THE HABITAT USE OF TWO SPECIES OF DAY GECKOS (*PHELSUMA ORNATA* AND *PHELSUMA GUIMBEAUI*) AND IMPLICATIONS FOR CONSERVATION MANAGEMENT IN ISLAND ECOSYSTEMS

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Abstract.—Many fragile ecosystems across the globe are islands with high numbers of endemic species. Most tropical islands have been subject to significant landscape alteration since human colonisation, with a consequent loss of both habitat and those specialist species unable to adapt or disperse in the face of rapid change. Day geckos (genus *Phelsuma*) are thought to be keystone species in their habitats and are, in part, responsible for pollination of several endangered endemic plant species. However, little is known about key drivers of habitat use which may have conservation implications for the genus. We assessed the habitat use of two species of *Phelsuma* (*Phelsuma ornata* and *Phelsuma guimbeaui*) in Mauritius. Both species showed a strong affinity with tree trunks, specific tree architecture and are both restricted to native forest. Tree hollows or cavities are also important for both species and are a rarely documented microhabitat for arboreal reptiles. Both *P. ornata* and *P. guimbeaui* avoid areas of high disturbance. Our data suggest that active conservation of *Phelsuma* requires not only the protection and restoration of native forest, but also implementation of forestry practices designed to ensure the presence of suitable trees.

Key Words.—habitat selection; Mauritius; *Phelsuma*; reptile conservation; tree cavities

INTRODUCTION

Island ecosystems are extremely fragile but important in global biodiversity due to species endemism (Noble et al. 2011), and display significant levels of speciation in some taxa (Losos 1986; Harmon et al. 2007). Most tropical islands have also been subject to significant landscape alteration since human colonization, with a consequent loss of both habitats and those specialist species unable to adapt or disperse in the face of rapid change (Safford 1998; Cheke and Hume 2008). The effects of habitat change are often compounded in island ecosystems through the introduction of non-native species; either the floral and structural composition of remaining habitat changes (North and Bullock 1986) and/or predators/competitors disrupting community assemblages (Losos 1986; North et al. 1994; Hanley et al. 1998). Within island ecosystems, reptiles are generally considered to form an integral and important role, filling empty niches occupied elsewhere by either mammalian or avian counterparts (Noble et al. 2011).

As a group, ectotherms are particularly susceptible to habitat alteration due to a strong dependency on environmental parameters (Sinervo et al. 2010; Lelièvre et al. 2013). Therefore, refugia selection and availability is an important determinant of the viability of many reptile populations (Croak et al. 2008). Selection of retreat sites is a specific process linked to multiple criteria in themselves connected to individual fitness (Shah et al. 2004; Croak et al. 2008) with individuals often being strongly philopatric to refugia sites (Pike and Grosse 2006). Refugia present opportunities for species associated with them; refuge from predators (Downes and Shine 1998), access to prey and critically, a suitable thermal and hydric environment (Schwarzkopf and Alford 1996; Kearney 2002; Croak et al. 2008). Overall, refugia selection is dependent on size and temperature (Pike et al. 2010). However, despite their importance for population viability, refugia are rarely studied in depth for terrestrial lizard species (*sensu* Downes and Shine 1998; Croak et al. 2008, 2013; Pike et al. 2010) and even far less documented for arboreal lizards, especially compared to mammal and bird species (Webb and Shine 1997).

Reliance on arboreal refugia has implications for the survivorship of species under certain forestry practices (Gibbons et al. 2002; Cole 2005) and in specific habitat types, such as transitional stage vegetation. The net result for many species is the creation of sub-optimal habitat and the need for conservation action and management. While it is important to understand the

historic mechanisms that have led to speciation, of more pressing concern is implementing management practices which assist species persistence in threatened habitats (*sensu* Buckland et al. 2014). To provide appropriate assistance, a clear understanding of the drivers of habitat choice, as well as proximal threats to survival, are required before conservation management can take place.

Typical island families such as anoles (*Anolis* spp.) and day geckos (*Phelsuma* spp.) exemplify role diversification and use a range of habitats, but exact refugia choice is less well documented (*sensu* Cole 2005). For example, many of the *Phelsuma* spp. are arboreal but differ in that they do not take typical gecko roles within the ecosystem (Losos 1986). In Mauritius, *P. ornata* is considered to be a keystone pollinator of several endemic plants, including endangered taxa (Nyhagen et al. 2001; Hansen et al. 2006). Further, it appears that endemic plants use these unique saurian pollinators and offer tailored nectar rewards, emphasising the importance of the genus in the ecology and persistence of endemic vegetation in the Mascarene Islands (Hansen et al. 2006). This interconnectivity between species potentially complicates conservation efforts, especially if the goal is to remove invasive flora and restore native habitat. Without understanding microhabitat requirements for the lizard, short-term removal of modified floral areas may impact on gecko population sizes, if measures are not taken to provide appropriate refugia (Webb and Shine 2000; Pike et al. 2010).

We identified the macro- and microhabitat use of *P. ornata*. Here, we ask: how does the habitat use of a *P. ornata* vary with vegetation composition, both structural and compositional type? To gain a more complete picture of the niche of *P. ornata*, we also consider whether habitat use is consistent between mainland and island sites and in the presence of a potential endemic competitor, *P. guimbeaui*. We consider the conservation implications of habitat use of both species and current management practices.

MATERIALS AND METHODS

Study sites.—We conducted surveys on *P. ornata* and *P. guimbeaui* between 1 April and 31 May 2000 at two sites in Mauritius in the Indian Ocean: Ile aux Aigrettes and Black River Gorges National Park (Black River Gorges). Ile aux Aigrettes is a 25-ha islet 700 m off the south-east coast of Mauritius (Parnell et al. 1989). The islet was originally covered with dry coastal forest, which also covered the east coast of Mauritius; however Ile aux Aigrettes together with the mainland and other offshore islands have seen severe deforestation and degradation (Bullock 1986; North and Bullock 1986; North et al, 1994). The introduction of Domestic Goats

(*Capra hircus*), Black Rats (*Rattus rattus*), Indian House Shrews (*Suncus murinus*), House Cats (*Felis domesticus*), Giant African Land Snails (*Achatina panthera*) and introduced flora has severely damaged the native flora (Monty et al. 2013; Carl Jones, pers. comm.). Since the declaration of the islet as a nature reserve in 1965, Domestic Goats, House Cats, and Black Rats have been successfully eradicated (Jones and Hartley 1995). At the time of study the floral composition was characterized by invasive species mixed with remnant Ebony forest. The only endemic *Phelsuma* species present was *P. ornata*. The Black River Gorges National Park is located on mainland Mauritius and, at 67 km², is responsible for protecting 44% of the total area of native vegetation, which includes dry lowland forest, humid upland forests, and marshy heathland (Safford 1998). We surveyed low altitude forest in the southwestern section of Black River Gorges and continued in a broken trail to native forest in a fenced, managed plot approximately 200 m above sea level. For comparison, the study site at Black River Gorges only focused on dry, lowland forest. Both endemic *Phelsuma* species (*P. ornata* and *P. guimbeaui*) are found within the Black River Gorges boundaries.

Transect line and point count positioning.—We established two 1.25 km transect lines, one on Ile aux Aigrettes and the second in Black River Gorges. To provide a balanced overview of habitat use, we ensured that transect lines passed through three major vegetation types (Table 1). Due to the higher altitude of the native forest at Black River Gorges, we found it was necessary to split the transect line to directly reflect the proportion of introduced vegetation to native vegetation over the transect line on Ile aux Aigrettes. Vegetation was defined in a survey of the island by John Mauremootoo of the Mauritian Wildlife Foundation (John Mauremootoo, pers. comm.) and by Parnell et al (1989). We spaced stratified point counts 25 m apart on alternate sides along the transect line, with 50 point counts in total, and a minimum of 16 in each vegetation category of monoculture, transitional vegetation, and native forest (Table 1). To limit potential sources of bias arising from edge effects between the vegetation and transect line, we set each point count 10 m into the vegetation, 90° from the transect line (*sensu* Sutherland 1998). Our point count positions were marked on the trail and at 10 m inside, to aid in location as well as form a center from which measurements of variables could be taken.

Data collection.—To avoid bias in observations likely to occur because of changes in the active period of geckos throughout the day, we changed the order in which we walked the point counts daily. We alternated between either morning (approximately 0830 to 1200) or afternoon (1201 to 1700) transect walks on each day,

TABLE 1. Vegetation categories and definitions developed from Parnell et al. (1989) and John Mauremootoo (pers. comm.) used to classify vegetation on transect lines at Ile aux Aigrettes and Black River Gorges National Park. The native forest in the Black River Gorges National Park was located at a higher altitude than the native forest of Ile aux Aigrettes; however, no other native lowland forest remains in Mauritius to provide a direct comparison.

Vegetation type	Site	
	Ile aux Aigrettes	Black River Gorges National Park
Monoculture	Coastal and inland community dominated by the introduced species *Leuceana leucocephla* (ca.2-3 m tall) containing other species such as *Casuarina equisctifolia* and *Cassytha filiformis*, occasionally interspersed with isolated endemic species such as *Draceana concinna* and *Gastonia mauritiana*.	The introduced species Guava (*Psidium cattleianum*) is dominant, replacing *Leuceana leucocephla* and coastal vegetation present on Ile aux Aigrettes, again interspersed with endemics.
Transitional	Highly disturbed areas of both introduced and endemic vegetation, variable in species composition but often containing *Flacortia indica, Coptosperma borbonicum,* as well as rare endemics such as *Diospyros egrettarum*.	Variable in species composition (both native and introduced), often containing *Eucalyptus* species, *Schinus terebenthifolia* and *Sideroxylon* species.
Native Forest	Areas with little or no introduced flora, minimal disturbance. A tall community (4-5m) dominated by *Diospyros egrettarum* with a ground layer of *Phymatodes scolopendria* (Parnell et al. 1989).	A tall community dominated by *Eugenia* and *Diospyros* species, equivalent to *Diospyros* dominant native forest on Ile aux Aigrettes.

therefore covering mornings and afternoons equally. We collected data from each point count for 6 min (1 min to settle and 5 min counting), a time frame chosen from results from a preliminary survey. During the point count, we scanned the surrounding area within a radius of 5 m (canopy to ground, 360°). We recorded the species and numbers of geckos observed. We also recorded the following data for each gecko observed: height in vegetation, estimated perch circumference, substrate present on (rock/soil, tree trunk, branch, foliage/canopy), time of observation, and tree architecture. Tree architecture followed the categories used in bird surveys, with category E added: Branching above half its height (A), Branching below half its height (B), Branching above half its height, but with scars or cavities (C), Vertical branching (D), Branching below half its height, but with scars or cavities (E; Bibby et al. 1998).

Identification of geckos.—We identified geckos using distinguishing marks as presented by Vinson and Vinson (1969). *Phelsuma ornata* is a distinct species with a clearly visible white ocular streak and brown markings around the head followed by an emerald green dorsal surface. Color patterns are consistent between adults and juveniles. *Phelsuma guimbeaui* is universally bright emerald green with brick red markings on the dorsal surface. Juvenile *P. guimbeaui* have a dull grayish coloration while sub-adults have indistinct adult coloration (Buckland et al. 2014).

Habitat data.—In addition to gecko data, we recorded habitat data at each point count; percentage cover herb layer (defined as: 0–0.5 m tall), percentage cover shrub layer (> 0.5–2 m), percentage cover canopy (> 2 m), tree height of nearest 10 trees (> 2 m), tree circumference at breast height of nearest 10 trees (> 0.1 m), percentage of trees within each tree architecture category, cavity numbers, and relative tree density. We counted the number of cavities within the area of the point count and placed cavities into bands: band 1 (0 cavities), band 2 (1–10 cavities), band 3 (11–20 cavities), up to band 12 (100+ cavities). Cavities are defined as holes or scarring within a tree trunk/branch greater than ca. 8 cm in length and ca. 4 cm in width. We calculated relative tree density for each point count according to Bibby et al. (1998): $D = 100,000/\pi \, (dmax^2)$ where D = tree density per hectare and dmax = distance to the furthest of the nearest 10 trees to the point count center.

Statistical analysis.—We analyzed all data using SPSS 9.0 for Windows (SPSS Inc., Chicago, Illinois, USA). We made comparison within sites, between species, and between structural variables using non-parametric tests, and despite applying transformations to the data (both logarithmic and square root), most of the data showed neither normality nor homogeneity of variances. We developed multiple regression models to determine gecko habitat use. Data for multiple regression analysis were log-transformed to normalize data. Primary relationships between variables and gecko numbers were gauged initially from scatter plots with fitted lines and visually inspected for departure from linearity and then by inspection of residual plots. We used simple linear regression to give a coarse overview

TABLE 2. Significant gecko variables (Kruskal-Wallis, *H*) measured at Ile aux Aigrettes and Black River Gorges National Park, Mauritius.

			Site			
			Ile aux Aigrettes		Black River Gorges	
Variable	Species	df	H	Significance	H	Significance
Change in gecko numbers between native forest, monoculture, or transitional type	*Phelsuma ornata*	2	5.95	0.050	42.64	< 0.001
	Phelsuma guimbeaui	2	-	-	21.37	< 0.001
Use of tree architecture E[1] in vegetation classes	*Phelsuma ornata*	4	73.20	< 0.001	-	> 0.050
Preference for tree architecture C[2] in vegetation classes	*Phelsuma ornata*	4	-	> 0.050	29.21	< 0.001
	Phelsuma guimbeaui	4	-	-	42.10	< 0.001
Difference in microhabitat use (tree trunks)	*Phelsuma ornata*	3	57.70	< 0.001	21.04	0.001
	Phelsuma guimbeaui	3	-	-	53.11	< 0.001

[1]Branching below half its height with scarring or cavities
[2]Branching above half its height with scarring or cavities

of the data and highlight which variables might be important in further analysis. We then produced a correlation matrix to identify any colinearity. Strong colinearity between variables can make understanding the results of multiple regressions difficult, as interaction between variables makes it hard to identify a single driver (Freckleton et al. 1999). We found strong colinearity using Pearson's correlation and scatter plots on normalized data between vegetation variables at both Ile aux Aigrettes and Black River Gorges. We therefore placed vegetation variables for each site into principal components analysis (PCA) to generate factor scores for the data set (Eigen value > 1), an appropriate approach when dealing with colinearity (Freckleton et al. 1999). We entered factor scores and variables with significant linear regression coefficients from data not entered into the PCA into stepwise multiple regression analysis. We regressed residuals from fitted models on excluded variables/factors to identify any masking effects. We used $\alpha = 0.05$ to determine statistical significance for all tests.

RESULTS

We recorded 339 observations of *P. ornata* on Ile aux Aigrettes. We made 56% of all observations in native forest, 28% in monoculture/coastal, and 16% in transitional vegetation. We found that *P. ornata* was mostly observed on tree trunks (ca.78% of all observations) as opposed to branches or canopy/foliage (Table 2). Our total numbers of observations at Black River Gorges were less than Ile aux Aigrettes. We observed 191 geckos (131 *P. ornata*, 60 *P. guimbeaui*). We found that *P. ornata* occurred exclusively in native

vegetation. At the same site, we found *P. guimbeaui* in all three vegetation types, but more commonly in native forest (ca. 80% of observations) than in either monoculture or transitional vegetation. We found both *P. ornata* and *P. guimbeaui* in Black River Gorges predominately on tree trunks and architecture C trees (Table 2). Habitat parameters changed between vegetation classes at both Ile aux Aigrettes and Black River Gorges (Table 3). We found that at both sites and for both species the presence of tree cavities influences gecko distribution. Our data suggest that both species respond in the same way, increasing in numbers with increasing cavity incidence (Fig. 1). Simple linear regression for *P. ornata* numbers showed a significant relationship with the number of cavities present for Ile aux Aigrettes ($F_{1,26} = 26.24$, $P < 0.001$; Numbers = 0.314 + 1.383 cavity band, $r^2 = 0.443$; Fig. 1a). The presence of cavities in Black River Gorges appeared to influence *P. ornata* occurrence ($F_{1,11} = 12.40$, $P = 0.003$; Numbers = -0.126 +1.508 cavity band, $r^2 = 0.470$; Fig. 1b). *Phelsuma guimbeaui* occurrence also responded to cavity presence ($F_{1,14} = 7.891$, $P = 0.011$; Numbers = -0.001 + 0.662 cavity band, $r^2 = 0.273$; Fig. 1c).

Macrohabitat selection and relationships.—We interpreted the factors produced by PCA in the following ways: both factor 1 and 2 at Ile aux Aigrettes (Table 4) have the potential to reflect disturbance of an area, a decrease of tree density or height being low in areas of high anthropogenic disturbance and shrub cover being high. Between them, factors 1 and 2 account for about 59% of the variance within the data set. From the PCA of vegetation variables at Black River Gorges, two factors are produced (Table 4). Both factors account for

TABLE 3. Significant changes in vegetation variables between vegetation classes: native forest, monoculture, and transitional (Kruskal-Wallis [H], df = 2, $P < 0.050$), measured at Ile aux Aigrettes and Black River Gorges National Park, Mauritius.

	Site			
	Ile aux Aigrettes		Black River Gorges	
Variable	H	Significance	H	Significance
Change in cavity numbers between vegetation class	8.222	0.016	29.65	< 0.001
Change in tree height between vegetation class	18.87	< 0.001	7.562	0.023
Change in tree circumference between vegetation class	15.19	0.001	10.29	0.006
Change in tree architecture A between vegetation class[1]	-	> 0.050	21.62	< 0.001
Change in tree architecture B between vegetation class[2]	-	> 0.050	16.39	< 0.001
Change in tree architecture C between vegetation class[3]	-	> 0.050	29.63	< 0.001
Change in tree architecture E between vegetation class[4]	18.36	< 0.001	-	> 0.050
Change in tree density between vegetation class	-	> 0.050	10.86	0.004
Change in % canopy cover between vegetation class	-	> 0.050	10.79	0.005

[1]= Branching over half its height

[2]= Branching below half its height

[3]= Branching above half its height with scarring or cavities

[4]= Branching below half its height with scarring or cavities

about 71% of the variance within the data set and reflect established forest areas. Again, the factors have the potential to act as surrogates for disturbance.

The presence of trees of architecture type E were important in determining the presence of *P. ornata* (Fig. 2a) on Ile aux Aigrettes ($F_{1,10}$ = 5.171, t = 2.274, P = 0.046; Numbers = 0.155 + 0.741 tree architecture E, r^2 = 0.341). However, if tree architecture is removed from regression, the next most important variable was vegetation factor score 1 ($F_{1,31}$ = 9.078, t = 3.013, P = 0.005; Numbers = 0.802 + 0.186 vegetation factor score 1, r^2 = 0.221; Fig. 2b). The multiple regression model for *P. ornata* in Black River Gorges showed that tree architecture was important for *P. ornata* presence. However, unlike Ile aux Aigrettes, the significant tree structure was of type A and was negatively associated with *P. ornata* ($F_{1,7}$ = 11.15, t = -3.339, P = 0.016; Numbers = 2.253 -1.124 tree architecture A, r^2 = 0.650; Fig. 3). Both vegetation factors were excluded from multiple regression of *P. ornata* at Black River Gorges (P > 0.05). Multiple regression showed that only vegetation factor score 1 (Fig. 4) has a significant relationship with *P. guimbeaui* numbers ($F_{1,19}$ = 7.693, t = 2.774, P = 0.013; Numbers = 0.292 + 0.258 vegetation factor score 1, r^2 = 0.312). *Phelsuma ornata* and *P. guimbeaui* are partitioned only by height ($F_{1,57}$ = 5.019, P = 0.032), with *P. guimbeaui* found at a higher perch height (4.040 ± 0.975 m) than *P. ornata* (3.280 ± 1.062 m). All other variables (perch circumference, tree architecture, vegetation type, and active period) did not influence partitioning (P > 0.05).

DISCUSSION

Phelsuma ornata is strongly associated with areas of native vegetation at both sites, as would be expected for a keystone pollinator species of native/endemic flora. However, the strength of association changes between sites. *Phelsuma ornata* is found throughout all vegetation types at Ile aux Aigrettes but solely in native vegetation at Black River Gorges. Interpretation of
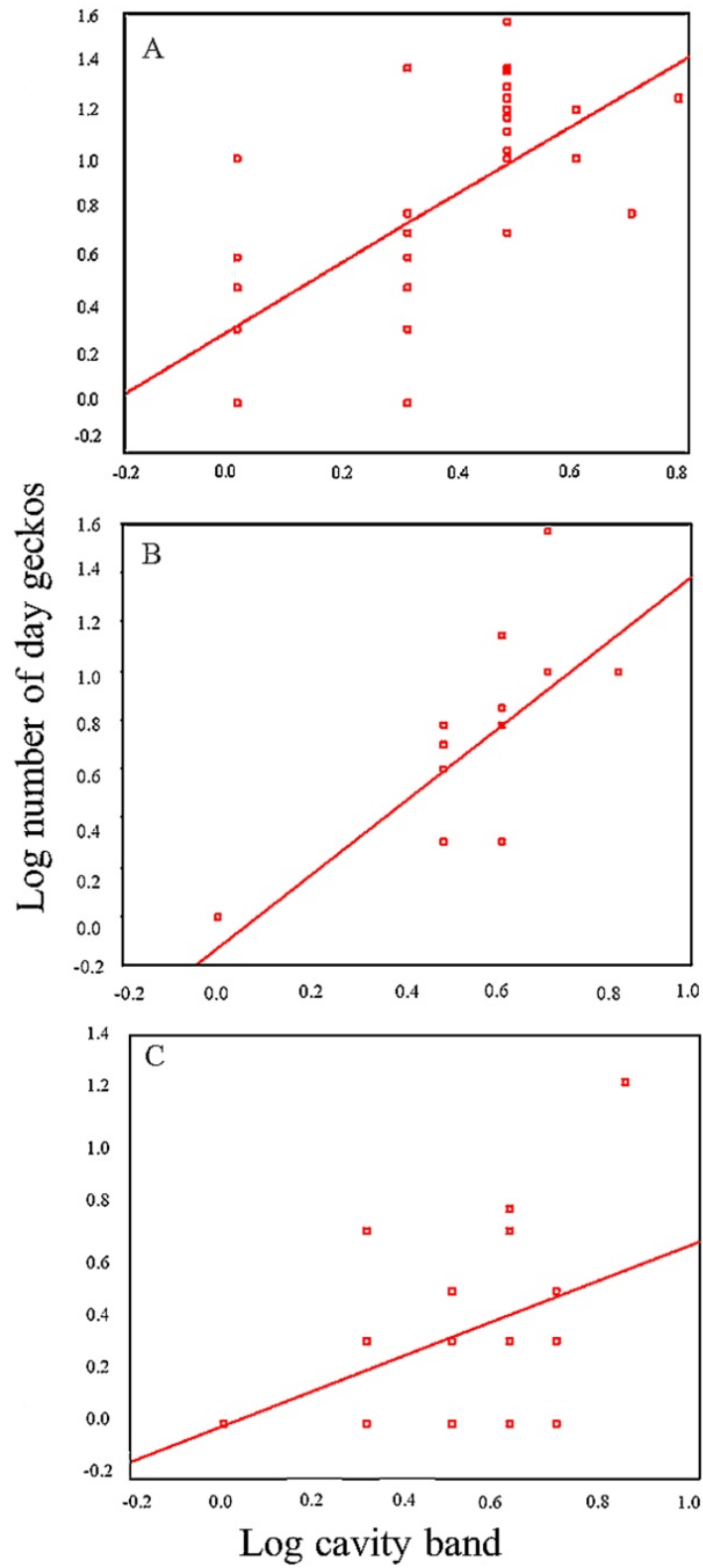
FIGURE 1. Relationship between numbers of *Phelsuma ornata* and cavity incidence, on Ile aux Aigrettes (A), Black River Gorges National Park (B), and between *Phelsuma guimbeaui* and cavity incidence at Black River Gorges (C).

results from habitat-based studies is complex; what allows a species to thrive in one area and appear to do poorly in others? Inclusion of a species into a community is through levels of filtration at multiple scales (Poff 1997; Mackey and Lindenmayer 2001). Initially, and at a broad scale, this filtration is controlled by abiotic factors, with fine tuning through biotic parameters, such as competition, down to eco-physiological level. Thus species distributions can be considered hierarchical, preferentially using landscape and then microhabitat details (Harvey and Weatherhead 2006; Buckland et al. 2014). A species' niche is ultimately at an eco-physiological scale relevant to the organism and thus for reptiles, selection of sites which reflect thermoregulation and hydric requirements are paramount (Downes and Shine 1998; Webb and Shine 1998; Downes 2001; Croak et al. 2008). While the role of pollinator may be both unusual and important in the maintenance of native vegetation, it is unlikely to dictate the distribution of a species within the Mascarenes. The pollinator relationship from the pattern of *P. ornata* distribution at both sites does not appear to be one of specificity; the native flora may benefit from geckos as pollinators, but the gecko does not rely on native vegetation (Nyhagen et al. 2001; Hansen et al. 2006). In fact, foraging is driven by achieving a constant body temperature (T_b) through basking in many reptiles (Brown and Griffin 2005; Polo-Cavia et al. 2012). Thus, it is unlikely that the act of foraging for nectar or abundance of food will in itself drive habitat selection (Calsbeek and Sinervo 2002). The corollary to that is that other aspects of vegetation structure and potentially, physical geography (*sensu* Cole 2005), are perhaps more important than vegetation type.

The results from this study suggest that tree trunks form an important aspect of niche breadth for both *P. ornata* and *P. guimbeaui*. Exposed trunks with large surface areas may allow geckos to follow patches of sunlight for basking while maintaining good visual acuity for spotting predators/competitors and, if required, provide sufficient width by which escape velocity is unimpaired (Irschick and Losos 1999). Although structural diversity of habitat has been shown to be an important agent in influencing gecko presence (Harmon et al. 2007; D'Cruze et al. 2009), little thermal heterogeneity is exhibited in dense vegetation (Fitzgerald et al. 2003; Pringle et al. 2003). Vegetation with high canopy cover and high density is not favored by *P. ornata*, which may be a consequence of thermally sub-optimal habitat. Thus, the need to thermoregulate may preclude geckos from areas where basking opportunities are reduced, such as vegetation with large proportions of invasive flora.

The data suggest that the association between *P. ornata* and tree cavities is not one of chance and as numbers of cavities increase, then so do gecko numbers. This pattern of association is not unexpected because population size of arboreal gecko species has been demonstrated to be a function of cavity number (Cole 2005; Buckland et al. 2014). It has been suggested that refuge use by *Phelsuma* species is not likely to be based on thermoregulation as the lizards actively basked during the day in patches of sun (Harmon et al. 2007). We suggest that while basking may take place on tree trunks and other suitable planes, refugia still fulfil a thermoregulation role by allowing reptilian species to either cool down or maintain temperature levels during the hottest part of the day (*sensu* Cole et al. 2005). What is clear is that we are yet to fully understand the detail of arboreal refugia use and further investigation into this

TABLE 4. Factor scores for principal component analysis of vegetation data from Ile aux Aigrettes and Black River Gorges National Park, Mauritius.

	Site				
	Ile aux Aigrettes			Black River Gorges	
Variable	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2
% cover herb	0.638	-0.362	-0.423	0.666	-0.602
% cover shrub	-0.603	-0.485	0.167	0.189	0.512
% cover canopy	0.521	0.655	-0.206	-0.639	0.625
Tree height	0.745	-0.367	0.300	0.832	0.230
Tree circumference	0.585	-0.497	-0.212	0.895	0.371
Cavity band	0.493	0.245	0.782	0.341	0.654
Tree density	0.004	0.832	-0.149	-0.902	0.048
Eigen value	2.184	1.929	1.018	3.313	1.636
% of variance	31.20	27.56	14.55	47.326	23.374
Cumulative variance	31.20	58.76	73.31	23.374	70.699
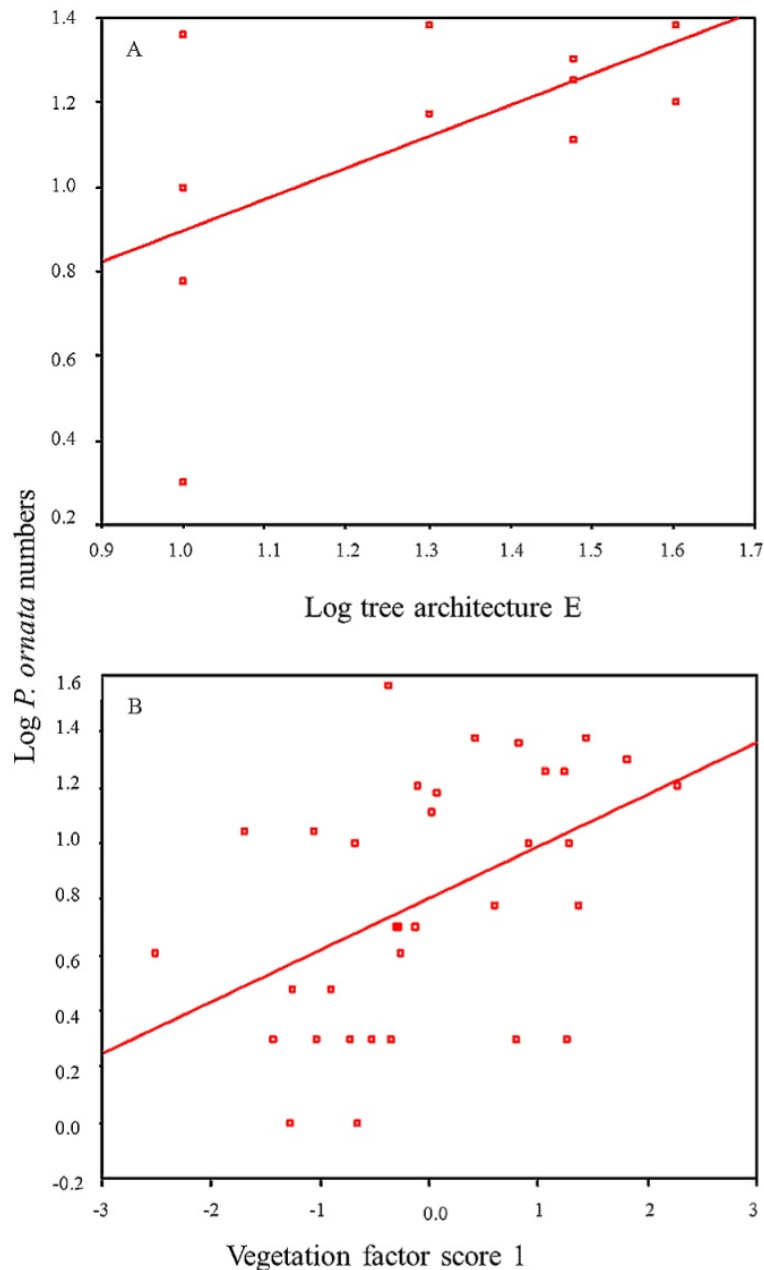
FIGURE 2. The relationship between *Phelsuma ornata* numbers on Ile aux Aigrettes, with (A) percentage of trees of architecture E, and (B) vegetation factor score 1 from principal components analysis.

impacting on habitat viability. specific aspect is warranted.

The results of habitat studies must be interpreted with care. Tree cavities may reflect a genuine microhabitat need of *P. ornata* or they could be considered a surrogate measure of disturbance, the effects of which are difficult to disentangle. From the multiple regression model at Black River Gorges, both species ultimately responded negatively to disturbance mechanisms; *P. guimbeaui* avoids areas with high canopy cover/high density and *P. ornata* is negatively associated with architecture A trees. Architecture A trees can be considered as a surrogate for highly disturbed areas, typically including rapid growth saplings. However, cavities or hollows are predominately formed from old growth trees (Whitford 2002; Whitford and Williams 2002). Further, not only may these areas present thermally sub-optimal habitat, but even where isolated
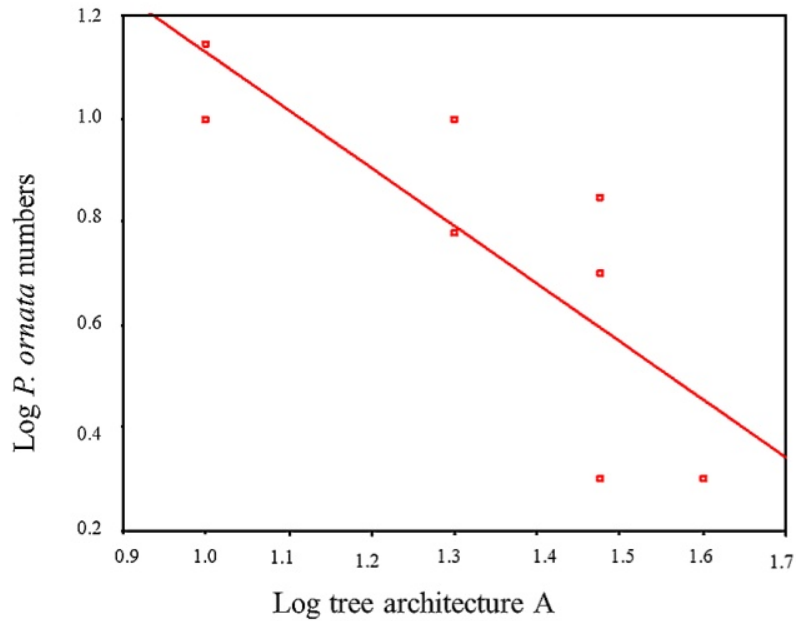
FIGURE 3. Relationship between numbers of *Phelsuma ornata* and percentage of trees of architecture A, at Black River Gorges National Park.
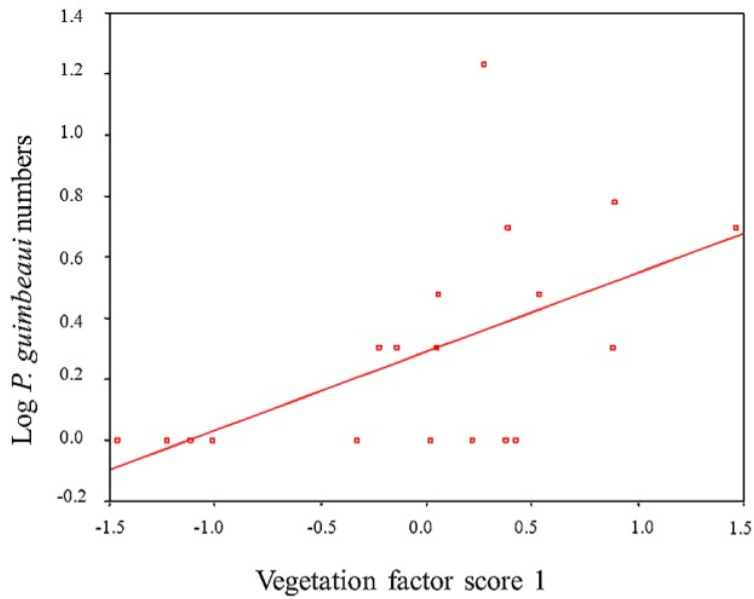

FIGURE 4. Relationship between the numbers of *Phelsuma guimbeaui* and vegetation factor score 1 from principal components analysis, at Black River Gorges National Park.

plants provide suitable refugia and basking surfaces regular anthropogenic activity may dissuade animals in returning to bask (Moore and Seigel2006), thereby both factors may be operating in Mauritius. Cavities form part of the microhabitat requirement for both species and are a product of old-growth areas, whereas non-native vegetation types do not promote cavity occurrence and they are also anthropogenically disturbed, thereby decreasing habitat suitability.

Restoration of vegetation in the Mascarenes is a continuing conservation goal in degraded areas. We collected these data in 2000 and since that time there has been a marked increase in native vegetation on Ile aux Aigrettes as a consequence of replanting and the introduction of grazing analogue tortoises (Kueffer and Mauremootoo 2004; Carl Jones, pers. comm.). It would be interesting to repeat the study 14 y on. In the long term, habitat restoration will obviously be beneficial for the endemic reptile fauna (*sensu* Kaiser-Bunbury et al. 2010). However in reaching long term goals, maintenance of native vegetation will require management practices that promote cavity formation and minimize disturbance. In the short term, restoration requires the removal of invasive flora creating areas of disturbance around isolated endemics, with young endemics taking time to reach a size capable of providing cavities. If disturbed habitat is supplemented with additional cavities (Webb and Shine 2000), the *P. ornata* population at least may suffer less detrimental effects than would be otherwise expected.

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