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# ABUNDANCE AND DISTRIBUTION OF THE PHILIPPINE BROWN DEER *(RUSA MARIANNA* DESMAREST, 1822*)* IN THE OBU MANUVU ANCESTRAL DOMAIN, MINDANAO ISLAND, PHILIPPINES

**Jhonnel P. Villegas*, Jayson C. Ibañez, and Clint Kenny T. Cabrido**

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**Abstract**
The Philippine Brown Deer *(Rusa marianna* Desmarest, 1822*)* is an endangered species endemic to the Philippines. Deforestation, habitat loss, and subsistence hunting continue to cause its rapidly declining population. To increase knowledge on deer's conservation and population status in Mindanao, the researchers assessed its abundance and distribution within the Obu Manuvu Ancestral Domain (OMAD) in Mindanao Island, Philippines. Five hundred four-camera trap days were conducted from June to August 2016, followed by 500 days from January to March 2020. Camera trapping was used to detect deer presence and calculate its relative abundance index (RAI). A total of ten cameras were installed in areas with preliminary evidence of deer presence, such as trails, dens, and fecal pellets, and were distributed at 250 m minimum distance intervals. Key Informant Interviews (KIIs) were also undertaken to document indigenous ecological knowledge. A total of four independent detections were documented in 2016 (RAI=0.79), while another four independent sequences were recorded in 2020 (RAI=0.80). Overall, the deer has a low population status and broad distribution across primary and secondary forests at an elevation of 1518 to 1709 m.a.s.l. Meanwhile, the deer was declared a cultural keystone species with several ethnozoological uses. They are important to the life, history, and culture of the Obu Manuvu indigenous community. However, hunting and habitat loss remained the leading anthropogenic threats against the deer despite local conservation efforts. Thus, there is a need to sustain and strengthen conservation efforts through the stringent implementation of wildlife monitoring and enforcement of culture-based protection policies.

Keywords: relative abundance index (RAI), species distribution, indigenous knowledge, Philippine brown deer, Obu Manuvu, Philippines

**Corresponding author: Jhonnel P. Villegas. Institute of Education and Teacher Training, Davao Oriental State University, City of Mati, Davao Oriental, 8200, Philippines, E-mail: jhonnel.villegas@dorsu.edu.ph; Department of Biology, Ateneo de Davao University, Davao City, Davao del Sur, 8000, Philippines*

*Jayson C. Ibañez. Philippine Eagle Foundation, Davao City, Davao del Sur, 8000, Philippines, E-mail: ibanez.jayson@gmail.com; University of the Philippines Mindanao, Davao City, Davao del Sur, 8000, Philippines*
*Clint Kenny T. Cabrido. Department of Biology, Ateneo de Davao University, Davao City, Davao del Sur, 8000, Philippines, E-mail: cktcabrido@addu.edu.ph*

## INTRODUCTION

The Philippine brown deer (*Rusa marianna* Desmarest, 1822*)* is endemic in the Philippines, particularly in Luzon, Mindanao, Samar, and Leyte faunal regions. Its population has significantly decreased in the last three decades due to deforestation, habitat loss, and degradation (Ravenelle & Nyhus 2017). Human encroachment on natural landscapes has also driven several species to hide in the remaining forest patches (Foley et al. 2005). Another prevalent threat is subsistence hunting induced by poverty and scarcity of livelihood opportunities (Tanalgo 2017). With an estimated 30% population decline, the deer are now considered Vulnerable. It is facing a high risk of extinction in the wild, according to the IUCN Red List of Threatened Species (MacKinnon, Ong & Gonzales 2015). The Philippine Red List Committee also declared the deer endangered, noting its dwindling wild populations (Biodiversity Management Bureau - Department of Environment and Natural Resources 2020).

Deer monitoring presents an ecology-based measurement of human impacts on biodiversity, for they thrive in environmental conditions with less or no human disturbance (Morrison et al. 2007). Therefore, its population status indicates the extent and effectiveness of conservation initiatives (Rapport & Hilden 2013). The deer is among the few relatively large-sized herbivores that forage in the Philippine forests and is an essential biological indicator that dictates the structure and type of vegetation in the ecosystem (Owen-Smith 1988). Aside from these ecological functions, the deer is also considered a Cultural Keystone Species (CKS). The deer was declared Pusaka, sanctifying its inherent value to the life, culture, and history of the Obu Manuvus in Davao City (The Unified Obu Manuvu Tribal Council 2017).

However, the deer remains understudied despite its known biological and cultural significance and the threats contributing to population decline. Many studies, including first biological description, were conducted in the Micronesian islands (Wiles et al. 1999). In the Philippines, the latest scientific account of the deer abundance and distribution dates back to 2014, which served as the basis for its vulnerable status. The Mindanao subpopulation is also understudied due to limited human resources and financial constraints (MacKinnon et al. 2015). This research gap inhibits the development of apposite and sustainable protection, management, and conservation plans.

This study aimed to establish the baseline data on deer abundance, distribution, and conservation in the Obu Manuvu Ancestral Domain (OMAD) in Mindanao Island, Philippines. Specifically, the study determined the deer relative abundance index (RAI) based on the camera trap detections in 2016 and 2020. Deer distribution was also analyzed relative to the forest cover, elevation, slope ranges, and proximity to water bodies. The in-depth interviews investigated the Obu Manuvus' indigenous ecological knowledge about the deer.

## MATERIALS AND METHODS

### Locale of the Study

Data collection was undertaken in Davao City, particularly in Barangay Carmen, Salaysay, Tambobong, and Tawan-tawan in 2016 and 2020. The study areas were inside the Obu Manuvu Ancestral Domain (OMAD). It was declared an ancestral domain under Commission En-banc Resolution No. 73-2008-AD by the National Commission on Indigenous People (NCIP). OMAD overlaps with the unprotected regions of the Mt. Apo Key Biodiversity Area (KBA) and is a declared watershed through City Ordinance 0310-07 of the City Government of Davao.

### In-Depth Interviews (IDIs)

The researchers developed a semi-structured interview guide that contained questions about the deer's abundance and distribution. The questions include: (a) What is the name of the

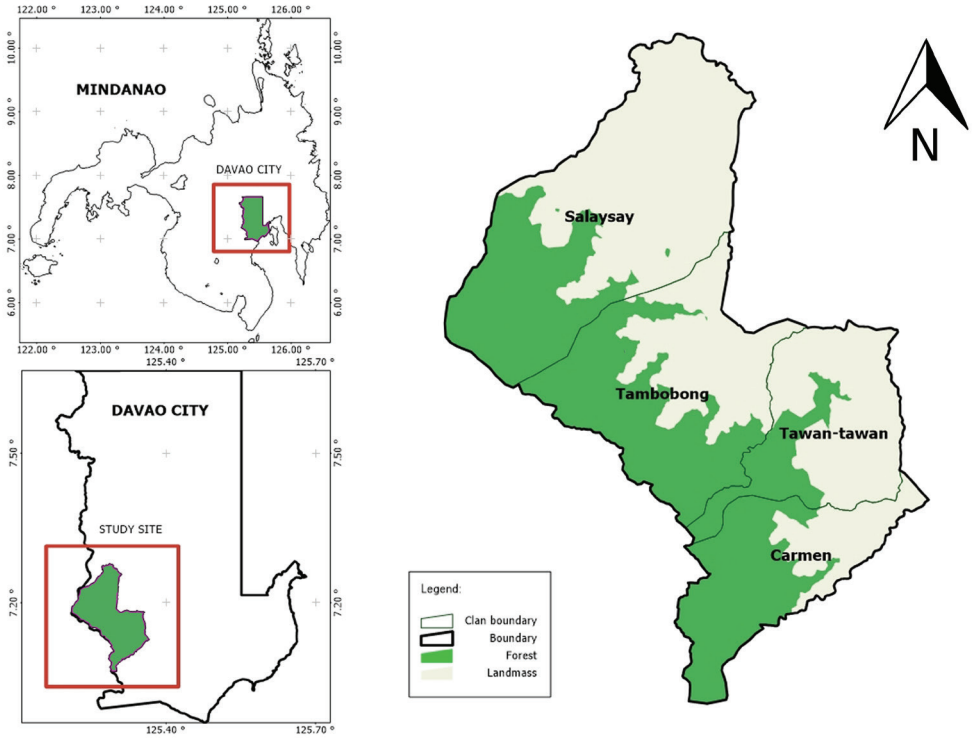



**Figure 1.** Map of the study area in the Obu Manuvu Ancestral Domain, Mindanao Island, Davao City. (Cartographers: Ricksterlie C. Verzosa and Shunjay L. Abordo).

Philippine brown deer in your tribe's dialect?; (b) What are the characteristics of the deer in terms of morphology, diet, reproduction, and movement?; (c) In your estimation, how many deer individuals are found in your locality?; (d) Is there an increase or decrease in the deer population over the last ten years?; (e) Is deer hunting being practiced in the locality?; (f) What are the anthropogenic and non-anthropogenic threats that affect the deer population?; (g) What are the signs of deer presence observed in the locality?; (h) What can you say about the deer's habitat use, distribution, and home range?; and (i) Is it necessary to protect and conserve the deer?

This qualitative component focused on the Obu Manuvu's indigenous knowledge of the population and the conservation status of the deer. Before administering the interview guide, it was subjected to a validation process. Two experts in wildlife research and another in ethnographic studies validated the research instrument. They focused on the theoretical construct, referring to face and content validity to establish the instrument's translational or representational validity. Furthermore, the questionnaire was translated to Cebuano, a dialect the respondents can comprehend and communicate. A language expert validated the translated version.

Twelve Obu Manuvu forest guards (Vis. Bantay Bukid) were interviewed in this study. They have sufficient knowledge about the natural environment, for they have been involved in conservation over the years. Reportedly, some were former hunters and rebels before joining the conservation work. This background allowed them to encounter wildlife and the natural environment closely. The interviews were conducted in the households of the forest guards. All proceedings were audio-recorded and transcribed verbatim for qualitative analysis.

**Camera Trapping**

Camera trapping is a direct observation often used to measure the relative abundance of shy and elusive species like deer. This method is non-invasive, requires minimal labor, and yields robust data (Kays et al. 2011, Palmer et al. 2018). This study used ten camera traps, including four HCO Scoutguard SG560C and six Bushnell Trophy Cam HD Aggressor No-Glow Trail camera traps. HCO Scoutguard SG560C has a highly-sensitive passive infrared (PIR) motion sensor, visible flash, high-quality photos up to 8 megapixels, and a maximum detection range of 25 meters. On the other hand, the Bushnell Trophy Cam HD Aggressor No-Glow Trail camera trap also has a high PIR motion sensor, 48-LED No-Glow flash, high-resolution stills, or HD video up to 20 MP resolution, and 0.2-second trigger speed. The cameras were set to capture three consecutive photos and 30-second videos.

The camera trap locations refer to the physical locations where the camera traps were installed to detect deer abundance and distribution. Optimizing the accuracy of identifying these points required a preliminary investigation of deer presence through the traces of its den, browsing, fecal pellets, trails, etc. This investigation was done through a participatory mapping method involving twelve forest guards invited to a transect walk within the forest interior. The researchers asked for physical evidence of deer presence to ensure that the survey was conducted where the deer was historically detected.

In 2016, a total of 504 camera trapping days were undertaken with 36 camera stations (9.0 km transect) established in Davao City. Four years later, 500 camera trapping days were conducted in Davao City (10.0 km transect). The camera traps were installed at least 250 meters apart and 1.5 m above the ground, following Kays et al. s (2011) methods. Around 12 to 14 days of observation were conducted per sampling station before the camera traps were transferred to another location. A team of forest guards monitored the camera traps every after seven days. They also replaced the batteries and inspected the camera functions regularly.

**Data Storage and Retrieval**

The image and video sequences from the camera traps were copied on an external hard drive. Duplicate copies of the files were also saved to prevent data loss. Each image sequence with deer detections was labeled appropriately with: (a) species name, (b) group size, (c) date, (d) time, and (e) location. This technique showed the frequency of detection and temporal distribution of the deer. The image sequences were categorized as either dependent or independent. Only the independent sequences were used to analyze the deer's relative abundance index (RAI). These refer to the consecutive photos and videos of different individuals of the same or different species, individuals of the same species taken in at least 30 minutes, and non-consecutive shots of individuals of the same species (Jenks et al., 2011).

**Distribution Mapping**

Mapping was employed to determine and visually represent the deer's spatial location and distribution across the study areas. Using a handheld Global Positioning System (GPS) device and the QGIS (previously known as Quantum GIS) version 3.4 software application, the deer's distribution in terms of forest and non-forest areas, forest cover, elevation, slope range, and proximity to the rivers and creeks were mapped.

**Data Analysis**

**Relative Abundance Index**

Relative Abundance Index (RAI) is the ratio between deer detection based on the photographic capture rates from camera trap surveys and the entire trapping days. This is a less complicated estimation method when true abundance is difficult or costly to measure

(Palmer et al. 2018). As a population estimation tool, this can be used as a baseline to employ more comprehensive species monitoring initiatives, such as tagging and radio telemetry (Rovero et al. 2014, Iannarilli et al. 2021). RAI is widely used to monitor deer abundance and distribution in the wild. The deer detection counts were analyzed using the photos and videos obtained in the camera trap surveys. Data such as the sampling date, GPS coordinates, and ecological description of the sampling points were documented. RAI was computed by dividing the total independent sequences per barangay by the number of trap days multiplied by 100, as shown in the studies of Jenks et al. (2011) and Relox et al. (2009).

### Thematic Analysis

The thematic analysis framework published by Creswell (2014) was followed. It involved organizing and preparing the data for analysis. The recorded interviews were transcribed, outlining the questions asked and participants' responses. The researchers then reviewed the qualitative data to obtain a general sense of the participants' information, overall depth, and credibility. The third phase involved coding the concepts and ideas that the participants frequently narrated. Based on these codes, the emerging themes were derived.

### Ethics

The researchers sought the permission of the Obu Manuvu Unified Ancestral Domain Tribal Council of Elders and Leaders (OMUADTCEL) through a public presentation. Afterward, the council issued Resolution No. 01 s. 2019 as permission to conduct the study in the ancestral domain. The researchers organized an indigenous ritual called *Panuvadtuvad* before the start of research undertakings. Special permits were also obtained from the Barangay Local Government Units (BLGUs). All interview participants signed the Free Prior and Informed Consent (FPIC), indicating their voluntary and willful involvement in the project.

## RESULTS

### Relative Abundance Index (RAI)

The first survey was conducted during the rainy season from June to August 2016. Six deer individuals were documented in four independent sequences, particularly in Carmen (RAI=2.38) and Tawan-tawan (RAI=0.79). Unfortunately, no deer individuals were detected in Salaysay and Tambobong. With four independent detections in 504 days, the RAI value is 0.79. Another survey was conducted from January to March 2020 during the dry season. After 500 camera trapping days, four independent sequences were documented, indicating the RAI value of 0.80. One deer individual was recorded in Salaysay and Tawan-tawan (RAI=0.8), two in Carmen (RAI=1.6), and none in Tambobong. The present study did not record any deer individuals in Tambobong after two surveys in 2016 and 2020.

A deer individual was documented in Barangay Carmen (Fig. 3A). It was foraging in a primary forest at 1604 masl at 3:57 am. One deceased individual was recovered in a primary forest at 1709 masl. The deer was characterized as an adult female based on the absence of antlers and believed to be deceased for more than three days as parasitic larvae are already evident at the epidermal layer. Strangulation was the most probable cause of death based on the recovered nylon wire wrapped around the deer's neck. Another deer individual was documented in a primary forest at 1533 masl in Salaysay (Fig. 3B). It was identified as an adult male due to the presence of antlers. The other camera traps were installed in Sitio Taupan with an elevation range of 1516 to 1539 masl. Unfortunately, camera trapping detected no deer individuals in Tambobong (Fig. 3C) (1238 masl to 1367 masl). This result does not necessarily indicate total species absence in the area as deer hoofprints, fecal pellets, and browsing areas have been documented. The forest guards reasoned that they had directly observed deer individuals during their foot patrolling activities. Among the camera trap stations established in Tawan-tawan (Fig. 3D), one deer individual was captured in a


**Figure 2.** Philippine Brown Deer (*Rusa marianna* Desmarest, 1822) detected through camera trapping in (A) Salaysay, (B) Tawan-Tawan, and (C) Carmen. A (D) deceased female deer was also documented in Carmen, Davao City.

**Table 1.** Relative Abundance Index (RAI) of the Philippine Brown Deer *(Rusa marianna* Desmarest, 1822*)* in the Obu Manuvu Ancestral Domain, Mindanao Island, Philippines.

| | Study Area | Independent detection | Detected group sizes of independent events | Trap-days | RAI |
|---|---|---|---|---|---|
| 2016 | Carmen | 1 | 1;2 | 126 | 2.38 |
| | | 1 | 1 | | |
| | | 1 | 1 | | |
| | Salaysay | 0 | 0 | 126 | 0 |
| | Tambobong | 0 | 0 | 126 | 0 |
| | Tawan-tawan | 1 | 1 | 126 | 0.79 |
| | **TOTAL** | **4** | **6** | **504** | **0.79** |
| 2020 | Carmen | 1 | 1 | 125 | 1.6 |
| | | 1 | 1 | | |
| | Salaysay | 1 | 1 | 125 | 0.8 |
| | Tambobong | 0 | 0 | 125 | 0 |
| | Tawan-tawan | 1 | 1 | 125 | 0.8 |
| | **TOTAL** | **4** | **4** | **500** | **0.80** |

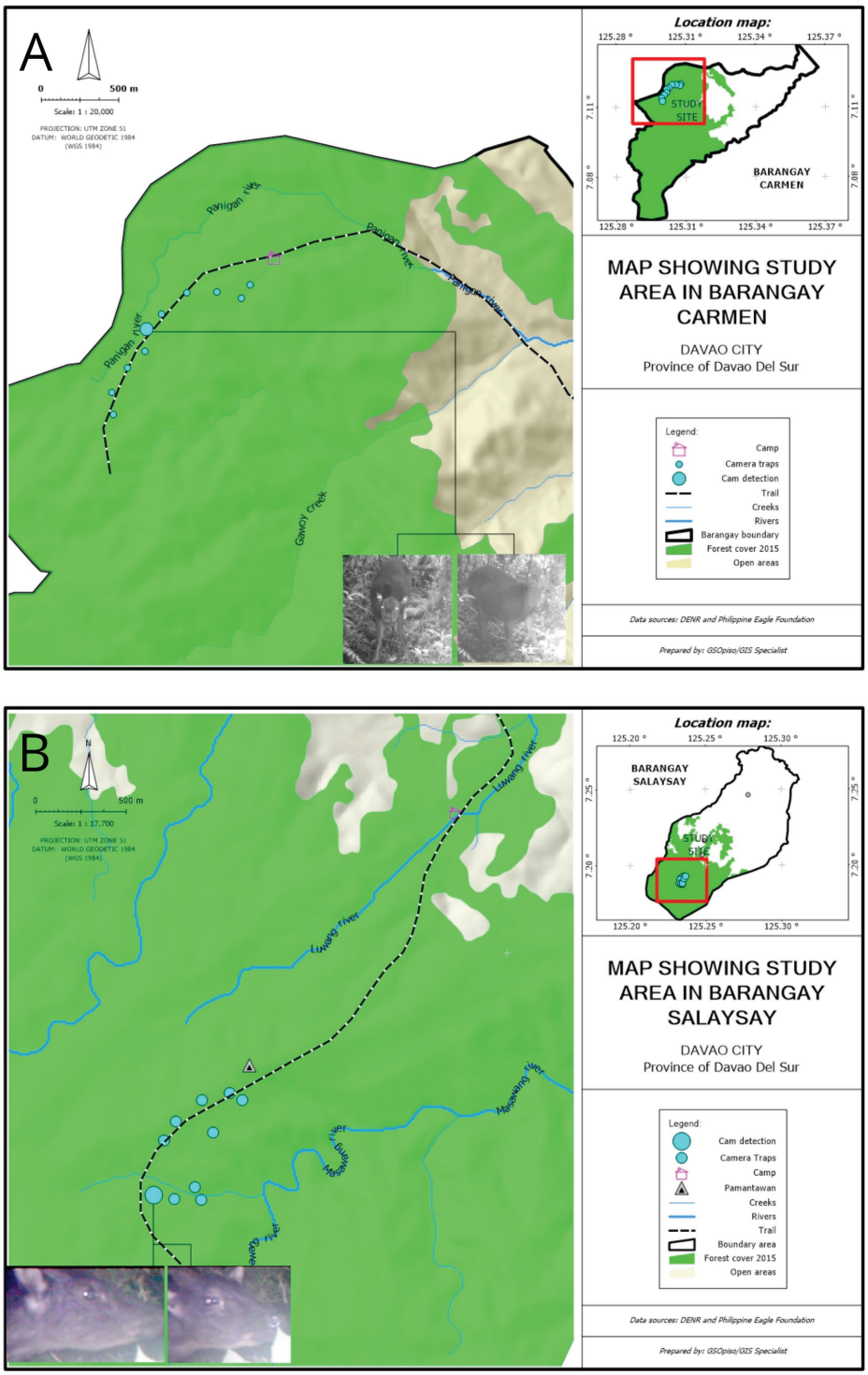



**Figure 3.** Location of the ten (10) camera trap stations in (A) Barangay Carmen, (B) Salaysay, (C) Tambobong, and (D) Tawan-tawan in the Obu Manuvu Ancestral Domain, Davao City, Philippines.

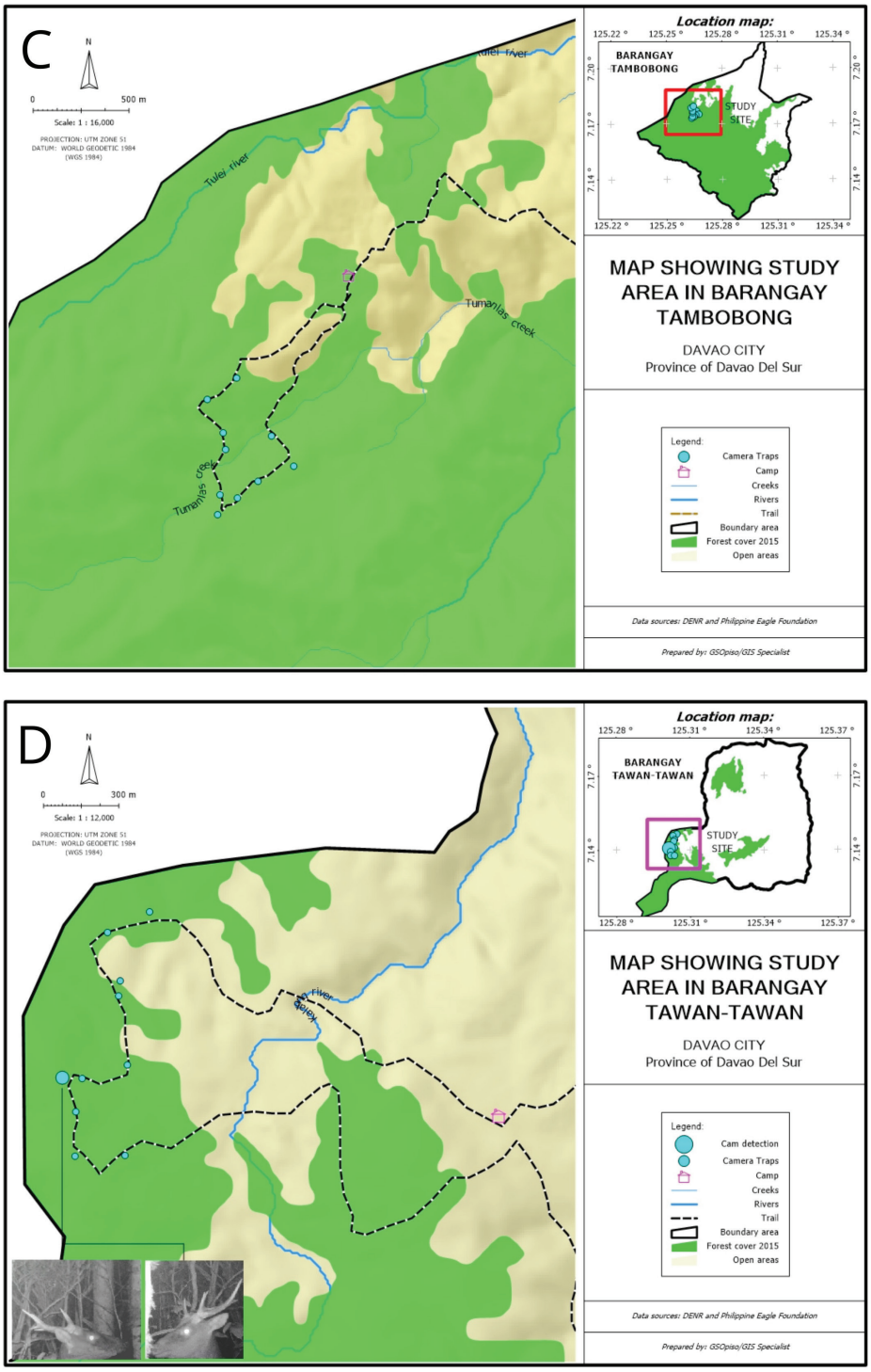



**Figure 3.** Location of the ten (10) camera trap stations in (A) Barangay Carmen, (B) Salaysay, (C) Tambobong, and (D) Tawan-tawan in the Obu Manuvu Ancestral Domain, Davao City, Philippines.

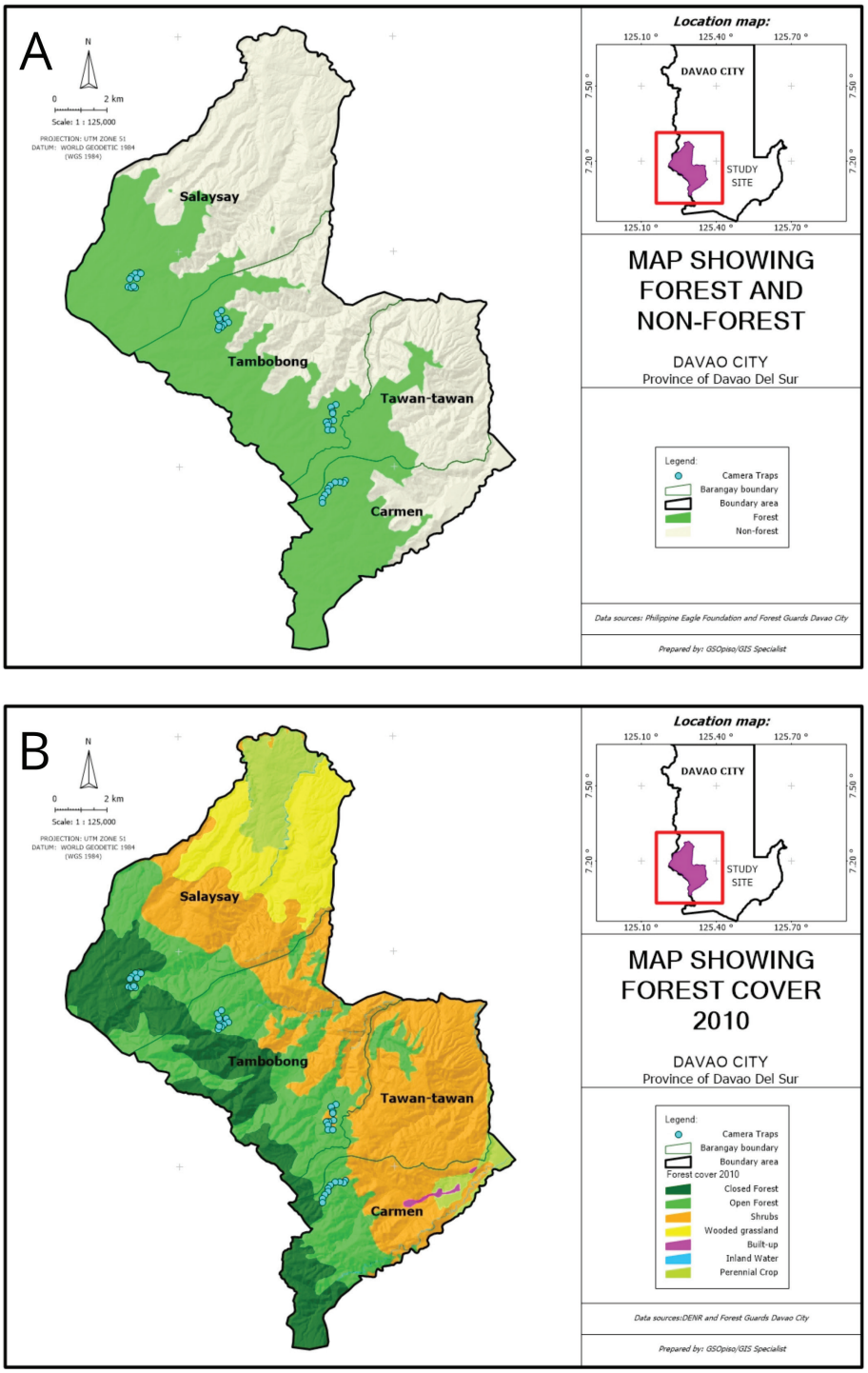
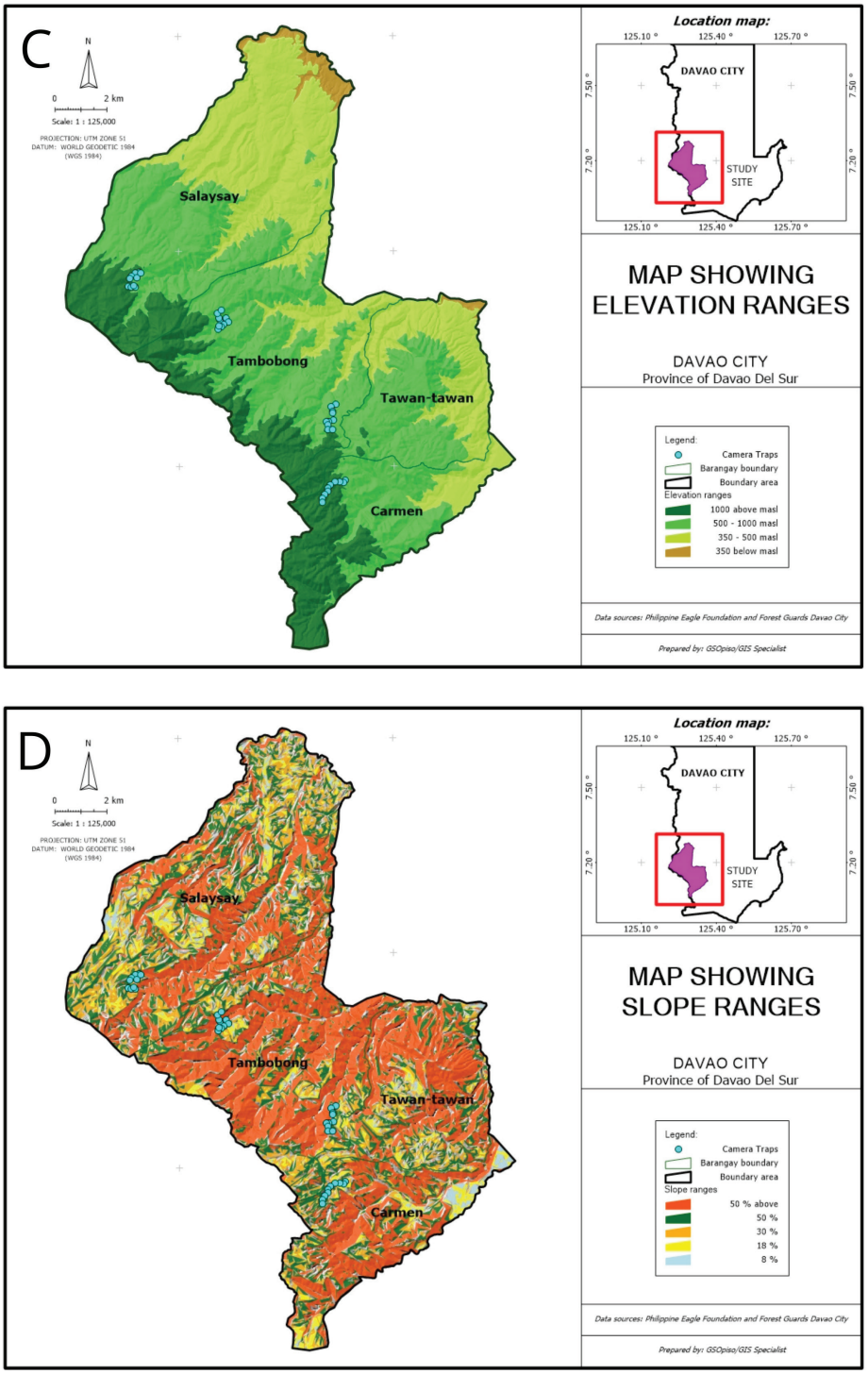



**Figure 4.** Map showing the location of the camera trap stations according to (A) forest and non-forest ecosystems, (B) forest cover, (C) elevation ranges, (D) slope ranges, and (E) water bodies in the Obu Manuvu Ancestral Domain, Davao City, Philippines.

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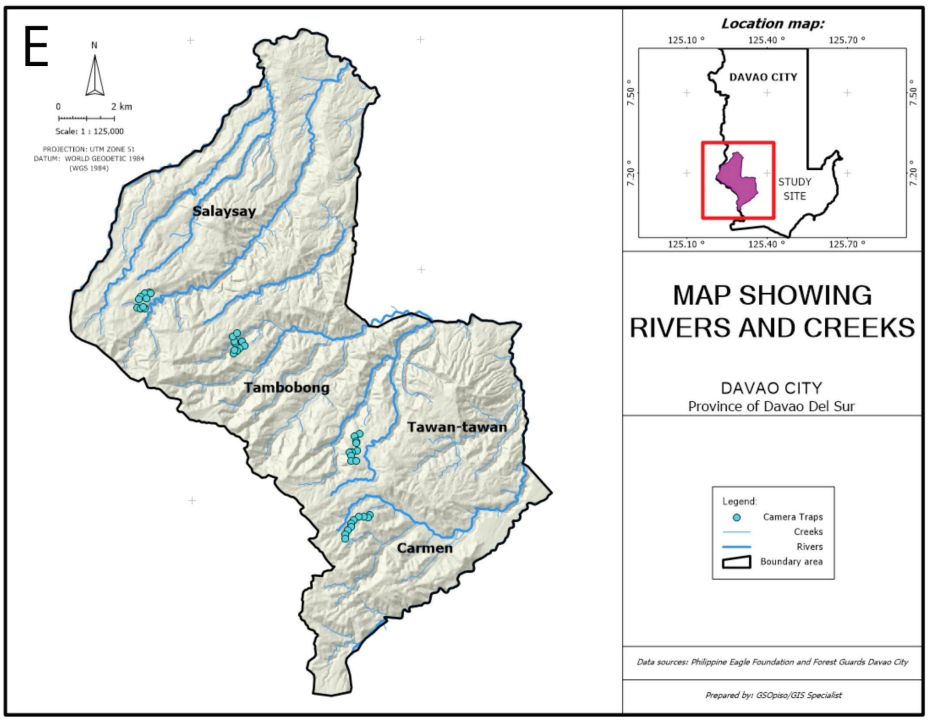


**Figure 4.** Map showing the location of the camera trap stations according to (A) forest and non-forest ecosystems, (B) forest cover, (C) elevation ranges, (D) slope ranges, and (E) water bodies in the Obu Manuvu Ancestral Domain, Davao City, Philippines.

primary forest at 1518 masl. The photographed deer was characterized as an adult male, six years old, based on the number of antler branches. It was also observed to be grazing in the area at 1:03 am.

**Distribution**

Deer individuals were recorded in an open forest near a closed forest canopy in Salaysay (Fig. 4B). In Carmen, another deer individual was documented in an open forest canopy. The documented deer in Tawan-tawan was found in the shrubby areas. Regarding elevation ranges, the deer were documented at an elevation ranging from 1518 to 1709 masl (Fig. 4C). The slope ranges were also mapped to show their influence on the distribution of the deer (Fig. 4D). Deer individuals were recorded in a slope range from 50% to 50% above. The distribution of the deer was also attributed to the presence of rivers and creeks (Fig. 4E). They were detected proximal to the water bodies in Salaysay, Tawan-Tawan, and Carmen.

**Indigenous Ecological Knowledge**

The in-depth interviews revealed the indigenous ecological knowledge (IEK) of Obu Manuvu forest guards about the deer's morphology, behavior, and ethnozoological uses. Several notable responses were presented in this study.

**Worldview**

*Ang Pusaka nga terminolohiya usa ka kulturanhon nga pama-agi sa paghatag og taas nga "value" ug pag-ila sa pagka-importante nga mga butang, mga kahayupan nga diin adunay daku nga kalambigitan sa kinabuhi nga makasay-sayanon* (pers. comm. Lipatuan Joel Unad, 2019).

Pusaka refers to a cultural practice of valuing and recognizing the importance of objects like wildlife concerning the tribe's life and history. *Kay di man pud na madali-dali namo na kay Pusaka man gud daw na sa katigulangan daw na. Mao ng dili gyud namo na dali buhian kay… Uy, mag-unsa na man tong gibilin sa katigulangan unya dili mo atimanon. Pusaka, kabilin na. Kabilin sa mga katigulangan. Pinaka importante sa tribu na* (CAP01). We cannot just take the deer for granted because we consider it a Pusaka, an inheritance from our ancestors. That's why we have to protect it. What will happen to our ancestor's gifts if we will not take care of them? Pusaka is an inheritance of our ancestors. It is essential to the tribe.

**Morphology**

*Walay sungay sa babae na binaw, lalake ra jud ang sungayan sa akong na obserbahan diri sa among bukid. Ang pagtubo ana gikan sa pagkabata, iyang sungay pirmerong tubo niya mao ng isa ka tuig. Mao ng ilhanan namo* (TWP01).

Females do not have antlers. Based on my observations, only the males have antlers. Our traditional way of determining the deer's age is through its antlers. The fawn's first set of antlers indicates that it is already one year old.

*Ang sungay nila pirmiro duha ug niya kung mu ingon ta nga mga mu abot nag unom ka tuig so adunay tulo-tulo ka sanga kada pikas. Unom siya tanan. Kada sungay niya kada pikas so, tulo. Pikas tulo. So unom na siya ka sanga. So mao na ang mu identify sa iyang edad. Unom ka tuig na siya* (TBP03).

At first, the deer has two antlers. When the deer reaches six years old, there are three branches per antler. That is our way of determining that the deer is already six years old.

**Behavior**

*Idlas jud na siya. Dili jud na sila makit-an sa tao. Ang kinaiya sa binaw maskin karon nag lubog siya, wala siyay nakit-ang tao. Pag nakabati siyag hikas-hikas didto, mulupad na siya. Mudagan na siya. Mao ng kasagaran sa binaw, naa sa bakilid tas pang-pang, mu-ambak na siya didto. Murag walay buot ba. Pag makalitan na siya, mu ambak na siya didto nga abi niyag ang iyang gi-ambakan kay dili lawom. Mao ng daghan na madisgrasya* (TBP03).

The deer is very elusive. Humans cannot see them. Even if they are sleeping, they will immediately escape once they sense human presence. Sometimes, they fall off the cliff due to their hasty and impulsive behavior.

*Kasagaran ana naa sa bungtod o sa mga dili maagian. Panid-an pana nila ang palibot nga dili matugaw sa tao mao diha mopundo, mubalhin lang sila kung naa silay mamatikdan* (TWP01).

Often, the deer can be found in hilly and sloppy areas where humans can't access. They will stay if the place is far from human disturbance. Otherwise, they will transfer to other locations.

*Kasagaran man gud sauna kadtong tig panulo pa mi sa lasang, isa lang gyud among makita nga makig-uban sa inahan. Mailhan man na kay mag-uban man sila. Naa puy panahon nga mag lakaw silang duha, laki ug bae. Ang nati nga laki mo uban pa gihapon na kung mag totoy pa pero kung dako na dili na mo uban* (TBP01).

When we were still hunting in the forest, we usually saw one fawn being accompanied by its mother. It is evident because they are together. There are also times we can see one male and a female together. The male fawn will be with them as long as it is breastfed and eventually leaves upon maturity.

**Ethnozoological Uses**

*Kay kung makakaon man gud ka, kana na hayop, halos tanan tambal, mao nay ginakaon nya. Kanang herbal halos ba. Mao nay ginakoan niya so kung baga kung mao nay ang among katigulangan sauna maluya, mao nang*


**Figure 5.** Conservation threats observed in the study areas: (A) deforestation, (B) hunting, (C) abandoned human camps, and (D) pollution.

*mangayam para mubaskog sya. Painumon ug sabaw para mubaskog sila. Herbal man kasagaran ginakaon ana* (SAP02).

The deer's diet usually includes herbal plants. That's why when our elders feel weak, they just hunt deer to feel healthy. They will drink the soup to regain their strength.

*Dako nang kagamitan kay saunang panahon, walay doctor, walay nurse, walay midwife. Wala tanan ang bata nga masakiton padung sa bukid didto tambalan. Kabalo ka unsay e tambal ana? Mag dakop og binaw kay kana siyempre kuhaan man gyud nag balhibo. E kuan lang ang bata didto paduolon kay kanang sa si kuan si kaning masimhotan niya didto tanan sa iyahang lawas mugawas unsay sakit. Pagka human ana, pakan-on* (CAP03).

The deer has a significant role in our tribe. Before, sick children were brought to the mountains when there were no doctors, nurses, or midwives. Do you know what the treatments are? We will capture deer, and during the de-skinning process, the children shall inhale the smoke to reveal their illness. Afterward, they will eat the deer meat.

*Unya manganak pud magamit pud na. Magamit pud ang kaning bukog labi nag kanang nati. Naa pa sa sulod sa tiyan na mugawas kuhaon gyud na dili na kan-on kay itambal gyud na ipa inom sa kaning kuan anak. Mao nang ang mga bata mugawas ra nga way kuan mananabang. Dili*

*muabot sa doctor. Unya inig gawas pud sa mga bata, matinga ka kay ka gamay pa siya kabalo na siya mag lakaw lakaw. Unya ang inahan pud dili masakiton himsog gihapon nga mag lakaw lakaw. O, tungod sa binaw. Kay ang binaw maka tabang gyud na sa mga kuan masakiton* (CAP03).

It can also be used in birthing. The bone can be used, especially from the fawns. If it is still in the female's womb, it will not be eaten because it will be given to the child. That's why most children will just be born without midwives. And when the child is born, it is unusual that it can easily walk. Also, the mother will be strong and not sickly because of the deer. The deer can help in treating sicknesses.

*Pwede gihapon magamit sa tambal. Kanang sungay, sunogon nimo. Pagka human ug sunog, magpa bukal ka og tubig, katong imong sinunog ibutang didto. Tambal sa ubo… Tambal sa lu… kaning luyahon bitaw ka* (CAP01).

It can be used as medicine. The antler will be burned. Afterward, scratches from the antler's surface will be mixed with hot water. It is used as a treatment for cough and fatigue.

*Kung nakita nimo ang binaw sa sulod sa area. So nagpasabot ang tanan mga tanom mabuhi bisag unsa'ng mga tanom mabuhi gyud na dihang dapita* (CAP03).

If there are deer in the area, it means that any plants can survive in the same place.

### Conservation Threats

Several conservation threats against the deer were documented during the field surveys. Deforestation activities were observed in some areas that eventually led to habitat loss. Human disturbances were also evident in the old camps abandoned within the study sites, forcing deer individuals to move to other forest patches far from human presence. The in-depth interviews revealed hunting as the most prevalent anthropogenic threat to the deer. Hunting may be done using rifles, traps (Vis. lit-ag), or animal-aided (i.e., dogs) (Vis. pagpangayam). The forest guards perceived a decreased deer population in the ancestral domain. It is reported that only a few deer individuals remained in the forest due to several anthropogenic and non-anthropogenic threats. Twenty years ago, the deer population was relatively abundant but had dramatically declined over the last ten years. The hunters experienced lower catch per unit effort (CPUE), claiming to spend more than one week to capture one deer. There are also narratives that, in the past, the hunters would capture two deer individuals within a day of hunting effort. Some reported that they had not documented any deer in specific forest fragments, especially at lower elevations.

## DISCUSSION

### Factors Influencing Deer Abundance

In this study, a limited number of deer individuals were documented in 2016 (RAI=0.79) and 2020 (RAI=0.80). Several factors influence the deer's very low abundance in the ancestral domain. The most common and recognized factor is habitat loss and fragmentation due to logging and slash-and-burn activities. Annually, it is estimated that 47,000 hectares of forest cover are depleted based on the Forest Management Bureau of the Department of Environment and Natural Resources data as reported by Cabico (2018). Illegal logging, slash and burned vegetation, and unsustainable agricultural activities were observed in the study areas. Natural disasters are also contributory, including forest fires, typhoons, droughts, and floods (Ali et al. 2021, MacKinnon et al. 2015). The deer is primarily found in lowland moist, moist montane, dry forests, seasonally wet/flooded grasslands, and montane grasslands in primary and secondary forests (Wiles 2012, Taylor 1934, Sanborn 1952, Rabor 1986, Heaney et al. 1998, Heaney et al. 2010). Damages in their natural habitats caused the deer population to decline over time and become extinct in Marinduque and Catanduanes (Wiles 2012).

Aside from habitat loss, subsistence hunting is another major cause of population decline. Like other deer species in the country, their meat is highly valued since it is rare and delicious. In the Philippines, it is sold for 375 pesos/kg, much higher than wild pig meat (Scheffers et al. 2012). It is considered a major protein source in many indigenous communities and thus is heavily hunted for bushmeat using conventional snares and rifles (Philippine Eagle Foundation et al. 2008). Despite existing wildlife laws and customary forest and species management policies, subsistence hunting is still prevalent. Reportedly, non-members of the community, unaware of these policies, sometimes hunt fauna in the forest, including deer and warty pigs.

Also, Republic Act No. 9147 or the Wildlife Resources Conservation and Protection Act allows indigenous communities to utilize wildlife for traditional purposes. This practice potentially contributes to the continuous deer population decline across the country. Consequently, the local deer population has dramatically decreased based on two independent camera trap surveys conducted in 2016 and 2020. The findings of this study are consistent with the report of Amoroso et al. (2019), indicating low mammal diversity (H'=0.615) in Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS) with the detection of only one deer individual in 223 trap nights. A similar pattern was observed in Mt. Malindang, wherein the Subanens claim that the previously abundant deer species are absent (Arances et al. 2006). The Philippine Red List Committee (PRLC) declared the deer Endangered in its 2019 assessment. It remains Vulnerable and rapidly declining under the IUCN Red List (DENR-BMB 2020, MacKinnon et al. 2015).

Another reason for the deer low occurrence could be the camera trap locations. Human footprints were observed along the transect, which could disturb the deer because they are shy and elusive. The informant interviews revealed that if the deer detects humans, they migrate to undisturbed locations and only return when the anthropogenic disturbance ceases. With the ancestral domain's extensive forest cover, the deer may hide in other forest patches not surveyed in this study.

Lastly, seasonal changes in the environment also affect wildlife populations. Deer movement, home-range size, and habitat selection are highly influenced by energy and nutrient needs, especially during gestation and lactation (Aung et al. 2001). Moreover, the species' mating season is usually between September and January, in which females create small groups while males are solitary and aggressive. During the sampling period, the deer hide in the forest interior for gestation, especially in Tambobong, where the forest cover is still vast. It is necessary to undertake population surveys across the year to determine the deer's spatial-temporal abundance.

**Distribution and Environmental Parameters**

The camera traps were installed in the forested areas within the ancestral domain (Fig. 4A). Strategically, the sampling points correspond to the areas with local sightings and preliminary evidence of deer presence, such as hoof prints, fecal pellets, den, and browsing areas. Based on this result, the deer are often found in forest habitats where their daily resource needs could be derived. The forest guards observed them forage in secondary forests, open spaces, and grasslands with abundant food supplies. Wiles et al. (1999) reported deer browsing in agricultural lands on the Micronesian islands. Hence, the deer are not restricted to forest habitats but can also use other habitats to sustain their nutritional needs. The absence of environmental disturbances could also be a factor for deer presence in particular habitats. MacKinnon et al. (2015) reported that the deer population had been driven to thrive in high elevation areas because of the anthropogenic activities in the lowlands. Ibañez (2010) reported that deer could be found in secondary lowland, montane, and transitional montane and mossy forests in Sultan Kudarat. Deer populations were observed in lowland dipterocarp forests but not in the montane and mossy forests in the Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS) (Relox et al. 2009).

Although it appears that closed forest cover is vital to the survival of the deer, its browsing activities in the open forest canopies and shrublands are indications of its dependence on food availability. The study of Ali (2020) showed that the deer actively browse for food sources outside closed forest covers. During the interviews, the forest guards revealed that some individuals could be sighted browsing in open areas but eventually return to their sleeping dens in the forest interior, usually in the daytime.

Elevational distribution conforms to the existing data that the deer can now be found in uplands due to habitat loss and fragmentation (Heaney et al., 1998; Heaney et al., 2010; Wiles, 2012). This fact is also supported by Ibañez (2010), who documented the deer from 1220 masl to 1696 masl in Sultan Kudarat. The present study documented deer individuals from 1518 masl to 1709 masl. This result conforms with local narratives that the deer usually thrives in sloppy and hilly areas. It is hypothesized that as elusive species, the deer prefers sloppy and hilly areas as these are far from anthropogenic disturbances. Unfortunately, the forest guards have observed deer mortality due to accidents in these habitats. The same behavior was demonstrated by the Visayan spotted deer *(Rusa alfredi* Sclater, 1870*)*, *R. marianna's* closest relative, with habitats restricted to steep and rugged slopes less accessible by humans (Brook 2016).

The deer are usually observed going to the rivers and creeks for drinking. Like most faunal species, distance to the water sources is one of the deer's considerations in using a particular habitat (MacKinnon et al. 2015, Ali et al. 2021). Kii and Dryden (2005) concluded that Rusa deer (*Cervus timorensis* Blainville, 1822) exhibited variance in drinking water requirements according to diet. Likewise, *R. marianna* needs a permanent water source to survive in the wild. The deer often drink water in the rivers and streams after browsing. It is also reported to share water sources with other wildlife species, such as the Philippine warty pig (*Sus philippensis* Nehring, 1886) (Villegas et al. 2021).

It was found that the deer have a broad distribution across primary and secondary forests in the surveyed sites. Deer distribution is influenced by many factors such as forest cover, elevation, slope ranges, and proximity to the water sources. The empirical evidence suggests that the deer thrived in areas with high food availability but less anthropogenic disturbance. Other deer species, such as the mule deer (*Odocoileus hemionus* Rafinesque, 1817), demonstrated a reduced use of certain foodscapes due to human disturbances (Dwinnell et al. 2019). Likewise, Carbillet et al. (2020) concluded that their proximity to anthropogenic activities influences the stress levels of the wild roe deer Capreolus capreolus (Linnaeus, 1758).

**Deer as a Cultural Keystone Species**

The Obu Manuvus declared the deer and other wildlife species and natural resources as Pusaka, an indigenous practice of sanctifying objects with recognized value to their life, culture, and history (TUOMTC 2017, Donato 2011). Before an object can be declared as Pusaka, it must satisfy several criteria: historical importance, faith relevance, cultural worth, economic value, and significance to the ancestral domain. As a species perceived to be culturally and biologically crucial to the Obu Manuvus, the deer is described as a culturally-defined keystone species (CKS). The concept of CKS describes species that have spiritual or symbolic value, vital to the culture's relationship and adaptation to the environment (Cristancho & Vining 2004). Consequential to this declaration is the deterrence of wildlife crimes and the protection of the deer.

Other species are also acknowledged as Pusaka, including the Philippine Eagle (*Pithecophaga jefferyi* Ogilvie-Grant, 1897), Philippine warty pig (*Sus philippensis* Nehring, 1886*),* Philippine long-tailed macaque *(Macaca fascicularis philippensis* Geoffroy, 1843*)*, Northern rufous hornbill *(Buceros hydrocorax* Linnaeus, 1766*)*, Palm Civet *(Paradoxurus hermaphroditus* Pallas, 1777*)*, Malay civet *(Viverra tangalunga* Gray, 1832*),* White-eared brown dove

*(Phapitreron leucotis* Temminck, 1823*)*, yellow-breasted fruit dove *(Ptilinopus occipitalis* Gray, 1844*)*, Tarictic hornbill *(Penelopides affinis* Tweeddale, 1877*)*, and woodpecker *(Picidae* sp.*)* (TUOMTC 2017).

Deer conservation is critical to the Obu Manuvus due to several reasons. Ecocentrism is the first conservation attitude, propounding that species and ecosystems are inherently valuable regardless of their importance to humans (Taylor et al. 2020). According to the Obu Manuvus, the deer have intrinsic values to live and survive because God created them like humans. They believed that the deer could survive independently even without humans. Additionally, the Obu Manuvus believed that the deer should be conserved due to its importance to their life and culture. This attitude pertains to anthropocentrism, arguing that humans contribute to environmental protection based on their direct benefits (Kopnina et al. 2018). The deer is perceived as an ancestral heritage and thus should be protected for future generations' sake. As a Pusaka species, the deer's loss negatively impacts their cultural identity. Also, they are known for their ecological services. The Obu Manuvus perceived that the frequent occurrence of floods, droughts, typhoons, and other natural calamities resulted from the deer's declining population. They considered the forest a marketplace, while the deer is an essential forest product. This perception illustrates the traditional use of deer as food, driving a local bushmeat industry. Periodic deer hunting is allowed in the community, especially during special occasions such as thanksgiving, fiesta, and planting and harvesting seasons.

The deer is locally known as *"Sarong."* Males are known as *"Gahapanga,"* while females are *"Kwaping."* It was described to have brown to dark brown pelage. Fawns have white spots, which eventually disappear upon maturity. Males are larger than females in size. Although not confirmed scientifically, some locals claimed a white deer to be present in the forest's innermost portion. Antlers are present only among male individuals, which is a traditional measure of determining their age in years. The locals perceived that every branch of the deer's antler corresponds to one year in age.

The deer is herbivorous with its diet mainly composed of plants, particularly the leaves, flowers, and even fruits of Wild Abaca *(Musa textilis* Hayata*),* Anotong *(Dicksonia antartica* Labill, 1807*),* Alingatong *(Urtica dioica* Linnaeus*),* Wild Sunflower *(Tithonia diversifolia* Hemsley*),* Lakatan *(Musa acuminate* Colla*),* Carabao Grass *(Paspalum conjugatum* Bergius*),* Almaciga *(Agathis philippinensis* Warb*),* Bunguti *(Unidentified* spp.*),* Daak *(Unidentified* spp.), and Manaba *(Unidentified* spp.). Reportedly, the deer frequently forages, matching other ruminant's diet behavior. In terms of reproduction, the deer produces only one fawn per mating season. According to the forest guards, no accounts of multiple births have been recorded.

As a nocturnal mammal, the deer have been documented foraging at night, although there are claims that they also browse during the daytime. Further studies are required to document the diurnal and nocturnal activities of the deer. In addition, the deer makes loud barking calls, especially during the new moon. They make the same loud calls during mating season, with females attracting the males. Generally, they are shy and elusive species, immediately running away whenever they sense human presence. This behavior makes them vulnerable to accidents, for they usually escape hastily. There are accounts of deer mortality due to falling from sloppy and hilly areas. Based on local accounts, the deer's sleeping den is found in sloppy and the hilly regions. They tend to stay in these locations where there is a minimal anthropogenic disturbance. Their den also includes fallen tree trunks, especially during rainy seasons. Male deer were observed to be solitary. Male-fighting using their antlers is a common incident, demonstrating aggressive and competitive behavior among males. The forest guards also observed the deer browsing in a herd consisting of one male, one female,

and sometimes, one fawn. The fawn eventually leaves the herd as it matures.

Biodiversity has long been considered of cultural importance by many local and indigenous communities (Clark et al. 2014). In addition to the deer being a favorite of the indigenous palate, it also serves other cultural uses to the Obu Manuvus. The deer is used in traditional medicine, with homeopathic properties attributed to its selective diet of herbal and medicinal plants. Its broth is used to treat fatigue and is often served to pregnant women for easy and healthy birthing. Deer consumption during pregnancy is also associated with healthier offspring and early ambulation. While access to medical and health facilities was more limited in the past, the deer is traditionally used in disease diagnoses. Sick children are made to inhale smoke from the fire used in deer skinning to determine the illness. Also, the surface of its antler may be charred and scratched. The velvet skin and antler periosteum are mixed with hot water to treat cough and fatigue.

Meanwhile, antlers are displayed as trophies. Hanging the deer's antler at the door indicates one's cultural identity. The Obu Manuvus also perceived that deer abundance implies a healthy forest ecosystem, supporting plant growth. Interestingly, there are also narratives that the deer's loud calls may be considered an omen, foretelling the occurrence of war and disasters. Upon hearing the loud calls, especially during noontime, one must rush to exit the forest to prevent untoward incidents.

**Anthropogenic Pressures on Deer Population**

Forest loss remains one of the leading causes of deer population decline. The Forest Management Bureau (2017) and Apan et al. (2017) reported that the dramatic decrease in forest cover in the Philippines has destroyed and fragmented the habitat of many wildlife species. Consequently, this phenomenon affects the deer's movement patterns, home range, and habitat use as they are forced to hide in the remaining forest patches with scarce food resources (Foley et al. 2005).

Meanwhile, hunting was a prevalent activity by the outsiders who were unaware of the conservation policies of the Obu Manuvus. This is a common felony by local populations, causing the deer population to decline (Headland & Greene 2011). While poverty is high across the archipelago, money appears to be the bushmeat industry's major impetus. Deer meat is sold at PhP375.00 per kilogram in some areas in Southern Luzon (Scheffers et al. 2012). Subsistence patterns in Northern Luzon are also evident even during the Neolithic and Metal Age of the Philippines, emphasizing wildlife hunting's historical roots (Amano et al. 2013). Likewise, poverty and lack of alternative livelihood in Mt. Apo, Mindanao Island, influence subsistence hunting, thus threatening deer abundance (Tanalgo 2017). Sy (2021) also reported that the deer is illegally traded on transnational platforms, including its skull, antler, and meat.

Traditionally, hunters track the deer's presence based on the hoofprints, wallowing areas, sleeping dens, and diet leftovers such as fruits and acorns (Ibañez et al. 2012). Their ecological knowledge serves as an advantage in hunting activities. Hunters bring rifles or marble guns to injure the deer. Others engage in active hunting through the aid of dogs *(Canis familiaris* Linnaeus, 1758*)*. The dogs are raised purposively for hunting and are considered a vital part of traditional households. Once inside the forest, the dogs are tasked to detect and chase the deer, abetting hunters to capture the prey quickly. Lastly, nylon traps are left in strategic places with abundant food sources. The traps are tied in tree branches approximately one meter above the ground to capture the deer during its browsing activity. The deer are usually trapped on the neck resulting in strangulation and eventual death, as observed in Barangay Carmen (Fig. 2D).

**Community-based Conservation Initiatives**

The promulgation of policies influences people to abide by biodiversity conservation initiatives (Adom 2016). Obu Manuvus set several

conservation policies to deter criminal offenses against wildlife, particularly towards the deer. They imposed penalties and punishments depending on the gravity of the violation, such as radios or other items in the first two offenses. However, the offenders were subjected to a legal action per the existing customary laws on the third offense. Obu Manuvus were keen on sending offenders to jail without behavioral reforms after receiving three warnings.

Conservation initiatives were handled by the Obu Manuvu Unified Ancestral Domain Tribal Council of Elders and Leaders (OMUADTCEL), composed of tribal chieftains and elders from the four barangays: Carmen, Salaysay, Tambobong, and Tawan-tawan. The OMUADTCEL further institutionalized the Pusaka Council, the highest governing body to uphold the Pusaka philosophy. As a Pusaka or culturally-defined keystone species (CKS), the deterrence of wildlife crime against the deer is a topmost priority. Hence, hunting deer is strictly prohibited within the ancestral domain, except on the designated hunting grounds. This practice consequently allows the deer to repopulate despite various conservation threats.

Meanwhile, the Philippine Eagle Foundation (PEF), the Department of Environment and Natural Resources (DENR), and the Davao City Government organized a group of forest guards. They were trained to monitor and document wild flora and fauna (i.e., Philippine brown deer) and report anthropogenic and non-anthropogenic threats against the natural resources to competent authorities. The forest guards are tasked to conduct regular foot patrolling through the forest interiors to conduct diurnal and nocturnal species monitoring for ten days per month. Deer monitoring involves documenting hoof prints, fecal pellets, and grazing evidence, among other indications of deer presence. With its rapidly declining population, it is imperative to consider deer as a focal species for conservation. A temporary total hunting ban must be institutionalized for at least ten years to ensure the deer's population status recovery. Likewise, the foot patrolling efforts must be strategically enhanced by employing less invasive monitoring methods such as camera trapping and radio telemetry.

The forest guards received a monthly incentive, life insurance, and other benefits for their ecosystem services. The provision of monetary incentives is an effective strategy to ensure the sustainability of conservation efforts. Hence, there is a need to standardize their compensation schedule, especially when they assist researchers and scientists. Also, there is a need to upskill the forest guards and indigenous communities through formal skills training, certified by competent agencies such as the Technical Education and Skills Development Authority (TESDA).

As an impact of these conservation initiatives, the deer population status is gradually recovering due to recent conservation efforts. The assistance of two non-government organizations (NGOs), namely the Philippine Eagle Foundation (PEF) and Euro Generics International Philippines (EGIP) Foundation, emerged to have contributed to the conservation initiatives. The forest guards conducted regular foot patrolling in the forest to monitor wildlife populations in the ancestral domain. These reports are then submitted to the mentioned NGOs for data banking and analysis. Aside from this, the information education and capacity-building program also abetted the deterrence of hunting and other wildlife crimes as the indigenous communities are made aware of the wildlife's biological importance. A holistic mechanism is an effective forest management strategy, but there is a need to develop an intensive monitoring mechanism for data deficient and threatened species like deer.

## CONCLUSIONS

This study detected four independent sequences after 504 camera trap days in 2016 (RAI=0.79) and another four independent sequences in a span of 500 camera trap days in 2020 (RAI=0.80). Deer individuals were documented in Carmen, Salaysay, and Tawan-tawan within the Obu

Manuvu Ancestral Domain in Mindanao Island, Philippines. Unfortunately, there is no camera-trap record of deer presence in Tambobong after two surveys, although there were hoofprints, fecal pellets, and scratches. The camera trap surveys reveal the dwindling deer population in the territory, demanding urgent conservation actions. It was noted that forested landscapes are vital to the survival of the deer, although non-forested areas also serve as important food corridors. This observation emphasizes the importance of holistic forest governance in biodiversity conservation. The surveys detected deer in an elevation range of 1518 masl to 1709 masl with 50% and 50% slope ranges. Deer individuals were also recorded proximate to water bodies, giving additional insight into their home range and distribution. The Obu Manuvus have promulgated local conservation strategies anchored on their cultural beliefs. They have declared the deer an indigenous protected species making it a conservation priority. However, several anthropogenic threats, usually from outsiders, were still evident despite the conservation efforts. Hunting and habitat loss remained the primary threats to the deer population. There is a need to implement a hunting ban to allow the species to repopulate. Also, reforestation programs must be implemented to regenerate the deer's habitat. Conservation efforts must be enhanced through wildlife monitoring, cultural integration, and strict implementation of species protection policies. Further population monitoring surveys are recommended through more sophisticated monitoring tools, such as tagging and radio telemetry.

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## STATEMENT ON CONFLICT OF INTEREST

The authors declare no conflict of interest in this project.

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