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Communities' Knowledge and Perceptions towards the Conservation of Nguru Spiny Pygmy Chameleon (*Rampholeon acuminatus*) in Nguru Mountains, Tanzania

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ABSTRACT

Rhampholeon acuminatus is a critically endangered species in Tanzania's Nguru Mountains. Its main threat is habitat loss due to human activities like farming and the pet trade. Understanding public awareness and perceptions about its conservation is crucial for the survival of this chameleon and other reptiles in the area. This study was conducted in five villages bordering the Mkingu Nature Forest Reserve (MNFR), part of the Nguru Mountains. This study assessed the communities' knowledge, perception, and practices towards conserving *R. acuminatus*. The results revealed that 31.5% of people perceived no benefits that communities get from the preservation of *R. acuminatus* p = 0.001. Moreover, about 25.2% of the respondents are unaware of the activities that threaten the conservation of *R. acuminatus* in Nguru mountains p = 0.148. The study also found that about 88.3% of the respondents cleared the land to create space for the cultivation of crops such as cardamom, cassava, beans, and maize. The majority of the respondents (97%) reported that there are no education programs or initiatives in place that target to increase awareness of the *R. acuminatus* Nguru mountains, thus making it difficult for communities to identify the species. Thus, only a few respondents were able to identify the *R. acuminatus* during the survey, and the rest were not able to identify it even after being shown a photo p = 0.139. Thus, the study recommends public awareness programs and conservation education as well as the reduction of forest-dependent activities that target chameleon species to ensure their survival and reduce perceived threats by dispelling myths and encouraging interest in reptiles' conservation.

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1.0 Introduction

The Eastern Arc Mountains (EAM) form a mountain range that extends along the eastern coastline of Tanzania and contains some of the most biologically diverse areas in Africa (Newmark 1998; Burgess et al. 2014; Menegon et al. 2022). The Eastern Arc is a mountain range that extends from the Taita Hills in southern Kenya to the Udzungwa Mountains in southern Tanzania. This region is home to a wide variety of unique amphibians and reptiles, which represent a significant portion of the region's endemic vertebrate species. As such, it is recognized as a global hotspot for biodiversity and endemism (Menegon and Salvidio, 2005; Menegon et al., 2008; Lyakurwa, 2019). The Nguru Mountains belong to the Eastern Arc Mountains and contain one nature reserve (Mkingu Nature Forest Reserve) and two central government-managed "catchment' forest reserves (Kanga and Magotwe). Within the reserve, there are 12 families of amphibians and 11 families of reptiles, both facing threats. Among these is the Nguru Spiny Pygmy Chameleon, an endemic and critically endangered chameleon species found exclusively in the Mkingu Nature Forest Reserve (Menegon et al., 2008).

The Nguru spiny pygmy chameleon (*Rhampholeon acuminatus*) is located in the remaining parts of the fragmented montane forest and is native to the Nguru Mountains, which are found in the EAM region of Tanzania. This species is only found in the Afromontane Forest, around 1,500 meters above sea level (Redbond et al., 2021). While it can be spotted perched in low bushes ranging from 50 cm to several meters high, its habitat is primarily the leaf litter of the forest (Tolley et al., 2014). The most extensive remaining forest patch where this species is found covers a 28 km² area within the newly established Mkingu Nature Forest Reserve (MNFR), providing the Nguru forest with the highest level of protection in Tanzania (Burgess et al., 2014; Tolley et al., 2016). The species is not distributed across the entire forest but is restricted to the lower valley slopes at around 1,500 meters; however, most of this submontane belt has already been cleared and destroyed, resulting in the species' area of occupancy being smaller than the area of the fragment (Redbond et al., 2021). Despite the limited information available, it is likely that the population is small due to the species' extremely restricted range (Tolley et al., 2014). The species is classified by IUCN as Critically Endangered due to its extremely limited distribution and population size (with no more than 45 km² of suitable habitat remaining within its extent of occurrence), its confinement to a narrow elevational band within this area, which constitutes a single location defined by chameleon and habitat exploitation, and the continuous decline in the quality of its forest floor habitat due to the cultivation of shade crops leading to habitat loss (Menegon et al., 2008, 2022; Tolley et al., 2014).

Rhampholeon acuminatus has been captured for the pet trade and exported outside the country, even though the remaining forest is located within the Mkingu Nature Reserve and is expected to remain undisturbed (Tolley et al., 2011; Tolley et al., 2014). Small numbers of this species have been brought into the pet trade two or three times every few years. This species has been imported, and numerous specimens are available for purchase online (Carpenter et al., 2004; Auliya et al., 2016). Consequently, this species is experiencing declines in the quality of its habitat and potentially in its area of occupancy. Moreover, the harvesting of this species from the wild for the pet trade was essentially unregulated as it was not listed on CITES (Carpenter et al., 2004; Menegon et al., 2008, 2022; Auliya et al., 2016). Given that this species was already threatened due to habitat loss and likely has a small population, its removal from the wild could be harmful. Most of the villagers around MNFR rely on agriculture for their livelihoods, and to generate income, they cultivate beans, bananas, yams, cardamom, sugarcane, cocoa, and maize, all of which require clearing forested areas for cultivation (Lyimo, 2014; Msalilwa et al., 2016). The increasing population of the villagers and their demand for land for cultivation pose a threat to this species (Menegon et al., 2008; Redbond et al., 2021). Although the forest is formally protected within the MNFR, this protection has not stopped ongoing human activities, including cultivation of the forest floor and collection of this species for the international pet trade, both of which endanger the survival of this chameleon. This study aimed to evaluate people's knowledge and perception of the conservation of *R. acuminatus.*

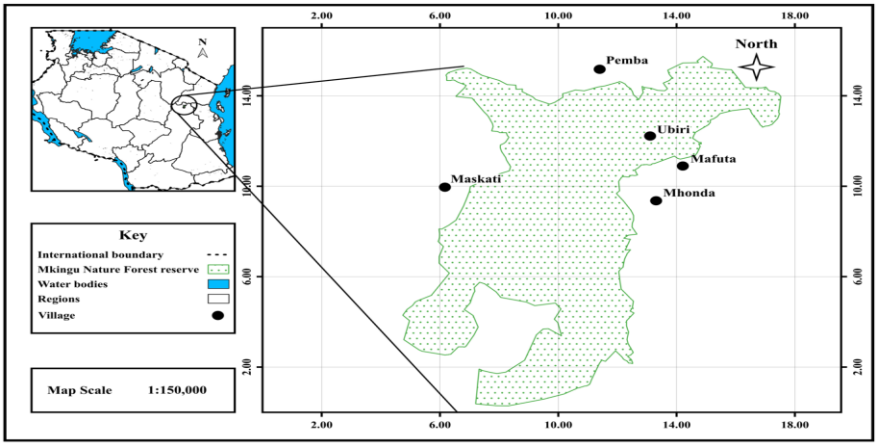
2.0 Materials and Methods

2.1 Study Site

The study was conducted between June 2024 and July 2024 in the communities living around the Mkingu Nature Forest Reserve (MNFR) in the Nguru Mountains, Mvomero district, Morogoro, Tanzania. The MNFR is surrounded by 21 villages, of which five were selected to be

included in this study due to their proximity to the MNFR. The villages covered were Pemba (-6.0046S, 37.5154E), Ubiri (-6.0616S, 37.5473E), Maskati (-6.1278S, 37.5762E), Mhonda (-6.1278S, 37.5762E), and Mafuta (-6.0862S, 37.5697E). The major economic activity in these villages is agriculture, and crops cultivated include cardamom, cocoa, maize, sugarcane, yams, beans, and bananas. (Lyimo, 2014) The weather conditions in the area depend on elevation, and the forest vegetation varies greatly. In the valleys of the eastern slopes, lowland rainforests can be found between 300 and 900 meters above mean sea level (m.a.s.l.) (Msalilwa et al., 2016). There are patches of submontane forest on the western slopes at 1400–1500 m.a.s.l., but the majority of the eastern valleys are between 900 and 1400 m.a.s.l. With moss-covered upper montane forests at higher elevations and drier montane forests on the western side above the Maskati mission at 1600–2000 m.a.s.l., montane forests can be found between 1400 and 1800 m.a.s.l. (Burgess et al., 2014; Msalilwa et al., 2016). There are isolated stands as low as 1200 m.a.s.l. where soil conditions do not allow forest growth, and heath is found on the upper ridges above 2000 m.a.s.l.

Figure 1
The Map of Tanzania Showing MNFR and the Five Villages Surveyed



2.2 Data Collection

Data on the knowledge and perception toward the conservation of *Rhampholeon acuminatus* was collected from the five villages close to Mkingu Nature Forest Reserve in the Nguru Mountains, Tanzania. Household surveys (HHS) and focus group discussions (FGDs) were conducted using methodologies described by Danielsen et al. (2014), Midega et al. (2016), and Nyumba et al. (2018). In each of the five villages visited, the respondents for the interviews were randomly selected using sampling lists provided by the village leaders from the five villages. A total of 111 respondents from HHS and five FGDs were interviewed. The minimum age requirement of the respondents was 18 years old, assuming that they are aware of environmental-related issues such as the impact of anthropogenic activities on biodiversity. To test the ability of local people to identify *R. acuminatus*, 2-coloured printed pictures of *R. acuminatus* were provided, and respondents were asked to identify the *R. acuminatus* from the provided pictures. A series of questions were developed to assess knowledge and perceptions toward the conservation identification, threats, and conservation of *R. acuminatus*. Examples of questions were, “Have you seen this chameleon before?” “How easily/often do you encounter this chameleon species?” “How was it in the past, i.e., 5 to 10 years ago? Was it seen easily?” “How do you and others in your community perceive/think of this Nguru chameleon species?” “Are there any benefits that people get from this chameleon?” What threats do you think this chameleon species faces? “Are you familiar with any conservation efforts that are being undertaken to protect the chameleon species?” “Are there any educational programs or initiatives conducted in your local community to increase awareness of the chameleon species?” and, “What could be done to increase awareness of this chameleon species in your local community?” Questions about the respondents included their age, gender, household size, farm size, occupation, and village.

2.3 Data Analysis

The survey data was summarized, and descriptive statistics, including means, standard deviations, and percentages, were calculated using the Statistical Package for Social Sciences (SPSS) version 26. For questions with multiple answers, percentages were calculated for each group of similar responses. The percentages of people in the five villages (Pemba, Ubiri, Mafuta, Maskati, and Mhonda) who gave similar responses to a question were calculated based on the total number of people who responded to each question. Comparative statistical tools, such as Chi-square and one-way analysis of variance (ANOVA), were used to assess statistical differences regarding socio-demographics, farm characteristics, knowledge, and perceptions toward the conservation of *R. acuminatus*. The significance level was set at 0.05, and means were separated by Tukey's HSD (honestly significant difference) test.

3.0 Results

3.1 The demographic and economic characteristics of the participants

A total of 65 male (58.6%) and 46 female (41.4%) respondents of different ages were interviewed using a structured questionnaire (Table 1). Most respondents were smallholder farmers with plots close to the MNFR and had been cultivating at least once per year. They all practiced mixed farming, with maize, beans, cardamom, cocoa, and cassava being common. The majority of the respondents, 35.1% (39), claimed to have seen the *Rhampholeon acuminatus* ($\chi2 = 2.194$, df = 1, $p < 0.139$), and 19.8% (22) were aware of conservation initiatives. About 31.5% (35) of respondents considered *R. acuminatus* to be important ($\chi2 = 76.692$, df = 1, $p = 0.000$, Figure 5). Moreover, 23.4% (26) of respondents correctly identified the *R. acuminatus*. 30.6% (34) reported it is rare to encounter this chameleon; 28.8% (32) respondents reported it was difficult to see the *R. acuminatus* even 5 to 10 years ago. About 49.5% (55) of respondents perceive *R. acuminatus* as normal, while 10.8% (12) perceive *R. acuminatus* as a bad creature, and 21.6% (44) perceive it as a good creature (Figure 4). About 80.2% were unfamiliar with any conservation efforts being undertaken to protect the *R. acuminatus*, and 78% reported there are no local regulations or laws in place to protect these chameleon species.

Table 1
Socio-economic Characteristics of the Respondents and their Perception toward the Conservation Status of R. acuminatus

Variable		Villages						
		Pemba	Ubiri	Mafuta	Mhonda	Maskati	Mean (SD)	Chi Square
Gender (%)	Male	61.11	46.67	66.67	64.71	63.16	60.46 (7.98)	x^2 =2.401; df = 1; p = 0.121
	Female	38.89	53.33	33.33	35.29	36.84	39.54 (7.98)	
Age (%)	18-25	19.44	16.67	0.0	41.78	21.05	19.79 (14.89)	
	25-35	19.44	20	11.11	29.94	42.11	24.52 (11.88)	
	36-45	27.78	13.33	0.0	5.88	10.53	11.50 (10.41)	
	46-55	16.67	30	55.56	17.65	15.79	27.13 (16.91)	
	Above 56	16.67	20	33.33	5.88	10.53	17.28 (10.49)	
Age (years)	Mean (SD)	7.2 (1.64)	6 (1.87)	1.8 (2.17)	3.4 (2.61)	3.8 (2.49)	4.44 (2.15)	x^2 = 3.619; df = 4; p = 0.460
Household size (%)	1-5	48.48	53.57	33.33	76.47	84.21	59.21 (20.85)	
	6-10	39.39	42.86	66.67	11.76	10.53	34.24 (23.56)	
	11-15	9.09	0.0	0.0	11.76	0.0	4.17 (5.79)	
	Above 16	3.03	3.57	0.0	0.0	5.26	2.37 (2.32)	
Household size	Mean (SD)	8.25 (7.37)	7 (7.62)	2.25 (2.87)	4.25 (5.91)	4.75 (7.54)	5.3 (2.36)	x^2 = 8.209; df = 3; p = 0.42
Farm size (%)	1-5	53.13	68.97	44.44	54.55	70.59	58.34 (11.16)	
	6-10	37.5	24.14	55.56	27.27	29.41	34.78 (12.63)	
	11-15	0.0	3.45	0.0	18.18	0.0	4.33 (7.89)	
	Above 16	9.38	3.45	0.0	0.0	0.0	2.57 (4.1)	
Farm size (ha)	Mean (SD)	8 (7.87)	7.25 (8.96)	2.25(2.63)	2.75 (2.5)	4.25 (5.68)	4.9 (2.15)	x^2 = 0.232; df = 3; p = 0.972

3.2 Perceptions and Knowledge of R. acuminatus Conservation among Community Members

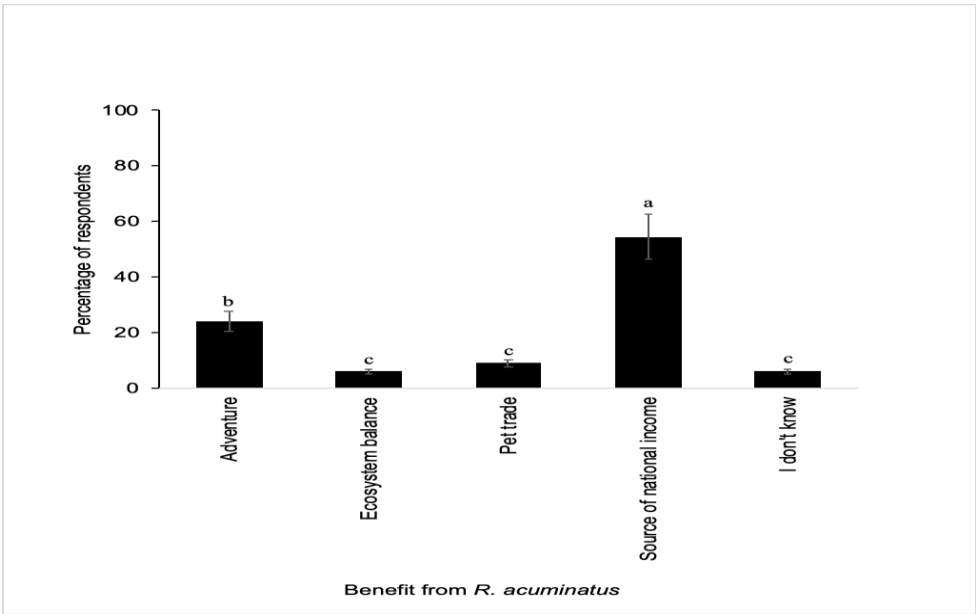
The binary logistic model analysis indicated that respondents' knowledge of *Rhampholeon acuminatus* is independent of their age and household level ($p > 0.05$, Table 2). However, it appears to be influenced by their perception of the value of *R. acuminatus* ($p = 0.029$). Additionally, 35.1% (39) of the respondents reported seeing *R. acuminatus*, while 49.5% (55) mentioned that most people in the communities perceive *R. acuminatus* as a common creature that is not easily spotted (Likelihood ratio test = 5.07, $p = 0.167$). Similarly, 5 to 10 years ago (Likelihood ratio test = 2.223, $p = 0.329$). Some respondents were aware of educational programs or initiatives aimed at raising awareness of the chameleon species in the community (Likelihood ratio test = 0.1, $p = 0.919$). Moreover, the majority of respondents (74.8%, 83) were knowledgeable about the threats facing chameleons ($\chi 2 = 25.381$, df = 19, $p = 0.148$, Figure 3) and the ecological roles of chameleons ($F = 6.138$, df = 4, $p = 0.005$, Figure 2). Nearly 97% of the respondents correctly recognised the importance of protecting this chameleon species and supporting conservation efforts.

3.3 Communities Perception on the Threats, Conservation Initiatives, and Loss of R. acuminatus

The local perception of *Rhampholeon acuminatus* impact varied significantly ($F = 6.37$, df = 4, $p = 0.012$). Respondents identified deforestation 21.26% (24), forest burning (23.42%, 26), habitat loss 10.81% (12), and chameleon pet trade (0.9%) as potential threats to *R. acuminatus* (see Figure 3). 25.23% (25.23) of respondents were unable to pinpoint any specific threats to *R. acuminatus*. Additionally, nearly half of the respondents, 47% (52), supported conservation initiatives such as environmental protection like planting trees, *R. acuminatus* education, and alternative income sources beyond reliance on forests. Collaboration between villagers and the government in species conservation and the reduction of detrimental agricultural activities was favoured by 31% (34) and 19% (21) of respondents, respectively.

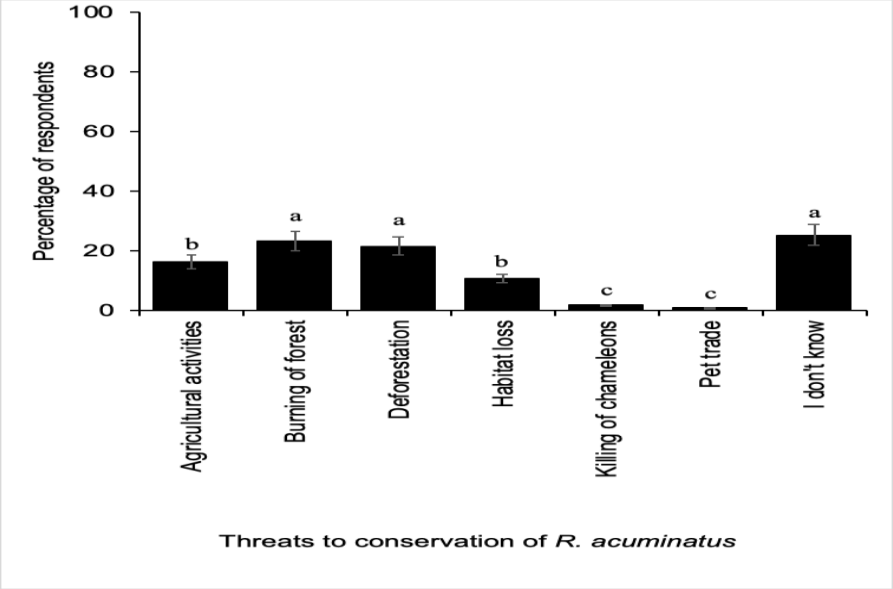
Figure 2

Respondents' Knowledge about the Importance of R. acuminatus was Recorded during the Questionnaire Survey in the Five Villages close to MNFR in Tanzania



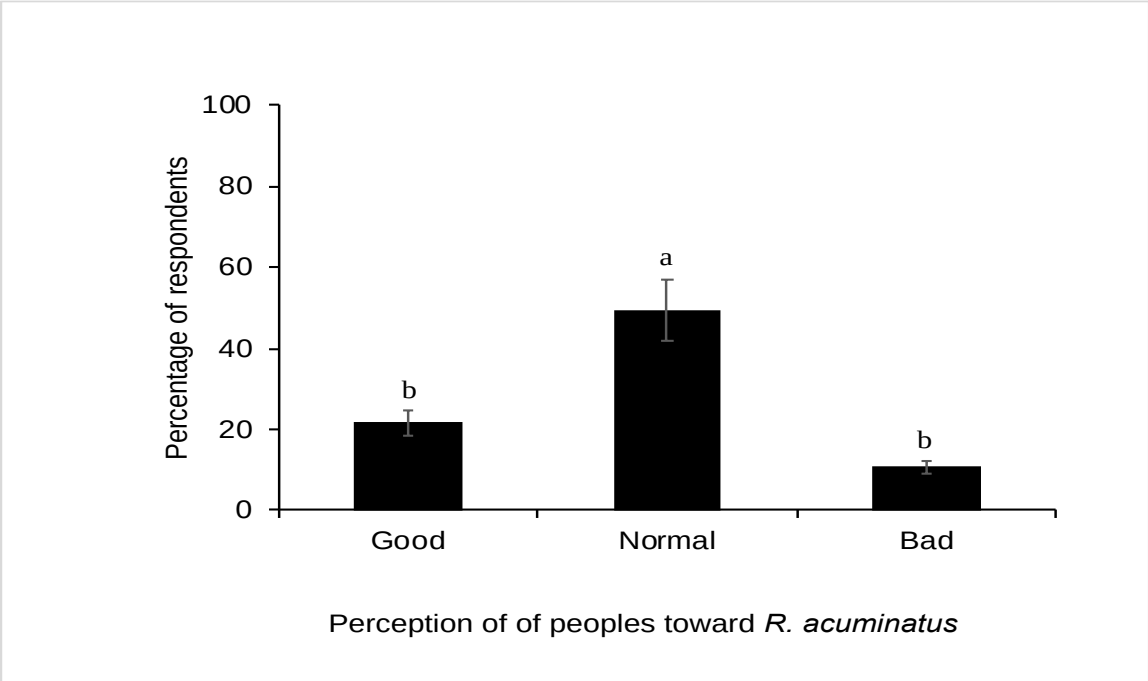
Bars with dissimilar letters are significantly different by Tukey–Kramer Test at $P \leq 0.05$.

Figure 3
Percentage of Respondents that Identified the Threats to R. acuminatus Effects from the Local Ecosystem according to the Questionnaire Survey in the Five Villages close to MNFR



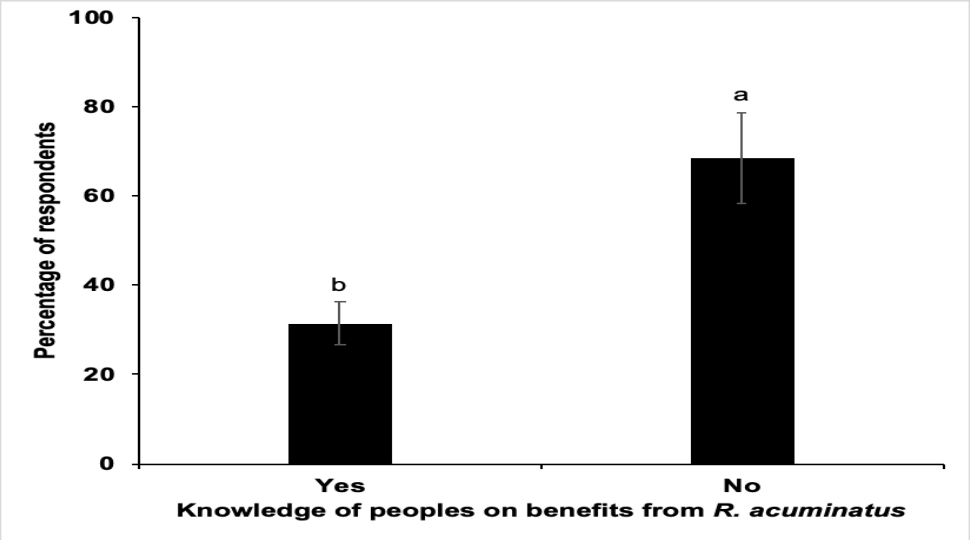
Bars with dissimilar letters are significantly different by Tukey–Kramer Test At P ≤ 0.05.

Figure 4.
Knowledge of Respondents toward R. acuminatus was Recorded during the Questionnaire Survey in the Five Villages close to MNFR Tanzania



Bars with dissimilar letters are significantly different by Tukey–Kramer test at p ≤ 0.05.

Figure 5
Knowledge of Respondents about the Benefits of R. acuminatus was Recorded during dhe Questionnaire Survey in the Five Villages close to MNFR Tanzania



Bars with dissimilar letters are significantly different by Tukey–Kramer test at $p \leq 0.05$.

Table 2
Logistic Regression to Determine Factors Influencing Knowledge of Pollination

Variable	Estimate	SE	Wald	Level of Significant (p)
Intercept	0.838	0.212	15.700	0.000
Age (18-25)	-0.461	1.216	0.144	0.705
Age (26-35)	0.904	1.329	0.463	0.496
Age (36-45)	1.072	1.484	0.522	0.470
Age (46-55)	0.686	1.591	0.186	0.666
Age (above 56)	0.867	1.423	0.001	0.385
Household size (1-5)	1.108	1.013	1.198	0.274
Household size (6-10)	-0.245	2.131	0.013	0.909
Household size (11-15)	-1.244	2.476	0.253	0.615
Household size (above 16)	1.101	1.035	1.164	0.199
Benefits that people get from chameleons	-2.524	1.158	4.755	0.029

Present significant levels at $p < .05$.

4.0 Discussion

Farmers around the MNFR had relatively good knowledge of reptiles, despite having received no awareness of *Rhampholeon acuminatus*. In general, most people have a poor understanding of chameleons and hold a negative perception of them (Whiting et al., 2009). This study supports what has been reported by several authors (Lyakurwa, 2019): most people are highly fearful and misinformed about reptiles, despite most of them being harmless to humans. Most people have been reported to sell chameleons erroneously due to a lack of knowledge and low income (Patrick et al., 2011), and the same actions were recorded by the respondents in this study. Despite reptiles being highly important economically in both traditional and modern medicine (Magnino et al., 2009; Alves & Araujo, 2017), most respondents in this study did not see any importance in having *R. acuminatus*. This is

probably attributed to the little attention given to reptiles by most people (Burgess et al., 2007; Howell, 2011) or due to the rarity and cryptic nature of most reptiles (Willson & Winne, 2016), which makes them difficult to observe and therefore not appreciated by many people. Contrary to this study, López-Del-Toro et al. (2009) reported that coffee farmers in Mexico who had attended some environmental knowledge courses were aware of the significance of reptiles and positively perceived snakes.

Awareness-raising campaigns (including field trips) have been recommended to improve the conservation of reptiles (López-Del-Toro et al. 2009; Ballouard et al. 2012; Menegon et al. 2022). Chameleons are also indicators of ecosystem health and biodiversity (Gardner et al. 2007; Schneider-Maunoury et al. 2016). Their presence and population dynamics can reflect changes in habitat quality and environmental conditions (Meng et al., 2016). According to Meng et al. (2016), declines in chameleon populations are due to habitat disruptions caused by agricultural expansion or deforestation, which may have broader implications for the ecosystem's balance. In Tanzania, chameleons contribute to the health of forest and savanna ecosystems by controlling insect populations and serving as prey for larger predators (Tolley et al., 2016). Conservation efforts that protect chameleon habitats, such as creating wildlife corridors and reducing habitat fragmentation, are essential for preserving their populations and the ecological functions they perform. Research on chameleons can also inform conservation strategies and environmental management practices (Lyakurwa 2019; Ract et al. 2024).

Reptiles are declining globally. Therefore, conservation strategies and raising awareness to protect reptiles are a major concern (Ngalason and Mkonyi 2011; Lyakurwa 2019). Reptile conservation awareness bridges the knowledge gap in communities to fully understand the role of reptiles and their conservation strategies and implications (Hariohay et al. 2018; Guzman et al. 2020; Truong 2022). During our study, the respondents showed awareness of the threats that could potentially endanger chameleons. Some of these threats include forest burning, agricultural activities, deforestation, the pet trade, and forest degradation, all of which can reduce the microhabitat of *R. acuminatus*. The agricultural encroachment led to the reduction of the number of *R. acuminatus*. The pet trade, which involves selling *R. acuminatus,* was also stated by local people to reduce the number of *R. acuminatus* in their natural habitat. This is because some people collect *R. acuminatus* in the forest and sell it to get income. As a result, some respondents showed a willingness to adopt various conservation strategies to protect chameleons and other species in the forest reserve. These strategies include education about the importance of reptiles in the ecosystem; planting trees to improve habitat; and minimizing forest dependence by giving them alternative sources of income. Some of these strategies are consistent with those described by Menegon et al. (2008) and Lyakurwa (2019). These strategies include maintaining natural vegetation around fields to provide habitat and food sources for chameleons, planting trees and shrubs to enhance their living environments, reducing the use of harmful chemicals, preserving forested areas to ensure adequate shelter, and educating future generations about chameleon conservation.

Conservation of chameleons has significant implications for socio-economic growth by enhancing ecosystem services and promoting biodiversity (Menegon et al., 2008; Lyakurwa, 2019; Redbond et al., 2021). If chameleons and their habitats are protected, they could potentially contribute to ecological balance and local income through ecotourism (Meng et al., 2016). This could lead to improved socio-economic development and poverty reduction within surrounding communities. This study highlights the importance of understanding community perceptions and knowledge in advancing chameleon conservation efforts. While chameleon conservation can influence the socio-economic growth of local people, awareness about non-chameleon reptile species remains limited among many respondents. This suggests that local communities could become effective conservation ambassadors and actively engage in protecting their environments if they are educated about chameleon species and their ecological roles. Increasing our understanding of chameleons and emphasizing their contributions can also reduce misconceptions and fears associated with these reptiles. Village leaders and environmental officers believed that by participating in the study and acknowledging the conservation of chameleon biodiversity on their farms, the MNFR management could potentially include their plots as part of the reserve. Results from FGD indicate that 62.5% of respondents claimed to know this *R. acuminatus,* 37.5% do not encounter them more often, and 62.5% are not aware of the conservation status of the *R. acuminatus* and endemism. Deforestation, forest burning, agricultural activities, and habitat loss are the main threats. 87.5% reported no conservation efforts or projects related to

R. acuminatus in their areas. Also, 62.5% reported that the forest has decreased compared to the past. Still, they suggested that planting trees and community empowerment can be solutions to reduce the threat to this charismatic species identified by the environmental committee. 37.5% reported there are cultural practices that promote the conservation of *R. acuminatus,* and 98% believe that education and awareness programs can benefit the conservation of *R. acuminatus,* which complements the data from HHS. Training local people to distinguish between different chameleon species and engage safely with them can foster participation in conservation programs and prevent negative interactions (López-Del-Toro et al., 2009). Moreover, communities should be informed about the benefits of all chameleon species, not just the most commonly recognised ones. This will enhance sustainable conservation efforts for chameleons and other reptile species (Burgess et al. 2007; Rovero et al. 2014; Ract et al. 2024). Overall, raising awareness about chameleons among local communities will bridge the existing knowledge gap and promote their conservation around the Nguru Mountains.

5.0 Conclusion

Based on the findings of the study, it is clear that the local community lacks awareness and understanding regarding the conservation status and significance of the *Rhampholeon acuminatus* (chameleon species) in the area. The majority of respondents are not acquainted with any conservation efforts or local regulations in place to safeguard this chameleon species. Many respondents reported they didn't even see *R. acuminatus;* some perceived *R. acuminatus* as a negative creature, indicating a need for educational and awareness programs to alter these perceptions.

6.0 Recommendations

Many of the people who answered the survey didn't know that *R. acuminatus* and other reptiles are protected (Meng et al., 2016; Msalilwa et al., 2016; Redbond et al., 2021; Coracero et al., 2022). This means that conservation groups and local governments should create and run educational campaigns to make more people aware of how important *R. acuminatus* is to the local ecosystem. These campaigns should also emphasise the necessity of conservation efforts and the existence of local regulations or laws designed to protect these chameleon species. There is a need to engage the local community, particularly smallholder farmers, to promote sustainable farming practices that support the conservation of *R. acuminatus* and its habitat (Meng et al., 2016; Msalilwa et al., 2016). It is essential to involve the community in conservation initiatives and provide them with the knowledge and resources necessary to contribute to the protection of the *R. acuminatus*, as recommended by key informants from TFS and the PAMS Foundation.

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9.0 Declaration of Conflicting of Interests

The authors declare no conflict of interest.

10.0 Reference

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