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Philippine hornbills' conservation status: problems and prospects

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Abstract: Philippine hornbill species comprise over 16% of the global Bucerotidae (Aves: Bucerotiformes), a charismatic group of tropical Afro-Asian birds. All 15 taxa (species and their subspecies) in the Philippines are endemic to the archipelago, often restricted to rain forests of a particular island or faunal region. Currently, half of the known hornbill species in the Philippines are regarded as threatened (IUCN 2012). Proposed taxonomic changes in hornbills follow a recent comprehensive molecular phylogenetic analysis of Bucerotidae (Gonzalez 2012), and re-evaluation of species limits based on the application of new criteria (Tobias et al. 2013). These proposed changes have elevated three taxa of Philippine hornbills to full species status, thus restricting their respective areas of occupancy. We evaluate the applications of these taxonomic changes and present revisions in their conservation status, based on IUCN categories. In this paper, we enumerate the implications of these revisions for the re-launching of the Philippine Hornbills Conservation Programme, focusing on problems and prospects in the action plans for priority conservation areas. These priority areas represent key island groups/faunal regions for endemic and threatened hornbills, including the West Visayas faunal region, Polillo group, Mindoro, Calamianes group, Greater Mindanao faunal region and Sulu islands.

Keywords: Philippines, hornbills, Bucerotiformes, conservation, molecular phylogenetic, mitochondrial DNA

INTRODUCTION

Hornbills (Order Bucerotiformes) are a charismatic group of tropical birds, characterized by syndactyl feet, a distinctive casque on the bill and a unique trait of plastering the entrance of their nest cavity (nest-sealing). They comprise two families, Bucorvidae and Bucerotidae with a total of 54 species in 76 taxa distributed across Africa and Asia (Kemp

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2001; Figure 1). Taxonomic revisions subsequent to Kemp (2001) have recognized 88 taxa in 61 species known worldwide (Gill and Donsker 2012). Asian hornbills represent 32 species distributed from India to the Solomon Islands (Table 1), and are considered to be largely obligate frugivores, thus important dispersers of rainforest seeds (Kinnaird and O'Brien 2007). From this total, nine species of Asian hornbills are categorized as threatened and 6 as Near Threatened (IUCN 2012). Some nine species are endemic to the Philippines, of which more than half (five) are currently threatened, including two that are regarded as critically endangered, such as the enigmatic Sulu Hornbill *Anthracoceros montani.*

A recent comprehensive study on the evolution of Bucerotidae (Gonzalez 2012) addressed several key points raised during the 5th International Hornbill Conference 2009 held in Singapore, focusing particularly on the keynote paper presented by Kemp and Kemp (2009). They noted the importance of re-evaluating species limits among hornbill taxa based on modern phylogenetic techniques, of which a consensus phylogeny was presented based mainly on the use of morphology (Kemp 1995) and analysis of the mitochondrial DNA (mtDNA) Cytochrome *b* (Cytb) gene (Hübner et al. 2003). Kemp and Kemp (2009) emphasized the questionable status of several taxonomically enigmatic species, including the dwarf hornbills (*Tockus*), Long-tailed Hornbill (*Tropicranus*), Helmeted Hornbill (*Rhinoplax*), small Indian hornbills (*Ocyceros*) and the Sulu and other Philippine hornbills. Alongside this need for further phylogenetic analysis, they also enumerated gaps in overall biology and ecology of both West African and Philippine hornbills, as well as outlining the ethno-biological importance of hornbills worldwide.

A pioneering study by Sibley and Ahlquist (1990) established the evolutionary relationships of birds using DNA-DNA hybridization techniques, and constructed one of the first molecular phylogenies of hornbills based initially on 17 species. This study was followed by that of Morin et al. (1994), who constructed a tree of seven species based on short sequences of mtDNA Cytb, and this was later expanded by Srikwan and Woodruff (1998) to include 11 hornbill species. Consequent phylogenetic trees were built on the established mtDNA Cytb sequences, and were expanded to include 22 species (Hübner et al. 2003) and then 34 species, thereby covering all known hornbill genera (Viseshakul et al. 2011). A more comprehensive molecular phylogeny of hornbills by Gonzalez et al. (2013a) covered all 61 known species of Bucerotidae.

Gonzalez et al. (2013a) addressed the taxonomic changes of hornbills at the generic and species level, but did not address issues at the subspecies or population level. However, they were able to sort out questions regarding evolutionary relationships mentioned by Kemp and Kemp (2009) such as the placement of dwarf hornbills, Long-tailed Hornbill, Helmeted Hornbill, small Indian hornbills and the Sulu

Hornbill. All nine Philippine species and the Samar Hornbill *Penelopides samarensis* were included in Gonzalez et al. (2013a), but additional subspecies from the Philippines were not tackled. Those were covered in two chapters in Gonzalez (2012) that focused on the phylogenetic analysis of all known subspecies of Asian hornbills, and a comparison of genetic and phenotypic divergence. Given these recent developments in the molecular and morphological analysis of Philippine hornbills, we apply the taxonomic revisions proposed by Gonzalez (2012) and Gonzalez et al. (2013a) as a basis for re-evaluating their conservation status. This paper also aims to discuss the consequential problems and prospects for developing action plans and re-directing conservation priorities for Philippine hornbills.

MATERIALS AND METHODS

The application of proposed changes in the taxonomy of Asian hornbills followed the recent study made by Gonzalez (2012) based on both molecular and morphological analysis. Proposed taxonomic changes were compared with the current IUCN (2012) threat status, and re-evaluated using the criteria set by IUCN based on consequent changes in population density, area of occupancy and present state of occupied habitats. Revisions in the conservation status of hornbills reiterate the importance of the Philippines as a global conservation priority, given that half the species are already regarded as threatened. Gonzalez (2012) constructed a comprehensive phylogeny of Asian hornbills based only on mtDNA Cytb and covered nearly all known geo-isolates (subspecies and island populations). A total of 78 taxa with 120 geo-isolates were included and placed emphasis on geo-isolates from the Philippines.

Molecular and phenotypic divergence was determined between pairs of geo-isolates as a basis for evaluating species limits. Proposed changes in taxonomy were largely based on this revised phylogeny and a corresponding pre-published chapter combining genotypic and phenotypic data to address the question of species limits in 54 pairs of Asian hornbills (Gonzalez et al., in prep). Phenotypic delineation was based on the criteria used for delimiting bird species established by Tobias et al. (2010). Cumulative scores for morphology, acoustics, behaviour and distribution were used to determine phenotypic divergence, based on the scores crossing beyond the threshold of 7. Molecular divergence was based on the model-fitted analysis of genetic distance using mtDNA Cytb (Fergin et al. 2012) and based on the scores crossing beyond the mtDNA divergence threshold of 4 (Price 2008).

RESULTS AND DISCUSSION

Recent proposed changes to the taxonomy of hornbills were discussed in Gonzalez (2012), which were published in two corresponding papers, describing the molecular phylogeny of Bucerotidae (Gonzalez et al. 2013a) and the subsequent corrigendum (Gonzalez et al. 2013b). Further proposed taxonomic changes were based on comparison of phenotypic scores and molecular divergence (Gonzalez et al., in prep). In this paper, Philippine hornbills were grouped into four distinct clades, with a total of 15 species and subspecies recognized (Figure 2). The Buceros clade is sister to other Asian *Buceros* (*B. bicornis* and *B. rhinoceros*) and comprises two species, the nominate *B. hydrocorax* from northern Luzon and *B. mindanensis* from southern Philippines. Kemp (1995) suggested splitting the Rufous or Great Philippine Hornbill but refrained from doing so given insufficient information. Molecular analysis indicated all three subspecies were genetically divergent, but *B. mindanensis semigaleatus* was retained as a subspecies since the phenotypic score was insufficient to consider splitting the two populations.

The *Aceros* clade included two Philippine species, *A. leucocephalus* and *A. waldeni*, which were found to form a cluster with *A. corrugatus* and *Penelopides exarhatus*. Given that *Aceros* was polyphyletic, Gonzalez et al. (2013a) suggested placing the writhed-hornbills in their own genus *Cranobrontes* (Riley 1921) joined by *P. exarhatus*, which shared similar use of the oil gland and produced a staccato call. Gonzalez et al. (2013b) reconsidered using the genus *Rhabdotorrhinus* (Wiglesworth 1895) given its seniority over *Cranobrontes*. Since the *Penelopides* clade was now polyphyletic, resurrection of *Rhabdotorrhinus* returned *Penelopides* into an endemic Philippine genus. Molecular and morphological divergence supported the split of *Penelopides panini*, which was previously considered as one polytypic species (Kennedy et al. 2000). Nominate *P. panini* from West Visayas was distinct from *P. manillae* from Greater Luzon, *P. mindorensis* from Mindoro and *P. affinis* from Greater Mindanao. Data further supported the split of *P. samarensis* and *P. basilanicus* from *P. affinis*. Genotypic and phenotypic scores also support retention of polytypic taxa, *P. panini ticaensis* and *P. manillae subniger*, both of which approach the threshold of 7 in the Tobias et al. (2010) criteria, but not enough to be elevated to full species.

An evaluation of the *Penelopides* clade within the comprehensive mtDNA Cytb tree indicated clustering of subclades based on related geo-isolates, including the clustering of Ticao with Masbate hornbills, thus suggesting the close relationship of the functionally extinct Ticao Tarictic Hornbill *P. panini ticaensis* to the nominate Visayan Tarictic Hornbill *(P. p. panini)* from Masbate. The island endemic *P. affinis*

basilanicus from Basilan also formed a subclade with the nominate *P. a. affinis* from Zamboanga Peninsula. Subsequent subclade formation within known clades of a particular species may suggest incipient taxa, and are sometimes regarded as Evolutionary Significant Units (Sutherland 2000). These include clustering between Northern and Southern Luzon populations of *P. m. manillae*, and Eastern and Western Mindoro populations of *P. mindorensis*, as well as clustering of *P. p. panini* between Panay and Negros-Guimaras.

The *Anthracoceros* clade is represented by two species in the Philippines, and represents the most recent arrival in the archipelago. As an Asian clade, *Anthracoceros* still has unresolved relationships with *Ocyceros* from India and Sri Lanka. However, the enigmatic Black Hornbill *A. malayanus* is sister to a monophyletic clade of "Pieds", which includes *A. marchei* and *A. montani*. Much like geo-isolates in the *Penelopides* clade, there are emerging subclades within *A. marchei* such as clustering of populations from Balabac, Palawan and the Calamianes group.

Both published and unpublished proposed changes in the taxonomy and phylogenetic relationships of geo-isolates of Philippine hornbills reveal implications for their conservation – in particular, changes to their conservation status.

A summary of proposed revisions to the conservation status of Philippine hornbills is presented concurrently with the re-launching of the Philippine Hornbills Conservation Programme. Current taxonomy and conservation status (IUCN 2012) are enumerated in Table 1, along with the corresponding revisions. These revisions accepted the elevated species status of three Philippine Hornbills, thereby increasing the total of species from nine to 11. The Rufous or Great Philippine Hornbill *Buceros hydrocorax* is split into two species, and the Mindanao Tarictic Hornbill *Penelopides affinis* is split into three species. These splits result in a reduction in area of occupancy of the elevated taxa, and a corresponding elevation in conservation status. Both the Great Luzon Hornbill *B. hydrocorax* and Great Mindanao Hornbill *B. mindanensis* are considered Vulnerable, elevated from Near Threatened prior to the split. Both the Mindanao Tarictic Hornbill *P. affinis* and Samar Tarictic Hornbill *P. samarensis* are considered Near Threatened, with the Basilan Tarictic Hornbill *P. basilanicus* placed as Data Deficient, all elevated from Least Concern prior to the split.

On the other hand, both the Luzon Tarictic Hornbill *P. manillae* and Visayan Tarictic Hornbill *P. panini* are retained as polytypic, and their conservation statuses retained. However, important considerations are needed concerning their corresponding subspecies, since the Ticao

Tarictic Hornbill is now functionally extinct and the Polillo Tarictic Hornbill is definitely threatened. Given the novel findings about the close relationship between Masbate and Ticao hornbills, it is likely that surviving hornbills on Masbate should be regarded as Critically Endangered.

Both geo-isolates from Polillo and Masbate represent taxa that require further deliberation, since the application of the IUCN categories is unsatisfactory at a 'species' level. Five other species are retained as monotypic, and the conservation status of four hornbills is more or less retained (IUCN 2012) – all of which are threatened. This includes the Mindoro Tarictic Hornbill *P. mindorensis*, Visayan Writhed Hornbill *Rhabdotorrhinus waldeni*, Palawan Hornbill *Anthracoceros marchei* and Sulu Hornbill *A. montani*. However, there is the exception of the Mindanao Writhed Hornbill *R. leucocephalus* where a recently observed decline in the wild population suggests elevating its status from Near Threatened to Vulnerable.

Philippine Hornbills Conservation Programme

The Philippine Hornbills Conservation Programme (PHCP) was developed under the auspices of the Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR), and is now re-launched in collaboration with the Philippine Biodiversity Conservation Foundation Inc. (PBCFI) and other national and international conservation agencies (Oliver and Wilkinson 2007). Important revisions in the current PHCP Proposed Conservation Action Plan for the next five years (2013 – 2018) are enumerated in the following section, further describing the key areas representing Regional Conservation Action Priorities (Figure 3). The renewed PHCP is accompanied by a covering Memorandum of Agreement (MOA) between DENR, Vogelpark Avifauna and the North of England Zoological Society. The '2013-2018 Action Plan' is attached as an 'annex' to the MOA, thereby also indicating the compliance and support of all signatory parties for the following priority activities. The revised PHCP includes a review of conservation status categorizations and consensually agreed conservation research and practical management interventions for all hornbill species; thereby including the new taxonomic arrangements proposed by Gonzalez (2012) and its correspondingly increased numbers of recognized taxa at both species and subspecies levels (Table 1).

Currently proposed species (regional) conservation action priorities West Visayas Faunal Region (in close collaboration with all existing and potential new partner agencies)

- Re-evaluate current conservation status and likely future conservation management priorities for '*P. p. ticaensis*', which taxon was formerly known only from Ticao Island (where now 'extinct'). However, following Gonzalez (2012) potential re-assignment of tarictics from the neighbouring, larger island of Masbate (formerly 'lumped' with *P. p. panini* from other West Visayan Islands) to *P. p ticaensis*, it seems this subspecies may be still extant; albeit 'Critically Endangered'. Leastways, Paguntalan et al. (2004) reported the continuing occurrence of small numbers of tarictics in one or more badly fragmented and degraded mixed mangrove and secondary forest patches in one or more locations with this habitat in southwest Masbate.
- Assist salient local authorities to develop a new Local Conservation Area (LCA) network or similar habitat protection and restoration strategy in Masbate, together with associated development of salient conservation management plans, para-legal and other personnel training, and local community forest wardening schemes and awareness campaigns.
- Develop and extend on-going LCA developments in central-east Negros (Oriental) and extreme south-west Negros (Occidental), later extending to selected locations in west and northwest Panay Island, with a view to the increased protection of selected priority (especially non-NIPAS) terrestrial habitats (especially lowland forest, cave and wetland ecosystems) and endemic taxa.
- Complete on-going assessment of *A. waldeni* and *P. p. panini* population status (*i.e.* distribution, habitat utilization, approximate numbers and threats) in North Negros Natural Park (NNNP), as 'indicator' species for also evaluating (and hence duly strengthening) current forest management practices and protection activities in this and other NIPAS sites.
- Sustain, develop and extend existing conservation breeding programmes for *A. waldeni* and *P. p. panini* on Panay, Negros and elsewhere.
- Develop and implement properly structured reintroduction projects for *P. panini* and other threatened endemic species (possibly/hopefully including *A. waldeni*) in selected 'vacant' habitats on both Negros and Panay Islands, with a view to also strengthening existing IUCN (and DENR) guidelines per add-on biodiversity conservation values (*e.g.* greatly increased protection/restoration of existing habitats and wildlife, development of local community-based wardening and other activities,

and sustainable financing mechanisms – *e.g.* local government annual budgetary allocations and other support).

- Per all of above activities: investigate and, where possible, promote increased collaboration between key local stakeholders and other salient interest groups (e.g. academe); whether governmental, non-governmental, corporate or private.

Mindoro and associated offshore islands (in close collaboration with the Mindoro Biodiversity Conservation Foundation and other salient local partner agencies)

- Sustain and develop current 'protected areas' (including proposed new 'LCA' network), with development/expansion in selected priority (especially non-NIPAS) sites in Mindoro and associated islands (*e.g.* Ylin and Ambulong, but possibly extending to Lubang Island).
- Sustain and develop other biodiversity conservation-related activities, including local public education/awareness campaigns, teacher-training workshops, local community wardening schemes, *etc*.
- Conduct preliminary (and more detailed follow-up) surveys in other potentially important but barely, if ever, previously explored and biologically inventoried areas *(e.g.* Mt. Malasimbo. Mt. Baco), with a view to development of future (*i.e.* second phase) biodiversity conservation development plans and strategies.
- Investigate altitudinal distribution (as well as overall range) of key 'indicator' species, per implications for current and future 'protected area' developments in this (globally critical) region.

Polillo Islands (in close collaboration with the Polillo Islands Biodiversity Conservation Foundation and other local partner agencies)

- Complete current NewCAPP (New Conservation Areas in the Philippines Project) project activities, including establishment of new LCAs on Patnangungan and Jomalig Islands;
- Maintain and develop all other pre-existing and on-going LCA/habitat protection and restoration activities, local awareness, personnel training and other local institutional capacity-building activities on Polillo Island.
- Investigate options for assisting continued development of proposed new network of coastal and marine protected areas (MPAs).

Calamian Islands (in close with the Calamian Islands Biodiversity Conservation Support Group, Katala Foundation and other local partner agencies)

- Sustain and develop Phase Two and Three activities per establishment of a new network of 10 or more LCAs in selected priority sites on

Calamianes.

- Describe new species and publish other important findings resulting from recent field site surveys per the aforementioned LCA network development programme on Busuanga and Culion Islands
- Investigate options for assisting salient authorities to enhance salient protection and restoration activities in Calauit Island Game Preserve and Wildlife Sanctuary and other key (watershed, *etc*.) sites outside the proposed new LCA network.

Sulu Islands (in close collaboration Mindanao State University and other existing, and likely future partner agencies)

- Re-assess current status of *Anthracoceros montani* in Tawi-tawi, Batu-batu, Sanga-sanga and associated Islands (if possible also extending to Jolo and its associated islands), with a view to developing comprehensive conservation management plans for this and other key threatened endemic taxa.
- Conduct preliminary surveys on Sibutu Island (extreme southwest Philippines), which has seldom been explored biologically. This is of considerable potential interest as a separate late Pleistocene isolate, with likely strong faunal associations with Borneo, and such surveys also to be conducted with a view to formulation of follow-up conservation measures.
- Promote and develop local education-awareness campaigns, local personnel training and other institutional capacity-building schemes.

Greater Mindanao and associated 'higher conservation priority' islands (in close collaboration with salient local partner agencies – both governmental and non-governmental in each location)

- Camiguin Sur: To sustain and develop on-going field research, protected area (Mt. Timpoong - Mt. Hibok-Hibok Natural Monument) development and associated personnel training, local awareness campaigns, *etc*.; this island is of particular importance as a Pleistocene isolate, with several, new single-island endemic species so far described, plus as yet unexplained hiatuses (despite its close proximity to the Mindanao mainland) in the distribution of key regional endemics (*e.g. R. leucopcephalus* is present, but both *B. mindanensis* and *P. affinis* are absent).
- Dinagat and associated islands *(i.e.* Siargao and Bucas Grande): To conduct follow-up surveys and networking consultations with a view to the proposed development of a possible new LCA network of 'protected areas' on Dinagat Island, as a matter of some urgency; Dinagat-Siargao-Bucas Grande seemingly form a sub-center of species endemism within

the 'Greater Mindanao Faunal Region', likewise characterized by the occurrence of increasing numbers of new 'single island (or 'Dinagat/ Siargao/Bucas Grande only) endemic species, and similar absences of some other species (e.g. Philippine rusa, *Rusa marianus*), although all three Greater Mindanao hornbills, *B. mindanensis, P. affinis*, and *R. leucocephalus* are not only present, but this island constitutes the northernmost extension of their respective ranges. Unfortunately, however, Dinagat (wherein most native forest still remains) was long ago declared a mining reserve and virtually all remaining forested areas are now threatened by DENR-licensed mining claims, several of which are already active.

- Basilan Island: Unfortunately, Basilan (like Jolo and associated islands in east Sulu Archipelago) has been effectively off-limits to scientific research and associated conservation-related for the past half-century or so. This circumstance has naturally prompted increased concerns regarding current conservation status and future survival prospects of key hornbill and other various threatened (local and regional) endemic species populations; a situation now exacerbated by Gonzalez's (2012) separation of *P. basilanicus* as a single island endemic species. Whilst it is apparently unlikely that any concerted conservation interventions will be feasible in the near future, efforts should be made to acquire updated status data regarding this and key other species' populations, whilst also investigating any other feasible means of promoting increased local interest and concern per the future survival prospects of these taxa.

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REFERENCES

Fregin, S., Haase, M., Olsson, U. and Alström, P. 2012. Pitfalls in comparisons of genetic distances: a case study of the avian family Acrocephalidae. *Molecular Phylogenetics and Evolution* **62**(1): 319-28.

Gill, F. and Donsker, D. (eds.) 2012. International Ornithological Congress World Bird List (v 2.10). Downloaded from http://www.worldbirdnames.org/names/ in November 2012.

Gonzalez, J.C.T. 2012. Origin and diversification of hornbills (Bucerotidae). PhD Dissertation. University of Oxford, U.K. (Unpublished)

Gonzalez, J.C.T., Sheldon, B.C., Collar, N.J. and Tobias, J.A. 2013a. A comprehensive molecular phylogeny for the hornbills (Aves: Bucerotidae). *Molecular Phylogenetics and Evolution* 67: 468–483.

Gonzalez, J.C.T., Sheldon, B.C., Collar, N.J. and Tobias, J.A. 2013b. Corrigendum to ‘‘A comprehensive molecular phylogeny for the hornbills (Aves: Bucerotidae)’’. [*Molecular Phylogenetics and Evolution* **67**: 468–483].

Gonzalez, J. C. T., Sheldon, B.C., Collar, N.J. and Tobias, J.A. In prep. Combining genotypic and phenotypic data to address the question of conservation units: a case study of Asian hornbills.

Hübner, V.S.M., Prinzinger, R. and Wink, M. 2003. Neue Erkenntnisse zur Taxonomie der Hornvögel (Aves: Bucerotiformes) und ihre Bedeutung für die Zucht. *Menschenobhut. Zoologische Garten N.F*. **73**: 396−401.

IUCN. 2012. Guidelines for Using the IUCN Red List Categories and Criteria (version 8.1). Prepared by the Standards and Petitions Subcommittee. Downloaded from http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf.

Kemp, A.C. 1995. *The Hornbills: Bucerotiformes*. Oxford: Oxford University Press.

Kemp, A.C. 2001. Family Bucerotidae (Hornbills). In: de Hoyo, J., Elliott, A. and Sargatal, J. (eds.). *Handbook of the Birds of the World. Vol. 6, Mousebirds to Hornbills.* Barcelona: Lynx Edicions. Pp. 436−523.

Kemp, A.C. and Kemp, M.I. 2009. The diversity and radiation of hornbills: How, when, where and why might these have occurred? Abstracts of papers, 5th International Hornbill Conference, Singapore Botanic Garden; National Parks Board, Singapore; Keynote paper 01.

Kennedy, R.S., Gonzales, P.C., Dickinson, E.C., Miranda, H.C. and Fisher, T.H. 2000. *A guide to the birds of the Philippines.* Oxford, U.K.: Oxford University Press.

Kinnaird, M.F. and O’Brien, T.G. 2007. *The Ecology and Conservation of Asian Hornbills: Farmers of the Forest.* Chicago: University of Chicago Press.

Morin, P.A., Messier, J. and Woodruff, D.S. 1994. DNA extraction, amplification, and direct sequencing from hornbill feathers. *Journal of the Scientific Society of Thailand* **20**: 31−42.

Oliver, W.L.R. and Wilkinson, R. 2007. Philippine Hornbills Conservation Programme. In: Kemp, A.C. and Kemp, M.I. (eds.) *The Active Management of Hornbills and their Habitats for Conservation*, CD-ROM Proceedings of the 4th

International Hornbill Conference, Mabula Game Lodge, Bela-bela, South Africa. Naturalists & Nomads, Pretoria. Pp. 13−30.

Paguntalan, L.M.J., Jakosalem, P.G., Pedregosa, M.Dg., Catacutan, M.J.G. and Bueno, R. 2004. Conservation status of forest birds in isolated forest patches in Masbate, Philippines. *Silliman Journal* **45**(2): 222−236.

Price, T.D. 2008. *Speciation in Birds.* Colorado: Roberts & Company Publishers.

Sibley, C.G. and Ahlquist, J.E. 1990. *Phylogeny and Classification of Birds.* New Haven: Yale University Press.

Srikwan, S. and Woodruff, D.S. 1998. Molecular genetics and the conservation of hornbills in fragmented landscape. In: Poonswad, P. (ed.). *The Asian Hornbills: Ecology and Conservation (Thai Studies in Biodiversity No.2)*. Thailand: Bangkok. Pp. 257–263.

Sutherland, W.J. 2000. *The Conservation Handbook: Research, Management and Policy.* Oxford, UK: Blackwell Science Ltd.

Tobias, J.A., Seddon, N., Spottiswoode, C.N., Pilgrim, J.D., Fishpool, L.D.C. and Collar, N.J. 2010. Quantitative criteria for species delimitation. *Ibis* **152**(4): 724−746.

Viseshakul, N., Charoennitikul, W., Kitamura, S., Kemp, A.C., Thong-aree, S., Surapunpitak, Y., Poonswad, P. and Ponglikitmongkol, M. 2011. A phylogeny of frugivorous hornbills linked to the evolution of Indian plants within Asian rainforests. *Journal of Evolutionary Biology* **24**:1533−1545.

Table 1. List of Asian Hornbills with proposed taxonomic changes based on Gonzalez et al. (2013a, 2013b) and Gonzalez et al. (in prep.), with emphasis on Philippine taxa.

Former Name	Former Threat Status	Proposed Name Change	Proposed Threat Status Change
Anorrhinus tickelli	Critically Endangered		
Anorrhinus austeni	Critically Endangered		
Anorrhinus galeritus	Critically Endangered		
Ocyceros griseus	Least Concern		
Ocyceros gingalensis	Least Concern		
Ocyceros birostris	Least Concern		
Anthracoceros coronatus	Critically Endangered		
Anthracoceros albirostris	Critically Endangered		
Anthracoceros marchei	Vulnerable		
Anthracoceros malayanus	Critically Endangered		
Anthracoceros montani	Critically Endangered		
Buceros bicornis	Critically Endangered		
Buceros rhinoceros	Near Threatened		
Buceros hydrocorax hydrocorax	Near Threatened	*Buceros hydrocorax*	Vulnerable
Buceros hydrocorax mindanensis	Near Threatened	*Buceros mindanensis*	Vulnerable
Buceros hydrocorax semigaelatus	Near Threatened		
Rhinoplax vigil	Least Concern	*Rhinoplax vigil*	
Penelopides exarhatus	Least Concern	*Rhabdotorrhinus exarhatus*	
Penelopides panini panini	Least Concern		IUCN category unsatisfactory at 'species' level

Former Name	Former Threat Status	Proposed Name Change	Proposed Threat Status Change
Penelopides panini ticaensis	Least Concern		
Penelopides manillae manillae	Least Concern		IUCN category unsatisfactory at 'species' level
Penelopides manillae subniger	Least Concern		
Penelopides affinis afinis	Least Concern	*Penelopides affinis*	Near-threatened
Penelopides affinis samarensis	Least Concern	*Penelopides samarensis*	Near-threatened
Penelopides affinis basilanicus	Least Concern	*Penelopides basilanicus*	'Data Deficient', but most likely 'Endangered'
Penelopides mindorensis	Least Concern		
Berenicornis comatus	Critically Endangered		
Aceros nipalensis	Near Threatened		
Aceros corrugatus	Least Concern	*Rhabdotorrhinus corrugatus*	
Aceros leucocephalus	Near Threatened	*Rhabdotorrhinus leucocephalus*	Vulnerable
Aceros waldeni	Critically Endangered	*Rhabdotorrhinus waldeni*	
Aceros cassidix	Least Concern	*Rhyticeros cassidix*	
Rhyticeros narcondami	Least Concern		
Rhyticeros plicatus	Least Concern		
Rhyticeros subruficollis	Least Concern		
Rhyticeros undulatus	Least Concern		
Rhyticeros everetti	Least Concern		

Figure 1. World map showing the distribution of extant and extinct hornbills across Africa and Asia (adapted from Kinnaird and O'Brien 2007).

Figure 2. Some threatened and endemic Philippine hornbills: (1) Visayan Writhed Hornbill *Rhabdotorrhinus waldeni* (Critically Endangered); (2) Great Mindanao Hornbill *Buceros mindanensis* proposed as Vulnerable; (3) Mindoro Tarictic Hornbill *Penelopides mindorensis* (Endangered); and (4) Palawan Hornbill *Anthracoceros marchei* (Vulnerable).

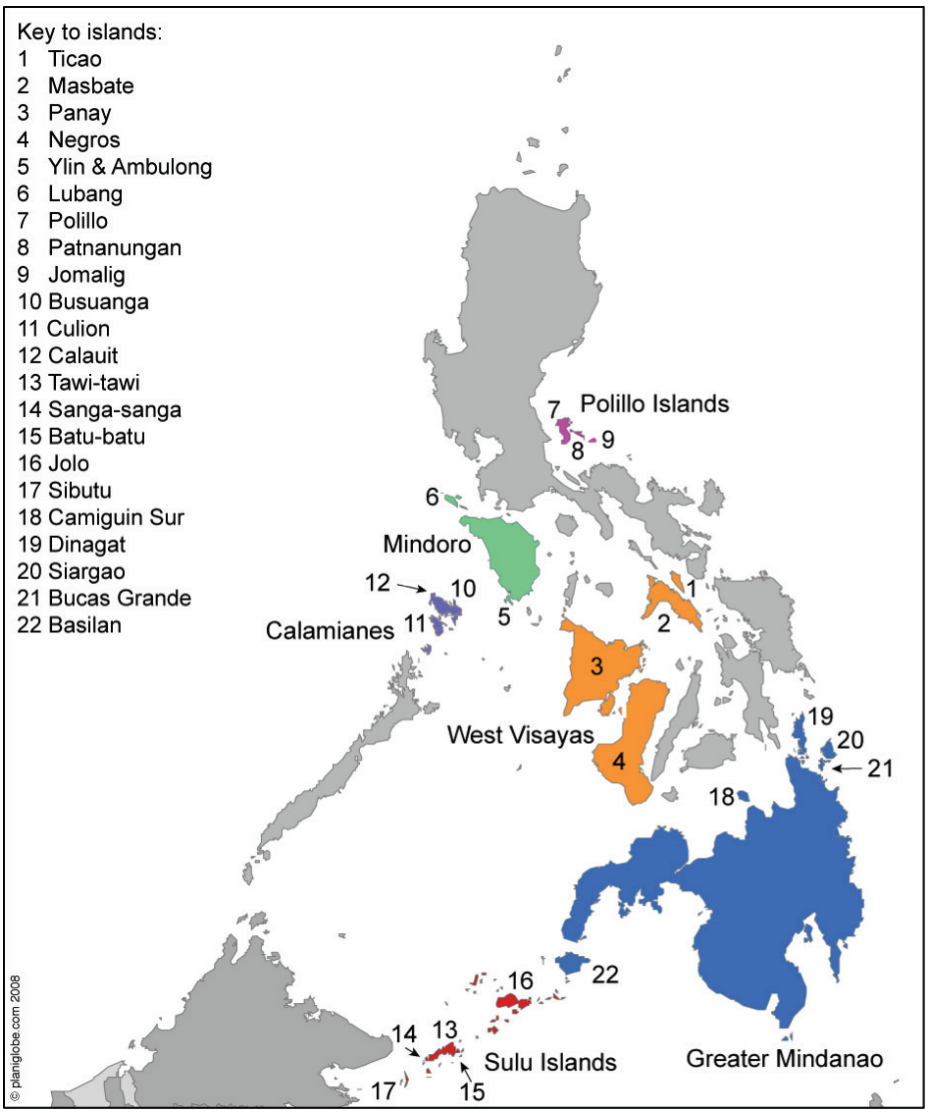

Figure 3. Map of the Philippines with emphasis on inclusive islands for proposed regional conservation action priorities based on revised Philippines Hornbills Conservation Programme (PHCP) 2013–2018.