

A brief overview of the natural history of the recently described, miniaturised leaf chameleon, *Brookesia nana* Glaw et al., 2021, from Sorata Forest, northeastern Madagascar

Jeanneney Rabearivony^{1,2,3,*}, Andriatsitohaina Ranaivojaona⁴, Asmeralie William¹, Crispin Jaohasy¹, Moussaina Jao^{1,2}, and Achille P. Raselimanana^{3,5}

Madagascar is known for its exceptional diversity of chameleons, which includes about half of the world's described species (Scherz et al., 2022; Uetz et al., 2025). This lizard group is divided into four endemic genera (*Calumma*, *Furcifer*, *Brookesia*, and *Palleon*), which in Madagascar includes both the world's largest and smallest chameleon species (Glaw and Vences, 2007; Glaw et al., 2021; Rakotoarison et al., 2024).

Of these four chameleon genera, *Calumma* and *Furcifer* species are mostly arboreal, although some *Furcifer* species also use low herbaceous vegetation (Scherz et al., 2022). *Brookesia* and *Palleon* species roost in low vegetation at night and are active during the day, when they forage on leaf litter on the forest floor (Raselimanana and Rakotomalala, 2003). *Brookesia*, *Calumma*, and *Palleon* are mostly associated with relatively intact forest, whilst *Furcifer* species occur in diverse habitats, including grassland, farmland, urban areas, humid forest, spiny forest, and deciduous forest (Scherz et al., 2022). For all these genera, new species continue to be discovered (e.g., Florio et al., 2012;

Prötzel et al., 2018; Glaw et al., 2021; Rakotoarison et al., 2024) and currently 100 chameleon species (*Calumma*: 42; *Furcifer*: 24; *Brookesia*: 32; *Palleon*: 2) are recognized in Madagascar (Uetz et al., 2025).

In terms of biogeography, the northern part of Madagascar has been described as the centre of diversity and endemism for *Brookesia* species (Raxworthy and Nussbaum, 1995). However, very few ecological studies have been undertaken to ensure the survival of these species in the natural environment. The majority of herpetofaunal studies conducted in the northern forest habitats consists of inventories (D'Cruze et al., 2008; Radonirina et al., 2023), that often result in the discovery of new species (D'Cruze et al., 2007, 2008).

Brookesia nana is one of the smallest chameleon species and a member of the *B. minima* group (Glaw et al., 2021). This group has been the subject of major taxonomic revisions in recent years, resulting in the description of many new species (e.g., Glaw et al., 2012, 2021; Rakotoarison et al., 2024). Unfortunately, most of these new species, including *B. nana*, have never received a detailed ecological treatment since their discovery. *Brookesia nana* is known only from Sorata Forest in northeastern Madagascar, where it is subject to various kinds of environmental pressures, mostly anthropogenic. It has been proposed as a likely Critically Endangered (CR) species (Glaw et al., 2021), but it has not yet undergone a formal IUCN Red List assessment. We here present some baseline data on the ecology of this species and a brief overview of its natural history, including summer abundance, demography, morphometric and roosting characteristics.

Materials and Methods

The current study was undertaken during 7–21 March 2024 in Sorata Forest (13.6857°S, 49.4418°E; Fig. 1). This forest is part of the Corridor Marojejy-Anjanaharibe

¹ Faculté des Sciences, Université d'Antsiranana, BP O, Antsiranana 201, Madagascar.

² Ecole Doctorale Sciences de la Vie et de l'Environnement, BP 566, Université d'Antananarivo, Antananarivo 101, Madagascar.

³ IUCN SSC Chameleon Specialist Group, Rue Mauverney 28, 1196 Gland, Switzerland.

⁴ World Wildlife Fund Madagascar, BP 738, Lot près II M 85 Ter Antsakaviro, Antananarivo 101, Madagascar.

⁵ Mention Zoologie et Biodiversité Animale, Faculté des Sciences, BP 906, Université d'Antananarivo, Antananarivo 101, Madagascar; and Association Vahatra, BP 3972, Antananarivo 101, Madagascar.

* Corresponding author. E-mail: r.jeanneney@gmail.com

Sud-Tsaratana partie Nord (COMATSA Nord) Natural Resources Reserve (Goodman and Wohlhauser, 2018), which is managed by the World Wide Fund for Nature (WWF) in collaboration with Ambodimandresy Miaro ny Ala (AMA), a local community organization. Sorata Forest is located in Andrafaikona Municipality, Vohémar District, northeastern Madagascar (Fig. 1). This forest fragment covers approximately 48,715 ha within an elevation ranging from 1257–1500 m. The climate in this area is tropical humid, with annual average rainfall of about 1863 mm, of which 87% falls between November and April (Goodman and Wohlhauser, 2018).

We set up 14 line transects in the study area, using existing forest paths as access points (Jenkins et al., 2003) because of the steep terrain. To minimise placement bias, we randomised the choice of transect section along each accessible path by drawing lots to determine the starting point before installation. Although this design does not constitute full random sampling in the statistical sense, it ensured representative coverage of accessible microhabitats within Sorata Forest. Transects were 150 m in length

and each was composed of three parallel lines of length 50 m, separated by at least 20 m. The 20-m separation is thought to be enough to minimize the possibility of animals being encountered twice from adjacent lines (Brady and Griffiths, 1999).

To minimize the impact of habitat disturbance on chameleon distribution within the transect area, all lines were set up at least 24 h before being surveyed. Nocturnal surveys were conducted by two surveyors moving slowly along each transect, searching on opposite sides of the transects for roosting chameleons using head torches. Whilst all chameleon encounters were recorded, the current study focused on *B. nana*. The abundance of this species was calculated as the number of individuals per 100 m of transect. Based on an animal's size and morphology (Glaw et al., 2021), individuals were sexed and classified according to life stage (adult, juvenile, and hatchling). Adult males are easily distinguished from adult females by the thickness of the base of their tail due to the presence of the hemipenis (Glaw et al., 2021). Hatchlings differed from juveniles by their tiny size (weight almost undetectable using a scale; Fig. 2), soft and fragile body, and large and more bulbous eyes.

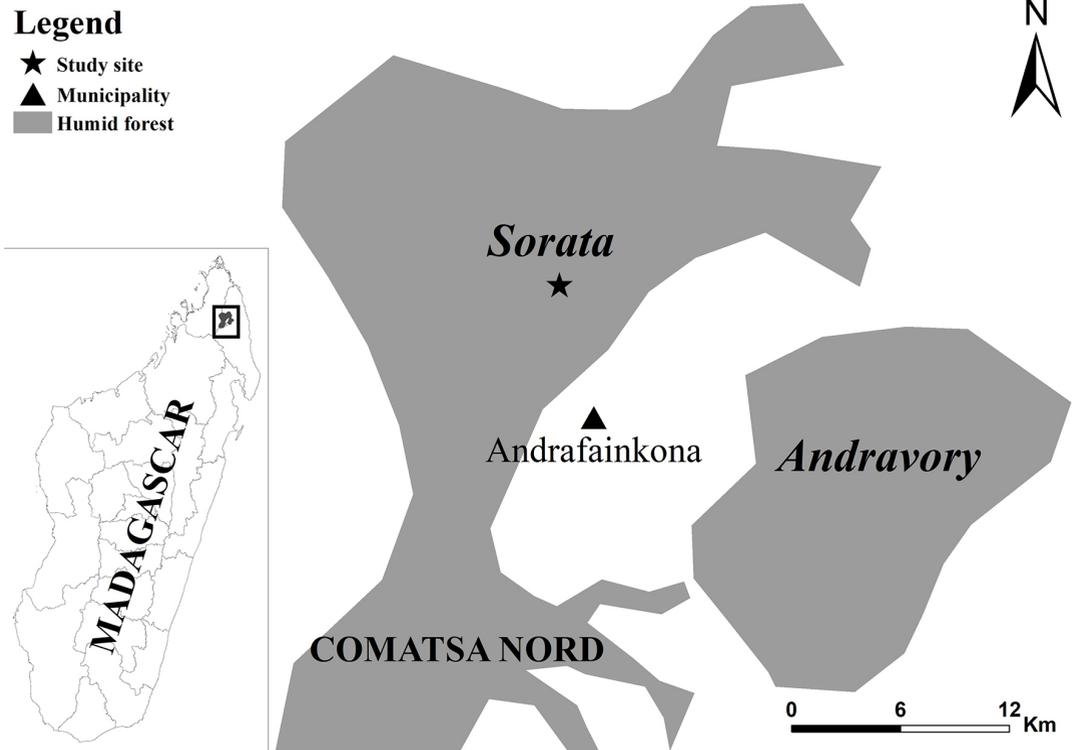


Figure 1. Location of Sorata Forest within the Corridor Marojejy-Anjanaharibe Sud-Tsaratana partie Nord, Madagascar.

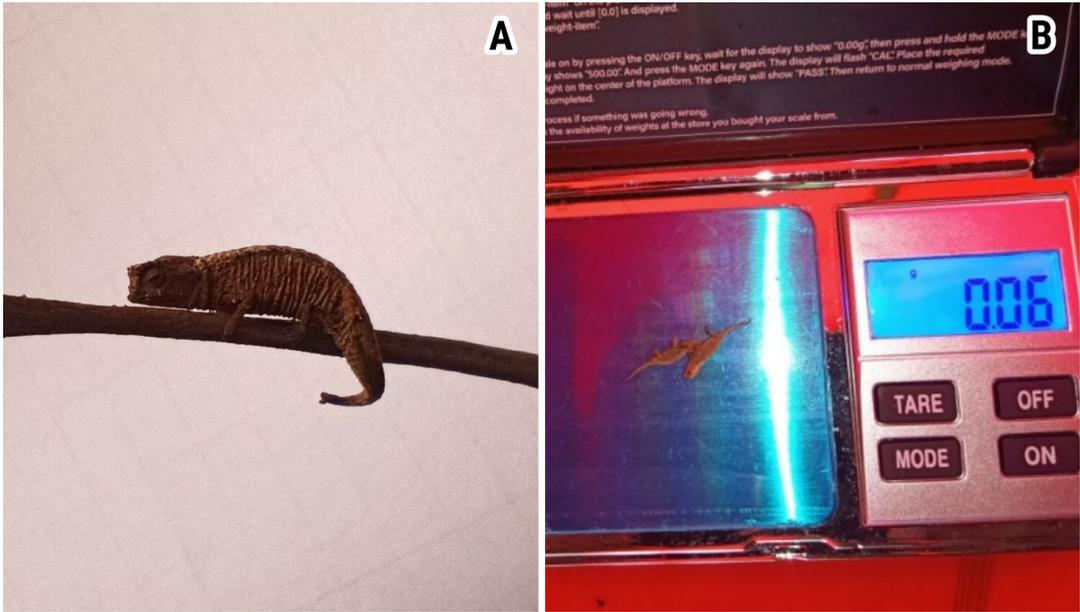


Figure 2. Individuals of *Brookesia nana* from Sorata Forest. (A) The adult male has a snout–vent length of 12.5 mm. (B) Two hatchlings on a scale, showing their low weight of 0.06 g. The snout–vent length is 6.0 mm. Photos by Asmeralie William.

Roost height was measured as a vertical distance from the forest floor to the roosting animal's belly and other roost characteristics were noted. These included plant type (mono- or dicotyledon, liana/vine), body orientation (vertical, horizontal, inclined) and head direction (upwards, downwards). Some individuals were brought back to the camp in a small cotton bag for measurements of snout–vent length (SVL), tail length (TaL), and total length (TL) using digital callipers to the nearest 0.1 mm. After measurements were taken, captured animals were released the next morning at the exact point of their capture. In accordance with the consultancy contract with the WWF Madagascar Country Office (MDCO N° 204/CTR-S/FY24/AND), no voucher specimens were taken.

Results

A total of seven *B. nana* (0.33 individuals per 100 m) were found along 2100 m of surveyed transect, including four (57.1%) adult males, one (14.3%) an adult female, and two (28.6%) hatchlings (Fig. 2). Morphometric data of all encountered animals revealed that adult female *B. nana* may attain larger sizes than adult males (Table 1). No other juvenile stage was recorded during this study.

All seven individuals were found at low perching height on tiny twigs, mostly belonging to dicotyledon

plants (42.9%) and vines (42.9%), with the remainder (14.2%) on monocotyledon plants. The average roost height was low, about 7 cm above the ground. Examination of body orientation showed that five individuals perched in an oblique position on their roosts (71.4%), with the remainder horizontal and vertical in equal measure (one in each position). Their heads were more frequently orientated upwards (71.4%) than downwards (28.6%).

Discussion

Compared to a previous study, *B. nana* was less abundant (0.33 individuals per 100 m) than other species within the *B. minima* group. For example, abundance values for *B. exarmata* were 0.7 at Bemaraha National Park in Ankily, 0.4 in Anjaha, 2.3 in Bendrao, and 0.5 in Ankazomanga (Randrianantoandro et al., 2008). The low abundance of *B. nana* and its limited distribution suggest the need for targeted conservation initiatives.

Since chameleon species are often polygamous (Karsten et al., 2009; Rebelo et al., 2022), the skewed sex ratio of *B. nana* in Sorata may reflect male sexual competition within the population. On 21 March 2024, a male from Transect T2L and the female from Transect T3R were positioned close to each other for a behavioural observation. These two transects were about 200 m apart.

Table 1. Measurements (in mm) of *Brookesia nana* in Sorata Forest., Madagascar. Abbreviations include the number of observations (*n*), snout–vent length (SVL), tail length (TaL), and total length (TL). Entries with a hyphen (-) indicate that no data were available.

Age/Sex	<i>n</i>	SVL	TaL	TL
Adult males	4	12.5	10.4	22.8
Adult females	1	16.3	12.7	29.0
Juveniles	0	-	-	-
Hatchlings	2	6.0	4.0	10.0

Despite the female already being gravid, the two chameleons were observed to copulate, which supports the possibility of multiple paternity in *B. nana*, as has been documented in other chameleon species (e.g., Tolley et al., 2014).

Our findings on the morphometric measurements corroborate the species description by Glaw et al. (2021), who stated that *B. nana* was the world’s smallest chameleon species, albeit with a slightly longer tail than *B. micra*. Furthermore, females of *B. nana* tend to be slightly larger than the females of *B. micra* (Table 2). Size differentiation between adult male and female *B. nana*, and probably in other species in the *B. minima* group, may be linked to reproductive adaptation. Despite their tiny size, adult male *B. nana* have a well-developed genital organ that facilitates mating with the larger females (Glaw et al., 2021). Larger female size may also be an adaptation for carrying eggs. Morphometric data on hatchlings provide additional natural history information for the *B. minima* group.

Regarding roost characteristics, *B. nana* perched at a very low height on average (7 cm above the ground), which is comparable to the height of other species in the *B. minima* group, such as *B. micra* (5 cm above the ground; Villeneuve, 2017). As in *B. micra*, the diminutive size of *B. nana* may limit its ability to perch at a greater height. For the larger species of *Brookesia*,

such as *B. decaryi*, newly hatched individuals have been found to perch at slightly higher levels above the ground (13 cm; Razafimahatratra et al. 2008).

The orientation of the body and head on the perch vary greatly in species of *Brookesia* and *Palleon*. In *B. therezieni*, *B. brygooi*, *B. stumpffi*, *B. legendrei*, *B. thieli*, *B. superciliaris*, and *Palleon nasus*, heads are frequently orientated downwards (Foley, 2002; Randrianantoandro et al., 2007), while in *B. decaryi*, *B. perarmata*, and *B. exarmata* this tendency is reversed with heads pointing upwards (Randrianantoandro et al., 2007; Razafimahatratra et al., 2008). *Brookesia exarmata* and *B. nana* are of the same taxonomic assembly within the *B. minima* group, and it will be interesting to explore if the upward head orientation is a typical ecological trait for miniaturised species of terrestrial chameleons. Another explanation for an upward-pointing head is that those individuals left their diurnal foraging sites late and are climbing their perches quickly, without turning down their head. However, *B. nana* shares the same sleeping posture with the larger *Brookesia* species (such as *B. decaryi*), whose the body direction during sleep is generally oblique (Razafimahatratra et al., 2008). The association with (herbaceous) dicotyledons was also commonly observed in *B. tuberculata*, another miniaturised leaf chameleon of the humid forest of Montagne d’Ambre (J. Rabearivony, pers. obs.).

Table 2. Comparison of measurements (in mm) between *Brookesia nana* and *B. micra*, the two smallest species of the genus. Abbreviations include the number of observations (*n*), snout–vent length (SVL), tail length (TaL), and total length (TL).

Species	Source	Age/Sex	<i>n</i>	SVL	TaL	TL
<i>B. nana</i>	Glaw et al. (2021)	Adult males	1	13.5	8.1	21.6
		Adult females	1	19.2	9.7	28.9
	This study	Adult males	4	12.5	10.4	22.8
		Adult females	1	16.3	12.7	29.0
		Hatchlings	2	6.0	4.0	10.0
<i>B. micra</i>	Glaw et al. (2012; 2021)	Adult males	3	15.6	7.5	23.1
		Adult females	4	19.4	8.2	27.6

Given the rainforest fragmentation in the Sorata area, a mountain forest exceptionally important for the conservation of threatened chameleon species (Rabearivony et al., 2025), we consider it essential to replicate this study across other forest fragments within COMATSA Nord to determine the current extent of occurrence of this rare species. WWF has proposed to extend this research into the nearby mountain forest of Andravory. If *B. nana* is confirmed to be present there, a management plan should be developed to sustain a healthy metapopulation of this species across the fragmented COMATSA landscape.

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