FINAL REPORT

THE APPLICATION OF PASSIVE ACOUSTIC MONITORING AS A NOVEL METHOD TO ENHANCE OUR UNDERSTANDING OF HORNBILL BEHAVIOR AND ECOLOGY IN THE LOWER KINABATANGAN WILDLIFE SANCTUARY WILDLIFE SANCTUARY, SABAH, BORNEO.

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SUBMITTED BY:

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PROJECT TITLE

The application of Passive Acoustic Monitoring as a novel method to enhance our understanding of hornbill behavior and ecology in the Lower Kinabatangan Wildlife Sanctuary, Sabah, Borneo.

PROJECT SUMMARY

Six out of eight species of hornbill that inhabit the Lower Kinabatangan Wildlife Sanctuary (LKWS) in Sabah, Malaysia are classified as globally threatened species (IUCN Red List). As little is known about hornbill behavior and ecology in Sabah, it is proposed that this study will enhance our understanding and inform the drafting and adoption of new methodologies and better informed conservation strategies. Passive acoustic monitoring enables audio data collection that is of high quality and, therefore, the application of this new method of data gathering will be used to complement existing records and be compared to standard manual surveys which will also be undertaken in parallel with this study. This study will (1) verify the positive elements in data collection efficiency between passive acoustic monitoring and manual survey techniques, and (2) produce an occupancy model as well as detection probability of hornbills using all the data gathered by both methods.

PROJECT OBJECTIVES

1. To explore the benefits of applying passive acoustic monitoring as an additional tool for recording hornbill occupancy, predicted population and distribution in the diverse landscape of the Lower Kinabatangan Wildlife Sanctuary, Sabah.
2. To identify the positive aspects of both acoustic and manual monitoring to devise new methods to more accurately gather hornbill point-count, occupancy, and behavior data in the field.

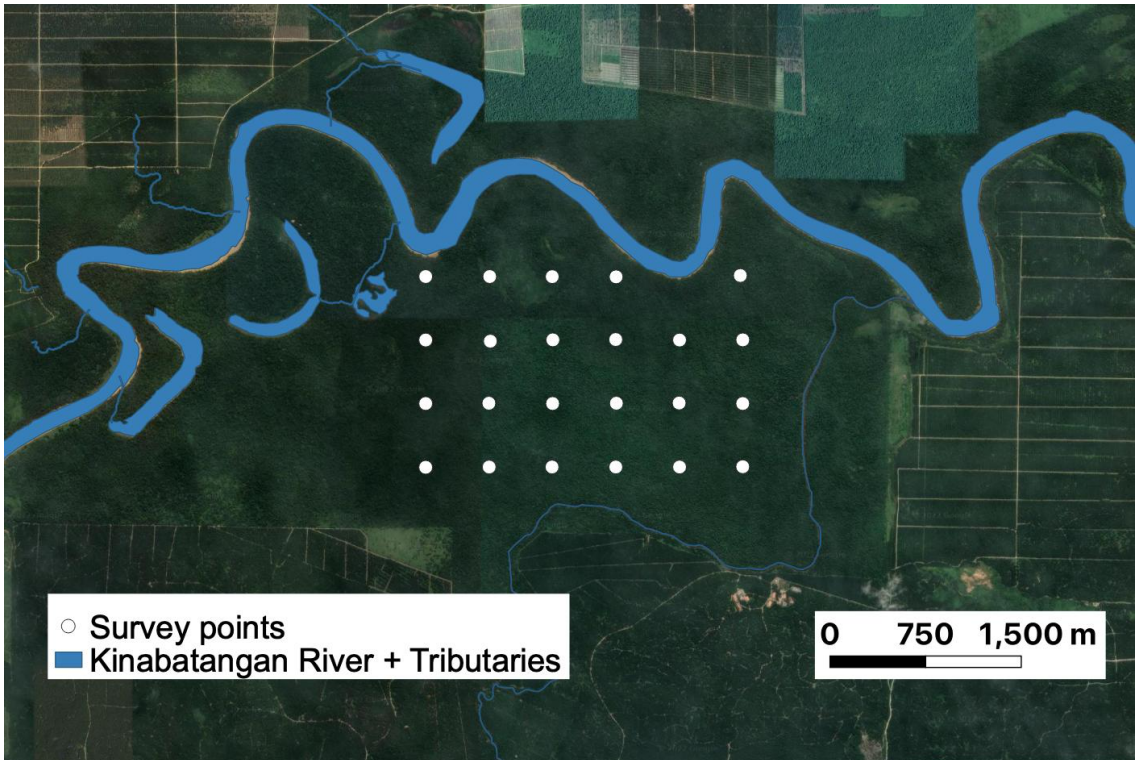
STUDY SITE

Protected in Law by the Sabah State Government in 2005, the Lower Kinabatangan Wildlife Sanctuary (LKWS) is located in eastern Sabah, Malaysian Borneo. LKWS is a highly fragmented landscape comprising various habitat types including riparian forest, seasonally flooded forest, swamp forest, secondary lowland dipterocarp forest, and estuary nipa palm. At 560 km long, the Kinabatangan river is the largest river in Sabah and flows through the LKWS. The river has a catchment area of approximately 16,800 km2, which covers almost a quarter of Sabah's total land area. LKWS is separated into 10 forest lots with a total area of 26,000 ha of forest with varying levels of connectivity. The LKWS is inhabited by eight hornbill species: helmeted hornbill (*Rhinoplax vigil*); wrinkled hornbill (*Rhabdotorrhinus corrugatus*); wreathed hornbill (*Rhyticeros undulatus*); rhinoceros hornbill (*Buceros rhinoceros*); white-crowned hornbill (*Berenicornis comatus*); black hornbill (*Anthracoceros malayanus*); bushy-crested hornbill (*Anorrhinus galeritus*), and oriental-pied hornbill (*Anthracoceros albirostris*).

METHODS

A total of 23 survey stations were established in the Lot 6 of the LKWS. Manual and acoustic surveys were conducted concurrently in March and April of 2022. Three replications of each survey was conducted at each station and every survey was conducted for 20 minutes from

06h30 to 09h00. For manual survey, two observers were taking data of visual and aural sightings of hornbills during the period of the survey. Conversely, acoustic recorders were deployed for the acoustic surveys and were recording in parallel with the manual surveys conducted. Surveys were only conducted during non-rainy days with clear sky in order to minimize variables affecting hornbill presence.



Map 1 shows 23 survey points established at in Lot 6 of the LKWS for this study.

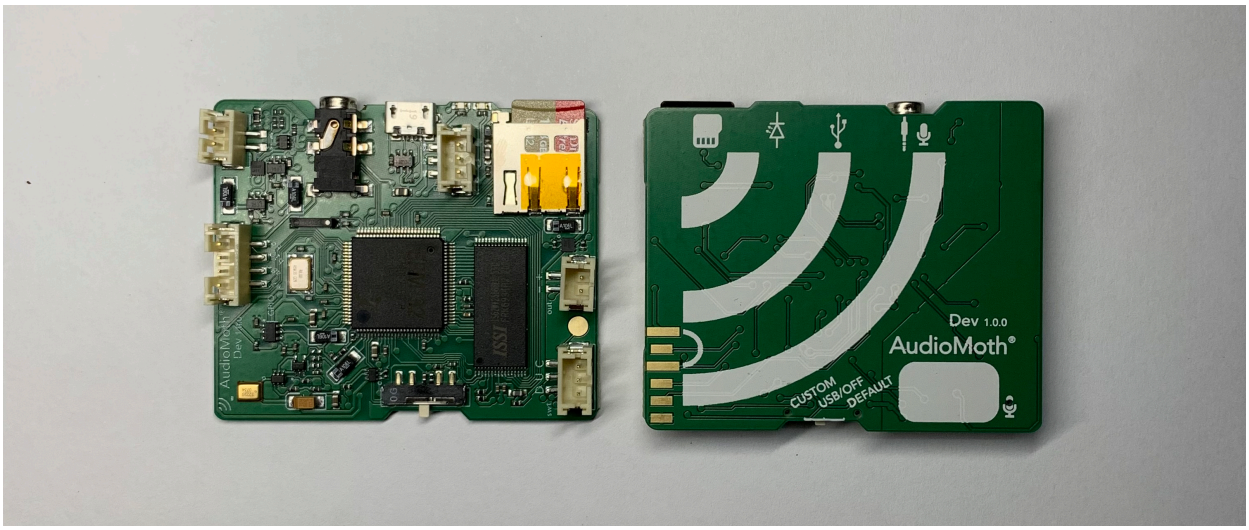


Image 1 shows an acoustic recorder used for this study: AudioMoth Dev, developed by Open Acoustic Devices.

PROJECT OUTCOMES

Our preliminary results show that aural surveys by human observers is generally more effective in detecting hornbills as compared to a visual survey. We also found that acoustic surveys using ARUs can generally detect hornbills although there is some discrepancy in frequency of detections to that of an aural survey in oriental pied hornbill (*Anthracoceros albirostris*) and black hornbill (*Anthracoceros malayanus*). This discrepancy may be attributed to the inability of ARUs to pick up distant calls or calls that are imbedded in noise.

Although small, the forest patch in which this study was undertaken recorded the presence of six out of the eight hornbill species that can be found in Sabah. As expected, wreathed hornbill (*Rhyticeros undulatus*) and helmeted hornbill (*Rhinoplax vigil*) were not detected in this semi-inundated forest area as they are known to prefer forests with high elevations. This finding further supports the high conservation importance of this particular forest area and its habitat. Our study also demonstrated that low-cost acoustic recorders could significantly improve efficiency in data collection, especially in geographically challenging study sites. Manual survey required our observers to track in the forest in the dark and as early as 05h30 on some days, as it would take an hour to reach some of the survey points. Consequently, semi-automated and automated recorders can offer flexibility and collect data of high temporal scale more efficiently.

Species	Manual		Automated
	Visual	Aural	Acoustic recorder
Rhinoceros hornbill	0	15	15
Wrinkled hornbill	0	5	5
White-crowned hornbill	0	2	2
Black hornbill	0	76	69
Oriental-pied hornbill	2	34	12
Bushy-crested hornbill	2	14	14

Table 1 shows number of detections in both manual and acoustic surveys of six hornbill species detected in this study.

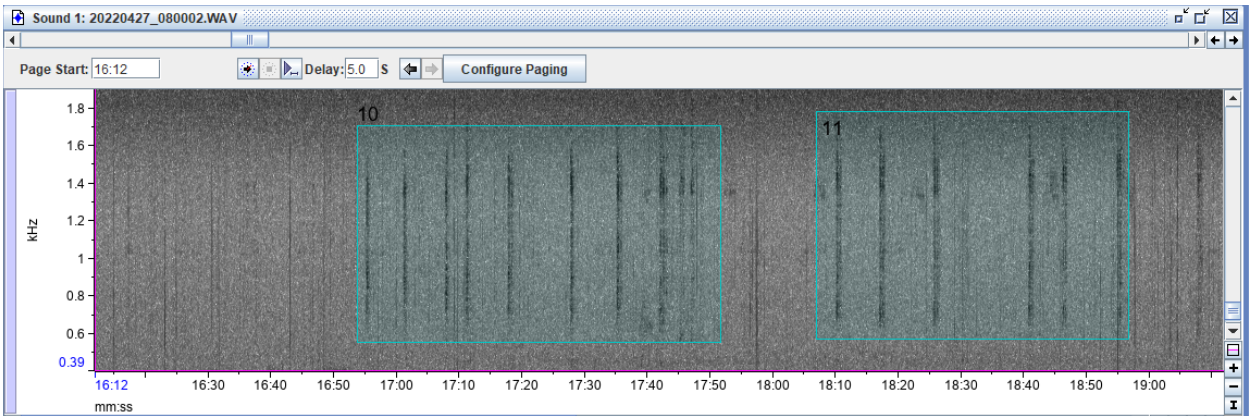


Image 2 shows a spectrogram (projected on Raven Pro 1.6 software) of a black hornbill call captured by an acoustic recorder during the survey.

CONCLUSION

Our preliminary results have shown that passive acoustic monitoring application in hornbill research should be adopted and explored further. Not only did our acoustic survey gather high frequency of detection throughout the study, it also produced 100% specificity when tested against aural surveys for all six species. However, it is worth noting that acoustic survey produced 100% sensitivity when tested against aural survey on all but black hornbill (91.6%) and oriental pied hornbill (60.7%). This discrepancy, however, should not discount the potential benefits of this method when undertaking hornbill research in Sabah on a larger scale. On top of that, the study we conducted was instrumental in gaining knowledge on hornbills and bioacoustics and we are in position to further develop this method for future hornbill research in Sabah.

RECOMMENDATIONS

Firstly, this study has demonstrated that it would seem beneficial to utilize audio data collection, hence using the audio files gathered at its full potential. This includes annotating the sample calls of all detected hornbill species into a template for pattern matching. This will then allow the researcher to perform automated detection for all future recordings. Should we are able to continue conducting this research in the future, more hornbill, and potentially other bird species, can be studied and have their calls recorded, processed, and analyzed for pattern matching templates. These templates can be shared widely especially among community-based NGOs in Kinabatangan which will improve participation of citizen science of indigenous community in the area. This will help the local community to conduct ecological research on their land while helping future researchers in Sabah to adapt this method.

Secondly, this study has further highlighted the need for further hornbill studies along the LKWS and across spatio-temporal scale to have a better understanding of their ecology. This may include activity pattern, intraspecies acoustic individuality, occupancy, and population density. Big audio data management is challenging, however data processing would be made easier should we create the required templates for automated processing of the audio files.

DIFFICULTIES EXPERIENCED DUE TO COVID-19 PANDEMIC AND EXTREME WEATHER EVENTS

During the study, the Lower Kinabatangan Wildlife Sanctuary experienced a series of extreme weather events with an unusually long rainy season. This resulted in the forests being submerged under a few meters of water, rendering our study sites inaccessible for a few months causing long-term disruption to the planned fieldwork schedule. For example, a pilot survey had to be cut short and was only conducted for 12 days before the study site was submerged underwater and tree climbing activity was almost impossible due to the unsuitable weather and the presence of estuarine crocodiles.

Due to the COVID-19 pandemic, the Malaysian government had imposed a Full Movement Control Order (FMCO) which led to a nationwide lockdown. As one of the study sites is located in Lot 6 of the LKWS, and although research in that area could continue, our study was not able to be conducted in Lot 2 or in the neighboring oil palm plantations. This was due to the access point of the forest in Lot 2 being through a village, and the required isolation of oil palm plantation workers from external visitors. This situation resulted in us only being able to conduct our study in Lot 6 of the LKWS.

Image 3 shows Field Assistant Samsir and Shah conducting survey before the forest was further submerged underwater and became inaccessible.

LIST OF TEAM MEMBERS

Ashraft Syazwan Ahmady Yusni
Role – Team leader: in charge of designing the study and took part in data collection as observer.

Samsir Laimun
Role – Field assistant: helped with data collection as observer and led the pilot survey and hornbill natural resources survey.

Shah Fitri Rosli
Role – Field assistant: helped with data collection as observer and led the tree climbing team.

Roslee Rahman
Role – Field assistant: helped with data collection as observer, led in the process of trail making, and was part of the climbing team

Jusmawati Latombong
Role – Field assistant: helped with data collection as observer.

Nazrul Moh Natsyir
Role – Field assistant: helped with data collection and trail making.

Dr. Liew Thor Seng
Role – MSc supervisor: advising in study design, data processing, and statistical analysis.

Dr. Ravinder Kaur
Role – MSc co-supervisor: advising in study design and statistical analysis.

Professor Dr. Benoit Goossens
Role – MSc co-supervisor: advising in study design.

Dr. Marc Ancrenaz
Role – Advisor: advising in study design.

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PERMIT

Permit for this study was conferred by the Sabah Biodiversity Centre and supported by the Sabah Wildlife Department (Licence Ref. No. JKM/MBS.100-2/2 JLD. 13(22)).