

Roost site characteristics of sympatric dwarf chameleons (genus *Brookesia*) from western Madagascar

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Abstract. Madagascar's *Brookesia* dwarf chameleons are believed to require relatively intact forest for survival. Although they have featured in herpetological surveys, taxonomic reviews and trade assessments, very little is known about their microhabitat requirements or ecology. Over a 5 night period in a deciduous forest in western Madagascar we recorded the night roosting sites for three sympatric *Brookesia* species. We calculated the area and distance between successive night roost locations and described the characteristics of each roost. Distance between roosts and the area used were larger for *B. brygooi* and *B. perarmata* than *B. exarmata*. The distance between roosts was significantly greater for male than female *B. brygooi* and *B. perarmata*. Roost sites were generally in low vegetation (<0.75 m) with the animals located on stems or leaves. Roost height differed significantly between the species, with *B. brygooi* using the highest perches and *B. exarmata* the lowest.

Keywords: *Brookesia*, chameleon, Madagascar, roost.

Chameleons lend themselves well to field study because they can be readily located at night whilst roosting and have distinct habitat preferences which often include intact forests. Some studies in Madagascar have reported differences in chameleon abundance or density between different forest habitats (e.g. Brady and Griffiths, 1999; Brady and Griffiths, 2003; Jenkins et al., 2003; Andreone et al., 2005) or documented relationships with forest features such as trails and rivers (e.g. Jenkins et al., 2003; Metcalf et al., 2005). It is believed that *Brookesia* chameleons are dependent on relatively intact forest and that they are threatened by ongoing deforestation and fragmentation. *Brookesia* are diurnal and forage for invertebrates in leaf litter but roost on plants above the ground

at night. There are few available data on how co-occurring dwarf chameleons use the forest habitat or whether there are gender-based differences in their ecology. Despite major morphological and behavioral differences between *Brookesia* and other Malagasy chameleons, only a few studies have focused on the natural history of *Brookesia* (Raxworthy, 1991; Raxworthy and Nussbaum, 1995). This preliminary study sought to describe the spatial and physical characteristics the roosting sites of three *Brookesia* species.

Parc National (PN) Tsingy de Bemaraha is situated on a karstic plateau in western Madagascar, near Antsalova, in the Province of Mahajunga. The park is a World Heritage Site and is characterized by jagged limestone outcrops, dry deciduous forest and sub-humid vegetation (Rasoloarison and Paquier, 2003). A number of herpetological inventories have been carried out and some reptile species are endemic to the park (Emanueli and Jesu, 1995; Schimmenti and Jesu, 1997). Our study site was located in Bendrao forest (18°47.542' S, 044°52.531' E; 414 m asl.) in the north-east section of the park. The forest consists of a fragment (112 ha) that is surrounded by small rivers, agricultural land and savanna grasslands.

Two 50 m transect lines were installed in our study site, 5 m apart, with the first orientated east-west and the second north-south. The transects were left undisturbed for 24 hours prior to the commencement of the chameleon searches. Equipped with LED head-torches (Petzl Myo XP),

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Table 1. Mean area encompassed within successive roosting locations and mean distance between successive roosting locations for three *Brookesia* species over five nights in western Madagascar. Samples sizes are given in parentheses.

Sex	Range size (m ²)		U statistic significance	Distance traveled (m)		U statistic significance
	Female	Male		Female	Male	
<i>Brookesia</i>						
<i>perarmata</i>	2.9 ± 1.12 (7)	4.5 ± 1.2 (5)	25.5, n.s	1.9 ± 0.45 (7)	4.2 ± 0.79 (5)	31, <i>P</i> = 0.03
<i>Brookesia</i>						
<i>brygooi</i>	1.7 ± 0.79 (5)	4.8 ± 1.37 (9)	32.5, n.s	1.0 ± 0.13 (5)	2.2 ± 0.34 (9)	28, <i>P</i> = 0.04
<i>Brookesia</i>						
<i>exarmata</i>	0.2 ± 0.20 (2)	0.2 ± 0.00 (1)	–	0.7 ± 0.00 (2)	0.3 ± 0.0 (1)	–

two observers simultaneously slowly walked the length of each transect, each checking the right or left flank respectively. Previous studies have found that this method is effective for locating forest chameleons up to approximately 5 m from the transect line (Jenkins et al., 1999). This was repeated on five successive nights. Surveys began at 19:00 and usually lasted three hours. All chameleons were individually marked using a small quantity of white correction fluid (Blomberg and Shine, 1996), a method used previously on forest chameleons and deemed to be suitable for short-term studies. For each capture animal we determined the sex and species, and measured (1) snout vent length (SVL), mm, with dial calipers, (2) the roost height from the ground to the middle of the chameleon and (3) recorded the vegetation part on which the chameleon was roosting (i.e. leaf or stem). For all subsequent captures, the bearing and distance to the original point were measured. We measured two components of roosting characteristics; area (minimum convex polygon around roosting perches, m²) and distance (straight-line distance between successive roosting perches).

The field measurements were projected in MapSource (Version 6.0, 1999–2004) to obtain coordinates of each animal location. These points were transformed into *x*, *y* coordinates with the ArcView GIS (Version 3.3, 1992–2002) for windows by using the extension Animal Movement SA v2.04 (Hooze and Eichenlaub, 1997). Convex polygons were analyzed using Ranges6 v1.08. Statistical comparisons were made with chi-squared tests for roost type and position. Roost height data were parametric and analyzed with ANOVA. All recorded roost heights for individual animals were pooled and the means used in analysis. *Brookesia exarmata* was omitted from statistical procedures because of the small sample size. Range size data were nonparametric and Mann Whitney tests were used.

A total of 30 chameleons were captured, 13 *B. perarmata* (SVL = 44.7 mm ± 3.06 SE), 14 *B. brygooi* (SVL = 42.5 mm ± 1.7 SE) and 3 *B. exarmata* (SVL = 22.6 mm ± 0.74 SE). Recapture rates were high for all species, with 12/13 *B. perarmata*, 13/14 *B. brygooi* and 3/3 *B. exarmata* observed on more than one occasion.

Mean area encompassed within roosting locations was similar for *B. perarmata* (3.5 m² ±

0.83 SE) and *B. brygooi* (3.6 m² ± 0.99 SE) but the mean distance between roosts was greater, but not significantly so, for the former species (*B. perarmata* 2.6 m ± 0.71 SE; *B. brygooi* 1.8 m ± 0.28 SE). Area estimates for *B. exarmata* were not possible to calculate because of small sample sizes, but mean distance between roosts was 0.47 m ± 0.19 SE. The distance between roosts for *B. perarmata* and *B. brygooi* was significantly greater for males than females (table 1).

Roost site vegetation type was noted on 113 occasions. *Brookesia exarmata* (67%) and *B. perarmata* (57%) used stems more frequently than *B. brygooi* (42%). Head orientation ($\chi^2 = 10.4$, *d.f.* = 2, *P* < 0.01) and body position ($\chi^2 = 27.2$, *d.f.* = 4, *P* < 0.01) varied between species; *B. brygooi* were usually head-down (61%) and *B. perarmata* (76%) and *B. exarmata* (66%) head-up. The majority of *Brookesia* were found roosting on vegetation that was green and the larger species were only rarely (*B. perarmata* 4%, *B. brygooi* 9%) found roosting on dead vegetation, but 20% of *B. exarmata* roosting perches were on dead material. There were few differences between male and females in roost site characteristics or position and the only significant result was for *B. perarmata* ($\chi^2 = 5.6$, *d.f.* = 1, *P* < 0.05), with 78% of the males found on stems, with females usually using stems (45%) or leaves (42%).

There were significant differences between the roosting height of *B. brygooi* and *B. perarmata* (ANOVA $F_{1,25} = 4.7$, *P* = 0.04) with the former species using higher perch sites (fig. 2). *Brookesia exarmata* consistently roosted at

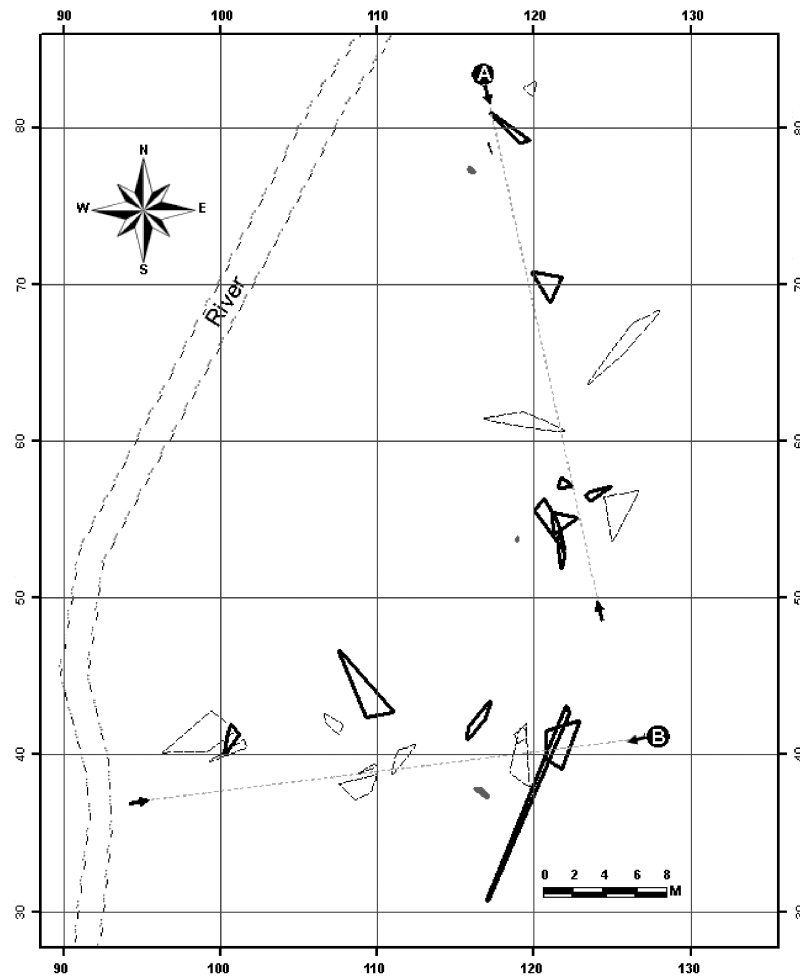


Figure 1. Minimum convex polygon based on successive nocturnal roosting sites for three *Brookesia* chameleons over a five day period from Parc National Tsingy de Bemaraha (*B. brygooi* broken, *B. perarmata* dark, *B. exarmata* grey). Black arrows mark the start and finish points of the transects.

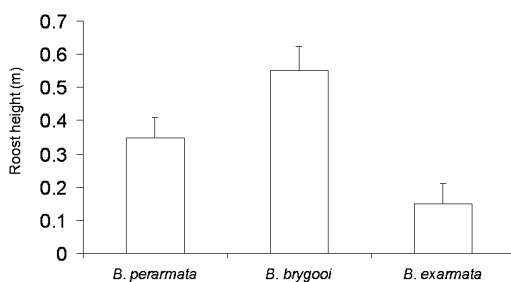


Figure 2. Mean height (+1 standard error) of chameleons found roosting at night in Parc National Tsingy de Bemaraha.

the lowest heights (fig. 2). There was no gender-effect detected on roost height.

There was very little interspecific overlap in the area defined by their outermost roosting locations during the duration of the study. Our study was conducted over five days and this short duration is an obvious caveat but nevertheless we detected significant differences in roosting height and spatial ecology between species and sexes, thus providing good reason to develop our methods and undertake an extended follow-up study. An understanding of which roost site characteristics are important for different species will assist the interpretation of variation in *Brookesia* density between areas within the same forest.

Brookesia use perches to provide protection from nocturnal predators which forage in the leaf litter (e.g. tenrecs, Raxworthy, 1991). As little is known about the diurnal behaviour of *Brookesia* it is not yet possible to assess whether the perches have other roles, such as early-morning feeding sites. The foraging activity of rain forest chameleons in Nigeria was highest between 0900 and 1100 (Akani et al., 2001) and the potential prey availability around a given roost site after sunrise may also be an important factor in roost selection.

The interspecific differences in roosting site in our study may be related to physical constraints, with large *Brookesia* being too heavy for small seedlings, especially as rainwater may accumulate and increase the weight of the animal. Raxworthy (1991) reported that *Brookesia* roost head down and that this facilitates water run-off during the night. Our study found interspecific differences in the head orientation of *Brookesia* and given the short duration of the study this is unlikely to have been caused by precipitation patterns.

Stems and leaves were the most commonly used parts of understorey vegetation and it is likely that ground cover and vegetation type is an important feature of *Brookesia* habitat. We found differences in the roosting height of the three species and with *B. brygooi* roosting in heights of up to 1.12 m, it is conceivable that some foraging is undertaken in low vegetation. This is in accordance with the suggestion of Raxworthy (1991) who noted that some *Brookesia* species spend very little time on the ground. *Brookesia exarmata*, of the *minima* group, is one of the smallest reptiles in the world (Glaw et al., 1999) and roosting heights for *B. exarmata* in our study were similar to those reported by Schimmenti and Jesu (1996). Assessments of *Brookesia* diurnal habitat use is now needed to assess if above ground habitats are used and to relate the range calculated from night perches to the size of diurnal foraging areas.

Differences in the spatial ecology of male and female chameleons have been reported pre-

viously from Madagascar (Kauffmann et al., 1997) and elsewhere (e.g. Hebrard and Madsen, 1984; Cuadrado, 2001). The life-history of *Brookesia* is poorly understood but copulation and egg deposition has been observed for *B. exarmata* during February (Schimmenti and Jesu, 1996). Reduced movements by females may therefore be related to reproductive behaviour and even possibly the maternal care of eggs. Schimmenti and Jesu (1997) observed a female *B. perarmata* defend a single egg immediately after deposition.

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