

# Exploring local ecological knowledge for the conservation of the Endangered and understudied Preuss's monkey (*Allochrocebus preussi*) in Ebo forest, Cameroon

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## ABSTRACT

Preuss's monkey (*Allochrocebus preussi*) which is listed as Endangered on the IUCN red list, class A in Cameroon wildlife legislation and endemic to Africa's Gulf of Guinea Forest, is a poorly known semi-terrestrial primate. This study explored local ecological knowledge held by local people bordering Cameroon's Ebo forest, one of the few bastions of this species, in view to evaluate the contribution of this knowledge system to the conservation of the understudied Preuss's monkey. Data were collected through interviews using semi-structured questionnaires, administered to 262 households from 17 villages of permanent settlements purposely selected based on their closeness and dependence on Ebo forest for livelihoods. Results indicate that the log-odds of being in favor of conserving *A. preussi* in the area was significantly higher for participants of secondary school level of education. The conservation of *A. preussi* was strongly supported by participants who use the species for subsistence. The log-odds of perceiving a decreasing trend of *A. preussi* in the area was significantly highest for participants who had last consumed this species  $\geq 5$  years ago compared to those who had recently eaten meat of the species. Participants who used *A. preussi* for income generation were more likely to perceive a decreasing population trend, compared to those who used it for food. Overall, this study highlights the possible value of local ecological knowledge as a tool that can provide important information to conservationists and decision-makers, useful to plan and prioritize conservation actions for *A. preussi*. Also, the findings suggest the urgency to monitor populations of *A. preussi*, assess the impact of hunting pressure on this species, and develop sustainable livelihood activities and community-based conservation education to strengthening the conservation of *A. preussi* in Ebo forest.

**Keywords:** Local ecological knowledge, Preuss's monkey, conservation, population trend, local use.

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## SIGNIFICANCE STATEMENT

Evidence-based conservation policy and planning largely depend on ecological field data. However, reports from field experts are sometimes limited to provide a robust baseline for understanding the status and conservation requirements of threatened species. Local ecological knowledge is increasingly recognized as a valuable alternative source of information about threatened species and biodiversity change. This may represent an important source of information for many poorly studied taxa. Here, we investigated the contributions of local ecological knowledge for the conservation of the Endangered and understudied *Allochrocebus preussi* in the Cameroon's Ebo forest, which is an important stronghold for this species and other threatened primates. Our findings provide a valuable baseline to guide the development of conservation strategies for *A. preussi* in the Ebo forest and further highlight the urgent need of assessment of threats, conservation education and involving local community participation and co-management.

## INTRODUCTION

Preuss's monkey (*Allochrocebus preussi*) also called Preuss's guenon is a poorly-known semi-terrestrial, diurnal primate endemic to Africa's Gulf of Guinea Forests (Oates *et al.* 2004). It is listed as Endangered on the IUCN Red list (Cronin *et al.* 2019), and a Class A species in Cameroon's Wildlife legislation, totally protected (MINFOF 2020). *Allochrocebus preussi* can be distinguished from other monkeys by its dark appearance that lacks very distinctive light markings other than their whitish throat (Oates 2011). Its population is restricted to southwestern Cameroon, southeastern Nigeria, and on Bioko Island of Equatorial Guinea, and it occurs in eight forest fragments estimated at approximately 17,300 km<sup>2</sup> (Cronin *et al.* 2019). *Allochrocebus preussi* is found in primary and secondary lowland, cloud forests, but occurs mainly in cloud moist forests above 800 m (Butynski 2013; Cronin *et al.* 2019). *Allochrocebus preussi* is a large-sized guenon (9-15 kg) with a semi-terrestrial behavior which makes it an easy target for poachers. Poaching has contributed to *A. preussi* decline across its range of distribution, particularly on Bioko Island (Cronin *et al.* 2017). Another major problem with this species is that a greater part of its population is not protected because the majority of its range is found outside of current protected areas. Consequently, *A. preussi* is threatened by habitat loss and fragmentation as a result of logging and agriculture (Cronin *et al.* 2019).

Information on local people's views, values and preferences for different conservation management interventions are increasingly gaining importance worldwide among conservationists and decision-makers (Albuquerque *et al.* 2021; Buchholtz *et al.* 2020; Ochieng *et al.* 2021). Local ecological knowledge is a robust and cost-effective method for gathering data from communities that live and interact with nature (Allendorf *et al.* 2020; Brittain *et al.* 2020; Djoko *et al.* 2022), and useful to assess threats to wildlife (Albuquerque *et al.* 2021; Buchholtz *et al.* 2020; Haenn *et al.* 2014) for the sustainable uti-

lization and conservation of ecosystem services (Boafo *et al.* 2016; Ens *et al.* 2015; Mavhura and Mushure 2019; Nash *et al.* 2016). It can equally provide important baseline information when there is a lack of scientific data, informing threats and impacts at a finer scale that can help inform management interventions (Corteés-Avizanda *et al.* 2018; Cullen-Unsworth *et al.* 2018; Nash *et al.* 2016; Ternes *et al.* 2023). The term local ecological knowledge is often used interchangeably with oral tradition, indigenous knowledge, local or community knowledge, or traditional ecological knowledge (Gilchrist *et al.* 2005; Johannes 1989). There is no universally accepted definition of local ecological knowledge, but it constitutes the knowledge and perceptions of a particular group of people about local ecosystems and their interactions with the environment (Caro-Borrero *et al.*, 2017; Gilchrist *et al.* 2005; Huntington 2000; Olsson and Folke 2001). It is context-specific, therefore it varies from one area to another (Mavhura and Mushure 2019). This set of knowledge has been increasingly invoked in biodiversity monitoring and conservation efforts and can provide essential contributions to answering ecological questions (Brook and McLachlan 2008; Buchholtz *et al.* 2020; Camino *et al.* 2020; Gilchrist *et al.* 2005; Zayonc and Coomes 2022). Therefore, the survival of threatened species and the maintenance of ecosystems functioning and services can be achieved by assessing and understanding conservation attitudes and perceptions of indigenous people. Perceptions are usually shaped by different socio-demographic factors such as household income levels, education level, age, size of livestock herd, length of residency, gender, sources of income, and household size (Ngonidzashe *et al.* 2015; Snyman 2012). To an extent, the success of wildlife conservation depends on community acceptance (Kleiven *et al.* 2004).

Little is documented on local knowledge on *A. preussi* in the Ebo forest (Whytock *et al.* 2021), yet such knowledge may be important for their conservation. Local knowledge, with growing interest in its role, scope, and value, represents a supporting complementary information for the conservation of bio-

diversity (Ghanbari and Turvey 2022; IPBES 2019; Turvey *et al.* 2014; Zayonc and Coomes 2022). The Ebo forest which represents the most important tract of intact forest landscape in the Cross- Sanaga-Bioko coastal forest ecoregion (Potapov *et al.* 2017) is one of *A. preussi* strongholds in Cameroon. Unfortunately, this forest is subjected to hunting pressure and exploitation concerns (Mfossa *et al.* 2022; Whytock *et al.* 2021). Interactions between human and non-human primates have positive and negative implications for both parties (Dore *et al.* 2017; Stafford *et al.* 2016). Investigating these interactions is an important step towards primate conservation due to the impact of human activities on primates (Fuentes and Hockings 2010; Fuentes *et al.* 2016; Freire Filho *et al.* 2018; Torres Junior *et al.* 2016).

This study aimed at exploring what novel insights local ecological knowledge can provide about the Endangered and understudied *A. preussi* in Cameroon's Ebo forest, which can guide conservation planning for this species. We sought to answer the following research questions. What socio-demographic factors (gender, age group, main occupation and level of education) and socio-ethnographic factors (consumption of *A. preussi* meat, last consumption of *A. preussi* and local use (s) of *A. preussi*) influence local perception towards the conservation of *A. preussi* in the Ebo forest? We hypothesized that there is a strong positive relationship between participants' socio-demographic and socio-ethnographic factors, and local people willingness to conserve *A. preussi* in the Ebo forest. Have local people perceived any trend in *A. preussi* populations in this area, and which participants' socio-demographic factors (gender, age group, main occupation and level of education) and socio-ethnographic factors (last consumption of *A. preussi*, local use (s) of *A. preussi* and consuming *A. preussi* meat) contribute to shaping such perceptions? We hypothesized that participants' main occupation, the type of use of *A. preussi* in the area and when bushmeat from *A. preussi* was last consumed would shape participants' perceptions on the population trend of *A. preussi* in Ebo forest.

## MATERIAL AND METHODS

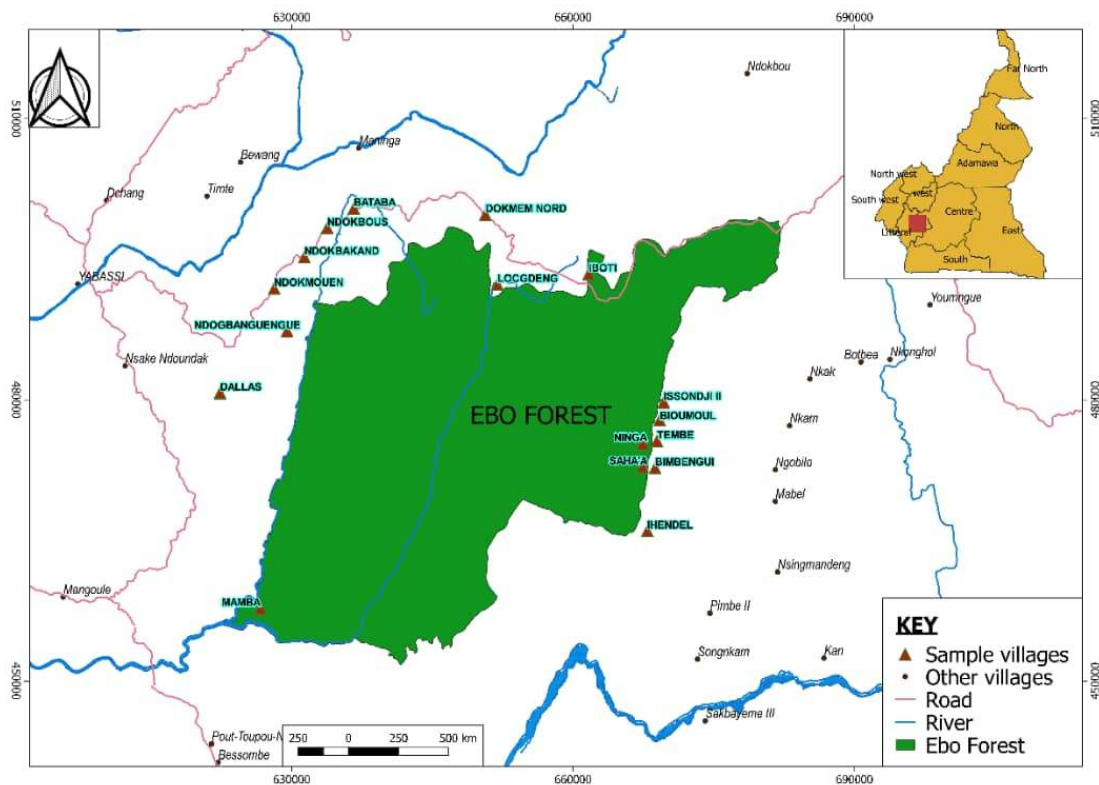
### Study area

The Ebo forest is situated in the Littoral Region of Cameroon (Figure 1). This forest lies between 4°05'09.5" and 4°31'01.6" N, and 10°02'59.2" and 10°38'30.9" W, and covers ~1,400 km<sup>2</sup> of mixed high-canopy and secondary lowland and cloud forest (Abwe *et al.* 2019). The Ebo forest constitutes ~50% of the Yabassi Key Biodiversity Area, with Makombe and Ndokbou forests summing up the rest (BirdLife

International 2021; Mfossa *et al.* 2022). The climate of the area is warm and humid tropical equatorial type with two weather conditions (wet and dry) and annual rainfall ranging between 2300 to 3100 mm (Abwe *et al.* 2019). Rainfall can occur year-round, but the months of May to September are considered the wet season (Whytock *et al.* 2021). There are over 40 villages adjacent to Ebo, dominated with two ethnic groups (Banen and Bassa). The forest has a complex history of human settlement and, although much of the region is devoid of permanent habitation today, until the 1960s, several villages existed within boundaries of the proposed "Ebo National Park" (Whytock *et al.* 2021). These surrounding villages live on shifting farming and hunting as main livelihood options, illegal commercial logging and oil palm plantations also exist in the area of Ebo forest (Mahmoud *et al.* 2019). The Ebo forest harbors threatened mammal species such as African forest elephant (*Loxodonta cyclotis*), Western gorilla (*Gorilla gorilla*), Nigeria-Cameroon chimpanzee (*Pan troglodytes ellioti*), Drill (*Mandrillus leucophaeus*) and Preuss's red colobus (*Piliocolobus preussi*) (Morgan *et al.* 2003; Oates 2011), and a high avian and anuran diversity (Dahmen 2013; Whytock and Morgan 2010). Botanical surveys in the area since 2005 led to the discovery and description of several plants species (Cheek *et al.* 2021, 2018; Mackinder *et al.* 2010; van der Burgt *et al.* 2015).

### Data collection

Over 40 villages exist around the Ebo forest; most have permanent settlements while some serve as temporal hunting camps (Abwe, 2018; Whytock *et al.* 2021). For this study, we purposely sampled 17 villages of permanent settlements based on their closeness and dependence on the Ebo forest for livelihoods (Figure 1). These villages are located in the West, North and East of Ebo forest while the Southern part is largely covered by Forest Management Unit (07-002) with no human habitations close to the forest. Methods for collecting data on local ecological knowledge typically involve interviews through which investigators obtain information directly from interviewees or key participants, using either questionnaires containing predefined questions or informal conversations (Camino *et al.* 2020; Ghanbari and Turvey 2022). Because most of the villages around the Ebo forest have few habitations (*per. obs.*), the survey protocol in every village consisted of interviewing as many households as possible (singly) to ensure comprehensive representation in local responses (Guest *et al.* 2006; White *et al.* 2005). These interviews were guided with a semi-structured questionnaire that comprised both open- and closed-ended questions with 262 household



**Figure 1.** Location of sample villages around the Ebo forest, Littoral Region of Cameroon

heads in the area. Participants were long-term residents ( $\geq 10$  years) in the area of study. To minimize interviewer bias and to ensure that the responses were comparable across all the interviewees in the area, this study used the criteria for evaluating the trustworthiness of naturalistic inquiries to reduce bias proposed by Guba (1981). We used fixed response questions to ensure precision of responses whereas open-ended questions permitted participants to express themselves in their own words (Kothari 2004). Examples of fixed response questions were [*Does this species of monkey raid crops? Is it important to protect primates, such as *A. preussi*?*] and open-ended questions such as [*What is the main factor affecting *A. preussi* population in the area? Why do you consume this species?* – See supplementary material for full list of questions]. We designed the questionnaire to gather information on the demographic profile of the participants (gender, age, main occupation and the level of education), identification of *A. preussi* among other primates, knowledge on *A. preussi* population trends, local use (s) of *A. preussi*, sightings of *A. preussi* in the area, motivation for eating this species, farm raids by *A. preussi* in the area as well as the willingness of locals towards conserving this species and its habitat. We also asked whether participants knew anyone who had hunted *A. preussi* in

the area, or whether the participants kept any primate as pet. Participants were also sampled on their knowledge of National Wildlife Legislation.

In each village, SNN first introduced himself to the village chief and explained the nature of the study. SNN was assisted by one village assistant whose facilitation to reduce suspicion and increased information gathering between the researcher and the participants. Interviews were conducted in French as most people around the study area are fluent in French. For participants with low literacy levels, the questions were interpreted on a real-time basis. For consistency, SNN and the village assistant agreed on the translations of keywords of the questions to avoid distortions in meanings. This team moved from one household to another during the survey, with each participant having a single interview that lasted 30 – 40 minutes. A household was considered as a sampling unit in every village. We defined a household head as any adult who had assumed responsibility for the household (Anthony 2007). When the household head was absent; the interview was conducted with any other adult member of the household aged more than 18 years, which is the adult age in Cameroon (Patrice 2019). Participants were interviewed individually to avoid audience effect bias. At the start of the survey, every participant was advised that his/her par-

ticipation was voluntary, and that all information provided will be treated anonymously (name of participants was not asked) and confidentially. We began interviews as an informal conversation with the participants, to gain their trust first, by inquiring about their general knowledge about the wildlife of Ebo forest. We also explained the benefits of the study for the conservation of wildlife in general and only proceeded with the interview if the participant agreed and was comfortable with the study. At the end of the interviews, we always informed participants that we were carrying out research in the area to specifically contribute to the conservation of *A. preussi*. We avoided providing this information prior to the beginning of the survey so that we did not influence the responses of the participants. We framed and piloted the questionnaire to better align the questions to the needs of the study. To enable a clearer identification of *A. preussi* by participants, we used large-sized high-resolution photographs that show the face and the entire body of the species. We visited the participants' houses from 06:00h – 10:00h before respondents left for their daily occupations and in the evening from 16:00h – 19:00h, when they returned home.

## Data analysis

All data were analyzed with R software version 4.2.1 (R Core Team 2022). For questions regarding local knowledge about *A. preussi*, sightings and crops raiding incidence by this primate in the area, we employed Chi-square test ( $\chi^2$ ) of homogeneity and independence to compare participants' responses. Where necessary, the same statistical tool was used for subsidiary analyses. We used the Bayesian effect size  $\tilde{V}$ cramer to determine the strength of association between knowledge on law protecting *A. preussi* and other primates, and participants' opinions on the primates' conservation in the area. We ran generalized linear mixed models (GLMM) with binomial error, using as outcome variables: respondents' perceptions of *A. preussi* population trend and opinions on *A. preussi* conservation in Ebo forest. In the first regression model, we tested if socio-demographic factors (level of education, gender, main occupation, age class), and socio-ethnographic factors (time of last consumption of *A. preussi*, local use of *A. preussi* and if respondent had consumed *A. preussi* meat) of participants could predict the perception of a decreasing population trend of this species in Ebo forest. The first outcome variable (the perception of *A. preussi* population trend) categories were collapsed into two classes: increase/stable (0) and decrease (1), for statistical convenience. In the second model, we modeled participants' attitude towards conserving *A. preussi* and other primates, using the same models above.

We used the “*buildmer*” package to run an automated backward selection of the best fit model in each case. This data science tool produces a multiple combination matrix of the independent variables corresponding to different possible sub-models from which the sub-model with the least Akaike's Information Criterion (AIC) value was selected. All the candidate predictors whose elimination from the model lead to an increase of at least 2 AIC values were retained in the final model. Participants' village (with 17 levels) was used as the random effect in the model to account for spatial dependency. Hence, our regression model contained both fixed and random effects. The fitted explanatory variables which contributed on the model fitness to predict the perception of decreasing population trend of *A. preussi* included: main occupation, local use of *A. preussi* and last consumption of *A. preussi*. The fitted explanatory variables retained for the model to predict opinions on *A. preussi* conservation in Ebo forest included: level of education, respondent time of last consumption of *A. preussi* and local use of *A. preussi* in the area.

## RESULTS

### Socio-demographic profile of participants

A total of 262 household heads participated in our study across 17 villages around Ebo forest: Ndogbanguengue ( $n = 29$ ), Dallas ( $n = 26$ ), Ndokmouen ( $n = 11$ ), Bataba ( $n = 11$ ), Ndokbakand ( $n = 8$ ), Ndokbous ( $n = 15$ ), Ihendel ( $n = 14$ ), Issondje II ( $n = 18$ ), Bioumoul ( $n = 6$ ), Tembe ( $n = 5$ ), Ninga ( $n = 7$ ), Saha'a ( $n = 10$ ), Bimbengui ( $n = 4$ ), Ndokmem North ( $n = 19$ ), Locgndeng ( $n = 28$ ), Iboti ( $n = 36$ ), and Mamba ( $n = 15$ ). Majority of participants were male (84%,  $n = 220$ ) compared to female (16%,  $n = 42$ ). The most represented age class of participants was 41 to 59 years (42%,  $n = 110$ ). Farming and hunting are main occupations in the area and most of our participants were involved in farming (51%,  $n = 135$ ). Most participants (45%,  $n = 119$ ) had primary school level of education, whilst only two had attended university level (Table 1).

### Presence, sightings and crop raiding occurrence by *A. preussi* in Ebo forest

Participants could identify *A. preussi* among other primates and accurately described it as a medium black and hairy monkey with a whitish throat that at times is seen walking on the forest floor and on trees, and locally called “Nten”. Majority of the participants (59.2%,  $n = 155$ ) sighted this species in a high number in the forest and from hunters in villages (26.7%,  $n = 70$ ) as compared to other areas (i.

**Table 1.** Socio-demographic profile of participants ( $n = 262$ ).

Demographics	Categories	Survey participants (%)
<b>Gender</b>	Male	220(84)
	Female	42(16)
<b>Age class (years)</b>	21 to 40	100(38)
	41 to 60	110(42)
	≥60	52(20)
<b>Main occupation</b>	Farming	135(51)
	Hunting	101(39)
	Others (teaching, business, timber prospector, building, student, cleric)	26(10)
<b>Education level</b>	Primary School level	119(45)
	Secondary School level	44(17)
	University level	2(1)
	No formal education	97(37)

e., market and around the house) (14.1%,  $n = 37$ ) (= 84.88;  $df = 2$ ;  $P < 0.001$ ). Last sighting was less than one year ago (55%,  $n = 144$ ), one to five years ago (36.2%,  $n = 95$ ) and greater than five years ago (8.8%,  $n = 23$ ) (Figure 2). At the time of the study, the number of participants who had last sighted *A. preussi* less than a year ago was significantly higher compared to those who had sighted greater than five years in the area ( $\chi^2 = 89.66$ ;  $df = 1$ ;  $P < 0.001$ ). *Allochrocebus preussi* was more sighted in wet (36.3%,  $n = 95$ ) than in the dry season (9.9%,  $n = 26$ ); in both seasons the primate was sighted in 82 opportunities (31.3%). Fifty-five people (22.5%) had no idea about the season they mostly sighted the species ( $\chi^2 = 39.34$ ;  $df = 1$ ;  $P < 0.001$ ). Participants (33.9%,  $n = 89$ ) complained of crop raiding occurrence by *A. preussi* but this conflict was most reported by local people whose main occupation was farming ( $\hat{p}=0.46$  Proportion test:  $\chi^2 = 15.10$ ;  $df = 1$ ; 99% CI:0.13-0.36;  $P < 0.001$ )(as opposed to people of other main livelihoods in the area ( $\hat{p}=0.21$ ) (Figure 2).

### Local perceptions of *A. preussi* conservation in the Ebo forest

Most participants (73%,  $n = 191$ ) were in favor of conserving *A. preussi* ( $\chi^2 = 57.2$ ;  $df=1$ ;  $P < 0.0001$ ). (Figure 3). Majority of participants (74%,  $n = 195$ ) were significantly in support of the gazettement of Ebo forest as a National Park. Among the seven candidate predictors, the level of education and when *A. preussi*

meat was last consumed were the two best predictors of participants positive attitude towards the conservation of *A. preussi* in the Ebo forest. The effect of “local use type” was borderline (Table 2).

Our model explained 37% (conditional  $R^2 = 0.373$ ) of the variation in the outcome variable (*A. preussi* conservation in the Ebo forest). The odds of being in favor of conserving this species was significantly higher for participants of secondary school level as opposed to participants with no formal school education (the intercept). Participants of secondary education level were 7.3 times and 2.7 times more likely to have positive attitude towards conserving *A. preussi* in the area than respectively participants with no formal education and participants who finished primary school level (GLMM: odds ratio =7.29  $\pm$  95% CI:1.81–28.32;  $P=0.005$ ) (See Table 3 and Figure 4). There was a clear trend between participants last time consuming this species and their opinions in favor of *A. preussi* conservation (Table 2 and Figure 4). The odds of being in favor of conserving *A. preussi* was 5 times increased when participants had last eaten the species as long as one year ago or more when compared to less than one month ago (GLMM :  $oddsratio = 5.03 \pm 95\% CI:2.07-12.19$ ;  $P = 0.001$ ). Similarly, it was increased by a factor of 2.8 when participants had last eaten *A. preussi* six months ago, when compared to less than one month ago (GLMM: odds ratio= 2.78  $\pm$  95% CI:1.00-7.73;  $P = 0.049$ ). The odd of the participants being in favor of the conservation of *A. preussi* was

lower for those who exploit this species for income generation compared to those who use it for subsistence *GLMM* :  $oddsratio = 0.49 \pm 95\% CI:0.24-1.02$ ;

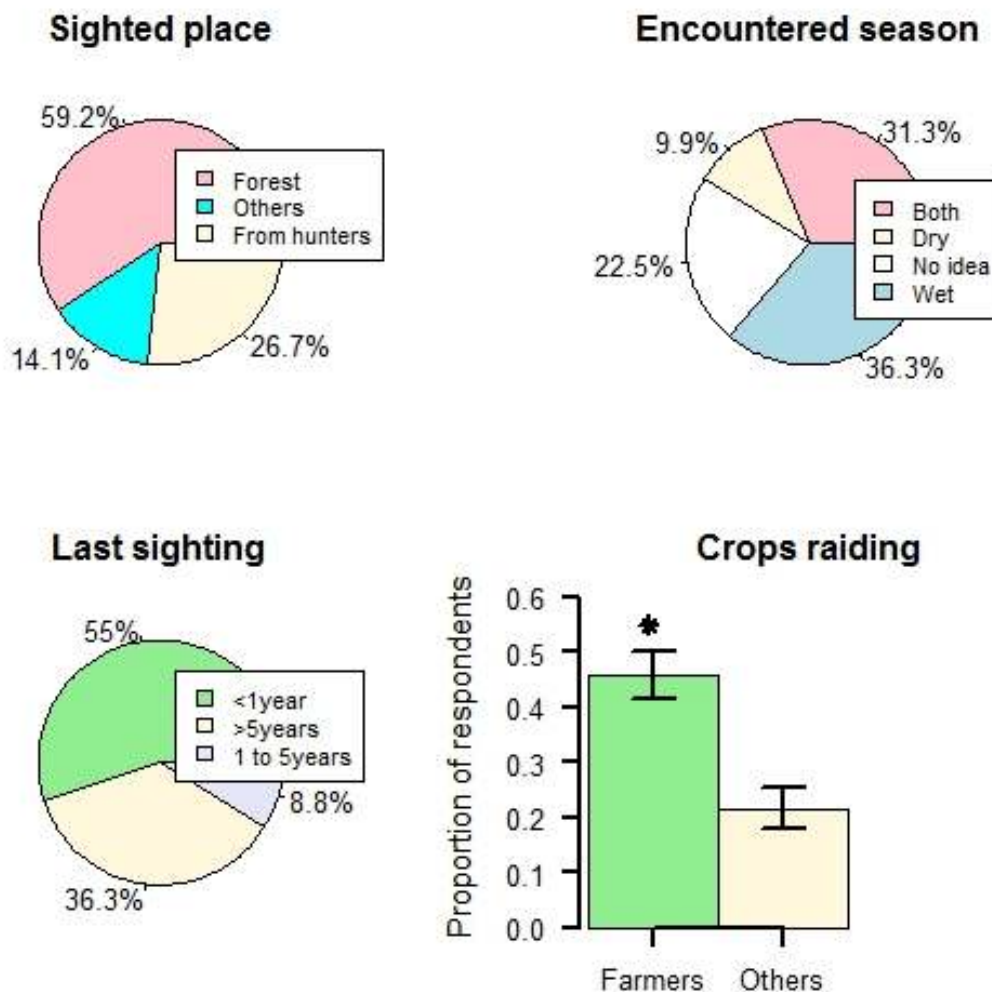
$P = 0.058$ .

Majority of the participants (74%,  $n = 193$ ) knew about the National Law that protects *A. preussi* and

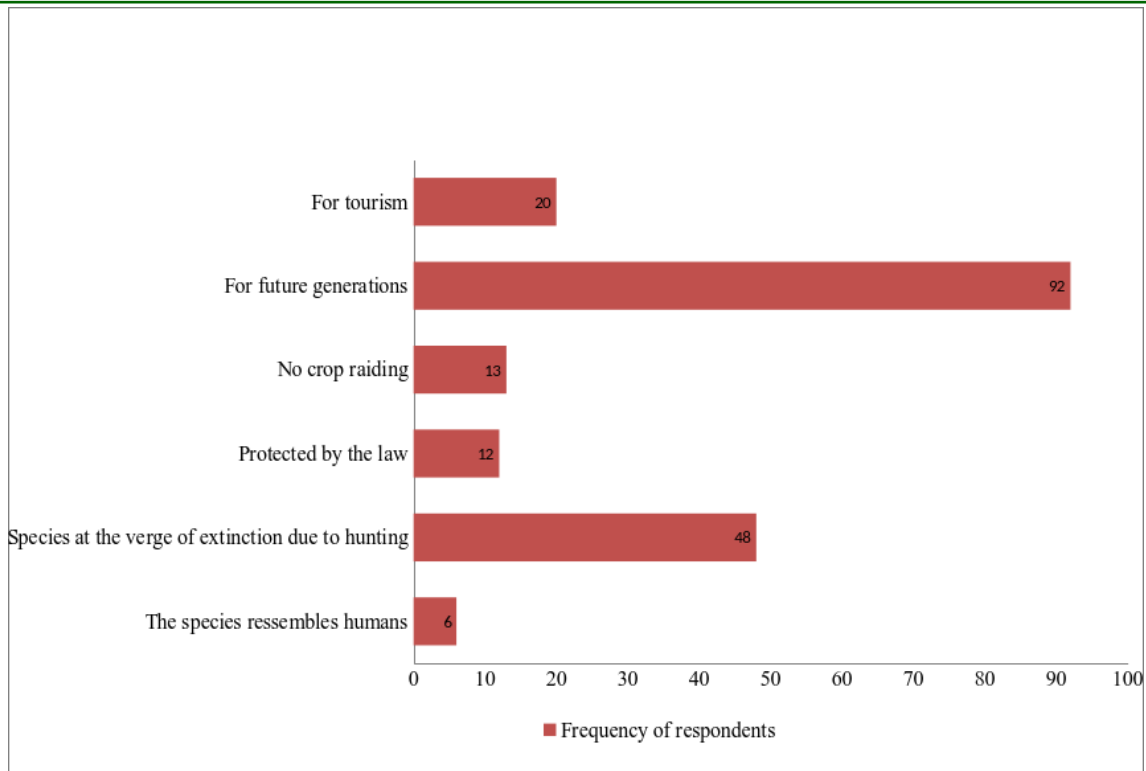
**Table 2.** Parameter estimates for the fixed effects obtained from the GLMM for answers to direct question about the conservation of *A. preussi* in association to participants' level of education, when *A. preussi* meat was lastly consumed and type local use of *A. preussi* in the area.

	Estimates	SE	Z-value	P-value
(Intercept)	-0.21	0.53	-0.40	687
Education Level: Primary	0.44	0.36	1.22	222
Education Level: Secondary	1.99	0.71	2.80**	5
Last Consumption: $\geq$ one Year Ago	1.62	0.45	3.57***	0.0003
Last Consumption: six Months Ago	1.02	0.52	1.97*	49
Use: Income Generation	-0.71	0.38	-1.90•	58

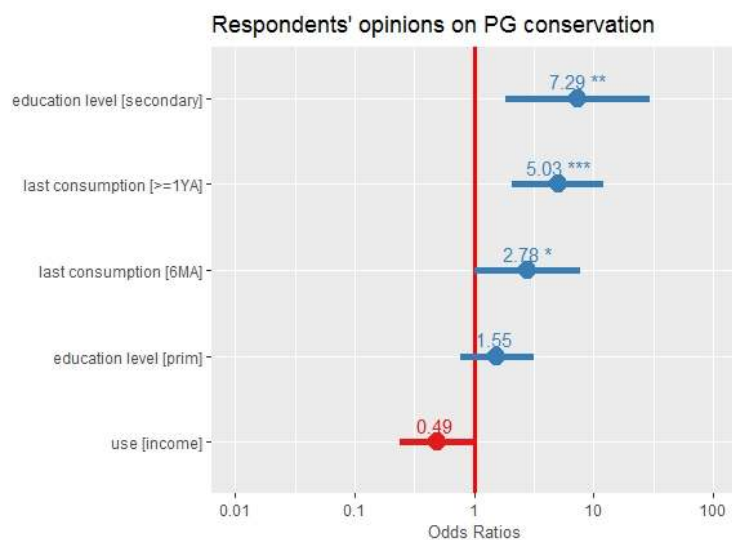
SE = Standard Error; intercept (No formal education, one month ago, use as food, university level).



**Figure 2.** Sightings and knowledge of crops raiding by *A. preussi* in the area.



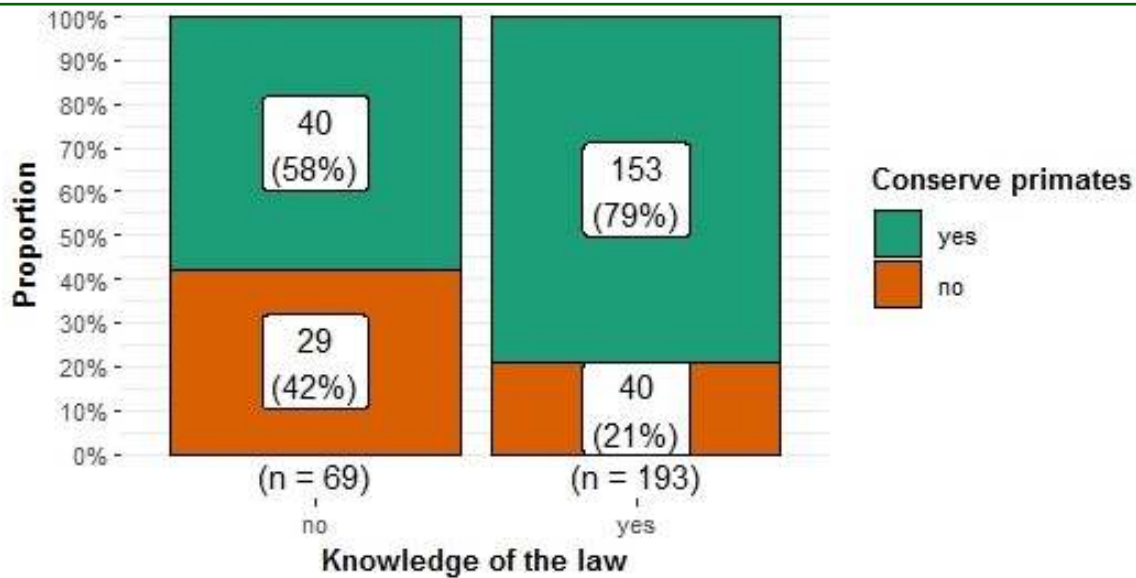
**Figure 3.** Participants opinions on the reasons for conserving *A. preussi* in the Ebo forest.



**Figure 4.** Predicted probability of participants' opinions on the conservation of *A. preussi* in relation to participant's level of education, local use of *A. preussi* and when *A. preussi* meat was last consumed by the respondent). NB: PG=Preuss's guenon.

other threatened wildlife species. Their opinion on the conservation of this primate had a moderate association ( $\tilde{V}_{\text{cramer}} = 0.26$ ;  $CI_{9\%}: 0.00-1.00$ ) with their knowledge on primates conservation in the area. Most participants who knew about the law expressed their support for primates' conservation in the area ( $\chi^2 =$

11.89;  $df = 1$ ;  $P < 0.001$ ) (Figure 5).



**Figure 5.** Participants' knowledge of the law protecting *A. preussi* and other primates in relationship to their opinions on the conservation of primates.

### Local perceptions of *A. preussi* population trend in the Ebo forest

The majority of participants (90%,  $n = 235$ ) had an idea about the population trend of *A. preussi* in the area, with those perceiving a decreasing trend (70%,  $n = 165$ ) significantly greater than those perceiving a stable or increasing trend (30%,  $n = 70$ )  $\chi^2 = 38.40$ ;  $df = 1$ ;  $P < 0.001$ . The majority of the participants (77%,  $n = 200$ ) reported hunting rather than habitat loss and fragmentation as the main threat to *A. preussi* in the Ebo forest ( $\chi^2 = 72.69$ ;  $df = 1$ ;  $P < 0.001$ ).

From the GLMM, we found that, the main occupation of the participants, the local use type of *A. preussi* and when *A. preussi* bushmeat was last consumed were associated to the participants' perceptions on population trend of *A. preussi* in Ebo forest (Table 3).

Our model explained 20% (conditional  $R^2 = 20$ ) of the variation in the response variable (perception of *A. preussi* population trend). The odds of perceiving a decreasing population trend of *A. preussi* was significantly the least, by 16%, for participants whose main occupation was hunting (Table 3 and Figure 6) compared with participants of other occupations lumped together (business, cleric, building, timber prospector, teaching and student) GLMM: odds ratio=  $0.16 \pm 95\%$  CI:0.03-0.77;  $P = 0.022$ . For participants with farming as their main occupation, the odds of perceiving a decreasing population trend of *A. preussi* was 54% (Fisher test: odds ratio=  $0.54 \pm 95\%$  CI:0.29-0.99;  $P = 0,042$ ).

There was a borderline relationship between the

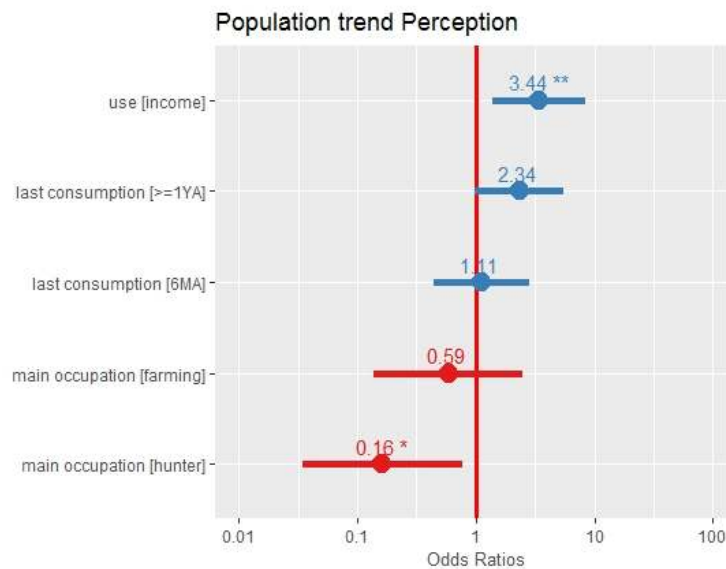
perception of a decreasing population trend of *A. preussi* and the time of last consumption by the participants (Table 3 and Figure 6). Participants who had last consumed *A. preussi*  $\geq 5$  years ago perceived more a decreasing trend of this species at 10% probability level, compared to participants who had consumed it one month ago (the intercept) (GLMM: odds ratio=  $2.34 \pm 95\%$  CI:0.99-5.54;  $P = 0.052$ ). This suggests that the later the time of last consumption the greater the likelihood that the participant will perceive a decreasing trend in the population of *A. preussi* in the area (Figure 6). Overall, participants who lastly consumed this species one year ago or more in the area were significantly more reported compared to those of six months ago and less than on month ago lumped together ( $\chi^2 = 11.85$ ;  $df = 1$ ;  $P=0.001$ ).

The odds of perceiving a decreasing population trend of *A. preussi* was strongly related to how participants use this species in the area. Participants who used *A. preussi* as source for income generation were 3.44 times more likely to perceive a decline in the population of the species compared to those who just used it for food (GLMM: odds ratio=  $3.44 \pm 95\%$  CI:1.40-8.46;  $P = 0.007$ ) (Figure 6). Overall, subsistence use of *A. preussi* (Figure 7) in the area (59.1%,  $n = 155$ ) was significantly more reported by participants compared to income generation purpose ( $\chi^2 = 6.12$ ;  $df = 1$ ;  $P = 0.013$ ).

**Table 3.** Parameter estimates for the fixed effects obtained from the GLMM for answers to direct question about the population trend of *A. preussi* in association to participant's main occupation, local use of *A. preussi* and when *A. preussi* meat was last consumed in the area.

Parameters	Estimates	SE	Z-value
(Intercept)	1.0038	0.8086	1241
Main Occupation: Farming	-0.5339	0.7362	-725
Main Occupation: Hunting	-1.8176	0.7931	-2.292*
Use: Income Generation	1.2363	0.4587	2.695**
Last Consumption: $\geq$ one Year Ago	0.8519	0.4391	1.940•
Last Consumption: six Months Ago	0.1084	0.4720	230

•, \*, \*\*, significant at probability levels of 10%, 5%, 1 %, respectively; SE = Standard error; intercept (Other occupation, use as food, one month ago).



**Figure 6.** Predicted probability of a perceived decreasing trend in the population of *A. preussi* in relation with respondent's main occupation and socio-ethnographic factors (local use of *A. preussi* and when *A. preussi* meat was last consumed in the area).

## DISCUSSION

This study explored local ecological knowledge to contribute for the conservation of the Endangered and understudied *A. preussi* in the Ebo forest, which is a stronghold for this species and other threatened primates. Local Ecological Knowledge of human communities that depend on natural resources can provide important conservation guidelines for threatened species.

### Presence, sightings and crop raiding occurrence by *A. preussi* in Ebo forest

This study revealed that local communities around the Ebo forest have good knowledge of *A. preussi*. This is similar to Whytock *et al.* (2021), where locals had some knowledge of this species in the area of Ebo forest. Most of the participants reported to have seen *A. preussi* in the forest. This can be attributed to the fact that these local communities rely on Ebo forest for food and livelihood. Our findings outline that majority of the participants had sighted *A. preussi* in the area less than a year at the time of



**Figure 7.** Photos of *A. preussi* cooked meat on sale at Dallas village (left) and for home consumption at Mamba village (right). **Photo Credit:** Standly Nkemnyi Nkengbeza

study. This is likely because local people farm at the edge of the forest, hunt and collect non-timber forest products, which put them close to *A. preussi* range in the area. In Africa, local communities living adjacent to forests depend on forest resources (e.g. fuelwood, bush/wild meat, medicinal plants, timber, and building pole) (Mugume *et al.* 2015; Naughton-Treves *et al.* 2011). Most *A. preussi* sightings in the area occur during the wet season because of the high availability of fruiting trees and plants such as *Uapaca* sp., *Irvingia gabonensis*, *Cola* sp. and *Aframomum* sp. reported by hunters as key food sources for this primate. This finding is in line with Fufa *et al.* (2020), where primates were more recorded in wet season than in dry season due to variability of forest resources. The only human-wildlife conflict involving *A. preussi* was crop raiding where farmers commonly reported attacks on some agricultural products such as plantain (*Musa* sp.) and cacao (*Theobroma cacao*). This result is in line with crop raiding activities by primates around Kainji Lake National Park, Nigeria (Adeola *et al.* 2018). *Allochrocebus preussi* involvement in crop raiding in the area might be because they prefer the taste of the fruits. The location of farmland too (proximity to the forest) can be the main cause of the crop raiding. Human-wildlife conflict (HWC) is forecast to increase globally and cover various dimensions (Merkebu and Yazezew 2021). HWC has undoubtedly ranked among the main threats to wildlife conservation in Africa, and among wild species of animals that cause damage to farmers' yield and trigger conflicts, primates top the ranking (Wiafe 2019). More than 40% of primates are now threatened due to human conflict-related causes such as overexploitation, hunting, and habitat destruction (Rylands and Mit-

termeier 2023). Generally, human-primate conflict occurs in tropical forest regions where monkeys are often killed in retaliation, and this conflict is amongst the main threats to biodiversity conservation (Nicole 2019; Yazezew 2022). Therefore, the prevention and mitigation of HWC is an imperative step for the conservation of threatened wildlife species (Warrier *et al.* 2021).

### Local perceptions of *A. preussi* conservation in the Ebo forest

Majority of participants are in support of conserving *A. preussi* and its habitat. This willingness to conserve *A. preussi* is attributed to reasons outlined in Figure 3. This finding shows that despite the cost of local people living and interacting with wildlife, some local communities express favorable attitudes toward wildlife and retain a positive attitude towards conservation (DeBoer and Banguetem 1998; Mir *et al.* 2015; Newmark *et al.* 1993). This willingness to conserve *A. preussi* is significantly the highest for local people with secondary education level. This supports our hypotheses that there is a strong relationship between socio-demographic factors (e.g. education level) and the willingness to conserve *A. preussi* in the area. Other studies (Dalum 2013; Lyamuya *et al.* 2016; Mutanga *et al.* 2015), also reported a correlation between the level of education and conservation attitudes. Level of education is an important factor that influences local people's attitudes toward wildlife conservation (Kwaslema *et al.* 2018). People's attitudes toward wildlife conservation can significantly affect the success of conservation initiatives and understanding the factors that influence these at-

titudes is essential for designing strategies to alleviate human–wildlife conflict.

Our findings confirmed our hypotheses that there is a strong relationship between participants' socio-ethnographic factors (e.g. last consumption time of *A. preussi* and local use of *A. preussi*) and the willingness for conserving *A. preussi* in the area. Participants who have consumed *A. preussi* one year and more during the time of our survey showed more willingness to conserve this species. Local people who used *A. preussi* for subsistence other than source for income generation showed more willingness to conserve the species. This could be due to conservation education activities championed by the Ebo Forest Research Project in the area for decades now, on the importance of conservation. Outreach activities have proven to contribute immensely to change community behavior towards conservation. Biodiversity awareness campaigns have been reported to raise knowledge and hence the higher level of community participation in the conservation of biodiversity (Montana and Mlambo 2019). Looking at Figure 5, a clear association exists between participants' opinions on conserving primates in the area and knowledge of National Law on primates (forestry and wildlife law). This suggests the willingness to conserve primates in the area does not correlate with the knowledge of the law protecting these animals.

### Local perceptions of *A. preussi* population trend in Ebo forest

Responses on the trends of *A. preussi* in the area show that the population of this species is decreasing as a result of hunting pressure for wild meat. This supports our hypotheses that local people perceived a trend in *A. preussi* populations in this area. Hunting is a widespread activity that threatens the survival of many wildlife species in Ebo forest (Mahmoud *et al.* 2019; Mfossa *et al.* 2022; Morgan *et al.* 2013). For instance, within the Ebo landscape, primate species were found to comprise one of the largest bushmeat biomass offtakes being only second to that of ungulates (Fuashi *et al.* 2019).

Local people who had other main occupations different from hunting were more likely to perceive a decreasing trend in *A. preussi* populations in Ebo forest. This could be due to the low supply of wild meat from *A. preussi* in the villages observed by locals with occupations other than hunting. In an area like the Ebo forest where hunting is prevalent, local people tend to depend more on wild meat as their immediate source of protein intake. The results support our hypotheses that local people who use *A. preussi* for income generation perceived a decreasing trend of this species in the area. This could be attributed to the increased

amount of purchasing carcasses of *A. preussi* in the area. These results also confirm our hypotheses that the later the time of last consumption the greater the likelihood that the participant will perceive a decreasing trend in the population of *A. preussi* in the area. Local people who have last consumed wild meat from *A. preussi* longer ago tend to say its population is decreasing. This could be due to hunting pressure on the species considering its large-bodied size and semi-terrestrial behavior, which make it an easy target for hunters (Cronin *et al.* 2019).

Overall, *A. preussi* is mainly used in the Ebo forest area for subsistence. In an area like this where access to livestock products is a challenge due to poor road network, villagers tend to rely more on consuming bushmeat as their source of animal protein. Bushmeat supplies 30-80% protein to rural communities in Cameroon (Lescuyer and Nasi 2016). In rural areas, wild meat plays a greater role as food intake than as a regular source of revenue in households (Nielsen *et al.* 2017). The habit of consuming bushmeat is often regarded as a key component of local diets because it provides poor communities with improved access to diverse and nutritious animal source foods (Ripple *et al.* 2016; Brashares and Gaynor 2017). Animal-based foods offer increased bioavailability of micro- and macronutrients that can be difficult to obtain when consuming foods from plants alone (Murphy and Allen 2003).

### CONCLUSION

This study aimed at exploring local ecological knowledge to contribute to inform the conservation of *A. preussi* in the threatened Cross-Sanaga-Bioko coastal forest ecoregion. Insufficient scientific information exists for many wildlife species, and local ecological knowledge can serve as an alternative data source when managing wildlife populations. Our findings support the notion of local ecological knowledge as an important indicator that helps to direct scientific investigations and is useful in developing conservation planning for *A. preussi* among other wildlife species. Also, we found strong evidence that local people have good knowledge of *A. preussi* and show a willingness to conserve this species in the area. *Allochrocebus preussi* is facing a population decrease in the Ebo forest as a result of hunting pressure for subsistence and income generation. There is an urgent need to co-design and develop local capacity for sustainable livelihood options to reduce the pressure of *A. preussi* in the area. It is also important to increase conservation awareness on *A. preussi* and its habitat and sensitize local people on the National Wildlife Legislation.

## ACKNOWLEDGMENT

Our gratitude goes to the Rufford Foundation for providing funding to the lead author to undertake this research. We thank the government ministry in charge of Scientific Research and Innovation for providing research permit to conduct this research. We equally acknowledge the Department of Animal Biology and Conservation, University of Buea, Cameroon for providing additional document to permit us carry field work. We thank the village chiefs, local people and our local guides for their peaceful collaboration and hospitality throughout the survey in the area. Our gratitude also goes to the Ebo Forest Research Project for providing us the map of the Ebo forest with all adjacent villages.

## DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

## CONFLICT OF INTEREST

The author(s) declared no conflicts of interest with respect to the research, authorship and publication of this work.

## CONTRIBUTION STATEMENT

Conceived of the presented idea: SNN, EBF, EDN, EEA

Investigation (field work): SNN

Carried out the data analysis: SNN and JPKD

Wrote the first draft of the manuscript: SNN

Reviewed and performed the final write-up of the manuscript: SNN, EDN, EEA, JPKD, NLM, PNA, EBF

Supervised the work: EBF

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Received: 17 November 2023

Accepted: 06 March 2024

Published: 22 March 2024

Editor: Rômulo Alves

## Additional Files

**Questionnaire on the ethnozoological, socioeconomic and cultural study on Preuss's monkey (*Allochrocebus preussi*) in village communities adjacent to Ebo forest, Littoral Region of Cameroon.**

**Dear respondent,** This questionnaire is elaborated for academic and scientific work and the responses are to be used for a PhD research program at the Department of Animal Biology and Conservation, University of Buea, Cameroon. Although your response is of the utmost importance to us, your participation in this survey is entirely voluntary. All your responses will be treated in a confidential manner and only for academic and scientific purposes.

### Section A: Background information

1. Village:
2. Gender
3. Age group
4. Occupation:
5. Level of education:

### Section B: Knowledge about Preuss's monkey in Ebo forest

**To enable the identification of various primates' species in the area, photographs will be used to identify each species.**

6. Do you know about primates?
7. Can you identify the species of primates that you know among these categories in your area? i) Preuss's monkey ii) Drill monkey iii) Chimpanzee iv) Gorillas v) other primates
8. Have you ever seen Preuss's monkey?
9. If yes, specify the locality (ies)
10. Do you know if there are protection laws for wild animals especially primates?
11. According to you, do you know Preuss's monkey is classified as Class A (totally protected) in Cameroon wildlife law?
12. According to you, when do you mostly encounter Preuss's monkey in the area?
13. How long have you stayed without seeing Preuss's monkey in the area?
14. Why...
15. According to you, what is the population trend of Preuss's monkey in the area?
16. Why?
17. According to you, what is the main driving factor (threat) affecting Preuss's monkey in the area?
18. According to you, what is the main use of this monkey in the area?
19. Have you ever eaten Preuss's monkey?
20. If yes, where did you get the bushmeat?

21. What is your main reason for consuming this species?
22. When did you lastly consume bushmeat from this species?
23. Do you know anyone who has ever hunted Preuss's monkey?
24. Do you know someone who has had, or currently has, this monkey as a pet?
25. According to you, does this species of monkey attack/destroy crops?
26. According to you, do you think it is important to preserve and protect the Ebo forest?
27. If yes, Why
28. Do you think it is important to protect primates, such Preuss's monkey?
29. If yes, Why?