

# PROJECT REPORT

Investigating the impacts and implications of hunting and wildlife trade on the conservation status of forest hornbills

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## **Acknowledgements**

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**Figure A:** Local guide from Ndokbanguengue village assisting with surveys in Ebo Forest

## Background

Known most prominently for the large casques from which they get their name, hornbills are long-lived, charismatic birds of tropical Africa and Asia. Due to their specialized habitat requirements and low population growth rates, they are extremely vulnerable to increasing anthropogenic pressures across their range including habitat loss and degradation, unregulated hunting, and regional and international trade (Trail 2007).

Despite these threats, hornbill populations throughout tropical Africa remain relatively unstudied, with most areas lacking even a baseline understanding of current populations. In Cameroon, many studies have been conducted over the years on these threats and their impact on mammals (e.g. Maisels et al. 2001, Fuashi et al. 2019), but only in recent years has a concerted focus been placed on the increasing pressures faced by the populations of hornbills and other large birds. A study from Cameroon's Littoral Region published in 2018 found that pressure on large bird populations due to bushmeat hunting was much higher than previously assumed, with a reported average of 29 hornbills being consumed per month in the villages surrounding the Ebo Forest (Whytock et al. 2018). In an additional study published this year, interviews with hunters in the Mt. Nlonako area were conducted, with results uncovering a novel demand for hornbill heads linked to foreign buyers (Su et al. 2024). Of the hunters surveyed in the study, 73% reported targeting hornbills specifically, with more than 90% of those reporting that trading hornbill heads was their primary motivation. Additional surveys of online markets found that at least seven species of forest hornbill native to Cameroon were actively being sold (Su et al. 2024). Because the trading of hornbill casques has previously been unreported in Cameroon, these findings specifically highlight a significant and novel threat to the continued survival of targeted hornbill species in these regions. An increase in uncontrolled hunting may have devastating effects on hornbill populations that are already facing intensive pressure from an array of anthropogenic threats.

To best assess the impact that these threats may have, it is crucial to establish a foundational understanding of hornbill populations in the area. To do so, it is important for all individuals in the survey area to be detected (Kissling et al. 2006). Although many forest hornbill species are large bodied with loud vocalizations, they are not always active or vocal, meaning individuals can often go undetected. Previous studies on birds

have employed the use of audio playback to help increase detection rates of cryptic species, and in environments like dense tropical forests where direct visual observations can be limited (Allen et al. 2004, Boscolo et al. 2006). Audio playback has even been used as a method to increase detection rates of forest hornbill species (Holbech et al. 2018), however, no empirical study on the impact of its use during surveys of hornbills has been published. This study offers the opportunity to better our understanding of the use and efficacy of available survey techniques, such as audio playback, in hornbill census surveys, and could therefore be beneficial to future research efforts aiming at establishing an accurate baseline for hornbill populations.

## **Project objectives**

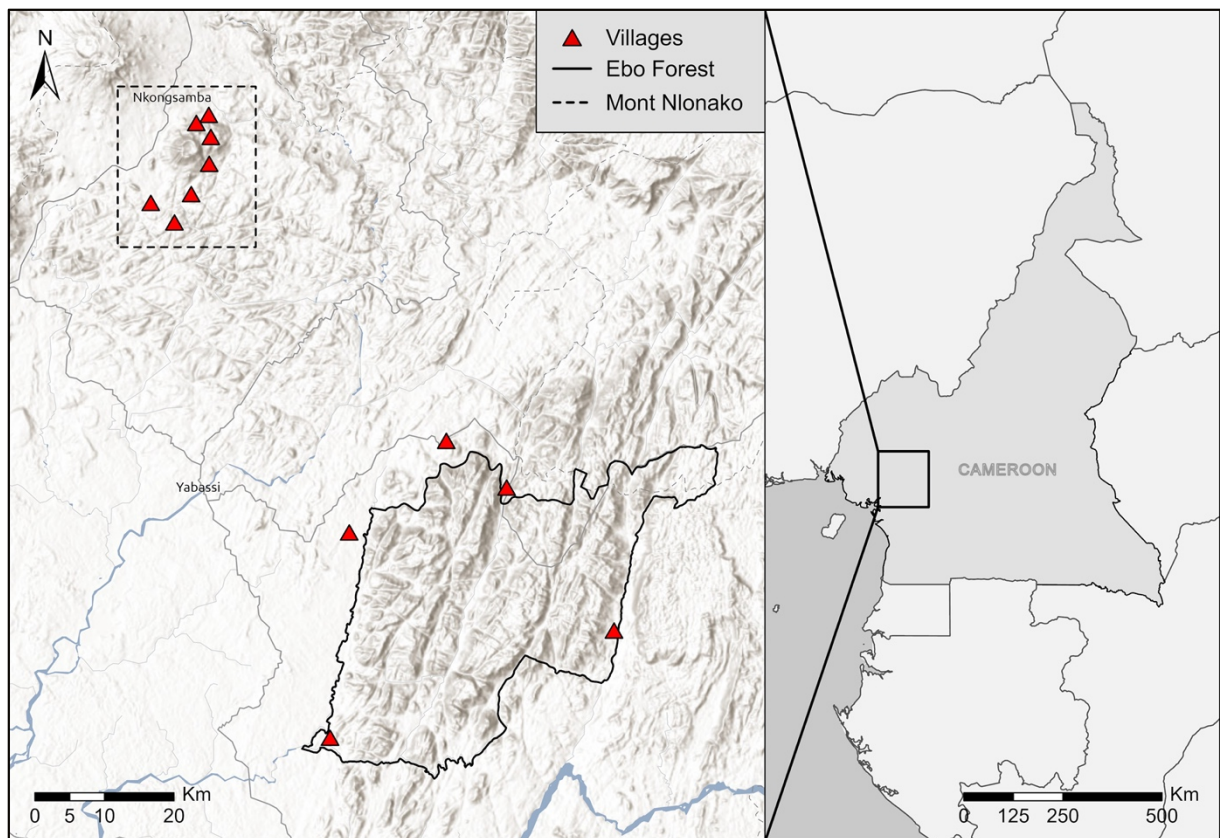
The aim of our project is to provide a foundational understanding of hornbill populations in the Ebo and Mont Nlonako forests, to better understand the dynamic relationship between hornbill populations and newly uncovered hunting pressures, and to offer recommendations on future research directions and survey methodology. To do so, we:

1. Conducted surveys on hornbills in the Ebo and Mont Nlonako forests
2. Investigated the relationship between hunting pressure and hornbill populations by documenting hunting signs encountered during hornbill surveys
3. Tested the efficacy of audio playback as an aide in the detection of forest hornbill species
4. Will make recommendations for next steps and future studies based on our research findings

## **Methods**

### *Study location*

Field work was conducted near villages in and around the Ebo and Mont Nlonako forest areas (see Fig. 1).



**Figure 1.** Study locations in Ebo Forest and Mont Nlonako areas.

Village locations were selected based on reported hunting pressures and their proximity to forests areas where hornbills were likely to be found. To assess hornbill populations in relation to hunting pressures, we focused on villages in the Mont Nlonako area where hunters have been reported to target hornbills for their heads (Su et al. 2024), and areas in Ebo Forest where hornbills were reported to be hunted for bushmeat (Whytock et al. 2018).

#### *Point count surveys*

To collect population data on hornbills, we implemented a series of field surveys between October 2023 and February 2024. During these surveys, we conducted 464 point counts and walked 140 km of modified line transects. Point count and line transect methodology was adapted from a previous study on hornbills conducted in Ghana by Holbech et al. (2018). Each of our point counts lasted for 15 minutes and consisted of three segments: (1) An initial five-minute point count documenting all hornbill observations, (2) a five-minute playback of hornbill vocalizations, (3) a second five-minute point count documenting all hornbill observations after the use of playback. We conducted surveys primarily during morning hours c. 06:30–12:30, with occasional

afternoon counts from 15:30-18:30, aligning with the periods of highest response frequencies recorded by Rainey et al. (2007). During the playback segment, we broadcast vocalizations of all nine forest hornbill species native to Cameroon. Hornbill vocalizations were acquired from XenoCanto, and were supplemented with local vocalizations recorded during our preliminary field surveys in Cameroon.

Point count locations were spaced at least 500 meters apart to account for the maximum audible range of the speaker (c. 245 m), to ensure that playback at one survey point did not impact counts at a second point. In a few villages in the Mont Nlonako forest, it was made clear to us that local hunters were actively pursuing hornbills for their casques. For this reason, we chose to omit the use of audio playback in these areas out of concern that hunters could have both the means and motivation to employ playback as a part of hunting efforts. We determined that the best course of action would be to only conduct passive surveys, as to not introduce a new tool to local hunters. In these villages (Nguéngué area), point count surveys were therefore reduced from 15 minutes to 5 minutes.

#### *Modified Line Transects*

We conducted modified line transect surveys by walking trails slowly in between point count surveys and recording all hornbill observations. We chose to not cut new line transects for this study, to avoid disturbing habitat and increasing ease of access for hunters into new forest areas. We walked existing trails, almost exclusively consisting of old logging roads and single-track forest paths primarily used by hunters.

#### *Environmental Variables*

At each point count site we recorded elevation, habitat type, canopy cover, and distance to nearest village. Habitat type scores were adapted from Whytock et al. (2010) and included four different habitat types. Canopy cover was recorded using a spherical densiometer, while distance to nearest village and elevation were calculated after the field work using ArcGIS. We quantified hunting pressure for each village and its surrounding forest area through direct observation of hunters and hunting activity, including bullet shells, hunting camps, kill sites, snare traps, and heard gunshots (e.g. see figures 2-5). All signs of hunting activity were recorded and were used to calculate a hunting pressure index (hunting signs per km walked).



**Figures 2-5:** Top to bottom, right to left. (2) Spent shotgun shell, (3) hunting camp in Ebo Forest, (4) snare trap, (5) *Bycanistes albotibialis* feathers discarded outside of hunting camp

### *Data Analysis*

We used paired Wilcoxon tests to analyze differences in species counts and species richness between non-playback and playback surveys done at each point. To test for differences in presence/absence observations at each site, we used the McNemars test. To investigate the relationship between hornbill counts, hunting pressure, and other environmental variables, we used the glmmTMB package (Brooks et al. 2017) in R (R Core Team 2024) to fit generalized linear mixed models for each species individually, and a combined model for all species together. To account for zero-inflation and overdispersion, we used a negative binomial model. We began with a fully saturated model, including all of our explanatory terms, and all combination of

interactions. We then employed a backward elimination process (Zuur et al. 2009) to find the best fitting model. AIC scores for each model were calculated, and models with the lowest score were determined to be the best fitting. Explanatory terms in the model included habitat type, canopy cover, elevation, distance to nearest village, and hunting pressure. Variables were checked for correlation, and habitat type was ultimately omitted from the final models due to strong correlation with percent canopy cover.

## Results

### Population Status

Eight of the nine forest hornbill species native to Cameroon were detected during the survey efforts. All eight were observed in the Mont Nlonako area, and seven were observed in Ebo Forest. Observation rates during point count surveys and on modified line transects are shown for each species in the two tables below (see Tables 1 and 2). The most commonly observed species during playback surveys across both forests was the Red-billed Dwarf Hornbill *Lophoceros camurus* at 1.23 individuals observed per survey. The most commonly observed species during transect surveys was the Black-casqued Hornbill *Ceratogymna atrata*, at 1.62 individuals observed per km walked. Almost twice as many hornbills were observed per playback point count in the Mont Nlonako area (6.13) than in the Ebo forest area (3.60).

Forest Area	Ebo										Nolanko						All forests			
	Village		Logndeng		Mamba		Ndok.		Saha'a		Total		Bajoki		Singa		Total		Total	
Days of work	5		6		5		6		22		4		4		8		8		30	
Km walked	15.5		25.9		20.2		23.7		85.3		22.3		11.7		34.0		119.3		119.3	
counts (C)	27	27	44	44	37	37	38	38	146	146	30	30	18	18	48	48	194	194		
Playback?	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
<i>C. atrata</i>	2.37	1.44	0.11	0.02	0.84	0.92	1.03	0.76	0.95	0.71	1.4	1.07	0.94	0.56	1.23	0.88	1.02	0.75		
<i>C. elata</i>	0	0	0	0	0	0	0	0	0	0	0.93	0.37	1.22	0.50	1.04	0.42	0.26	0.10		
<i>B. albotibialis</i>	0.30	0.19	0.98	0.77	0.11	0.03	0.32	0.21	0.46	0.33	0.63	0.07	0.89	0.56	0.73	0.25	0.53	0.31		
<i>B. fistulator</i>	0.22	0.04	0.05	0.14	1.16	0.14	0.24	0.03	0.41	0.12	0.40	0.17	1.11	0	0.67	0.10	0.47	0.16		
<i>L. fasciatus</i>	0.33	0.04	0.45	0.23	0.68	0.43	0.87	0.39	0.60	0.29	0.53	0.50	0.39	0.06	0.48	0.33	0.57	0.30		
<i>L. camurus</i>	1.56	0.07	0.71	0.05	0.86	0.05	1.32	0	1.06	0.04	1.43	0.13	2.22	0.22	1.73	0.17	1.23	0.07		
<i>H. cassini</i>	0.52	0.19	0	0	0	0	0	0	0.10	0.03	0.27	0	0.11	0.06	0.21	0.02	0.12	0.03		
<i>H. hartlaubii</i>	0.04	0	0.05	0	0	0	0	0	0.02	0	0.03	0	0.06	0	0.04	0	0.03	0		
Total responses (R)	144	53	103	53	135	63	143	53	525	222	169	69	125	35	294	104	819	326		
Total frequency (R/C)	5.34	1.97	2.35	1.21	3.65	1.57	3.78	1.39	3.60	1.52	5.62	2.31	6.94	1.96	6.13	2.17	4.23	1.72		
Total species recorded	7	6	6	5	5	5	5	4	7	6	8	6	8	6	8	6	8	8		

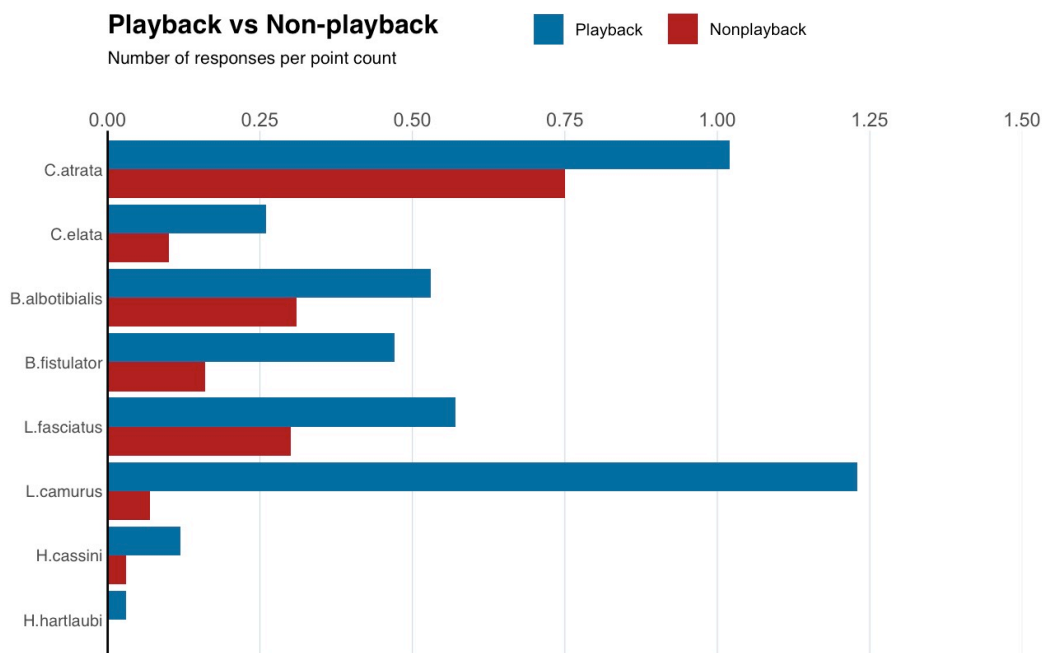
**Table 1:** Observation rates (individuals counted per point count) for each of the eight species detected during playback surveys. Counts are shown for both playback and non-playback surveys.

Forest Area	Ebo					Nlonako				All forests
	Village	Logndeng	Mamba	Ndok.	Saha'a	Total	Bajoki	Singa	Nguengue	
Days of work	5	6	5	6	22	4	4	5	13	35
Km walked	15.5	25.9	20.2	23.7	85.3	22.3	11.7	20.3	54.3	139.6
<i>C. atrata</i>	4.06	0.19	2.28	2.07	1.91	2.06	1.45	0	1.16	1.62
<i>C. elata</i>	0	0	0	0	0	2.06	2.39	0	1.36	0.53
<i>B. albotibialis</i>	0.45	1.97	0.40	0.30	0.86	0.72	0.68	0	0.44	0.70
<i>B. fistulator</i>	0.13	0.35	1.29	0.17	0.48	0.31	0.17	0.25	0.26	0.40
<i>L. fasciatus</i>	0.45	0.46	0.99	0.84	0.69	0.09	0.26	0.99	0.46	0.60
<i>L. camurus</i>	0.32	0.19	0.10	0.30	0.22	0.72	0.68	0.25	0.53	0.34
<i>H. cassini</i>	0.32	0.15	0	0.17	0.15	0.09	0	0	0.04	0.11
<i>H. hartlaubii</i>	0.06	0	0	0	0.01	0.04	0	0.05	0.04	0.02
Large hornbills	4.51	2.16	2.68	2.37	2.93	4.84	4.52	0	2.96	2.84
Medium fru-inse	0.58	0.81	2.28	1.01	1.18	0.40	0.43	1.24	0.72	1.00
Medium ins	0.32	0.15	0	0.17	0.16	0.09	0	0	0.04	0.11
Small ins	0.38	0.19	0.10	0.30	0.25	0.76	0.68	0.30	0.57	0.36
All hornbills	5.79	3.31	5.06	3.85	4.52	6.09	5.63	1.54	4.29	4.31
Total species recorded	7	6	5	4	7	8	6	4	8	8

**Table 2:** Observation rates (individuals counted per km of trails walked) for each of the eight species detected during transect surveys.

### Audio Playback

Results from the Wilcoxon tests showed that use of audio playback significantly increased counts of all eight of the observed focal species. The strongest effect was seen on *Lophoceros camurus*, with the observation rate increasing by more than 1500% in playback surveys. The smallest effect of playback was on *Ceratogymna atrata* counts, which had a significant increase of 36% (1.02 vs 0.75) in observations per survey.



**Figure 6:** Number of responses per point count for each species during playback and non-playback surveys

Species	V=	p-value
<i>C. atrata</i>	1692.5	0.001137
<i>C. elata</i>	216	0.003039
<i>B. albotibialis</i>	905.5	0.0008549
<i>B. fistulator</i>	455	0.0003075
<i>L. fasciatus</i>	1032	0.0004643
<i>L. camurus</i>	5420	2.20E-16
<i>H. cassini</i>	130.5	0.008238
<i>H. hartlaubi</i>	15	0.03689

**Table 3:** P-values and V scores for signed rank Wilcoxon tests of playback versus non playback point counts for each species

### *Hunting pressure GLMM*

Results from the GLMM indicated that the independent effects of hunting index, percent canopy cover, and distance from village were not statistically significant in explaining the variation in hornbill counts at a species or group level.

Significant variables from the model varied among individual species. The interaction between high hunting index and percent canopy cover had a significant negative effect on hornbill counts for both *Bycanistes fistulator* ( $\beta=-6.4298$ ,  $p=0.00517$ ) and *Ceratogymna atrata* ( $\beta=-0.8935$ ,  $p=0.00196$ ). For the latter, the interaction between high hunting index and distance from village was shown to have a significant positive effect on count numbers ( $\beta=0.86613$ ,  $p=0.00273$ ).

For *Lophoceros camurus*, elevation ( $\beta=0.361407$ ,  $p=0.00148$ ) and percent canopy cover ( $\beta=0.374858$ ,  $p=0.00695$ ) were both positively associated with hornbill counts.

*Horizocerus cassini* count numbers exhibited a significant positive effect from elevation ( $\beta=1.5161$ ,  $p=0.00844$ ), and a significant negative three-way interaction between high hunting index, elevation, and percent canopy cover ( $\beta=-6.7325$ ,  $p=0.00905$ ).

For all hornbills, elevation ( $\beta=0.34635$ ,  $p=1.05e-06$ ), the interactions between high hunting index and elevation ( $\beta=-0.52388$ ,  $p=1.30e-05$ ), high hunting index and percent canopy cover ( $\beta=-0.48014$ ,  $p=0.00294$ ), high hunting index and distance from village ( $\beta=0.29256$ ,  $p=0.03402$ ), and between percent canopy cover and distance from village ( $\beta=-0.32571$ ,  $p=0.00444$ ) were significant.

## Discussion

### *Population Persistence Amidst Increased Hunting Pressures*

Despite recent increases in hunting pressure, our survey results show that populations of eight hornbill species are still present in Mont Nlonako, and seven species are present in Ebo. Based on previous inventories from the region (Dowsett et al. 2001), these results confirm that all species of hornbill that were expected to be present in each forest area were observed in our study. One species was absent from both areas, the Black-and-white-casqued Hornbill *Bycanistes subcylindricus*, whose absence is consistent with previous inventory studies in the region (Dowsett 2001). Similarly, the absence of the Yellow-casqued Hornbill *Ceratogymna elata* in Ebo aligns with the documented range extent of this species, which falls just west of the Ebo forest area (Dowsett 2001). These results are encouraging, as some other forest regions in Africa have already seen complete extirpation of certain forest hornbill species (Holbech et al. 2018). However, the mere presence of populations of these species in Ebo and Mont Nlonako is not an indicator of population health or stability. Unfortunately, without historic data on hornbill populations in these areas, it is impossible to assert that our results indicate any sort of population trend. As is the case across most hornbill populations in tropical Africa that have been previously surveyed (e.g. Holbech et al. 2018), it is likely that hornbill population numbers in Ebo and Mont Nlonako have also decreased in recent decades. Although species inventories conducted in the Littoral Region from the late 1990s and early 2000s observed the same hornbill species as we did, these reports lacked counts or population estimates. Many species were described as "common" or "seen throughout," which may be superficially comparable to our observations, however without numerical data, it's impossible to definitively assess population trends. Therefore, our results provide a foundational understanding of hornbill populations and observation rates in these two regions as they exist currently, but they do not make a statement on how populations have developed over time.

### *Efficacy of Audio Playback*

Results from our test of audio playback provided clear and strong support for the notion that broadcasting vocalizations during point count surveys is a powerful method to increase observations of hornbills. In our study, all of the species we observed were observed more frequently after the use of audio playback. Although we recognize that

the use of playback will never guarantee hornbill response or a 100% detection rate, when compared to passive surveys alone, the use of audio playback provides a statistically significant way to increase detections of forest hornbill species. As future studies in this region are planned and implemented, we suggest that researchers intending to survey hornbill populations strongly consider the use of audio playback as a way to increase detections, and maximize survey efforts.

#### *Implications of Increased Hunting Pressure*

Although results from our study did not show a direct link between hornbill counts and hunting pressure, findings from our GLMM analysis suggest that a complex relationship exists between counts, hunting pressure, and other environmental factors. These results indicate that the impact of hunting pressure on hornbill populations may not be determined solely by the level of hunting, but rather by a more intricate combination of factors. Availability of food and breeding sites, habitat quality, and initial population size are just a few of the additional factors that could influence how vulnerable a population of hornbills is to increased hunting pressure. Because the exact level of vulnerability is still unknown, it is increasingly important to monitor and evaluate the emergence of casque hunting and its potential to spread throughout the region. Although the hunting of hornbills for their heads and casques appears to currently be a localized phenomenon occurring in a few select villages in the Mont Nlonako area, it has potential to spread quickly to other parts of Cameroon.

#### *Need for Long-term Monitoring*

We suggest that our results provide a strong foundation and much needed baseline of information on forest hornbill populations in the Littoral Region of Cameroon. However, we also recognize that this study is only a first step towards understanding complex population dynamics, and that further research in the area will be crucial to the long-term survival of these species. We suggest that future studies should be conducted over a larger temporal scale, to more comprehensively assess population trends and better understand how increased hunting pressure plays a role in these trends. Because some hornbill species move seasonally (Rainey et al. 2007), it is additionally important to understand how populations of certain species may fluctuate throughout the year, and if these fluctuations play a role in determining a species' vulnerability to hunting pressure. Ultimately, longer-term studies would also

allow us to more actively analyze the emerging threat of casque hunting in the region, and help to monitor its spread.

#### *Key Project Takeaways*

1. A high number of forest hornbill species are currently found in the Ebo and Mont Nlonako forests, but any trends in their populations remain unknown
2. Audio playback is an effective tool at increasing hornbill observations and maximizing survey efforts
3. The relationship between hunting pressure and hornbill counts is complex, and is most likely a combined function of several environmental factors
4. Continued research needs to be done to help us better understand population trends and to further quantify the impact of increasing hunting pressure

#### *Future Research and Conservation Strategies*

Despite the increased pressure on hornbills from old and newly emerging threats, hornbill populations in the Ebo and Mont Nlonako forest ecosystems have persisted until now. However, the long-term sustainability of these new pressures, and the future of hornbill populations remains unknown. More research needs to be done in this region to help us better understand hornbill population dynamics, and the vulnerability that they have to increasing and newly emerging threats.

To do this, we propose that future studies should focus on:

1. Long-term monitoring conducted over several years to better establish population trends and changes
2. Investigating the socio-economic drivers of the hornbill casque trade to better understand what and who is driving the demand for hornbill casques
3. Further investigating the relationship between hunting pressure, hornbill populations and their environment by incorporating more detailed environmental variables into studies

By addressing these areas, we can develop a more comprehensive understanding of hornbill ecology and implement effective conservation strategies to protect these iconic birds.

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