Scientific Reports in Life Sciences 6 (3): 33-40

DOI: https://doi.org/10.5281/zenodo.16895177

Habitat quality and roost preference of jewelled chameleon (*Furcifer campani*) in Ankaratra highlands, central Madagascar

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Received: 26 January 2025 / Revised: 22 March 2025/ Accepted: 25 March 2025/ Published online: 20 August 2025.
How to cite: Andriantsimanarilafy, R. R., & Randrianantoandro, J. C. (2025). Habitat quality and roost preference of jewelled chameleon (Furcifer campani) in Ankaratra highlands, central Madagascar, Scientific Reports in Life Sciences 6(3), 33-40. **DOI:** https://doi.org/10.5281/zenodo.16895177

Abstract

We studied the habitat preferences of *Furcifer campani* from Ankaratra motne, the second-highest montane of Madagascar. Density of the species differs between habitat qualities, which is a lower density in high-disturbed areas, and the animal's nocturnal roost height varies between area types; however, this variation isn't significant. Bushfire is one of the main threats to this species, which acts in two directions such as: destroying its habitat and also directly killing it by calcination.

Keywords: Ankaratra, Distance sampling, Conservation, *Furcifer campani,* Habitat

Introduction

Madagascar is currently home to 98 endemic chameleon species (Prötzel et al., 2017; 2020), making the island a key biodiversity hotspot for chameleons. Malagasy chameleons belong to four genera, *Brookesia, Palleon, Calumma,* and *Furcifer* (Glaw, 2015). *Brookesia*, *Palleon* are endemic to the island (Glaw et al., 2013). A recent study indicated that the *Calumma* genus is not exclusively endemic to Madagascar (Čerňanský et al., 2020). *Furcifer* spp can be found in the nearby Reunion Island (Glaw & Vences, 2007; Glaw, 2015). Unfortunately, more than 50% of Malagasy chameleons are classed as threatened on the IUCN red list, with four of them being

Critically Endangered (Jenkins et al., 2014). The primary threat to Malagasy chameleons is the rapid destruction and degradation of habitat, especially forests (Raxworthy, 1988; Jenkins et al., 2014). High altitude species were also considered potentially at risk from up-slope displacement due to climate change (Raxworthy et al., 2008). Exploitation for trade was also considered a threat (Jenkins et al., 2014). *Furcifer campani* is endemic and known from highland central to Madagascar (Jenkins et al., 2011). The species exists in the savannas of the central mountains of the island from an altitude of 1,500m (Raxworthy & Nussbaum 1996). It was assessed as Vulnerable on the IUCN Red List basis that this species has an extent of occurrence of 14,513 km², it occurs as a severely fragmented population, and there is a continuing decline in the extent and quality of montane heathland within its range because of slash-and-burn agriculture (Jenkins et al., 2011). A previous study indicated a variation in the population densities across the years. This species is of interest to the pet trade. This species used to be collected in large quantities, and 10,324 were legally exported from Madagascar between 1977 and 2001 (Carpenter et al., 2004), but in recent years, the number of individuals exported has dropped markedly. Between 2000 and 2009, 320 live individuals were reportedly exported from Madagascar, with most of these occurring in 2001 (UNEP-WCMC 2010). On the other hand, exportation for international trade of this species was increased since 2013 when the species disposed an annual export quota of 250 individuals per year (www.cites.org). This study aims to understand the impact of habitat quality on the jewelled chameleon population density to propose measures for its management.

Martial and methods

The study was undertaken within Ankaratra new protected area (19.334528S, 47.274426E; WGS 84), Ambatolampy District, Vakinankaratra Region. The study site altitude is between 1601 to 2656 m (above sea level). The average annual temperature is between 11.9° C in July to 17.9° C in January in the weather station Manjakatompo. The average annual precipitation is 2012 mm; the highest value of precipitation is 362 mm month January (Vences et al., 2002). The Ankaratra massif is formed by a dense rain forest, plantation forest, and savanna. The high plateau of Madagascar is almost entirely forest before the arrival of humans (Humbert, 1927). It is believed that the high plateau grasslands of the current artificial habitats are following a succession of burning and livestock grazing (Humbert, 1927; Koechlin, 1972). Currently, large areas of highland and existing secondary formations, typically dominated by *Philippia* and herbs, are

usually interpreted as anthropogenic habitats (produced by human burning of sclerophyll or primary forest) that are depleting wildlife levels (Humbert, 1927). Therefore, these savannas are considered secondary to similar pseudo-steppe grasslands of the high plateau. In mountainous regions, however, there is evidence of normal bushfires occurring in all the Holocene (Burney, 1987), and more recent reports of lightning-caused fires suggest that savanna is a normal stage of successive fire. Savanna is formed mainly by grasses, *Philippia* sp., and *Helichrysum* sp. We surveyed this species during different months of the year from 2012 to 2015. Distance sampling using a line-transect was the main method (Buckland et al., 2001) for the field data collection. We placed three parallel lines of 50 m spaced by 25 m each over and the survey can't be done before 24 hours after the installation to avoid disturbance (Randrianantoandro et al., 2010). Transect location was identified based on the vegetation history, especially the fire. We considered as a less disturbed area when the last fire occurred more than five years and both vegetations' characteristics (*Philippia* sp. and *Helichrysum* sp.) were well developed. In contrast, a highly disturbed area represents all areas with fire less than five years. An animal search was done during the night by two experts using a head torch. In case of observation, we collected different parameters such as the perpendicular distance of the animal from the transect line, perch height from the ground was measured using a tape measure, age, and sex of the animal.

Figure 1. Photos of jewelled chameleon (left: adult female; right: adult male)

Data analysis

The density analysis was carried out using *Distance* software, considering the combination of four models recommended by Thomas et al., 2010. To ensure a good reliability of our analysis, we used perpendicular distance truncation at 10m, which corresponds to the maximum of our net observation of the animal during the fieldwork. For the perch height preference, we used RStudio

with R version 4.3.1 (R core team, 2002) for the analysis. Comparison the perch height preference from both habitat types was undertaken using the non-parametric Mann-Whitney test because the Shapiro-Wilk test indicated that the animal perch heigh data distribution wasn't normal.

Results

Density

In total, we surveyed 16,947 m of total effort, with 8,550m from less disturbed areas and 8,397 m from the highly disturbed areas. For the density analysis, we divided the survey into two groups based on the last fire, such as a highly disturbed area when the last fire happened in less than four years from our survey period, and a less disturbed means that the last fire happened more than four years. Density changes according to habitat disturbance. It is high from the less disturbed area with 19.06 individuals per hectare (95% confidence interval 14.31 – 25.39) against 12.62 individuals per hectare (95% confidence interval 7.96 – 20.00) from the high disturbed area.

Table 1. Density of *Furcifer campani* in less and highly disturbed areas

Disturbance level	Model	Effort	N	Density	CV	IC @ 95%
Less disturbed	Uniform/cosine	8,550	176	**19.06**	14.42	14.31 – 25.39
High disturbed	Half normal/cosine	8,397	83	**12.62**	23.50	7.96 – 20.00

N: number of encountered animals; CV: coefficient of variation; IC: interval of confidence

Animal perch height

During the night, *Furcifer campani* perches in vegetation from 0.04 to 3.0 meters from the ground (Fig. 2). Both the minimum and maximum values were found from a less disturbed area. Perch height differs from both target habitat types, with *F. campani* perch higher in less disturbed areas, with a mean of 0.47 (± 0.02) meters from less disturbed against 0.40 m (± 0.02) from high disturbed, and the statistical analysis indicates that this difference is significant (W = 6034.5, *p-value=0.007*).

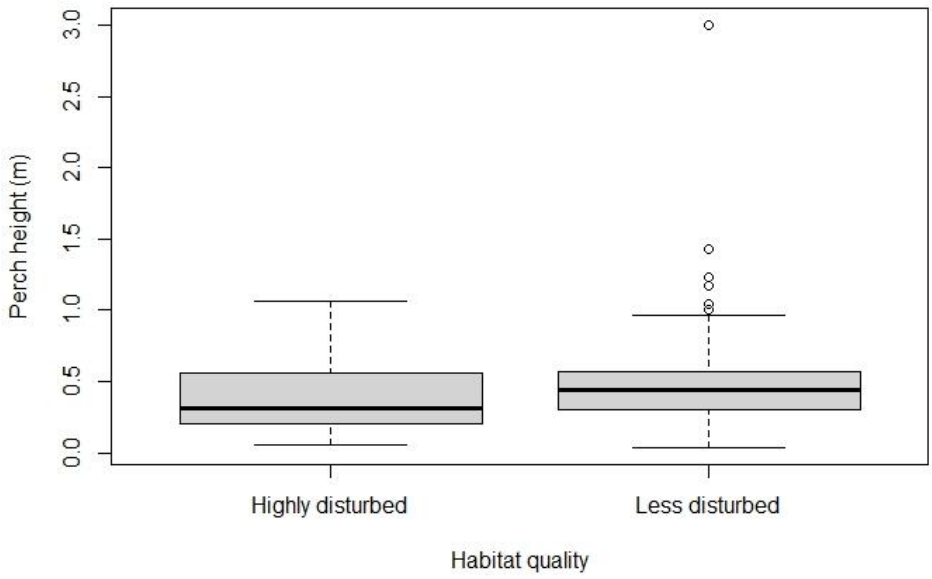

Figure 2. Box plot showing the perch height of *Furcifer campani* from the less and highly disturbed areas

Other findings

During the period of field work, we identified two main threats to the savannah biodiversity of the Amkaratra massif, including animals or plants.

Bush Fire

As in other regions of the island and for other species, fire is a major factor in reducing the size of a population by the total loss of their primary habitats. Although there is some time for regeneration, there is always a different type than the first. Direct losses can happen to be burnt by the fire, as we observed in October. This pressure is developed during the dry season, that is to say, between July and October.

Invasive Plants

The study area was used to produce tree pine; many extensive areas of planted pines are managed by different organizations from time to time. Currently, the surface returns to the Malagasy state, and control of exotic plants, including its easily dispersed by the wind, is not a priority. They begin to invade the other part of the station like the natural forest and savanna. These plants are classified as dominant as they kill other plants around them. As *Furcifer campani* is totally a savanna, the species can't live in a pine forest.

Discussion

Our results indicated that the density of *Furcifer campani* is affected by habitat disturbance. This case was already observed for many species of Madagascar chameleons according to the previous study, such as Jenkins et al. (2003), which studied the impact of habitat disturbance from riparian habitat. Also, Andriantsimanarilafy et al. (2024) reported that land use change affects chameleons' distribution and abundance. This change can be the result of prey availability, which is very low in open areas, but also by the high predation from the disturbed area and might be related to the animal ecology and exigence. The jewelled chameleon is mainly found in montane savanna habitats, including secondary heathland and savanna grasslands (Jenkins et al., 2011), and it was considered tolerant of a narrower range of abiotic conditions (Raxworthy & Nussbaum, 1996; Vences et al., 2002). However, this study indicates that the species is vulnerable to habitat disturbance, which needs to be considered for the future conservation measures of the site and the next Red List status assessment. Fire is the main threat to this species by changing the habitat quality, but it also directly affects the animal, as we observed an adult male die from burns during the fieldwork. Regarding the perch height preference, a previous study indicated that chameleons' perch height may change according to the animal body size, which Body size was significantly positively correlated with perch diameter and perch height, but not with vegetation height (Razafimahatratra et al., 2008). Previous study indicated that this difference in perch height is related to the height of vegetation used by chameleons for roosting during the night (Randrianantoandro et al., 2010). Based on those results, the low perch height of the jewelled chameleon from a highly disturbed area can be explained by the dominance of small vegetation from this area. Some researchers also assumed that the perch selection by chameleons may be related to foraging opportunities the following day, as well as predation avoidance, but other factors, such as morphological constraint and climate condition, cannot be excluded (Razafimahatratra et al., 2008).

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