling ordination (MDS) based on vegetation descriptors showed high dissimilarity but little gradation between lizard census sites (Figure 4). Large differences in vegetation structure were found in laurel forest, with relatively higher similarity between leeward and windward interior sites, and important differences between unpaved and asphalt road edges (Figure 4). No clear pattern appeared in pine forest regarding distance to road edge, as the three distances seemed roughly equidistant in terms of vegetation structure (Figure 4). In the laurel forest, four original habitat variables changed significantly between edge and interior. Canopy height (CANO) ($U = 50.5$, $p < 0.001$), litter cover (LITT) ($U = 69.5$, $p < 0.001$), and density of tree stems in various dbh classes (TR10: $U = 110.5$, $p < 0.001$; TR20: $U = 23$, $p < 0.001$ and TR30: $U = 51.5$, $p < 0.001$) were lower along road edges than in forest interior. Contrastingly, neither there were no

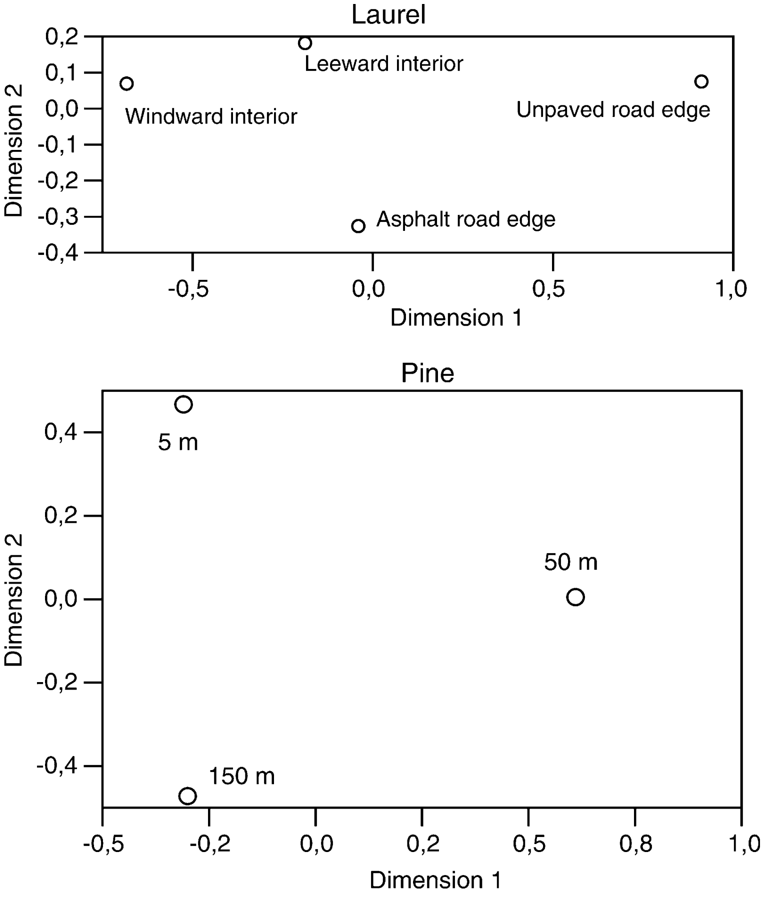

Figure 4. Non-metric multidimensional scaling (MDS) analysis of habitat traits in relation to road edges in laurel (S-Stress = 0.025) and pine (S-Stress = 0.00011) forests.

significant changes in habitat features among distances to the edge, nor between any two given distances in the pine forest ($p > 0.05$).

Discussion

In this study we found that *G. galloti* was consistently more abundant along road edges than at forest interior in both laurel and pine forests (i.e., there is an edge effect on lizard relative density). High road density attained in Tenerife forests may allow lizards to penetrate into the transformed forest by locally creating favourable conditions. By dispersing along forest road corridors, these island lizards can pass through inhospitable forest matrix and reach previously isolated habitats. In fact, both presence and abundance of *G. galloti* lizards have probably increased in Tenerife due to creation of artificial edge habitats, including agricultural infrastructures, deforestations, and road creation (Machado et al. 1985). Potential consequences of lizard expansion through road corridors deserve attention. High microgeographic variation has been reported among different subpopulations of*G. galloti* in Tenerife (Thorpe and Báez 1987). In this context, the connection of distant habitats by a dense road net within an island might promote decrease of genetic variability, or increase homogenization, of the gene pool of naturally isolated subpopulations of *G. galloti* (see e.g., Coates 1991). Such homogenization could take place both within and between ecosystems, and both horizontally and on the altitudinal gradient, since roads interconnect practically all habitat types and vegetation belts in Tenerife. As in our study, it has been shown that some widespread lizard species may have greater densities near road edges, whereas others are significantly less abundant (New South Wales, Australia, Driscoll 2004). In such fragmentation contexts, isolation of remnants of native vegetation by a hostile matrix causes decline in sensible species with weak dispersal power and small population size, whereas widespread species are less affected or even favoured (Driscoll 2004).

Increase of population densities and movements of *Gallotia* lizards along road edges in laurel and pine forest may have also ecological consequences, in the form of edge effects on seed dispersal systems in these forests. Canarian lizards are omnivorous with a strong herbivorous component in their diet, especially fleshy fruit (Olesen and Valido 2003; Valido et al. 2003). *G. galloti* from semiarid Tenerife lowlands are mostly frugivorous during a great part of the year (Valido and Nogales 1994). Fleshy-fruited plants are dominant along the margins of laurel forest roads, but are rare in Canarian pine forest edges (Delgado et al. 2004). Hence, lizards might represent an important vector for seeds of many plants, which would be dispersed along and across road edges to unknown distances. Also, important lizard predators such as kestrels (*Falco tinnunculus*) and feral cats (*Felis catus*), are frequent users of road gaps (Meunier et al. 2000; Burrows et al. 2003) and they can act also as secondary seed dispersers (Nogales et al. 2002). It would be interesting for the future dynamics of forest edges to know how far *Gallotia* lizards can disperse seeds along, to and from roads, and how large are lizard home ranges and movement patterns in these linear habitats (see e.g., Tischendorf and Wissel 1997). A comparison between different altitudinal ecosystems traversed by roads from coast to summit would provide insight on road edge effects on Canarian lizards.

Environmental planning regarding road schemes has included lizard species as indicators of areas of conservation interest elsewhere (Treweek et al. 1998). Whereas the two giant *Gallotia* lizards recently discovered in Tenerife and La Gomera are endangered species due to small population size, introduced predators and habitat fragility (Hernández et al. 2000; Nogales et al. 2001), more common species such as *G. galloti* are expanding their potential habitat areas due to anthropogenic transformation of the territory (Tello-Marquina 1979; Machado et al. 1985). To our knowledge, there is no published evidence of competence between the smaller and abundant *G. galloti* and the giant and endangered *G. intermedia* in Tenerife, but it seems likely to occur where they cohabit (Rando and López 2001). However, such interaction is unlikely to be directly related with roads, since *G. intermedia* populations are limited to inaccessible cliffs located far from roads.

Relative population density of lizards was higher in the laurel forest than in the pine forest, regardless of edge proximity. However, lizards were found in higher densities on leeward (south-facing) than on windward laurel forest, where their presence was largely restricted to the road gap. We could not perform transects along leeward road edges, but lizards probably might find more suitable habitat in forest adjacent to leeward road edges. Although it was not a primary objective of our study, these differences suggest that, through variation in exposure to dominant trade winds and sun angle, aspect of the forest area is an important factor conditioning road use by *Gallotia* lizards at the island scale. Furthermore, differences in lizard relative abundance between laurel and pine forest could be partly caused by the large variation found in lizard numbers in laurel forest. This, in turn, could be attributed to a higher within- and between-transects variation in habitat features in the more heterogeneous laurel forest.

The degree of lizard association with road edges, and penetration from these to forest interior may depend on forest type and vegetation structure, as well as on the lizard's thermoregulatory capabilities (Báez 1985; Díaz 1994; Sartorius et al. 1999). The use of edge structures by lacertid lizards is conditioned by habitat structure and thermal habitat preferences, predator avoidance and food availability, as reported for other ecosystems (Ouboter 1981; Carrascal et al. 1989; Díaz 1994; Valido and Nogales 1994). As it has been found in other lizard species (i.e., *Ameiva ameiva*, Teiidae, Sartorius et al. 1999), forests are marginal habitats in terms of the thermal performance of some lizards. Other species show different responses to forest edge depending on season (i.e., *Norops*, Iguanidae, Schlaepfer and Gavin 2001). In our interior sites lizards showed higher densities under sparse, low tree canopy with some tall shrub cover, which probably provides a less constrained thermal environment within forest habitats. Forest clearings such as roads provide higher environmental temperatures (Bogren and Gustavsson 1991), and thus may favour a more efficient foraging and predator avoidance in lizards (Sartorius et al. 1999). In addition, vegetation and substrate structure traits showed a marked variation between edge and interior in laurel forest but not in pine forest (see Figure 4).

In the laurel and pine forests, the zone of road edge influence characterized by higher sun exposure, higher temperatures, high shrub, grass and rock cover is relatively narrow. In a previous work, Delgado et al. (2004) reported road edge effects in microclimate, vegetation structure and floristics in laurel and pine forests in Tenerife. Vegetation and microclimate (i.e., light, moisture and temperature regimes) changed abruptly within the first 5–10 m from forest road edges, especially in laurel forest. Ground temperatures experienced drastic reductions between road edge and 100 m toward the forest interior (11 °C in laurel forest, 5 °C in pine forest), and average light intensity reaching the ground was also significantly reduced. Furthermore, corridor types differing in surface type (asphalt vs. earth) may differ in some abiotic and biotic traits (Forman et al. 2002; Delgado et al. 2004) that may affect reptile population density and behaviour (e.g., Shine et al. 2004). However, *Gallotia* densities were apparently similar between unpaved and asphalt road edges, despite remarkable differences in vegetation and road surface type.

In Tenerife lowland areas, *G. galloti* prefer low shrub cover with interspersed rocks as refuges and basking perches (Díaz 1994; Valido and Nogales 1994). Apart from the forest canopy features, which mostly affect the behaviour of regulation of body temperature through sun exposure, the availability of rocks for basking is critical for the regulation by contact and thus for the distribution of *G. galloti* (Báez 1985; Díaz 1994). The cover of exposed rocks (>10 cm diameter) was rather low along edges and in laurel forest interior, which could be a further factor precluding high densities of lizards inside the forest. In the pine forest lizard density was negatively and weakly related to tall shrub and rock cover. Rock cover was, however, very high at both edge and interior of pine forest. Also, lizard relative densities are, on average, lower in the Tenerife forests (about 1–6 lizards, 0.1 ha^{-1}, this study) than in coastal ecosystems (15–20 lizards, 0.1 ha^{-1}, A. Valido, personal communication), a factor that may itself yield statistically weaker lizard–habitat associations in forests compared to habitats at lower elevations and with more dense and shrubby vegetation.

The degree of road fragmentation of the whole Canarian archipelago is alarming: about 8568 km of roads bisect the Tenerife island, occupying ca. 5700 ha (3% of the island area as a conservative estimate). Such a dense road net might influence patterns of distribution and abundance of native as well as introduced vertebrate species (Delgado et al. 2001). The road influence zone, as defined by Forman and Deblinger (2000), may provide new potential habitats for opportunistic species such as some native lizards, and thus promote their range expansion to new areas that are otherwise hostile at the island scale.

Further studies should investigate the potential effects of roads on the overall population size of these endemic island lizards, and to assess the possible spurious genetic effects of road connection of previously isolated lizard subpopulations.

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