Population density of Visayan Tarictic Hornbill *Penelopides panini* on Negros Island, Philippines

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The Visayan Tarictic Hornbill *Penelopides panini* is an Endangered species endemic to the islands of Negros and Panay in the Philippines. Very few studies have been conducted on the species to date. We surveyed the three largest remaining forests on Negros from April 2014 to December 2019. A total of 232 sampling points were surveyed for a total of 635 incidences, resulting in 66 hornbill detections. Using a distance sampling approach, we estimated the population of hornbill in the three protected areas at 3,107 individuals. This is higher than the current total population estimate for both islands. Hornbill population density was found to be highest in the Balinsasayao Twin Lakes Natural Park, followed by the Northern Negros Natural Park and Mt Kanlaon Natural Park. Conservation initiatives integrating hornbill conservation with the local development agenda are discussed.

INTRODUCTION

Hornbills (family Bucerotidae) occur in the Old World tropics, from Africa, India and South-East Asia to New Guinea and the Solomon Islands (Poonswad *et al.* 2013). The hornbills of Asia inhabit the upper levels of the multi-layered rainforests, foraging for fruit in the canopy and nesting in the cavities of tall trees (Santhoshkumar & Balasubramanian 2010, Poonswad *et al.* 2013). There are 10 species of hornbills in the Philippines and all are endemic to the country (Gonzalez *et al.* 2013, Poonswad *et al.* 2013). All typically occur in lowland forests below 1,200 m (Kennedy *et al.* 2000) but deforestation may have pushed the elevational limit up to 1,500 m for some species (Poonswad *et al.* 2013).

Two hornbill species are found on the islands of Negros and Panay: the Critically Endangered Rufous-headed Hornbill *Rhabdotorrhinus waldeni* and the Endangered Visayan Tarictic Hornbill *Penelopides panini*. Following recent taxonomic changes there are now two recognised subspecies of the Visayan Tarictic Hornbill: *P. p. ticaoensis* on Ticao Island (now extinct in the wild) and *P. p. panini* on the islands of Negros, Panay, Masbate, Sicogon, Pan de Azucar and Guimaras (Gonzalez *et al.* 2013). Subspecies *panini* is now extinct on the latter three islands and only survives in small forest fragments on Negros and Panay (Paguntalan *et al.* 2002, 2004, Poonswad *et al.* 2013). It is uncertain if populations remain on Masbate Island although locals have reported the presence of small forest fragments (Lorica & Oliver 2006, Paguntalan *et al.* 2004). The loss of forests combined with hunting threatens the survival of the bird in the wild, as is demonstrated by the extinction of the Ticao subspecies (Klop *et al.* 2000, Poonswad *et al.* 2013).

Like most Philippine hornbills, very little information on the ecology of this species is available and data are currently limited to populations on Panay (Klop *et al.* 2000, Paguntalan *et al.* 2002, Turner *et al.* 2003). The most recent population estimate in 2001 (BirdLife International 2020) of 1,800 individuals, with 1,200 mature individuals, was based on an analysis of records, and field surveys (Klop *et al.* 2000, Gonzalez 2007). Even then it was suspected that the population may be closer to 1,000 individuals (IUCN 2021). Today, only three protected areas (PAs) exist in Panay: Northwest Panay Peninsula Protected Landscape, Sibalom Natural Park and Bulabog-Putian Natural Park (Biodiversity Management Bureau 2015). Despite ongoing conservation efforts, the largest remaining area of forest and a stronghold for hornbill populations, Central Panay Mountain Range (hereafter 'Central Panay Mountains'), remains unprotected.

Information on the status of the hornbills on Negros is even more limited and is outdated. Deforestation on Negros has been severe, with only 4% of the island covered with forest in the 1990s (Heaney & Regalado 1996). Since 1991, the local government of Negros has been actively engaged in reforestation and conservation programs, including the declaration of the largest remaining forest fragments as protected areas. Currently, four significant areas of forest are left on the island: Northern Negros National Park (hereafter 'Northern Negros'), Mt Kanlaon Natural Park (hereafter 'Mt Kanlaon'), Balinsasayao Twin Lakes Natural Park (hereafter 'Balinsasayao') and Cuernos de Negros. The Visayan Tarictic Hornbill survives in all four areas. This paper presents information on the distribution, population density and conservation status of the species on Negros. Conservation initiatives primarily led by the local government and the Department of Environment and Natural Resources (DENR) are also presented. This research was undertaken as part of the Philippine Hornbills Conservation Programme of the Philippines Biodiversity Conservation Foundation Inc.

METHODS

Overview

A total of three sites were surveyed in our study: Northern Negros (April 2014, June 2017, March 2018); Mt Kanlaon (August 2015, June 2017, December 2018) and Balinsasayao (30 May–2 June 2017, March 2018, February 2019). As we have only observed Visayan Tarictic Hornbills in areas below 1,200 m, we only included sampling points below this elevation (Figure 1). We spent 62 field days (140 observation hours) in total, with 26 days (57 observation hours) allocated to Northern Negros, 26 days (67 observation hours) to Mt Kanlaon and seven days (21 observation hours) to Balinsasayao.

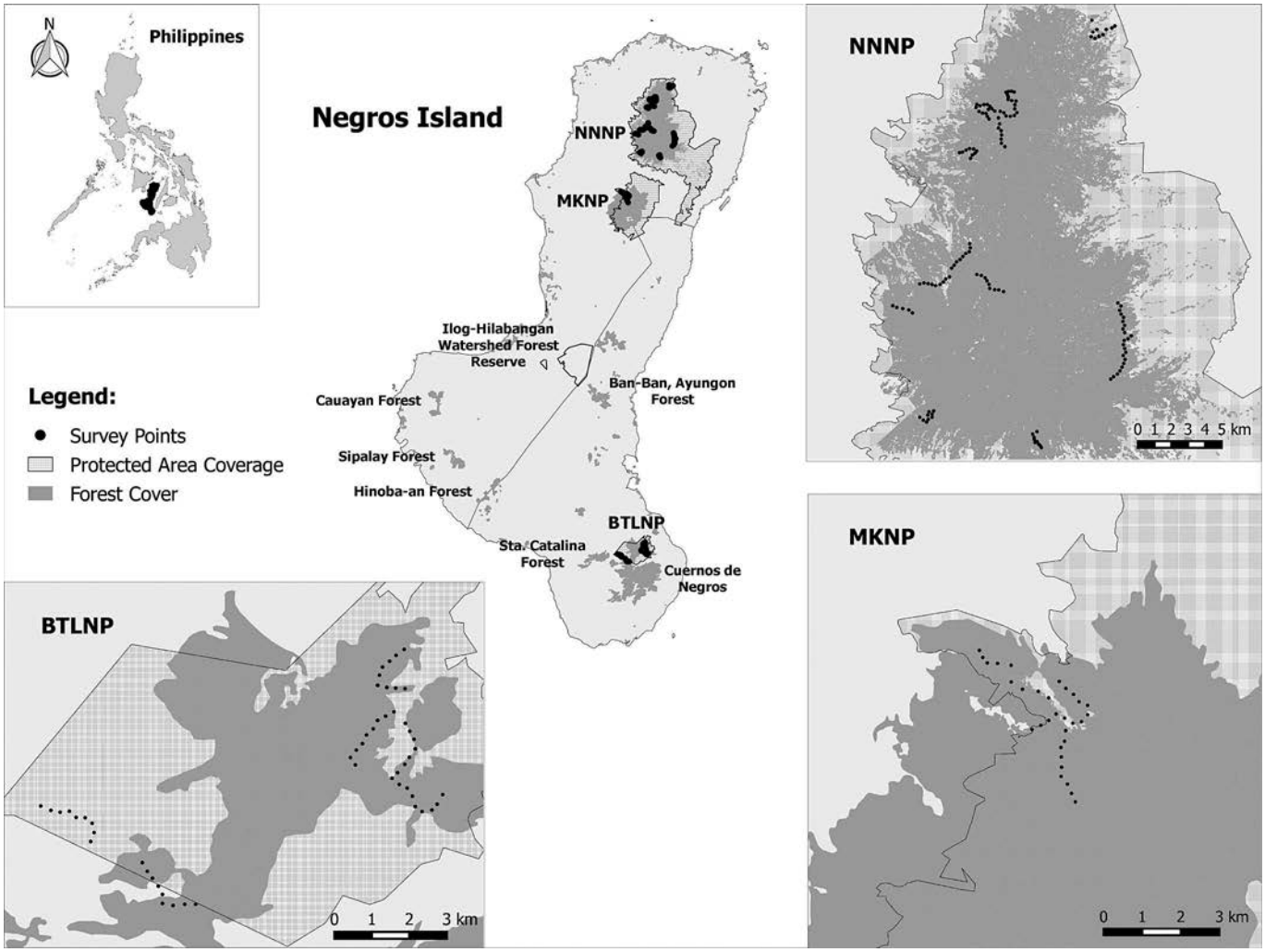
Site description

The island of Negros holds at least six terrestrial Key Biodiversity Areas (KBA) (Ambal *et al.* 2012), three of which are nationally declared protected areas and two of which are recognised as KBAs (Table 1; see also Figure 1).

Northern Negros National Park is composed of two mountain ranges: Mt Silay and Mt Mandalagan. It covers a total area of 70,826 ha, of which about 24,000 ha remains forested (Philippines Biodiversity Conservation Foundation Inc. & Biodiversity Management Bureau 2018), with the highest peak reaching 1,683 m. Logging was prevalent from the 1930s to the early 1970s following the declaration of the site as a forest reserve in 1946 (Collar *et al.* 1999, Chechina & Hamann 2015) and as a Natural Park in 2004. Hamann *et al.* (1999) characterised the forests on Mt Mandalagan as a transition zone between tropical lowland evergreen rainforest and tropical lower montane rainforest dominated by *Litsea luzonica, Canarium asperum, Platea excelsa* and *Palaquium* sp.

Mt Kanlaon covers a total land area of 24,388 ha, with the highest peak (Mt Kanlaon) reaching 2,435 m. Secondary logged-

Figure 1. Location map of study areas and sampling points in Northern Negros National Park (NNNP), Mt Kanlaon Natural Park (MKNP) and Balinsasayao Twin Lakes National Park (BTLNP).



over forests mixed with tree plantations can be found in the lower elevations from 800–900 m. Primary lowland evergreen and lower montane rainforests are located at elevations between 1,000–1,200 m, while upper montane rainforests are confined to elevations between 1,200–1,600 m where there are fewer visible signs of human activity. Mt Kanlaon is an active volcano and a well-known destination for mountain climbers and trekkers.

Balinsasayao is located in southern Negros and covers an area of 8,016 ha. The site's twin lakes are surrounded by three mountains: Mt Guintabon, Mt Balinsasayao and Mt Guinsayawan. Of these, Mt Guinsayawan is the highest, with elevations reaching 1,600 m. Primary lowland evergreen rainforest with patches of secondary forest surround the twin lakes and the mountains around Kabalinan Lake, while more degraded secondary and regenerating logged-over lower montane rainforest is found around Mt Guinsayawan. Forest cover starts at 800 m in areas around the twin lakes while it starts at almost 1,000 m in Mt Guinsayawan.

Distance sampling

Point transects following existing trails inside the forests were used to sample hornbills. A total of 232 sampling points were visited 635 times. Of these, 170 points were sampled more than once. Each point was set at least 250 m apart with a maximum radial distance of 200 m. Points were marked in the field using a GPS set.

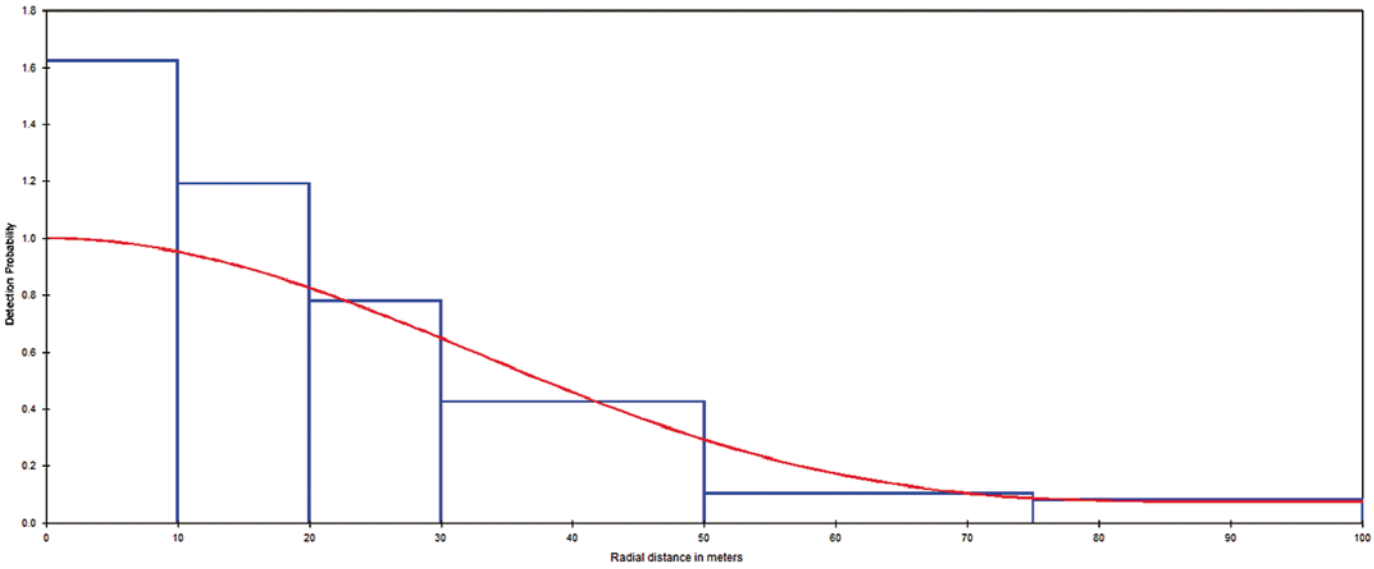
Prior to conducting our surveys, observers underwent three to four days field training in bird identification and survey methods, with an emphasis on distance sampling. Each observation team had at least one assigned trained member. Observations ran from 06h00

Table 1. List of forests areas and their conservation status on Negros Island.

Name	Status	Area (ha)	Estimated forest (ha)	Forest <1,200 m (ha)
Northern Negros National Park	Protected Area	70,826	24,000	~10,000
Mt Kanlaon National Park	Protected Area	24,388	8,000	~2,500
Balinsasayao Twin Lakes National Park	Protected Area	8,016	3,000	~2,000
Ilog-Hilabangan Watershed Forest Reserve	Forest Reserve	10,400	500	~500
Cuernos de Negros Mountain Range	Forested land[1]	4,096	2,000	~500
Sta Catalina	Forested land	500	200	~200
Ayungon (Banban) - Bindoy	Forested land	10,000	200	~50
Southwestern Negros (Cauayan, Sipalay and Hinobaan)	Forested land[1]	~1,000	500	~500

Sources: NAMRIA (2010), DENR-FMB (2013), PBCFI-BMB (2018).
[1]Key Biodiversity Area (KBA)

Figure 2. Uniform cosine detection probability function model.



to 10h00. For each detection of the Visayan Tarictic Hornbill, the following information was recorded: (1) whether the record was a sighting or call, (2) the number of hornbills visually observed or heard, (3) sex, (4) estimated distance from point of detection, and (5) the observed activity of the hornbills (i.e. feeding, calling, flying, preening, perching). Count duration at each point lasted eight minutes. Point-to-observation perpendicular distances were also measured or estimated (Howe 1993), allowing our data to be analysed as point transects (Buckland *et al.* 2001). Distance to each detection was estimated to the nearest metre. All records were mapped and compared by location and time of observation to eliminate the possibility of double counting.

Habitat assessment

Plant surveys were conducted from 16–24 November 2016 in Northern Negros, and 21 November–20 December 2018 at all three sites. Three habitat types were sampled: lowland evergreen rainforests below 1,000 m, lower montane rainforest from 1,001–1,200 m, and upper montane rainforests with elevations above 1,200 m. No hornbills were recorded in forests above 1,200 m, hence we excluded these areas from analysis.

We established 30×30 m plots in areas where we positively identified Visayan Tarictic Hornbills and in areas where we did not record the hornbills to quantify habitat variables. A total of 336 plots were established at all three sites. The number of fruiting trees, number of large trees with >60 cm diameter at breast height, tree height (10–15 m, 16–20 m, >20 m), percent canopy cover, percent understory cover, presence and absence of tree cavities were recorded. Canopy cover was estimated using a densiometer.

We used the National Mapping Resource Information Authority's (NAMRIA 2010) map and information from the National Greening Program of the Philippines (DENR-FMB 2013) to validate forest cover on the ground in all three protected areas from 2017–2018. We also made an effort to visit other remaining forest patches on Negros (Table 1). Using the QGIS 3.0 software, we calculated suitable habitat for the Visayan Tarictic Hornbill for each protected area.

In estimating the amount of suitable forest habitat for the Visayan Tarictic Hornbill, we are confident of the high level of accuracy in all three protected areas. We used the Negros forest cover map from the National Mapping and Resource Information Authority (NAMRIA 2010) and verified this with further ground truthing. The forest cover in Sta Catalina, Cauayan, Sipalay and Hinobaan were also validated with ground truthing. Although we have only visited a small section of Cuernos de Negros Mountain range, where most remaining forest is found above 1,300 m, we were able to locate some areas of remnant forest below 1,200 m. We were unable to visit Ban-ban or Ayungon forest and the Ilog Hilabangan Watershed Forest Reserve. We did not encounter hornbills in residual and heavily disturbed forest remnants of less than 100 ha and therefore excluded these areas from analysis. In estimating the amount of suitable hornbill habitat, we considered lowland evergreen rainforest and lower montane forest, and the altitudinal profile of the area. We excluded exotic tree plantations, forest with trees of less than 15 m in height and forests above 1,200 m. Our estimates for the remaining suitable hornbill habitat on Negros is c.14,500 ha (145 km^2).

Data analysis

Density and population estimation

A total of 232 sampling points were surveyed for a total of 635 incidences (effort) resulting in 66 detections. Both visual and aural records were pooled to calculate densities (expressed as individuals/ha) using *Distance version 7.3* (Thomas *et al.* 2010). Effective detection radius (EDR) is 48 m, with most records within the 0–40 m distance band and very few records beyond 100 m from the observer. All data were right-truncated at 100 m to remove any outlying records and improve model fit (Buckland *et al.* 2007). Different models were assessed to select best fit and the model with the lowest Akaike's Information Criterion value (AIC) and AIC corrected for small samples (AICc) (Table 2) was selected as the best fit (Buckland *et al.* 2007).

The uniform cosine model showed the best fit with our data (Figure 2) and this was further confirmed by the Kolmogorov–Smirnov goodness-of-fit test. Post-stratification of the data by protected area enabled comparisons of density estimates and differences in detectability within each protected area. We then used the combined detection function for all three protected areas based on all 66 detections and post-stratified it by protected area to obtain site-specific estimates (Buckland *et al.* 2007). Density estimates are presented as the number of individuals per hectare.

Table 2. Comparison of models based on three detection functions fitted to our dataset. Akaike's Information Criterion value (AIC), AIC corrected for small samples (AICc) and coefficient of variation (CV).

Fitted models	AIC	AICc	CV
Half-normal simple polynomial	635.70	632.41	26.11
Uniform cosine	630.19	630.37	26.01
Hazard-rate cosine	635.68	635.86	35.38

Habitat associations

We compared eight habitat variables across the three protected areas. Because our data were not normally distributed, and transformation was not straighforward, we used the Kruskal-Wallis ANOVA to determinine differences for these parameters across the study areas.

We then related hornbill presence or absence around our habitat plots to a series of habitat variables, including: number of trees in a plot with heights of 10–15 m, 16–20 m and >20 m; number of large trees with >60 cm diameter-at-breast-height; percent canopy cover; number of fruiting trees; number of trees with cavities; and percent understory cover. We used a logistic regression model with a logit link function in *R Deducer 2.15.0* (R Core Team, 2013) based on the general logistic regression formula:

$$Logit\ (Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k$$

where Y = dependent variable (occurrence of hornbill), X = independent variables, α = intercept; and β = coefficient.

In assessing our models, all eight habitat variables were fitted in the global model and progressively removed until a minimum acceptable model was reached, where further removal of variables resulted in an increase in the model's Akaike Information Criterion value.

RESULTS

Habitat characteristics

The three protected areas studied were similar in terms of canopy cover, understory cover and number of trees with cavities, but the number of smaller trees (10–15 m; p<0.0001) in Mt Kanlaon and Northern Negros was higher compared to Balinsasayao. Both Northern Negros and Mt Kanlaon also have more trees of >21 m height (p<0.001) as compared to Balinsasayo (Table 3). The number of trees of 16–20 m height was also significantly higher (p<0.05; Table 3). Curiously, Balinsasayao had a marginally higher number of fruiting trees than the other two areas (p<0.001; Table 3).

Our logistic regression modelling (Table 4) showed that the number of large trees was positively correlated with the probability of hornbill occurrence (β estimate = 0.226; p<0.0001). We observed a weak negative correlation of hornbill presence with understory cover (β estimate = -0.014; p<0.01). Increase in understory cover reduces the probability of hornbill occurrence by 0.214.

Population estimates

Hornbill density varied across the three protected areas. Hornbill density was higher in Balinsasayao (0.825 individuals/ha) than in Mt Kanlaon (0.235 individuals/ha) and Northern Negros (0.087 individuals/ha) (Table 5). Both Balinsasayao and Mt Kanlaon have smaller estimated suitable hornbill habitat as compared to Northern Negros.

Northern Negros Natural Park

A total of 27 individuals were recorded from 15 observation instances at 234 sampling points. The species was observed in 10 of 11 localities from 680 to 1,100 m. Lowland forests with trees above 15 m in stature in Northern Negros were estimated to cover 10,000 ha. Using the mean density estimate of 0.087 individuals/ha, the population of Visayan Tarictic Hornbill in Northern Negros is approximately 870 individuals.

Mt Kanlaon Natural Park

A total of 39 individuals were recorded from 12 observations at 180 sampling points. The bird was only encountered in three localities within the park, near the cities of Bago and La Carlota and in the town of Murcia, where forests begins at 860 m. We recorded Visayan Tarictic Hornbill up to 1,100 m. We estimated the remaining suitable habitat in Mt Kanlaon to be 2,500 ha. Hornbill mean density estimates were around 0.235 individuals/ha here and we estimated the population at 587.5 individuals.

Balinsasayao Twin Lakes Natural Park

A total of 61 individuals were recorded from 39 observations in 86 sampling points. The Visayan Tarictic Hornbill was more frequently encountered in the eastern part of the park where primary forest is concentrated. The forest area with trees above 15 m in height totaled 2,000 ha. The hornbill mean density estimate was 0.825 individuals/ha at this site and we estimated the population to be at approximately 1,650 individuals.

Table 3. Summary of eight habitat variables (means ± standard deviation) in the three protected areas studied. Dbh = diameter-at-breast height; N = number of plots.

Habitat variables	*H* statistic	NNNP (n=94)	MKNP (n=45)	BTLNP (n=30)
Number of trees 10–15 m in height	19.45***	13.5 ± 8.1	16.0 ± 8.5	7.6 ± 7
Number of trees 16–20 m in height	8.03*	6.4 ± 6.4	6.4 ± 5	1.3 ± 4
Number of trees >21 m height	16.26**	4.4 ± 7.1	5.7 ± 5.6	1.7 ± 2.8
Number of trees (>60 cm dbh)	4.5	1.5 ± 4.4	2.5 ± 2.8	2.0 ± 3
% understory cover	4.3	48.0 ± 62	44.0 ± 25	33.0 ± 33
% canopy cover	4.6	47.0 ± 33	72.0 ± 12	68.0 ± 16
Number of fruiting trees	5.8*	0.4 ± 0.5	0.3 ± 05	0.6 ± 0.5
Number of trees with cavities	2.2	0.14 ± 0.3	0.2 ± 0.4	0.2 ± 0.4

*P<0.05; **P<0.001; ***P<0.0001

Table 4. Summary statistics of best-fitting regression model relating habitat parameters to hornbill presence. βs are coefficients of the best fit regression model. Z values are βs divided by the standard error. Dbh: diameter-at-breast height.

Habitat variable	β coefficient	Standard error	z-value
Number of big trees (>60 cm dbh)	0.226**	0.048	4.683
Understory cover	-0.014*	0.006	-2.402
Intercept	-1.289	0.344	-3.740

*p<0.01; **p<0.0001

Table 5. Hornbill density at each protected area based on DISTANCE estimates. LCL = lower confidence limit and UCL = upper confidence limit.

Protected area	LCL – UCL	Mean density (individuals/ha)
Northern Negros Natural Park	0.03 – 0.26	0.087
Mt Kanlaon Natural Park	0.10 – 0.54	0.235
Balinsasayao Twin Lakes Natural Park	0.49 – 1.38	0.825

DISCUSSION

Our study showed that the occurrence and population density of the Visayan Tarictic Hornbill may be influenced by multiple habitat variables. The species was found to favour areas with trees greater than 15 m in height and >60 cm in diameter at breast height. This is consistent with studies from Panay, where forests with large and tall trees were considered important habitats for the species' survival (Klop *et al.* 2000). However, lowland evergreen rainforest with tall and large trees is now limited on Negros and Panay. Among the three protected areas studied, Northern Negros holds the largest extent of lowland evergreen rainforest on Negros, with tree height ranging mostly between 15–20 m. Conversely, both Mt Kanlaon and Balinsasayao still retain patches of primary lowland evergreen rainforest with trees more than 20 m tall. However, in Mt Kanlaon forest below 1,200 m is limited and only found in the

western parts of Mt Kanlaon and this is where the hornbills are largely concentrated.

Balinsasayao has the highest population estimate (c.1,650 individuals) despite having the smallest forest cover among the three sites. On the other hand, the small number of hornbill records in Northern Negros relative to the effort spent in the area may potentially introduce biases that underestimate the true density of the area. We also noted the limitation in the use of distance sampling in estimating hornbill density as bird abundance and movements can be influenced by breeding and distribution of ripe figs (Kinnaird *et al.* 1996), which may introduce overestimates of counts.

Threats such as hunting activities were more frequently encountered in Northern Negros and Mt Kanlaon as compared to Balinsasayao. We observed at least three hunters' huts in Northern Negros in April 2014 and four in December 2017, while three hunting groups and two hunters' huts were encountered in Mt Kanlaon during the survey in October 2019. Locals have also reported instances of poaching hornbill chicks from a nesting tree in Northern Negros in March 2020. Poaching activities may contribute to the lowered densities of Northern Negros and Mt Kanlaon despite their greater extent of suitable habitat. There is a need to further investigate the impacts of hunting on Negros as it has been documented to significantly reduce hornbill populations elsewhere (Naniwadekar *et al.* 2015, Holbech *et al.* 2018).

We estimated the population of Visayan Tarictic Hornbill in all three protected areas by multiplying the density estimates at each site with the estimated area of suitable habitat. This totaled 3,107 individuals and is higher than the existing estimates of 1,800 individuals for both Negros and Panay Islands (BirdLife International 2020). While we suggest that the island-wide population is larger than previously thought, it would be unwise to generalise that the hornbill is faring equally well in all areas. The legal protection status of the three protected areas did not stop hunting activities. Existing threats such as hunting and forest fragmentation likely qualify the species for IUCN Red List criterion B2b (ii and iii) and we propose to maintain its current IUCN conservation status as Endangered.

In the last 15 years, three of the four largest remaining forests of Negros (Mt Kanlaon, Northern Negros and Balinsasayao) have been declared as protected areas. The Expanded National Integrated Protected Areas System (E-NIPAS) Act enacted in June 2018 has provided increased annual budget allocations for protected areas in the Philippines (Republic Act No.11038 of 2018). Habitat rehabilitation and native tree planting programs remain as priority activities of the local government and the Department of Environment and Natural Resources. There is a conscious effort to better conserve native species in protected areas but implementation remains a challenge. In 2018, the two provinces of Negros developed the Negros Island Biodiversity Strategy and Finance Plan (PBCFI & DENR 2018), effectively increasing annual budgetary allocations for biodiversity conservation. In addition, data from these surveys were used as a basis to advocate for conducting protected area suitability assessments in Cuernos de Negros Mountain Range in Negros Oriental and Central Panay Mountain Range in Panay by the Department of Environment and Natural Resources. The Energy Development Corporation has also adopted the Visayan Tarictic Hornbill as its flagship species in their biodiversity monitoring program in Cuernos de Negros Mountain Range as well as in Mt Kanlaon. We hope that these efforts will aid in the maintenance and growth of Visayan Tarictic Hornbill populations in the future.

We also make the following recommendations for the continued protection of hornbill population in Negros' forests.

Collaboration with Local Government Units in monitoring protected areas (PAs)

Average annual national budget allocations for monitoring PAs is USD581, while class A local government units have annual funds of at least USD19,380 for environmental programs including monitoring PAs. The Protected Areas Management Board (PAMB), Provincial Government and the Biodiversity Management Bureau (BMB) of the Department of Environment and Natural Resources should adopt hornbills as priority indicator species through regular conducting of biomonitoring of protected areas and Key Biodiversity Areas. It is also strongly recommended that the Department of Environment and Natural Resources, local government units and non-government organisations continue conducting standardised biomonitoring in each Protected Area using improved line-point transect sampling and DISTANCE analysis.

Protection of remaining forests on Negros

The protection of the forests in protected areas from further degradation and eliminating hunting activities should remain a priority program of the government. Both the local government and the Department of Environment and Natural Resources in collaboration with non-government organisations should push for the protected area declaration of the Cuernos de Negros Mountain Range and Central Panay Mountain Range.

Surveys of threatened hornbills of the Western Visayas

Surveys are needed in the other identified forests patches such as the Central Panay Mountain Range, Northwest Panay Peninsula Protected Landscape, Cuernos de Negros Mountain Range, Sta Catalina forest and Masbate Island to determine the presence of surviving populations. There is also a need to conduct targeted searches for the Rufous-headed Hornbill and other threatened species on both islands.

CONCLUSION

The population density of Visayan Tarictic Hornbill in the three protected areas on Negros was estimated at 3,107 individuals. This was greater than the population estimates given by the International Union for the Conservation of Nature (IUCN) totaling 1,800 individuals (with 1,200 mature individuals) for both Negros and Panay Islands (IUCN 2021). While the island-wide population is larger than previously thought, the hornbill is still threatened with hunting and habitat loss. The Visayan Tarictic Hornbill requires lowland evergreen forests with tall and large trees to survive. Protection of the remaining forests and reduced hunting activities in the protected areas on Negros would help ensure the long-term conservation of the species.

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