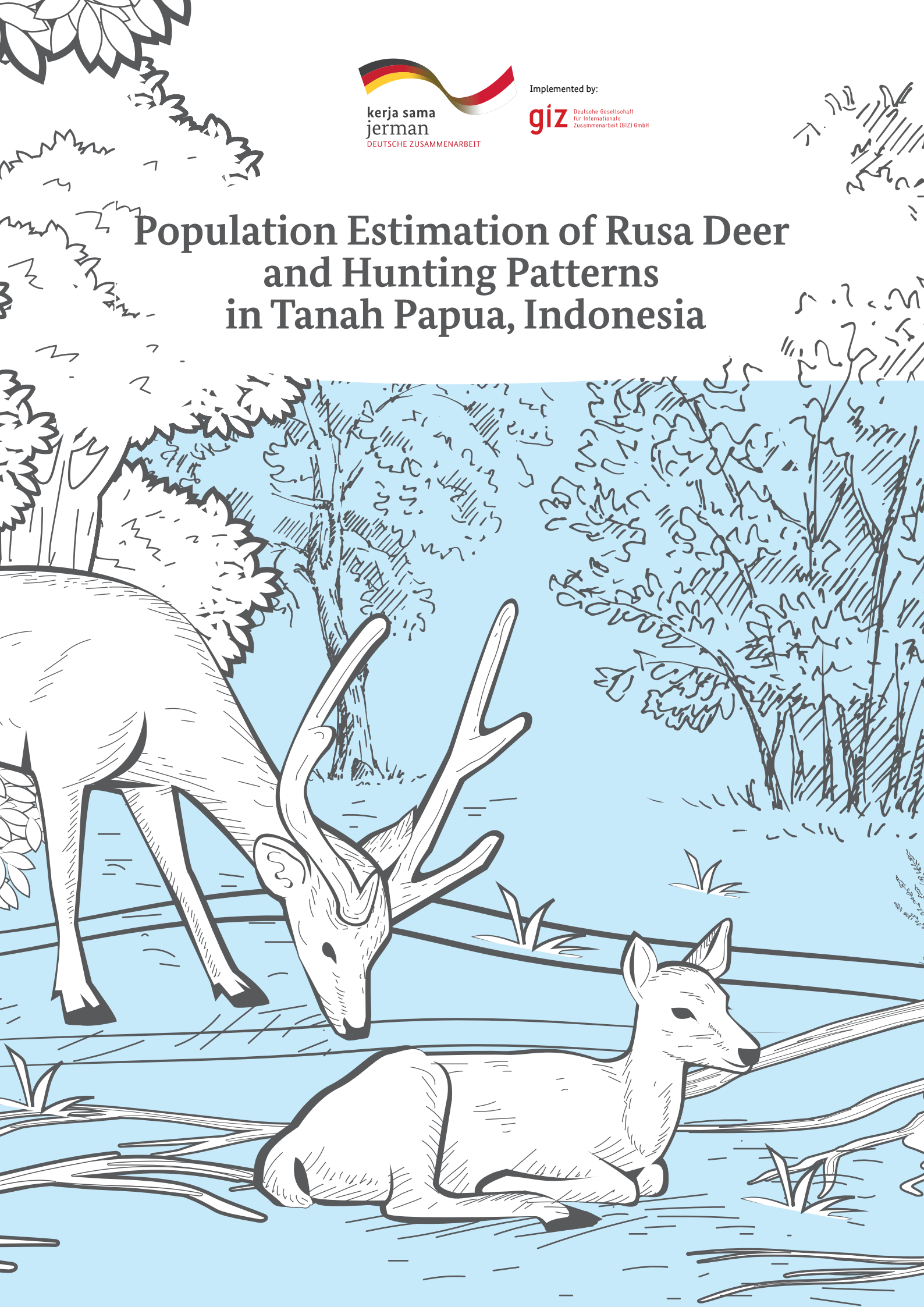
kerja sama jerman
DEUTSCHE ZUSAMMENARBEIT

Implemented by:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Population Estimation of Rusa Deer and Hunting Patterns in Tanah Papua, Indonesia



Population Estimation of Rusa Deer and Hunting Patterns in Tanah Papua, Indonesia

Based on the recent field study in collaboration between the University of Göttingen Germany and GIZ

Published by:
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
FORCLIME Forests and Climate Change Programme
Manggala Wanabakti Building, Block VII, 6th Floor Jln. Jenderal Gatot Subroto, Jakarta 10270, Indonesia
Tel: +62 (0)21 572 0212, +62 (0)21 572 0214
Fax: +62 (0)21 572 0193
www.forclime.org

In cooperation with:
Ministry of Environment and Forestry

Authors:
Margaretha Pangau-Adam, Mahmood Soofi, Matthias Waltert

Photo credits:
Margaretha Pangau-Adam; Moses Yenggreng; Betwel Yekwam

Acknowledgement:
Daud Yekwam (field assistant) and Jan-Niklas Trei for GIS support

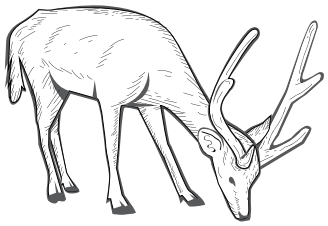
Printed and distributed by:
FORCLIME

Jakarta, October 2020

Forests and Climate Change (FORCLIME)
FORCLIME Technical Cooperation (TC), a programme implemented by the Indonesian Ministry of Environment and Forestry and GIZ, and funded through the German Federal Ministry for Economic Cooperation and Development (BMZ)

Disclaimer: The views and opinions expressed in this publication are those of the author and do not necessarily reflect the official policy or position of GIZ or the Indonesian Ministry of Environment and Forestry

Contents

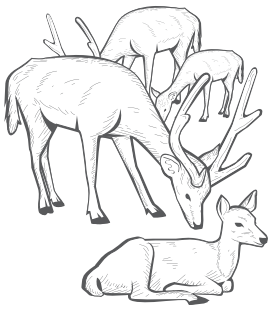


4 ***Executive Summary***

6 ***Study Context and Objectives***

8 ***Project Study Area***

Human Population 9
Study Site 9
Research Methods and Analysis 10

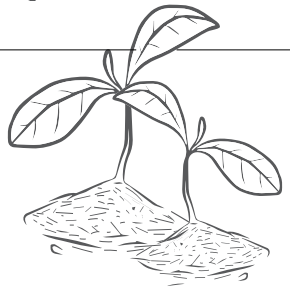


12 ***Project Result***

Distribution Range of Rusa Deer 12
Population Density and Abundance of Rusa Deer 13
Factors influencing rusa deer population 17
Effects of Rusa Deer on Vegetation Structure 16

18 ***Hunting Patterns***

Reasons/Motivation of Wildlife Hunting 19
Hunting Techniques 19
Hunting Sites 20
The Importance of Rusa Deer to the Local Communities 21
Rusa Trade in Tambrauw 22
Wildlife Hunting and Sustainability 22



24 ***Lessons Learned***

26 ***Recommendations for Future Management Decision***

A Model of Community-Based Co-Management 26
Information on Collaboration with Government, NGOs and Local Communities, Workshop and Trainings 28

Contents

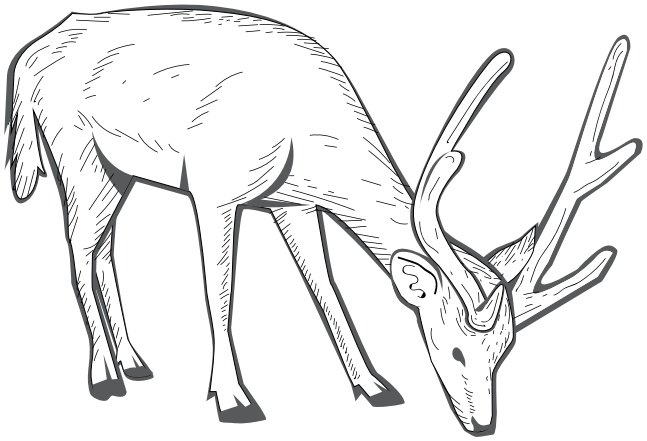
LIST OF FIGURES

Figure 1. Secondary forest at study site— Margaretha Pangau-Adam 5
Figure 2. Tambrauw landscape behind Bano village.— Margaretha Pangau 7
Figure 3. Bano village is located on the hill and considered as one of tourism spots in Tambrauw regency 9
Figure 4. Map of study area, Tambrauw region, Tanah Papua 10
Figure 5. Study site - Tambrauw Regency 11
Figure 6. Kwoor basin in Tambrauw region 11
Figure 7. Deploying camera traps with local staff and guides 12
Figure 8. Interviews with local hunters 13
Figure 9. Grassland ecosystem in Kebar 15
Figure 10. A rusa deer detected from camera trap 17
Figure 11. Samplings damaged by rusa deer 18
Figure 12. Kwoor river vegetation 19
Figure 13. Traditional techniques for hunting 21
Figure 14. Habitat of rusa deer 25
Figure 15. Training local staff and guides 27
Figure 16. Meeting with the Government of Tambrauw 30
Figure 17. In Kwoor basin Tambrauw, rusa antler was taken and the skull often left in the forest 31
Figure 18. Followings are some pictures of rusa deer taken through camera traps 31

LIST OF TABLES

Table 1. Summary of the distance sampling models to estimate Rusa deer density in Tambrauw,West-Papua, Indonesia 16
Table 2. The site specific conditional posterior abundance estimates (95% credibility intervals) of the rusa deer for Poisson (P) and negative binomial (NB) models obtained from Bayes's rule 16
Table 3. Summary of wildlife hunting in fifteen districts of Tambrauw Regency, West Papua 22
Table 4. The frequency of wild meat as a component of the meals of villagers 23
Table 5. Sasi practiced by local communities in Tambrauw 25

Figure 1. Secondary forest at study site.— Margaretha Pangau-Adam



Executive Summary

Javan rusa deer is an introduced species in New Guinea and has successfully dispersed across much of the lowlands of West Papua and Papua provinces (Tanah Papua) including Vogelkop Peninsula. This ungulate and other wild animals play important role in the livelihoods and culture of local people in Tanah Papua. In this study, we quantify the distribution and population size of Javan rusa deer and hunting practices in Tambrauw region to propose management strategies. The results indicate that distribution of Javan rusa deer (hereafter referred to as 'rusa deer') is ranging from coastal areas in the north, lowland forests, grassland habitats in Kebar to the hill forest up to 900 m a.s.l.

Population density of rusa deer in 48 km^2 of the studied area was 10.3 to 23.8 individuals/km^2. Diversity of habitats, adequate foraging resources, less human population density and favorable climate conditions were determinant factors associated with high abundance of rusa deer in this region. Our results further suggest that traditional hunting is a significant livelihood activity in Tambrauw regency, because it provides the majority of animal protein for local families. Hunting of rusa deer were mainly motivated by subsistence/income generation, commercial purposes and traditional/religious events. Hunting sites are related to clan and traditional forests (hutan adat), which include primary forest, secondary forest and forest gardens. Rusa deer and wild pig represent the most frequently hunted mammals in the surveyed areas except at the high elevation forests (800-900 m asl).

The meat of rusa deer (venison) often being sold within villages or occasionally offered at the roadside of the Trans Papua. The main trade of venison occurs at trading points, local markets in towns and in the cities of Sorong and Manokwari. Our analyses of hunting and capture rates, combined with population estimation and rates of increase have shown that hunting of rusa deer appears to be sustainable. The potential harvest within the 48 km^2 study area (*PH*) = 97.34 individuals per year is higher than current harvest rates of ca. 69 individuals per year. Because wildlife plays an

important role as protein source for local people and for additional income generation, many local communities are seriously concerned to manage the capture rates of rusa deer. If the abundance of these animals dramatically decreases and natural resources depleted, the so called *sasi* system would be applied.

Sasi refers to a traditional system of natural resource management and includes banning of resource harvest on the land and in the sea. Moreover, we found that wildlife taboos, for instance taboo of cassowary, cuscus, and tree kangaroos, are practiced by several clans in Tambrauw region. Both the *sasi* system and taboos are such forms of traditional knowledge and beliefs which can provide important mechanisms to support sustainable management of natural resources and biodiversity conservation. Combined with traditional ecological knowledge, the professional guidance is needed to pursue a sustainable rusa hunting in Tanah Papua, therefore a form of 'Community-based Co-management' (described below) should be established. Further research projects and collaborative programs are thoughtfully recommended to support community development and sustainable forest and biodiversity management in Tambrauw and generally in Tanah Papua.

Figure 2. Tambrauw landscape behind Bano village.— Margaretha Pangau-Adam

Study Context and Objectives

Rusa deer (*Cervus timorensis*) is native to Southeast Asia including the islands of Java, Bali and Timor. It has been introduced to various regions including New Guinea, Borneo, the Lesser Sunda Islands, Maluku, Sulawesi, Pohnpei, Mauritius, Pacific islands, Nauru, Australia, New Caledonia, and New Zealand (Long, 2003). Rusa deer was first introduced into New Guinea in the 19th century along with early human migrations, presumably for meat (Flannery, 1995, Brodie et al, 2018). This species has widely dispersed across much of the lowlands of the provinces of West Papua and Papua (Tanah Papua) including the Trans-Fly region, the entire southern lowlands, Vogelkop Peninsula and the vicinity of Jayapura (Flannery, 1995). There is very limited information about the population status of rusa deer in Tanah Papua, but a preliminary survey in Nimbokrang forest suggests that this mammal species has a relatively high abundance in disturbed forest areas (Pangau-Adam, unpubl.). The introduction of mammalian species to Tanah Papua has become the focus of conservation concern, because the region lacks most placental mammal lineages, and increased abundance of introduced/invasive species (e.g. Rusa deer, wild pigs) can adversely affect the native flora and fauna in this region. Systematic assessments of the distribution range and population status of rusa deer is therefore critical to understand, to develop sustainable management strategies.

Wildlife in Papua, particularly the rusa deer play significant role both in the livelihood and the culture of local people in Tanah Papua. Moreover, transmigrant communities and other ethnic groups appear to rely on wildlife hunting and utilize them for various purposes. However, the utilization of wildlife should be carried out within sustainable biological boundaries. Wildlife is part of the natural resources that can be sustainably utilized for subsistence and commercial purposes if the sound management plans are in place. The populations of rusa deer has potential benefits to support economic developments in the rural areas of Tambrauw regency, and rusa hunting would be part of conservation initiatives to protect forest and its native biodiversity. However, other than a preliminary study on wildlife hunting in the Jayapura region (Pangau-Adam et al, 2012), there is lack of information about the current hunting practices on rusa deer and the importance of the game products in Tanah Papua, Indonesia.

Given that there is a paucity of data about the existence of rusa deer in Tanah Papua, there is an urgent need for field studies designed to provide baseline data of population abundance and current hunting practices allowing for informed future management decisions.

The aim of this study was to assess the population status of rusa deer and to determine the extent of hunting practices on this species in Tambrauw Regency, West Papua Province. The study further aimed to provide training on wildlife assessment techniques for local staff (i.e., student and scientists).

Specifically the study was intended to:

- Investigate the distribution range and population abundance of rusa deer in Tambrauw region.
- Assess the level of hunting and the overall importance of rusa deer to local people and other communities.
- Quantify the harvest rate of rusa deer and associated economic trade.
- Establish co-operative links with government agencies in order to develop strategies aimed at sustainable utilisation of hunting products in Papua and other island of Indonesia.
- Train local Papuan students and young scientists from universities and other institutions in wildlife assessment.

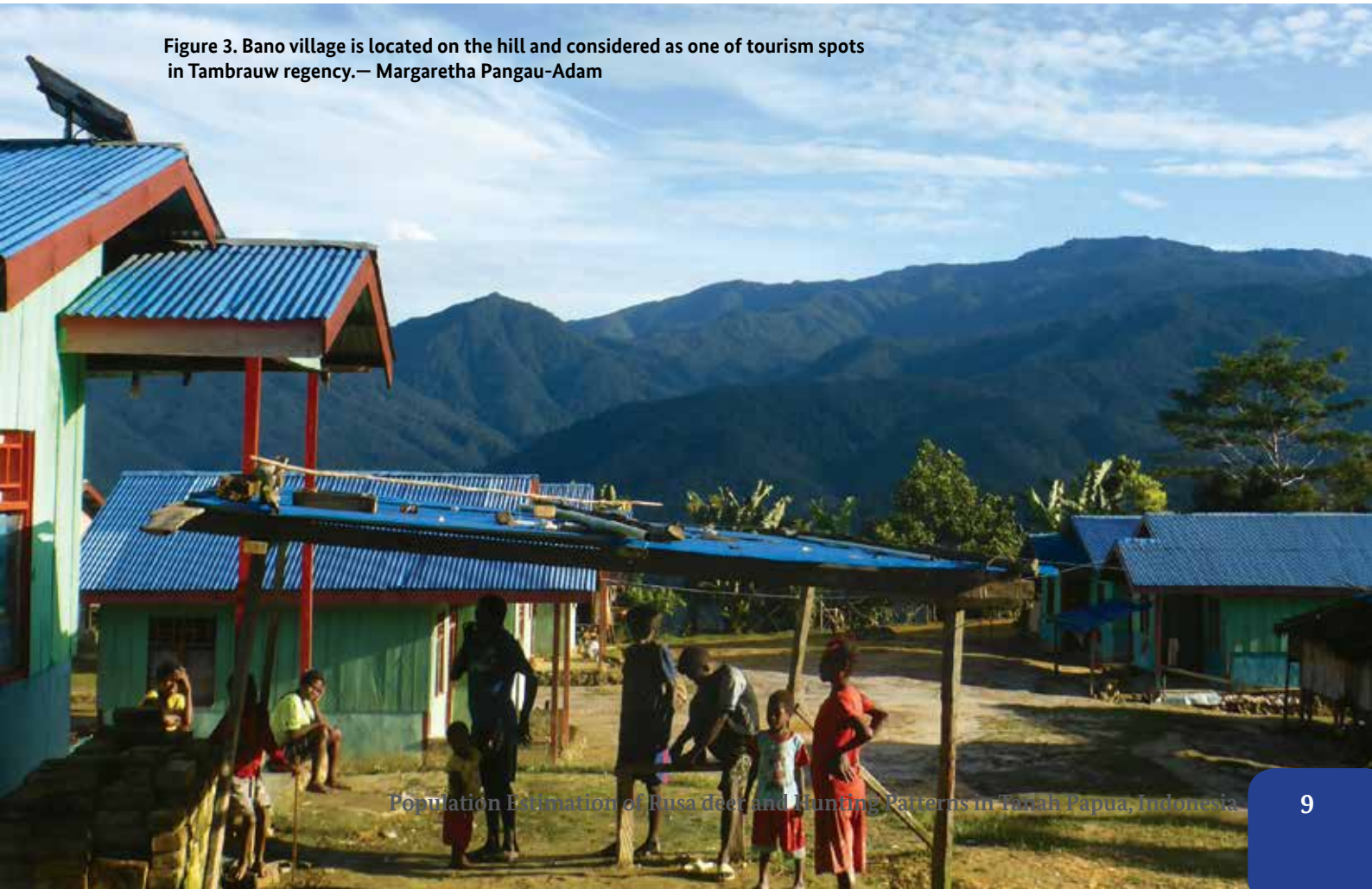


Figure 3. Bano village is located on the hill and considered as one of tourism spots in Tambrauw regency.— Margaretha Pangau-Adam

Project Study Area

This study was conducted in Tambrauw Regency which is located in the upper part of Vogelkop Peninsula, West Papua Province, Indonesia. This regency covers 11,592.18 km^2 area and consist of 29 sub-districts. Claimed as a conservation regency by the government, over 80% of Tambrauw land areas have been set aside as conservation areas and protected forest (Bappeda Tambrauw, 2014). This regency is the largest conservation area in Tanah Papua, with not only protected forest areas but also the conservation of rare turtles and bird species that are amongst the main conservation focus (Fatem, 2015). West Papua forests in alluvial plains host high species richness of different species, particularly high number of tree species that are found all over Tanah Papua (Petocz, 1987). Grassland ecosystem occurs in Kebar valley and this area is dominated by alang-alang (*Imperata cylindrica*). The beaches along the north coast of Tambrauw is a major breeding ground and habitat for the Leatherback Sea Turtle (*Dermochelys coriacea*). This coastal area so-called Jamursba Medi has become the focus of multiple research projects like Blue Abadi Turtle Conservation, WWF and other NGOs.

Figure 4. Map of study area, Tambrauw region, Tanah Papua

Human Population

Tambrauw regency is amongst the regencies in Tanah Papua with small number of human population. In 2010, this regency was the smallest population in Indonesia (6144 people), but the human number is increasing and has become 32,027 (2.78 people/km^2) in 2019 (BPS Tambrauw, 2020).

Study Site

Field surveys were conducted in Kwoor basin (Kwoor and Tobouw districts) and Jamursba coastal forest (Abun district). The study sites cover a total area of 4800 hectares or 48 km^2 (Figure 3).

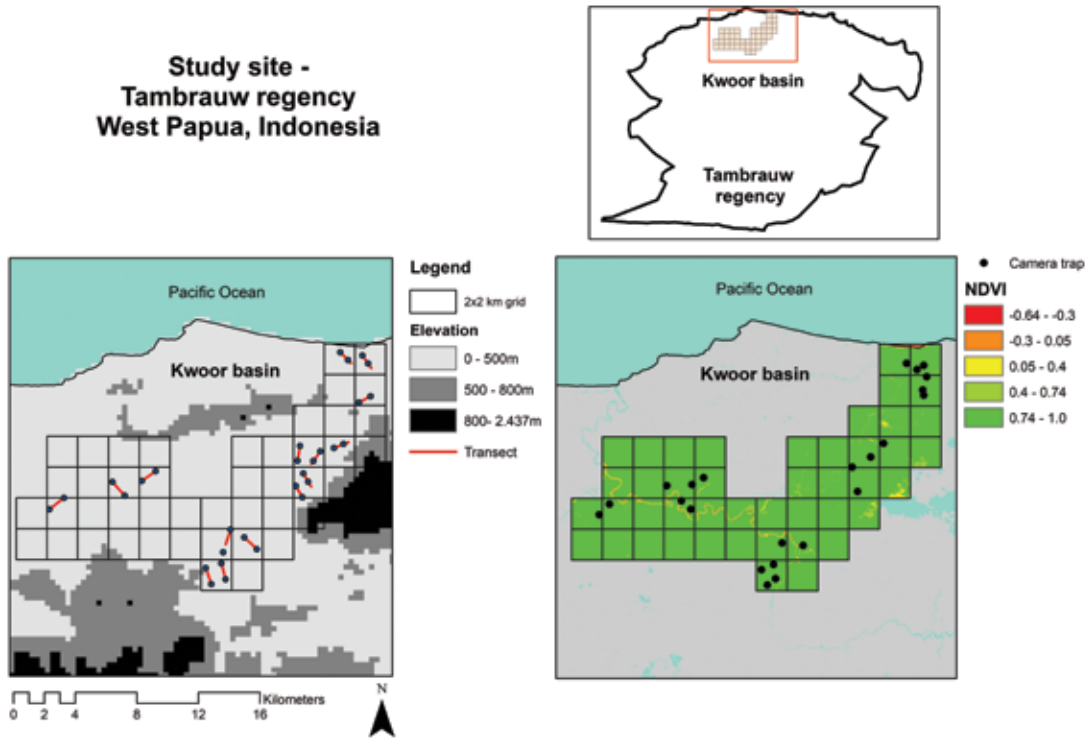


Figure 5. The top right map shows the Tambrauw regency and the study site, Kwoor basin. The bottom left map displays the surveyed transect lines distributed across grid cells superimposed in Kwoor basin and Jamursba forest with elevation background. The bottom right panel shows our deployed camera traps locations.

Figure 6. Kwoor basin in Tambrauw region.— Margaretha Pangau-Adam

Research Methods and Analysis

1. Distance sampling surveys

We superimposed a grid of 2 × 2 km cells across the study site, each cell included 1 or 2 transect with a random starting point (Figure 5). We surveyed 15 transects with 2 km length during field surveys in 2019. The transect lines were distributed across grid cells and were spaced at least with 1-km distance to avoid double counting. We implemented our transect surveys by a teams of 3 observers, one master and two skilled indigenous people, who were able to unambigously identify and detect the rusa deer. Our detections of rusa deer could not be misidentified to other sympatric species, as they are the only deer species introduced to the region in the past century (Hedges et al. 2015). Surveys was began roughly at about 07:00 a.m. and ended in late afternoon (18:00 p.m.). Forest in West Papua is owned by indigenous clans and therefore, prior to the surveys, we discussed the goal of our study with respective clan's head/leader. This led to variation in our sampling effort (i.e. transect length, non-uniform coverage of the study site), and as such that some transects were left unsurveyed, because they were located in forest territories for which there was no permission to implement our surveys.

Along each transect, we measured the detection distances (r) and angles (θ) from the line to animals using a laser range finder (Leica1000-R) and GPS (Garmin 64s). The perpendicular distances (x_i,..., x_n.) were then calculated as $x = r \sin \theta$ (Buckland et al. 2001; Thomas et al. 2010). The frequency distributions of perpendicular distances were used to calculate the probability density function $f(x)$ that models the reduction in detection of rusa deer group sizes with distance from the line. We estimated the detection probability $g(x_i)$ as function of observation distances (Buckland et al. 2015). Abundance estimates for a survey region can be calculated as $A \times N/a$ where A is the survey region, and N is the abundance in the covered (sampled) region (Miller et al. 2019).

We ran several distance models using the 'ds' function in R package 'Distance' (Miller et al. 2019). Three key functions were used including the half-normal with default 2 cosine adjustment terms, a hazard-rate, and a uniform key function with 1 and 2 cosine adjustments. The detection function models were only fitted for the pooled rusa deer data without stratification of the area. However, we fitted multiple covariates in our distance models such as normalized vegetation difference index (NDVI), the mean elevation and the observers as factor. We used Akaike's Information Criterion (AIC) to select between candidate models (Burnham and Anderson 2003; Buckland et al. 2015).

2. Camera trap surveys

During the survey we set up 23 camera stations in six forest sites in May 2019. The Reconyx HC500 camera-trap were deployed at random start and end points of the line transects, and camera traps were spaced at least with *ca*. 1 km distance. The distance from the cameras to near villages or roads was recorded. Camera traps were mounted to the bases of trees (~50 cm height) and housed within protective metal cases. They were set up to operate 24 hours per day, recording color images during the day and black-and-white at night. The battery pack can last in the field for six months. These camera traps were collected in October 2019 and documented data have been analysed. A total of 21 cameras could be collected from study sites whereas 2 cameras were missing.

Figure 7. Deploying camera traps with local staff and guides.—Margaretha Pangau-Adam

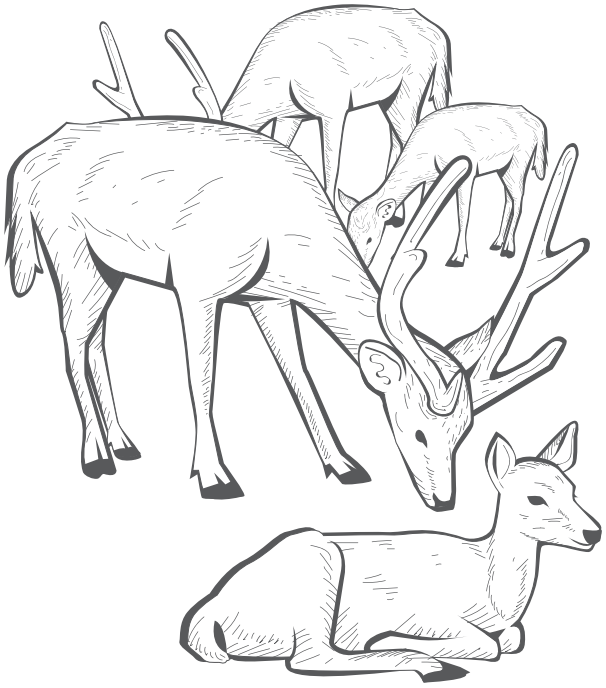
3. Modelling rusa deer population from camera trapping data

Initially we defined sampling occasions (which is equal to the definition of 'season' in occupancy modelling) which is the replicated counts of rusa deer for every two weeks from camera trap operations (Ngoprasert et al. 2019). So the count data included eleven occasions (i.e. May, May-Jun, June, June-July, July, July-August, August, August-September, September, September-October, October). We calculated two sets of covariates for each sampling unit: 1) Site covariates included: 'distance to village' (i.e. a distance from camera trap location to the nearest village), distance to river, elevation and Normalized Difference Vegetation Index (NDVI) and 2) Survey covariates included 'trapping effort' (i.e. the number of days that each camera trap has been operated over the entire of the camera trapping period).

4. Assessment of rusa hunting and trade

Data on wildlife especially rusa hunting were collected through interviews, questionnaires and hunting surveys. A set of questions was emphasized on reason for hunting, methods used, frequency of hunting trips, hunting ground and target species. The interview surveys were conducted in 30 villages of 15 districts in Tambrauw regency. A total of 145 hunters and key informants, and 90 households have been interviewed using semi-structured questionnaires. Prior to the interviews village, tribe and clan leaders were approached for permission and to obtain general information on hunting activities. Several interactive focus group meetings and discussion were undertaken, where community leaders and villagers may participate in providing explanation concerning wildlife hunting and related subjects. Local markets and trading centers were surveyed and monitored to obtain data and information on wildlife particularly rusa deer trade. In addition, three wildlife handlers were requested to provide information concerning rusa deer trading.

Figure 8. Interviews with local hunters .— Moses Yenggreng



Project Results

Distribution Range of Rusa Deer

Based on field surveys, village meetings and interviews, our study suggests that the distribution of rusa deer in the Tambrauw region is ranging from coastal areas in the north, lowland forest, grassland ecosystem in Kebar to the hill and rugged forest up to 900 m a.s.l. Rusa deer were distributed across Tambrauw region particularly in the 15 studied districts. Apparently this ungulate had adapted with different habitats and found suitable conditions with adequate foraging resources and favorable climate. The absence of main predators may support their increasing population in Tanah Papua. Rusa deer mainly inhabit lowland forests, grassland and hill forest, and were rarely found at high elevation sites. The habitat of rusa deer in lowland forest holds typical canopy tree genera including *Terminalia, Pometia, Ficus, Alstonia, Canarium, Artocarpus* and *Intsia*, whereas mid-story trees include *Myristica, Syzygium, Garcinia, Diospyros, Maniltoa*, *Spondias, Gnetum and Pandanus*. These forest vegetation provide food and resting place for rusa deer. Additionaly, Kebar grassland provides natural pasture or grazing areas for rusa deer. The secondary forest in Kebar is mostly dominated by matoa (*Pometia pinn*ata), binuang (*Octomeles sumatrana*) and damar (*Araucaria* sp.) (Pattiselano, 2012). Rusa deer has also been detected in the forests along coastal areas of Tambrauw, where the major breeding ground and habitat for the Leatherback Sea Turtle (*Dermochelys coriacea*) is situated.

Figure 9. Grassland ecosystem in Kebar.— Margaretha Pangau-Adam

Population Density and Abundance of Rusa Deer

Our field surveys using direct distance sampling method in a 48 km² studied area in Tambrauw region estimated the population density of rusa deer to be 10.34 individual/km² (95% CI 5.36–19.98) (Table 1). Moreover, the estimation abundance of this ungulate was 497 individuals (95% CI 257–959).

The camera traps were operated about six months (May-October 2019) across 21 sites which resulted to the detection of 1349 individuals of rusa deer. Estimation of population abundance under the Poisson mixture model ranged from 625 to 853 individuals (mean = 734), and based on negative binomial model was 909 to 1406 (mean = 1142) individuals (Table 2). Using both models, the population density of rusa deer was estimated to be 15.3 and 23.8 individuals/km², respectively. This may indicate the high population of rusa deer in the area studied, Kwoor basin. Pattiselano (2012) using point count methods reported an estimation of rusa deer abundance in Kebar grassland to be 3 individuals/ha. The methods used in Kebar was different, and rusa deer could be much easier detected in grassland habitat than in dense forests. In comparison, a study in Australia (Moriarty 2004) specified on the abundance of rusa deer in the Royal National Park found the estimated density to be 16.7 and 19 individuals/km² in 1999 and 2001, respectively. Along with other introduced deer species, rusa deer could potentially occupy most of the continent especially the northern Australia (Davis 2016). Due to its increasing population and predicted distribution, rusa deer has been classified as a pest species in several states of Australia (Moriarty 2004, Davis 2016). It appeared that rusa deer in Tambrauw would become overabundant unless its population is limited through traditional wildlife hunting. Further study is needed to assess the likelihood of rusa deer as a pest in the region.

Table 1. Summary of the distance sampling models to estimate Rusa deer density in Tambrauw, West-Papua, Indonesia. CI stands for confidence interval, CV is the coefficient of variance and df indicates the degree of freedom.

Region	Area (km^2)	Covered sampled (km^2)	Encounter rate group per km^2 (SE)	Expected group (SE)	Model	Goodness-of-fit			Abundance (0.95% CI)	Density, km^{-2} (95% CI)	CV%
						Cramér -von test	p-value	df			
Kwoor	48	2.65	0.60 (0.15)	2.35 (0.12)	Half-normal cousine, adjustment 2	0.19	0.29	29	497 (257–959)	10.34 (5.36–19.98)	0.33
					Hazard-rate cosine + habitat	0.15	0.39	27	461 (237–893)	9.60 (4.96–18.60)	0.33
					Uniform cousine, adjustment 1, 2	0.14	0.41	18	449 (166–1219)	9.36 (3.45–25.40)	0.51

Table 2. The site specific conditional posterior abundance estimates (95% credibility intervals) of the rusa deer for Poisson (P) and negative binomial (NB) models obtained from Bayes's rule.

Site	Model	Mean (λ)	Mode	2.5%	97.5%	Model	Mean (λ)	Mode	2.5%	97.5%
1	P	8.85	8	4	15	NB	3.95	2	1	10
2	P	12.42	102	6	19	NB	16.75	11	3	41
3	P	7.32	7	5	11	NB	11.64	11	6	19
4	P	12.56	12	10	16	NB	41.60	40	29	57
5	P	39.23	39	35	44	NB	107.45	106	89	128
6	P	31.92	32	27	37	NB	74.59	74	60	91
7	P	65.29	65	58	73	NB	119.82	119	103	138
8	P	25.92	26	21	32	NB	30.76	30	23	40
9	P	49.29	49	41	58	NB	145.23	149	117	166
10	P	47.68	47	38	58	NB	91.67	89	66	122
11	P	67.68	67	59	77	NB	50.26	50	43	59
12	P	156.20	157	145	166	NB	123.55	123	113	134
13	P	128.29	128	118	140	NB	162.41	167	152	167
14	P	29.28	29	23	36	NB	69.14	68	51	91
15	P	8.87	8	6	13	NB	17.27	16	9	28
16	P	8.54	8	5	13	NB	14.00	13	7	23
17	P	23.96	24	17	31	NB	37.59	36	23	56
18	P	10.44	10	7	14	NB	24.04	23	14	36
Total		733.74	818	625	853		1141.72	1127	909	1406

Figure 10. A rusa deer detected from camera trap

Factors Influencing Rusa Deer Population

High population density of rusa deer in Tambrauw is influenced by several determinant factors. During field surveys and observation, rusa deer was detected in each study site and along each transect. However the variation of detection between sites indicated their habitat preference. Detection probability of rusa deer decreased in areas adjacent to river system compared to other forested areas. Rusa deer occurred infrequently around river banks because river sides are actively used by villagers for fishing and other daily activities. Like in other parts of Tanah Papua rivers serve as travel corridors for humans and therefore provide hunting access (Brodie *et al* 2018). In addition, the abundance of rusa deer appeared to be higher in July and August than in other months, because of the breeding season which peaks in these months. This period also coincided with the fruiting season of forest trees such as *Terminalia* spp, *Syzygium* spp, *Cerbera* spp and *Myristica* spp, which presumably influence the activities of rusa deer. The results indicated that rusa deer tend to occupy habitats with a high density of forest vegetation including secondary forests, which provide adequate foraging places. Moreover, this species was less detected in the areas close to human settlements. Low human population in rural areas of Tambrauw results into less settlements may favor an increased population of rusa deer. Our results also suggest that rusa deer were significantly abundant in higher altitudes, because a rough terrain hinders intensive human activities and therefore reduces hunting efforts. However as reported by villagers and hunters, rusa deer is rarely found in the forests at elevation of 800-900 m a.s.l.

Effects of Rusa Deer on Vegetation Structure

During field surveys, the observation of vegetation structure along all transects at rusa deer habitats were conducted and a number of damaged young trees in almost all study sites were encountered, showing the consequences of rusa deer herbivory on understory forest vegetation. Ungulates are known as ecosystem engineers because they maintain the heterogeneity of landscape, but if they are introduced in habitats wherein they are invasive, they can adversely affect species composition of plant communities (Gordon et al. 2004, Davis et al 2016). For instance, in Papua New Guinea (Kwapena 1975), New Zealand (Allen et al. 1984) and Australia (Keith & Pellow 2005), the vegetation structure has been substantially altered by the browsing of introduced rusa deer and other ungulates. Further study and predictive modelling are needed to assess the impact of rusa deer on vegetation and forest structure in Tanah Papua, and especially in the Tambrauw region. Moreover, the relationships between different forms of rusa management and the potential impacts of rusa deer on native vegetation, as well as secondary cascading effects on the ecosystem, would require further monitoring and research programmes.

Figure 11. Samplings damaged by rusa deer.— Margaretha Pangau-Adam

Figure 12. Kwoor river vegetation.— Margaretha Pangau-Adam

Hunting Patterns

Our study suggests that traditional hunting is a significant livelihood activity in Tambrauw region, because it provides the majority of animal protein for the local families. This finding is consistent with the studies on wildlife hunting in other regions in Tanah Papua (Pangau-Adam et al, 2012; Pattiselano, 2014). Based on the interviews and surveys in 15 districts, we found a total of 18 wildlife species and several canopy birds were hunted in this region. Rusa deer and wild pigs have become the main target species of hunting activities in the study sites.

Hunting trip was pursued alone and/or in a group with family and clan members. Hunting in groups was occasionally done, if they need to hunt animals for family/community festivals, religious and traditional ceremonies. Hunting trips varied from 3 times a week to 2 times a month. Depending on encounters and the abundance of wildlife, several animal kills might be made per hunting trip. Checking snares on hunting grounds was frequently done by at least two hunters as anticipation of plenty harvest. Hunting was mostly pursued by adult men, although school children also searched and hunted wildlife after school time or during school holiday. Hunting activities decreased during rainy season, because of heavy rains, flooding and enlarged rivers.

Concerning rusa deer population, hunters from eleven districts reported that the abundance of rusa deer is relatively high in their traditional forests, whereas hunters from Kebar areas, Moraid and Sausapor districts complained that road construction and increasing car transports have driven the animals far from their hunting grounds. Hunters from Selemkai district reported about intensive hunting operation of people from Sorong city including the participation of army personals in their clan forests. This may considerably influence rusa abundance in their forest areas.

Reasons/Motivation of Wildlife Hunting

Wildlife hunting in Tambrauw was practiced for several reasons. The main reasons are for subsistence, commercial purposes and traditional/religious events. Prior to western contact, local people in this region have hunted wildlife only for subsistence purposes. However the introduction of a cash market economy, combined with rapid urban and infrastructure development in Vogelkop Peninsula have brought a significant change in hunting purposes and practices in this region. In our study, about 41% of interviewed hunters declared that they hunted for commercial purposes, showing that there has been a market shift from local-level subsistence hunting for meat consumption towards more intensive commercial hunting. Cultural and religious differences affected hunting practices across the study area. Rusa deer are hunted and consumed by all type of communities, whereas wild pig is taboo in particular groups. In forest and riverside villages, hunting was also carried out to avoid rusa deer and wild pig raiding crop fields and forest gardens.

Hunting Techniques

A variety of methods were used for wildlife hunting and most hunters used more than one technique to hunt. Hunting methods include setting snares, bow and arrow (archery), spear, using dogs, ambushing, jack-lighting (hunting at night using flashlights), air rifle and machetes. The most prevalent hunting techniques were the use of traditional methods (e.g., spear, archery, with dogs) and setting snares. In the past, hunters mainly used traditional hunting tools and ambushing. Using snares and air rifle are the results of immigrant influences into the local communities. Snares usually

Figure 13. Traditional techniques for hunting. — Margaretha Pangau-Adam

are targeted to capture wild pig and rusa deer, but other non-targeted animals can also be trapped upon encounters. Most hunters using snares usually installed more than 20 snares and these were monitored at least twice a week. Hunting with dogs, archery and spears are often practiced to catch rusa deer, wild pig, wallaby, and also cassowary if available. Although it is prohibited, about 8.3% of all hunters reported the use of air rifles for hunting birds, bats and arboreal marsupials, but also other animals upon encounters. Hunting with dogs was usually done in dry season, which enables to move through dense vegetation rapidly. Ambush was practiced during late dry season and early rainy season, typically from near or in tree whose fallen fruit attracts animals, feeding at the day or night. It is found that hunting strategies among local communities differ depending on the organization of clan, hunters, general seasonal conditions and the immediate need for meat. Hunting using snares can be detrimental to native wildlife species such as cassowaries, crowned pigeons, brush turkeys and ground marsupials, therefore this technique should be replaced and hunters should return to traditional hunting methods.

Hunting Sites

We found that hunting sites are related to clan and traditional forests (Hutan adat), which include primary forest, secondary forest and mixed or forest gardens (Table 3). The location of some traditional forests along river systems is far from the villages, thus, hunters should own a boat or rent it to reach into their hunting grounds. Renting a boat is quite expensive and it is not cost-effective to compensate for, if there is no harvest at hunting sites. At high elevation areas hunting on rusa is less successful. Rusa deer hunting intensity and success varies according to differences in accessibility of the surrounding terrain, traditions, and socioeconomic status of the inhabitants.

Table 3. Summary of wildlife hunting in fifteen districts of Tambrauw Regency, West Papua

Hunting purposes	Subsistence, trade (occasional, professional), festive and traditional ceremonies
Main techniques	Archery, spear, with dogs, snares, machetes, air rifle, jack lightings
Sites of hunting ground	Primary forest, secondary forest, forest gardens
Target species	Rusa deer, wild pig, ground and arboreal marsupials, ground and canopy birds, Varanus lizard, echidna, bats
Most hunted species	Rusa deer, wild pig, bandicoots (ground marsupials)
Frequency of hunting	Three times per week to 2 times a month

The Importance of Rusa Deer to the Local Communities

Wild meat are important sources of animal protein in rural communities, particularly in the remote forest villages with limited access. Rusa deer and wild pig represent the most frequently hunted mammals in all the fifteen districts surveyed with exception in Bamusbama district, where rusa deer was rarely found at the high elevation forests (800-900 m a.s.l). In the very distant areas away from towns and marketplace, hunting on wildlife was practiced at subsistence level to fulfill the protein needs of families. Hunters with access to local markets, in towns and trading points were able to pursue commercial hunting. Sausapor and Fef towns provide markets for wild meat. Because of some religious reasons the consumption of wild pig meat is limited in some community groups, whereas rusa deer meat (venison) can be consumed by all community groups. This has led to the extend demand of rusa deer meat from markets in towns and the cities of Manokwari and Sorong. Following the increased market demand hunters from three districts only concentrated on hunting on rusa deer using snare traps.

Based on the household surveys, the most consumed wild meat in study area were that of rusa deer and wild pig, but marsupial meat was also frequently consumed by local communities. The proportion of wild meat in the diet of villagers surveyed varied greatly between sites depending on the remoteness, habitat type and participation in cash economy (Table 4). In the remote forest villages with limited outside access, wild meat and/or wild fish were the most frequent protein items in the meals. In the coastal areas, wild meat was less important than marine fish. Moreover, in accessible areas with alternative sources protein including poultry, wild meat was also less consumed.

Table 4.The frequency of wild meat as a component of the meals of villagers

Site description	Number of household	Percentage meals containing wild meat (mostly of wild pig and rusa) per week	Other protein sources
Forest villages	27	65-70	Fresh water fishes
Coastal areas	12	25-30	Marine fishes, sea turtles, turtle eggs
Riverside villages	14	55-60	Fresh water fishes, shrimps
Town and surroundings	20	20-25	Marine fishes, poultry, canned fish and meat
Kebar valley	17	50-55	Fresh water fishes, poultry, nuts

Rusa Trade in Tambrauw

We found that wildlife trade in the Tambrauw region focused on the meat of introduced species, namely rusa deer meat (venison) and wild pig meat. Wildlife meat was sold within villages or occasionally offered at the roadside of Trans Papua, but the main trade of venison occurs in trading points and markets in towns and in the cities of Sorong and Manokwari. The distance from Sausapor to Sorong is *ca*. 115 km and takes about 4 hours by car. From Miyah and Kebar to Manokwari are about 6 and 4 hours travel by car, respectively. The price of venison sold in the cities is much more expensive, than in villages or towns, but the benefit goes to middlemen and meat vendors. Hence, there is a big challenge for local hunters to act as key players in the trade of venison and wild pig meat. Recently, one hunter has become a wild meat handler for rusa harvest in Kwoor basin. This indicates the improvement of wild meat marketing which is now involving local people. A number of hunters would also smoke the venison as to turn it into dendeng rusa (i.e. smoked venison) and then brought into the market over the following few days. Some hunters from Kwoor and Sausapor also offered their harvest to the restaurants in the town. Because of increasing demand of venison at certain occasions like Christmas and Eid feast, several hunters increased their hunting efforts during feast periods. In addition, antlers of rusa deer were collected and traded in towns and cities for home decoration. In Kebar areas rusa pelt was also traded for different purposes including artistic home decoration (Pattiselano, 2012).

Local people are often poorly equipped with traditional methods of handling and marketing of venison. If this would be developed towards professional trading activities, sustainability should be thoroughly considered and implemented in order to secure the long-lasting utilization of forest products.

Wildlife Hunting and Sustainability

It is well known that unsustainable hunting will lead to population decline of species. Unsustainable harvest, exceeding recruitment, will likely cause the extirpation of target species. However, the extermination of introduced/invasive herbivores that are well adapted and increased abundantly is not possible through predators or hunters, especially if – as in Tambrauw region, there are areas for refuge. A preliminary assessment of sustainability of hunting on rusa deer using models proposed by Robinson and Redford (1991) shows that information on population density, demographic characteristics of the species, area size and hunting patterns are required. The analyses of hunting and capture rates, combined with estimates of population densities and rates of increase have shown that hunting levels of rusa deer in Kwoor basin, Tambrauw, is apparently sustainable under the condition of maximum production (P_{max}) = 5.07. The potential harvest within the 48 km² study area (*PH*) = 97.34 individuals per year is higher than current harvest rates of ca. 69 individuals per year. However, since September 2018, parts of the studied sites in the Kwoor basin were established as a *sasi* area which bans hunting of rusa deer. The implementation of this traditional law influenced the capture rates of rusa deer, being lower than the potential harvest.

Because wildlife plays an important role as protein source of local people and recently also for income generation, many local communities are seriously concerned to manage the capture rates of animal targets. If the abundance of animals dramatically decreases and natural resources depleted, the so called *sasi* system would be applied. *Sasi* refers to a traditional system of natural resource management and includes banning on resource harvest on land and in sea (McLeod et al. 2009). *Sasi* forest and wildlife may describe specific traditional rules and regulations governing access to cutting forest areas and to hunt particular wildlife. This system has been practiced in the Mollucas and in many part of Tanah Papua since hundreds years. *Sasi adat* is governed by traditional law and practices,

and *sasi gereja* (church) is governed by the Christian church. This system can be implemented in a specific rotation way or within certain agreed periods. We found that some communities in Tambrauw have developed and implemented *sasi adat* and *sasi gereja* to avoid overexploitation of forest, wildlife and marine resources (Table 5). According to the clan and community leaders *sasi* was established because the abundance of large-sized wildlife has reduced drastically after intensive harvesting in the previous years. *Sasi* is also addressed to attract and improve ecotourism and wildlife tourism to benefit local communities. Our field observation and camera trapping data indicate the high number of wildlife species and high encounter of rusa deer in sasi forests.

Table 5. Sasi practiced by local communities in Tambrauw.

District/Village	Type of sasi	Resource ban
Tobouw/Syunggak	Sasi gereja	Forest and wildlife
Bikar/Bikar	Sasi adat	Large wildlife
Bikar/Werur	Sasi adat	Rusa deer and marine fish
Kwoor/Kwoor	Sasi adat/clan	Wildlife

Wildlife taboos, for instance taboo of cassowary, cuscus, cockatoos and tree kangaroos, are practiced by several clans in the study area. It is traditionally believed, whoever hunts the taboo animal will get punishment in supernatural form. Taboos are a significant component that should be considered in forest management. Both the *sasi* system and taboos are forms of traditional knowledge and beliefs which can provide important mechanisms to support sustainable management of natural resources and biodiversity conservation.

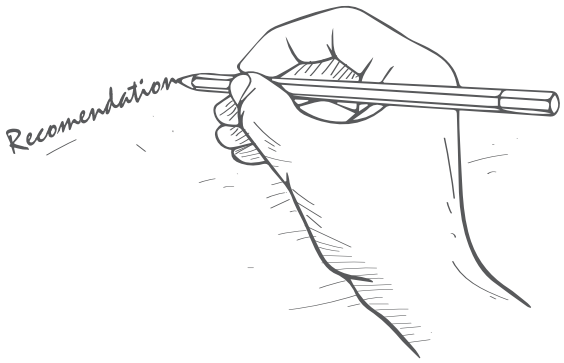
Figure 14. Habitat of rusa deer. — Margaretha Pangau-Adam

Lessons Learned

As an introduced species, rusa deer successfully colonized much of the Tambrauw region and has become an important target of wildlife hunting. Basically, the rusa deer is protected by the national law (Government Regulation PP No. 7, 1999) and considered as vulnerable in the IUCN Red List of Threatened Species (Rahman *et al*. 2020), however its presence in Tanah Papua as an introduced species can negatively affect the composition and persistence of Papuan native flora and fauna. Thus, in order to reduce their negative impacts, it is critical to limit their population size. This could be undertaken by adopting integrated local policies on rusa deer hunting and trade based on traditional ecological knowledge of local communities, and the recent analyses on hunting practices and rusa population. As humans have lived and hunted in Papuan forests for many thousands of years, a special regional regulation (*Perdasus*) of wildlife hunting for Tanah Papua should be issued at regency and provincial levels. Regulation for commercial hunting could be established by the government, involving the decisions from external experts professionally trained in wildlife and habitat management. The trade scheme need to be properly monitored and managed so that hunting merely targets the introduced/invasive species (i.e. Rusa deer and wild pigs) as the trade incentives may otherwise escalate hunting pressures on native species in the region. The *sasi* system and wildlife taboos should be integrated in regional management by the regency government as local conservation initiatives to support sustainable hunting. Moreover, hunting using snares can be detrimental on native wildlife species such as cassowaries, crowned pigeons, brush turkeys and ground marsupials. The snare technique should be replaced by traditional hunting methods like hunting by dogs, using archery and spears. Traditional institutions together with the Tambrauw regency government (Environment and Forestry Service) could plan and set up the regulations on all types of exploitations pertaining to wildlife and forests, including the rules of preventing using shotguns to hunt.

The existing collaboration with GIZ, the University of Göttingen (UGOE) and Universities in Tanah Papua (Universitas Cenderawasih or UNCEN in Jayapura and Universitas Papua or UNIPA in Manokwari) should further undertake monitoring of rusa deer population and hunting practices in Tambrauw region to guide the practice of sustainable hunting and ensure that local people get benefit of rusa trade. In the meanwhile, rusa deer hunting scheme should not elevate the hunting of other native species. A form of community-based co-management could be established to properly manage and maintain sustainable wildlife hunting in the region. Furthermore, intensive research is required to clarify the ecological effects of rusa deer on the forest ecosystems.

Figure 15. Training local staff and guides (Betwel Yekwan and Moses Yenggreng) on GPS handling.—Betwel Yekwam



Recommendations for Future Management Decision

Rusa deer and wild pigs are abundant in the Tambrauw region, Tanah Papua. Hunting on these introduced species can generate alternative income for local communities. However professional guidance is needed to pursue a sustainable wildlife hunting, therefore a form of 'Community-based Co-management' (described below) should be established.

A Model of Community-Based Co-Management
(modified from Bodmer and Puertas, 2000)

Wildlife management should involve the combination of community-based and co-management strategies. The community-based side recognizes that communities are responsible for performing wildlife management. The co-management side involves stakeholders who have a meaningful interest in the appropriate management of Tambrauw forests and this includes local communities (e.i. dewan adat, kelompok pemuda adat, women group), government agencies, NGO, extension workers and researchers. The communities will make decisions on how to manage wildlife and other forest resources. Community members vote on resource use and management issues democratically during community meetings. When communities vote, government officials, extension workers, and researchers can be present and provide advice if needed. The government programmes, extension activities and research results will be incorporated in the management and resource use decisions. Wildlife extension workers should link government regulations and results from wildlife research back to the communities. Community-based co-management relies on the acquisition and communication of information. For example, local people perform management that affects animal populations. Biological studies that focus on population assessments may generate information on the impact of hunting and effectiveness of management. The extension activities will convey results from biological studies to local people. The impact of management can only be determined through research on target species. Therefore, research and extension will link the realities of animal populations back to community-based management.

Wildlife researches and extension workers should adopt participatory approaches that involve local people. This requires building interest and trust in community-based wildlife management by researchers working with hunters when evaluating the impact of harvests. For example, one of these methods will use skulls from rusa deer that hunters have caught. By collecting skulls, hunters

and their families become involved in the data collection. Women will be actively participate as they usually cook and clean the skulls, and may help their husbands or sons for labelling and storing them. Such a participatory approach may help researchers, extension workers and hunters to find common ground namely the 'rusa skull' to discuss wildlife hunting issues. To make this happen, a dedicated core group should apply consistent research project to advance the process. This group may consist of the wildlife researchers, extension workers including dedicated professionals who work with communities, and community representatives.

The following potential research projects and programmes would be recommended:

Research projects

1. Field research with focus on rusa deer-vegetation interactions aiming to characterize and quantify the impacts of rusa deer on native vegetation communities (*students from Germany have shown interest to work on this subject*).
2. Further research on the monitoring of rusa population abundance.
3. Assessment of the impacts of introduced species (rusa deer and wild pigs) on native wildlife assemblages.
4. Inventory of traditional forests, ecosystem services and forest value analysis, and potential sites for wildlife tourism and ecotourism.
5. Assessment and compilation of *sasi* systems, traditional directives and taboos related to sustainable forest management and protection.

Social forestry and community development (*with consideration of the information from local authorities*)

1. The extensive and monitoring studies of sustainable hunting practices (e.i. harvest rates, monitoring population trends) should be further conducted with researchers.
2. Provision of infrastructure like boat, refrigerator boxes and solar cell power would be required by local hunters and meat vendors to manage animal captured, handling and marketing of rusa deer. In collaboration with the government, the hunters and local meat vendors in need of these facilities will be identified to avoid the misuse of fund. This effort can be combined with government programs that provide supports to empower the small-scale community entrepreneur.
3. In collaboration with provincial and regency government (Trade and Industry Service), training for local hunters and vendors in wild meat handling and marketing should be done, and training on basic financial management for households should be addressed to villagers (women and men).
4. Mapping of traditional forest territories and *sasi* sites. This could be assisted by GIZ and UGOE (University of Göttingen, Germany).
5. UGOE, UNCEN and UNIPA in collaboration with GIZ and Tambrauw Government (Service of Tourism and Creative Economy) would organize training on agroforestry system, ecotourism and wildlife tourism for local people.

Information on Collaboration with Government, NGOs and Local Communities, Workshop and Trainings

In collaboration with local Government, NGOs and universities in Tanah Papua, the team had organised workshop, meetings and field trainings for local students, young scientists, local communities and government staff. Followings are several related activities undertaken during the project:

- Presentation and meeting with staff of the Ministry of Environment and Forestry Indonesia and GIZ.
- A short workshop was held at UNIPA Manokwari to introduce the project and establish collaboration between GIZ, University of Göttingen and Universities in Tanah Papua.
- Meeting of the research team with the Vice Rector of UNIPA (Dr. Bambang Nugroho) and staff of Balai Penelitian dan Pengembangan Lingkungan Hidup dan Kehutanan (BP2LHK), Manokwari to discuss potential collaboration programs with GIZ and Universities in Germany.
- Establishment of collaboration with Government of Tambrauw Regency including the Service of Environment and Forestry, the Service of Tourism and the Service of Community Empowerment. They supported the rusa deer study with a great interest, and suggested to obtain the research results. The government proposed to organise workshops and training aimed at improving capacity building of governmental staff in natural resources management. It is planned to deliver some materials and books related to Tambrauw forest, flora and fauna of Tanah Papua to Tambrauw government and Traditional Institutions.
- Interactive field training on wildlife assessment for local staff and students of the Universities in Tanah Papua (UNIPA and UNCEN).
- Sharing information and discussion with Kelompok Pemuda Adat Tambrauw, and NGOs like Blue Abadi Turtle Conservation and Samdhana Institution.
- Involvement of scientists and one PhD student from the University of Göttingen in field activities during the collection of camera traps.
- Collaboration with the University of Montana, US (Prof. Dr. Jedediah Brodie) for the use of most camera traps.
- A policy brief based on this study has been produced and a webinar has been conducted.

Figure 16. Meeting with the Government of Tambrauw.—Betwel Yekwam

Figure 17. In Kwoor basin Tambrauw, rusa antler was taken and the skull often left in the forest.— Margaretha Pangau-Adam

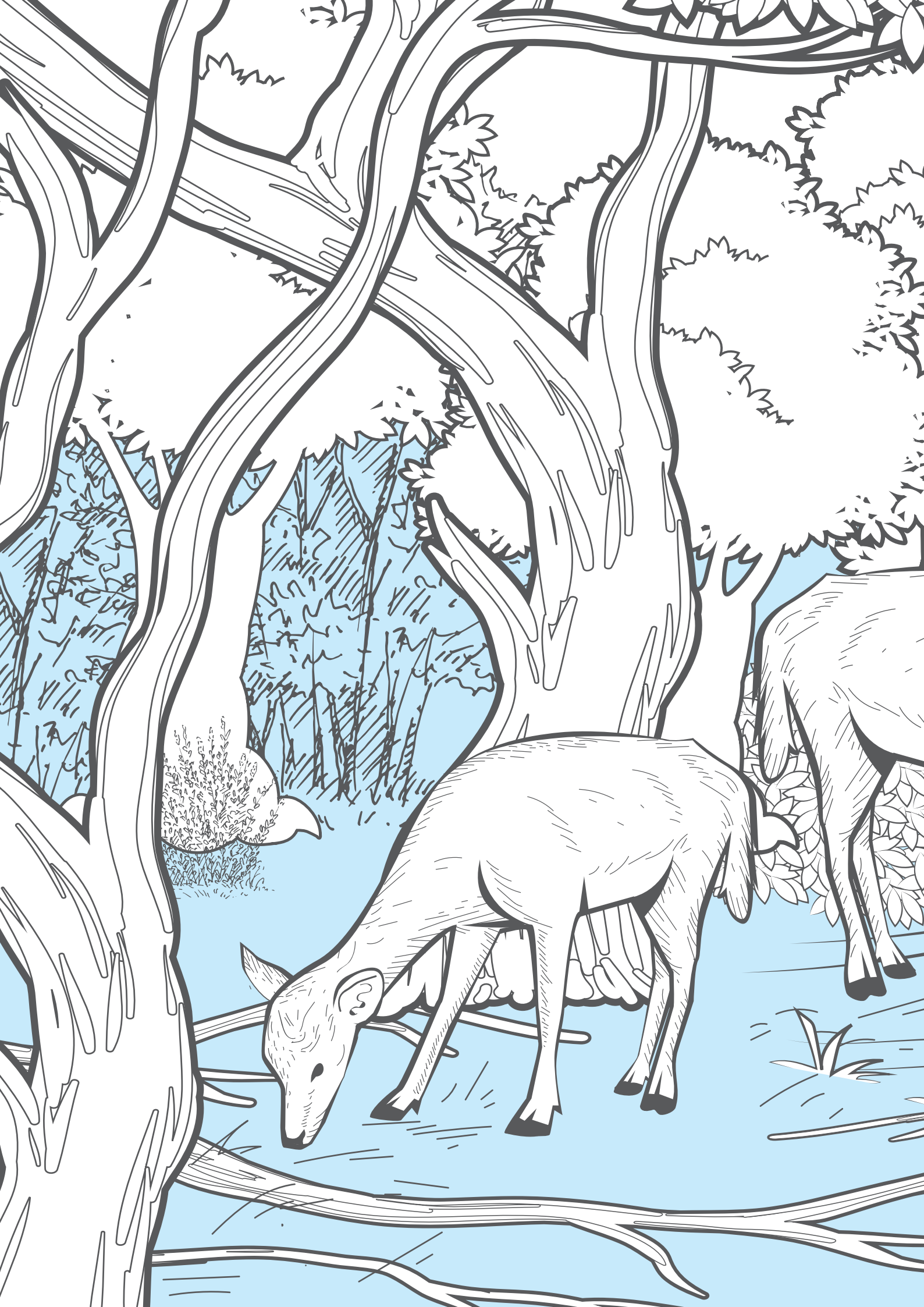



Figure 18. Followings are some pictures of rusa deer taken through camera traps: