PROJECT REPORT

Developing an optimal monitoring program for the endangered Togean Island babirusa (*Babyrousa togeanensis*) through the support of citizen scientists

Agus Jati

Alessio Mortelliti

Bayu Broto

illustration by
I Gede Ema Damesha

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DEVELOPING AN OPTIMAL MONITORING PROGRAM FOR THE ENDANGERED TOGEAN ISLANDS BABIRUSA (*Babyrousa togeanensis*) THROUGH THE SUPPORT OF CITIZEN SCIENTISTS

PROJECT REPORT

Prepared by Agus Jati, January 2023

Project team	**Agus Jati (PI)** Dept. Wildlife, Fisheries, and Conservation Biology The University of Maine, Maine, USA agus.jati@maine.edu agussudibyojati@yahoo.co.id **Alessio Mortelliti** Dept. Wildlife, Fisheries, and Conservation Biology The University of Maine, Maine, USA alessio.mortelliti@maine.edu **Bayu Wisnu Broto** Institute for the Implementation of Standards for Environment and Forestry Instrument Makassar (BPSI LHK Makassar), South Sulawesi, Indonesia wisnubroto87@gmail.com
Affiliation & Partner organization	Dept. Wildlife, Fisheries, and Conservation Biology, The University of Maine AMINEF - Fulbright Indonesia Institute for the Implementation of Standards for Environment and Forestry Instrument Makassar (BPSI LHK Makassar) Kepulauan Togean National Park Aliance for Tompotika Conservation (AlTo)
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A male Togean Islands babirusa recorded by a camera trap in this project

1. INTRODUCTION

1.1. Background

The Togean babirusa (*Babyrousa togeanensis*) is classified by the IUCN as endangered and the population trend is estimated as decreasing. The species is endemic to the Togean Archipelago and is characterized by an extremely small distribution range (<1000 km^2), with a total population size estimated between 100-1000 individuals (Macdonald et al., 2016). Key threatening factors for this species include: 1) the small population size which drastically increases the risk of inbreeding depression, 2) heavy hunting of this species (as a food source and for crop protection), and 3) habitat loss (approximately half of the forest on the islands has been converted to other land-uses). The species is reported to utilize human-modified habitats (such as crop fields), which further increases the potential for conflict with local populations (Akbar et al., 2007). The Togean babirusa has been protected by the Indonesian government since 1931 and listed as Appendix-I CITES since 1982 as a sub-species of *Babyrousa babyrussa*. IUCN/SSC published a conservation action plan for babirusas in 1993 (Macdonald, 1993), which contains management guidelines for the species. Furthermore, the Indonesian government also published a more detailed babirusas' national conservation action plan for 2013-2022 (Regulation of Ministry of Forestry Indonesia No: P.55/Menhut-II/2013).

The Togean babirusa is among the least-studied mammals in Indonesia (Broto and Mortelliti, 2019). Despite being endangered and endemic to small isolated islands, this species has been the subject of only one article where population size was estimated by interviewing locals (Akbar et al., 2007). The ecology and behavior of this species have been speculated from knowledge about other babirusa species (Ito and Melletti, 2017) which may be misleading. While the presence of Kepulauan Togean National Park is expected to provide protection for babirusas and their habitat, it is unknown whether the assigned national park areas cover the core distribution of babirusas. The absence of a standard monitoring protocol for the babirusa further hinders the effort to conserve this species. Consequently, there is an urgent need for robust field-based assessments of the status of this species.

1.2. Goals and objectives

Through this project, we aim to fill several critical knowledge gaps on the ecology and distribution of the Togean babirusa. We will also develop tools to monitor the species and ensure knowledge transfer by involving citizen scientists in this project. The specific objectives of our project are:

1. **Map the distribution of Togean babirusas (Deliverable 1)**. We used occupancy modeling to predict the distribution of the babirusa across the Togean Archipelago. This map shows where the babirusa is most likely to occur, indicating priority areas for conservation. Through occupancy

modeling, we also identified critical environmental conditions affecting the occupancy probability of babirusa, contributing to the knowledge of the basic ecology of the species. It is important that the designated national park area covers the core distribution of the babirusa and protects the important habitat of the species. This first objective will provide empirical evidence to evaluate the effectiveness of the Kepulauan Togean National Park zonation in conserving the babirusa and its essential habitat.

2. **Develop a cost-effective monitoring protocol for the Togean babirusa (Deliverable 2)**. Currently, there is no standard monitoring protocol for the Togean babirusa. Through this project, we will provide the national park with a statistically robust monitoring protocol to help authorities track babirusa's occupancy trends over years.
3. **Train national park wardens and local citizen scientists to conduct the monitoring (Deliverable 3)**. To ensure knowledge transfer, we organized training workshops to teach park wardens and citizen scientists how to perform the monitoring protocol. At the end of the project, the participants received a monitoring kit (camera traps, GPS units, and data management skills) to continue the monitoring program.

2. IMPLEMENTATION OF PROJECT ACTIVITIES

2.1. Study sites

The project took place in the Togean Archipelago in Central Sulawesi, Indonesia. Specifically, we worked on four islands: Batudaka (244 km^2), Togean (177 km^2), Talatako (96 km^2), and Malenge (13 km^2) islands (Figure 1). These four islands are the only locations where Togean babirusas are known present and thus represent the entire distribution range of this endangered species. Some portions of the islands' interior are also part of Kepulauan Togean National Park.

This archipelago lies on the Wallacea biogeography zone, known to have an extremely high degree of endemism and unique fauna communities. This area is among the least studied in Indonesia (Broto and Mortelliti, 2019), with only a few reports on the wildlife community available.

The islands experience intense pressure from human activities, including (illegal) logging and forest conversion for agriculture. Through remote sensing, we estimated that the islands' remaining forests cover only about 40% of the land surface.

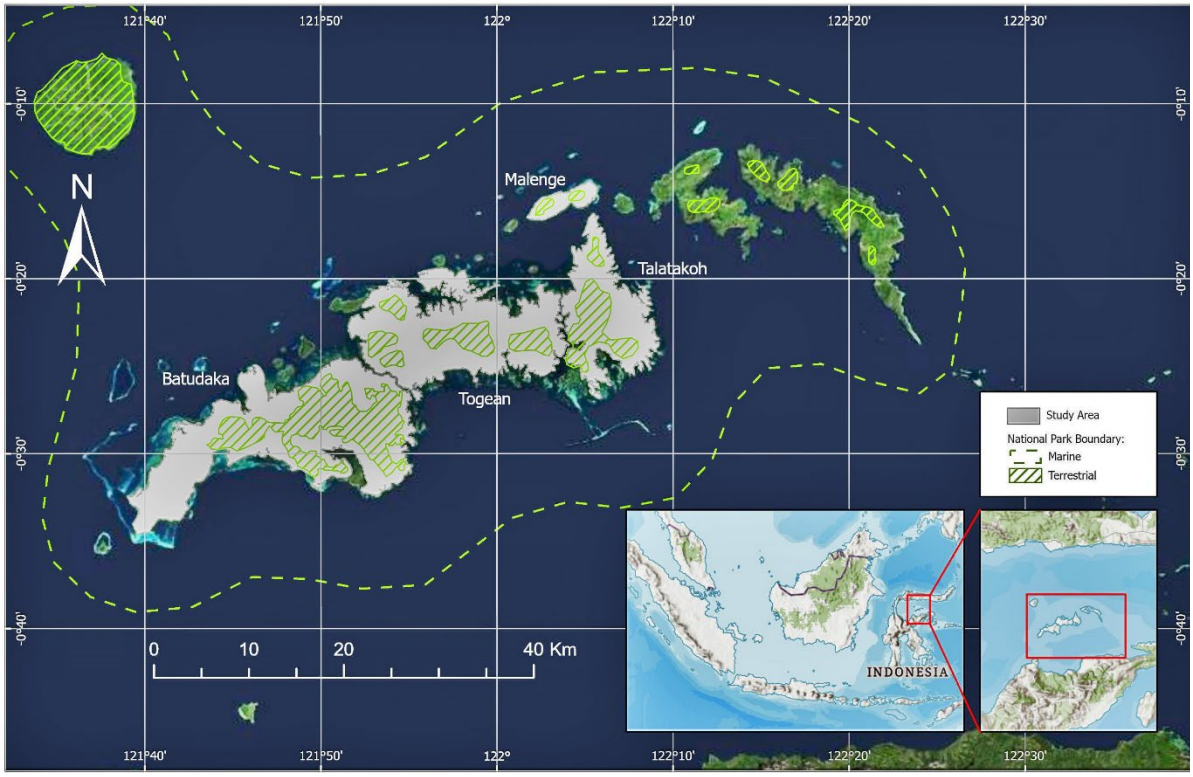

Figure 1. Overview of the Togean Archipelago, including the major islands. The grey polygons indicate our study areas with the islands' names printed next to each island. The Kepulauan Togean National Park boundaries are shown with light-green lines. The archipelago's relative position to Indonesia is displayed on the inset map. The satellite image shown is the ArcGIS-Pro basemap imagery.

2.2. Data collection

Camera trapping

In June, we run a pilot trial to test whether using bait at the camera point would increase the detection of babirusa. We also tested if our camera setting was adequate to record our target species and other wildlife. We distributed camera traps at ten randomly selected sites in an area where we knew (according to locals) babirusas were present. Each site consisted of four cameras placed at the corners of a 100 by 100 m square. The camera points had four different bait treatments: no bait, cassava, copra, and fermented shrimp. All cameras were active for eight days. We ran one-way ANOVA to test whether babirusa's detection differed after bait treatments. We did not find a significant difference in babirusa's detection among different bait treatments ($F=1.33$, $p=0.28$); thus, we decided not to use bait for the data collection.

We collected the babirusa's data by deploying camera traps at 103 camera stations throughout the study sites (Figure 2). The location of camera stations was generated following a random sampling procedure, stratified by land cover area on the islands. In each station, we deployed two camera traps spaced about 100 m apart at locations where the chance to record the babirusa were high, such as

mud-pond or animal track. Each camera was installed on a study tree trunk about 30-50 cm above ground level, but sometimes we placed the camera higher depending on the surrounding environment. The cameras were set to take a 20-second video each time the sensor was triggered and were active 24 hours a day. With the number of camera traps available, we were able to deploy 25-27 stations simultaneously. After 15-21 days, we collected the cameras, downloaded the data, and redeployed them at different stations. Overall, we were able to sample 103 stations after four camera trapping rotations from July to October 2022.

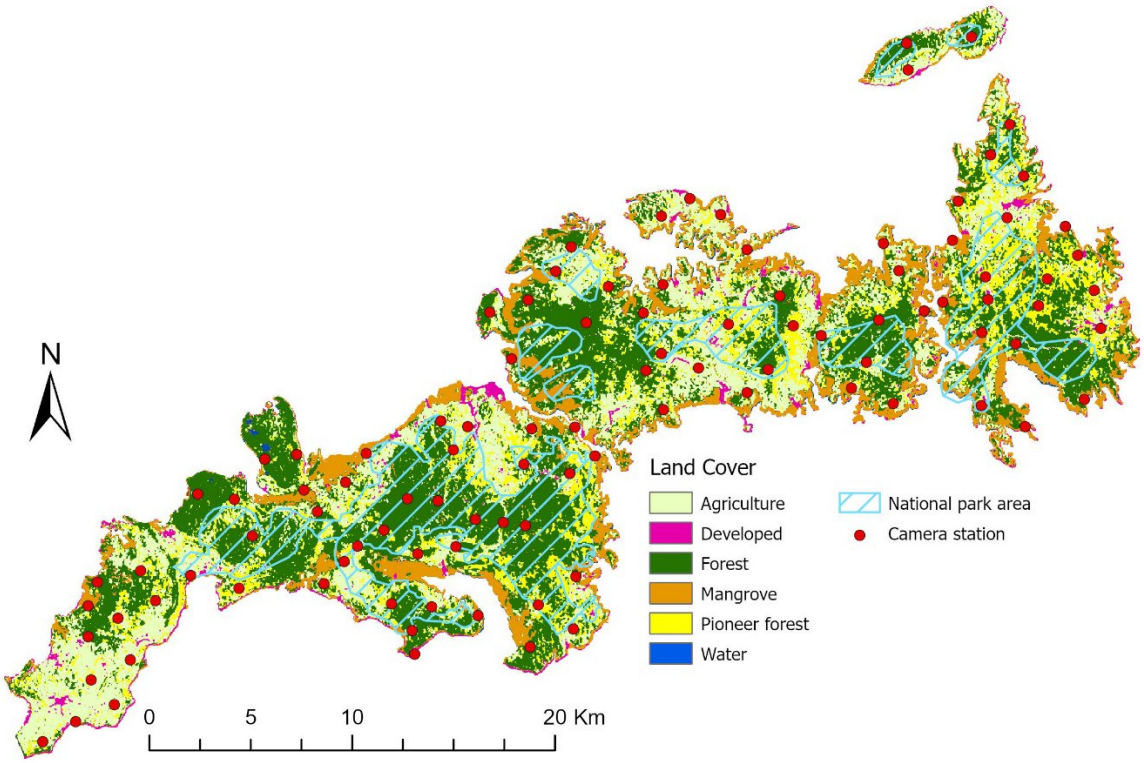

Figure 2. The placement of 103 camera trap stations in the study site. We performed stratified random sampling to distribute the camera stations. On each station, two camera traps, spacing about 100 m, were deployed. The map shown is a land cover map developed from Landsat-8 imagery.

Habitat characteristics

We used remote sensing and GIS to assess habitat characteristics of the study area. The variables include normalized difference vegetation index (NDVI), slope, human influence indexes (i.e., distance to human settlement), landscape heterogeneity, and fragmentation index. We performed an image classification on Landsat-8 images to generate a land cover map of the study area which we used as a base map to distribute the camera sites (see figure 2 above). The Landsat-8 image used was mosaiced from images acquired in 2018-2021 using Google Earth Engine to produce a cloud-free image. Besides remote sensing, we also measured canopy coverage at the camera trap points using a 180-degree fisheye camera.

2.3. Map the distribution of the Togean babirusa (Deliverable 1)

We detected the babirusas at 73 out of 103 camera stations (approximately 70% of sites). The babirusas were found in all types of land covers we surveyed: oldgrowth forest, pioneer forest, mangrove, and agriculture. Based on this data, we performed a preliminary Single-Species Single-Season Occupancy Modeling using *unmarked* package on software R to model the occupancy probability of the Togean babirusa (Fiske and Chandler, 2011; MacKenzie et al., 2002). We fitted several competing models using different combinations of habitat characteristics as covariates, then selected models through AICc model selection to determine the relatively best model to predict the detection probability and occupancy of the species. We emphasize that these analyses are exploratory and preliminary, during the next months we will finalize these analyses and conduct multi-model inference.

The selected model shows that the babirusa's detection probability differed among islands, and the occupancy was affected by landcover types and distance to a large forest patch. Here, a large forest patch is defined as a continuous forest (oldgrowth and pioneer combined) larger or equal to 1 km^2. Togean Island had the highest detection probability of babirusa (0.48±0.02 SE), followed by Malenge (0.42±0.07 SE), Talatako (0.31±0.03 SE), and Batudaka (0.23±0.02 SE). The babirusa had the highest occupancy probability in pioneer forest, followed by oldgrowth forest, mangrove, and agriculture. The occupancy probability also depended on how far they were from the nearest large forest patch. The closer a site to a large forest patch, the babirusa occupancy tended to be higher (Figure 3).

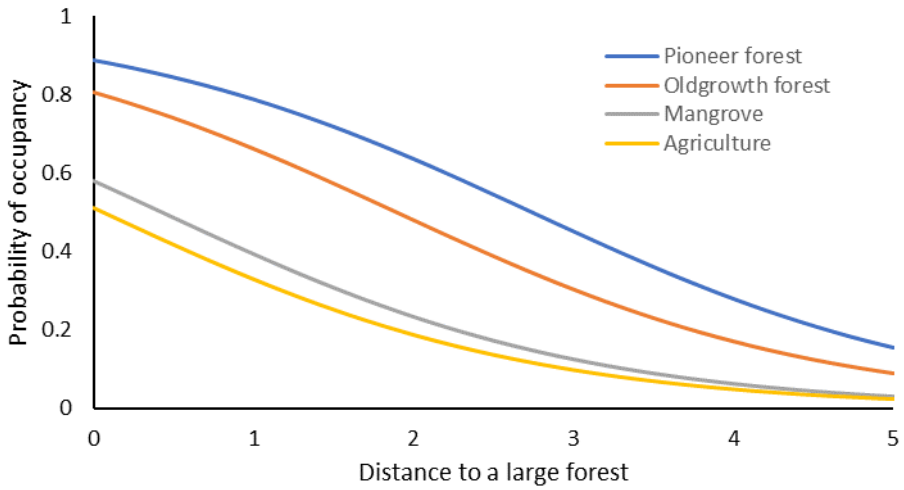

Figure 3. Relationship between babirusa's occupancy probability and distance to a large forest patch accross different landcover types. Occupancy probability is higher when distance to a large forest patch is closer, and the occupancy is higher in pioneer and oldgrowt forest than mangrove and agriculture.

Using ArcGIS Pro, we created Figure 4 based on the top ranked occupancy model to predict babirusa's occupancy throughout its entire distribution range. On this map, areas with high babirusa occupancy

are indicated by green color, and areas with low occupancy are red. The red areas in Figure 4 are areas where a large forest patch was unavailable nearby; thus, the babirusa's probability of occupancy was almost zero.

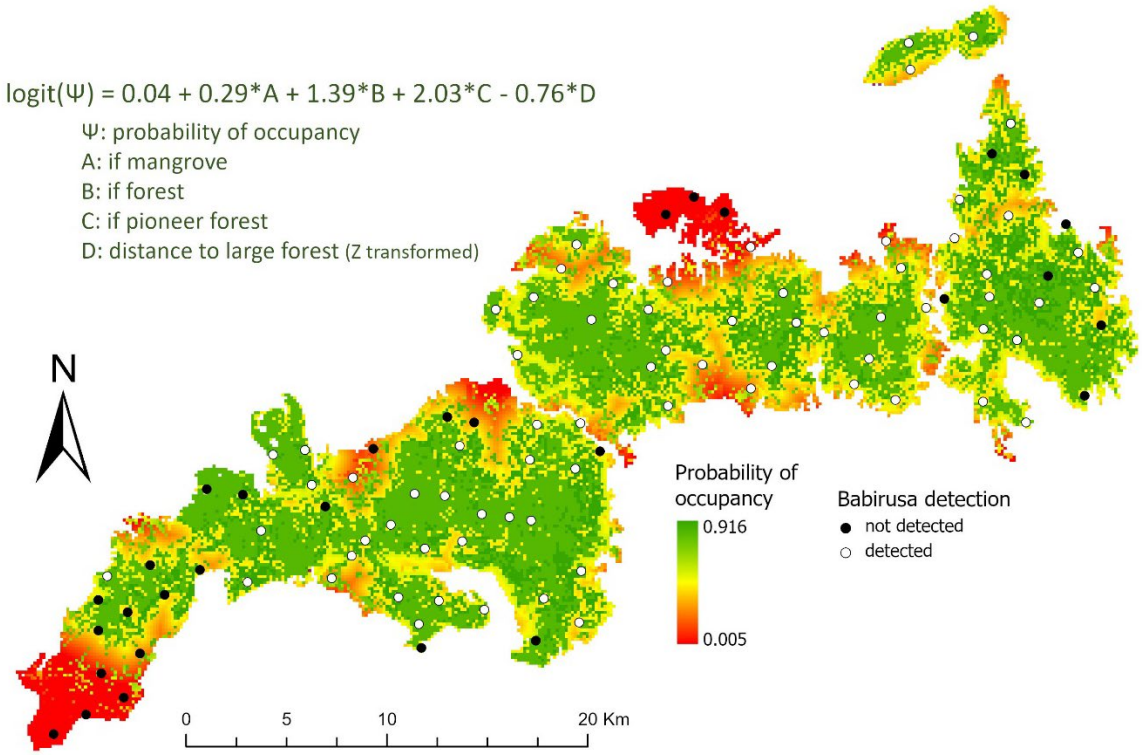

Figure 4. The predicted map of the Togean babirusa's probability of occupancy. Dark green color indicates high occupancy, and red indicates low occupancy. The mathematical model used to create this map is presented in the top-left corner.

Our results indicate that the presence of forests is essential for the Togean babirusa. Therefore, forest loss is among the greatest threats to this species. During our fieldwork, we witnessed deforestation in the Togean Islands, mainly for agriculture. In our opinion, the national park area is ineffective in protecting the remaining forest of Togean. Many areas within the national park boundary are not forests, and a large area of forests was not part of the national park (see Figure 2 for a reference). We have discussed our findings with the national park official and suggested revising the national park zonation to protect the remaining forest more effectively. Besides forest loss, we found indications that poaching might be another significant threat to this babirusa. Our camera traps recorded many babirusas with severed legs because of snares (see this YouTube video)

We emphasize that these analyses are preliminary, more thorough analyses will be conducted during the next months. We also acknowledge that we used Landsat-8 imagery from 2018-2021, while this study was conducted in 2022. Therefore, we need to revise the analysis using a new satellite image acquired in 2022.

2.4. Developing a cost-effective monitoring protocol (Deliverable 2)

During the next months we will develop a monitoring protocol to track changes in occupancy of the Togean babirusa over time. We will adopt the algorithm developed by Guillera-Arroita & Lahoz-Monfort (2012). We will provide options for the managers to deploy their sampling effort, i.e., the number of camera traps installed and the study period, based on their resource availability. The sensitivity of the monitoring protocol will depend on the sampling effort they choose. For example, using more camera traps will allow them to detect a smaller decline in babirusa occupancy.

The Institute for the Implementation of Standards for Environment and Forestry Instrument Makassar (BPSI LHK Makassar), a government agency whose scope includes developing standard instruments for the environment and forestry sector in Sulawesi, is working with us to make this babirusa monitoring protocol a regulation. This will ensure that the management authorities (i.e., the Kepulauan Togean National Park and the Natural Resources Conservation Agency Central Sulawesi) will apply the protocol to monitor the species. Considering this importance, we will work on the monitoring protocol over the next six months, allowing us to utilize more resources and analysis to produce this procedure.

2.5. Train national park wardens and local citizen scientist (Deliverable 3)

We organized a training workshop entitled "*Pemodelan Okupansi dan Penggunaan Camera Trap untuk Monitoring Satwa Liar* (Occupancy modeling and camera trapping for wildlife monitoring)" from 22-24 November 2022 at the Kepulauan Togean National Park headquarter and Tanjung Api Nature Reserve, Central Sulawesi. In this training, we invited Dr. Alexander Moßbrucker (International Elephant Project) as a facilitator, together with Agus Jati and Bayu Broto. Our field assistants, Mr. Suardi and Ikal (see section 2.7 below) were also involved as facilitators to assist training participants. There were more than 30 people participated in this event in person. They consisted of the Kepulauan Togean National Park officers, Togean Islands locals, and Alliance for Tompotika Conservation (AlTo) officers. The workshop was also attended virtually by over 40 people from all over Indonesia.

Initially, we planned to hold this training on the Togean Archipelago. However, infrastructure limitations, such as electricity and internet coverage, made organizing the event on the islands impractical. Moreover, transportation costs for participants would become excessive. For those reasons, we did this training at the national park headquarter in the Sulawesi mainland. When we presented our proposal at the national park headquarter back in June 2022, many people showed interest in this training. They requested to involve more participants from many other national parks in Indonesia. Because we did not have resources for that, we facilitated them by accepting participants from anywhere in Indonesia to join virtually through Zoom.

This three-day training consisted of five main sections: 1) classroom seminars to learn basic camera trapping, monitoring species, and occupancy modeling, 2) fieldwork at Tanjung Api Nature Reserve to have hands-on-practice with camera trap deployment, 3) camera trap data management practices, 4) occupancy modeling simulation, and 5) group presentation. We used the data collected during this project as training materials. This way, the participants would also be introduced to the biodiversity of the Togean Archipelago. At the end of the workshop, we officially donated our camera traps and GPS to the national park agency. We used those camera traps during the training, so they are already familiar with operating the donated cameras. Figure 5 shows some pictures taken during the training workshop. Other photo documentations of this event are available online (See appendix 2)

Figure 5. From top, left to right: Dr. Alexander Moßbrucker explaining camera trap features to the training participants; A group of participants demonstrating camera trap deployment; A group photo with training participants; Agus Jati symbolically donates the monitoring equipment by handing over a camera trap to Ir. Bustang, the Kepulauan Togean National Park chief.

2.6. Other Species Recorded in This Project

Beside the Togean babirusa, we also documented 25 other wildlife species, including mammals, birds, and a reptile. One of the most interesting species was the Niemitz's tarsier (*Tarsius niemitzi*), which is also endangered and endemic to the Togean Islands. This tarsier was taxonomically described in 2019 and was predicted to occupy all main islands of the Togean Archipelago (Shekelle et al., 2019). Before,

the national park had not successfully confirmed the presence of this primate despite all of their surveillance efforts. Through this project, we confirmed the existence of this tarsier in all four islands we surveyed. We believe the camera trap videos we collected are the first documentation of this tarsier behavior in the wild. Other mammalian species we identified through the camera trap videos were the Javan deer (*Rusa timorensis*) and the Tonkean macaque (*Macaca tonkeana*). All detected mammals are protected by Indonesia law.

For birds, we identified at least 21 species. Among them, six species are nationally protected; they are Sulawesi serpent eagle (*Spilornis rufipectus*), Nicobar pigeon (*Caloenas nicobarica*), taboon scrubfowl (*Megapodius cumingii*), elegant pitta (*Pitta elegans*), Sahul pitta (*Erythropitta celebensis*), and blue-faced rail (*Gymnocrex rosenbergii*). For reptile, our cameras recorded the Togian water monitor (*Varanus togianus*) several times. Table 1 shows a list of species identified in this project.

Table 1. Wildlife species identified in this project

No	Class	Family	Species	Scientific name
1	**Bird**	Accipitridae	Sulawesi serpent eagle	*Spilornis rufipectus*
2		Alcedinidae	Common kingfisher	*Alcedo atthis*
3		Alcedinidae	Ruddy Kingfisher	*Halcyon coromanda*
4		Ardeidae	Purple heron	*Ardea purpurea*
5		Columbidae	Emerald dove	*Chalcophaps indica*
6		Columbidae	Nicobar pigeon	*Caloenas nicobarica*
7		Columbidae	Sulawesi cuckoo dove	*Macropygia albicapilla*
8		Columbidae	White faced cuckoo dove	*Turacoena manadensis*
9		Cuculidae	Bay coucal	*Centropus celebensis*
10		Cuculidae	Drongo cuckoo	*Surniculus lugubris*
11		Estrildidae	Black faced munia	*Lonchura molucca*
12		Megapodiidae	Tabon scrubfowl	*Megapodius cumingii*
13		Monarchidae	Pale blue monarch	*Hypothymis puella*
14		Phasianidae	Red junglefowl	*Gallus gallus*
15		Picidae	Ashy woodpecker	*Mulleripicus fulvus*
16		Pittidae	Elegans pitta	*Pitta elegans*
17		Pittidae	Sahul pitta	*Erythropitta celebensis*
18		Rallidae	Barred rail	*Hypotaenidia torquata*
19		Rallidae	Blue faced rail	*Gymnocrex rosenbergii*
20		Rallidae	Slaty legged crake	*Rallina eurizonoides*
21		Rallidae	White-breasted waterhen	*Amaurornis phoenicurus*
1	**Mammal**	Artiodactylla	Togean Island babirusa	*Babyrousa togeanensis*
2		Artiodactylla	Javan deer	*Rusa timorensis*
3		Cercopithecidae	Tonkean macaque	*Macaca tonkeana*
4		Tarsiidae	Niemitz's tarsier	*Tarsius niemitzi*
1	**Reptile**	Varanidae	Togian water monitor	*Varanus togianus*

2.7. Citizen Scientists Involvement

We recruited two locals as our primary assistants: Mr. Suardi and Ikal. Mr. Suardi is a member of MMP, a group of locals who assists the national park in performing activities in the field. Ikal is a local youth whose previous job was gathering rattan in the forest. When we negotiated with Ikal to join this project, he was unemployed. These two have outstanding skills in forest exploration and identifying animals' tracks. However, they had very little experience with GPS and camera traps. During our first month, we extensively trained them to operate hand-held GPS, set up camera traps, and collect field data. We also involved them when reviewing videos and identifying animals from our camera traps, thus introducing them to the biodiversity of their homeland.

We are very proud of Mr. Suardi and Ikal for their growth in becoming citizen scientists. They are now very capable of leading their own team to perform babirusa monitoring. When we worked in a different village territory, we usually involved more locals from that village, allowing us to split into two small teams: one was led by me, and the other was led by either Mr. Suardi or Ikal. When working with new locals, we always shared our knowledge and skills with them. Many people often assumed that Ikal was the project leader (or the student) because of his abilities and the fact that he led the team.

We promoted Mr. Suardi, Ikal, and some other locals who helped us in the field to the national park management. We hope the national park will involve them in the future monitoring programs and learn camera trapping from Mr. Suardi and Ikal.

Figure 6. Mr. Suardi (left) and Ikal (right) setting up a camera trap. Despite their limited background in science, they are very skillful with GPS and camera trapping today.

3. UPCOMING WORKS

This project is the first step of what we hope will become a long-term conservation project in the Togean Archipelago, especially for the Togean babirusa. We realized that within our project's timeline,

we had limitations on what we could achieve. Therefore, we planned the following activities to follow up on our current work:

1. **Developing the monitoring protocol for the Togean babirusa**. As previously mentioned, we will develop the monitoring protocol over the next six months. We will work with The Institute for the Implementation of Standards for Environment and Forestry Instrument Makassar (BPSI LHK Makassar) to make this protocol a regulation.
2. **Publish the results in international journals and participate in conferences**. Over the next two years, we are hoping to publish project results in international peer-reviewed journals (e.g., Journal of Mammalogy) and participate in international and national conferences to disseminate our findings on babirusas and other wildlife in the Togean Archipelago.
3. **Organize wildlife monitoring training for broader participants**. We will work with the BPSI LHK Makassar to organize another training on wildlife monitoring in mid-2023. We plan to invite all national parks and conservation agencies in the Wallacea region to participate in the training.
4. **Organize follow-up project**. We will apply for further grants to initiate direct conservation projects and more studies for babirusa and other wildlife in the Togean Archipelago. These grants may target activities such as habitat improvement, genetics and behavioral study, community empowerment to reduce their dependency on converting forests, and strengthening the local monitoring team (i.e., train more locals to be citizen scientists).

Acknowledgment

We thank the following institution for sponsoring this project: American Indonesian Cultural & Educational Foundation (AICEF); Zoological Society for the Conservation of Species and Populations (ZGAP) - Project code: 1.Babyrousa togeanensis.IDN.2021; IUCN Save Our Species – Project code: 2022C-1; The Mohamed bin Zayed Species Conservation Fund – Project number: 212527935; The Rufford Foundation – Project ID: 36883-1; and Graduate Student Government, University of Maine.

We thank the Kepulauan Togean National Park Agency for facilitating our project activities, assisting us, and providing invaluable discussions to make this project doable. We also thank the Alliance for Tompotika Conservation for sending one of their most experienced staff, Pandji Ariyo Kresno, to help us settle in during the project's initial commencement. To Pandji himself, we thank him for his assistance and friendship. We also thank Dr. Alexander Moßbrucker for coming to the Togean Archipelago and becoming a facilitator in our training workshop.

We thank Mr. Suardi and Ikal for their dedication as project assistants. Without them, exploring the Togean Archipelago and deploying camera traps would not be possible. We thank Mr. Suardi's family for allowing us to stay in their house and treating us as family members. We thank all locals who supported and helped us implement this project.

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Appendix 1. Some selected camera trap footages collected in this project

No	Link	Note
1	https://youtu.be/ae6gT26Krow	A male Togean babirusa mud-bathing
2	https://youtu.be/XQyACyPaRv4	First videos of Niemitz's tarsier in the wild
3	https://youtu.be/D2cxdJdHMZI	A Togean babirusa scratching its back on a wallowing-pond
4	https://youtu.be/BMsIsg9G4jM	Togean babirusas fighting a reticulated phyton
5	https://youtu.be/bmlXby_uX2A	Two young male Togean Islands babirusas fighting
6	https://youtu.be/_MkdCzunwPw	The Tonkean Macaques of Malenge Islands
7	https://youtu.be/Nt12DGO1aeY	Togean babirusas got their feet severed because of snares

Appendix 2. Project documentation

No	Link	Note
1	https://photos.app.goo.gl/uMdJohpLkajuQRgB7	Photo album: Project Babirusa Togean: Camera trapping
2	https://photos.app.goo.gl/UmBg4NjQmanEnfeU8	Photo album: Training Workshop "Occupancy modeling and camera trapping for wildlife monitoring"
3	https://youtu.be/aLxaWvIjb4Q	A GoPro video of the camera trapping activities
4	https://youtu.be/KMeMEfWg5bU	Aerial video of the Togean Archipelago