Diversity of Mammals
in the Catchment Area of Sa'dang River
South and West Sulawesi Provinces

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2022

Introduction

This is the wet season mammals biodiversity study in this area. Sulawesi's fauna has long been fascinating scientists and naturalist. Located in the central part of Indonesia, Sulawesi is the biggest island in Wallace-Bioregion and is well-known as biodiversity hot-spot, habitats of at least 127 indigenous mammal species, and 79 (62%) are endemic (Whitten et al 1987), and new species of mammals continue to be found. Among the enigmatic and iconic mammal species are the dwarf buffaloes, lowland (*Bubalus depressicornis*) and mountain anoa (*Bubalus quarlesi*), babirusa (*Babyrousa babyrussa*), Sulawesi black macaques and the smallest living primate, tarsier. This island is also habitat of endemic marsupials, bear cuscus and Sulawesi dwarf cuscus. Sulawesi is the west border of natural distribution of the endemic marsupials.

One of the high mammals diversity on the island is forested areas in the western parts wich is in the border of South and West Sulawesi provinces. Wildlife habitats on this region are characterized by mountanious and hilly landscapes, with primary forests at higher altituden and secondary forests at lower altitude. Mixed plantations of coffee, cacao, clove, durian, cinnamom, and other annual commodities dominated the lower altitudes. Dryland agriculture of corn plantation could also be found at lower altitude both on the flat, steep and extremely steep areas. Patchy paddy fields that are close to the villager's settlements could be found along the riverine of Saddang River. The landscape is also characterized by rocky-cliffs along the riverine. This study aimed to reveal mammals diversity in the catchment area of the river, especially mammal species inhabiting various habitat types at 0 – 3 km distance from the river banks covering many habitat types including secondary and primary forests, riverine forest, schrubs, and dryland agriculture of mixed plantation, and paddy fields.

Methods

Data collection

This study was conducted at eight different stations along of the Saddang River in the dry season from July to August 2018, and in the wet season from Januray 21 st to February 2nd, 2019 aimed to identify mammals in the region.

Diurnal Mammals

Transect method was used to undertake mammals survey at each of the station. The survey conducted at 06:00-10:00 AM and at 02:00-06:00 PM. Interview and discussion with the community were conducted to collect additional data about mammal species around survey location. Several people interviewed during the survey, including the headman and farmers encountered in the plantation areas. Pictures and illustrations of Sulawesi's mammals were presented, including sulawesi's forest ungulates (anoa, babirusa and sulawesi warty pig), primates, rodents and small mammals. The result was used to get supplement about species in survey location and gain addition of species which not found during survey. Interview with the locals, also identified which species could be found in the past (5 – 10 years) yet no longer inhabit the study area.

Nocturnal mammals

The bat catch was made by installing two mist nets in separate locations. Mist nets were mounted 0.5 to 3 meters above the ground using bamboo rods of diameter 5 cm along 5 meters. Mist nets were placed determined by adjusting the sampling points. Parameters noted were: species of bat, gender, and age. The mist nets installed at night time at 06:00 until 09:00 PM. The presence of other nocturnal mammal including arboreal rats, Sulawesi Dwarf Cuscus, civets was observed during the bats survey.

Rodents

Catching rodents conducted by installing 40 live traps on the observation path. Live trap placement was determined at random, along a straight line path with a 10 meter spacing between the traps. The traps were installed at afternoon and be checked at the end of night survey and the morning of the next day.

Data analyses

All data be analyzed to know the conservation status, diversity equitability, and richness. The available method that potential to use in this study area:

Shannon-Wiener Diversity Index

This index was calculated as follows:

$$D = -\sum_{i=1}^{s}\left[\frac{n_i}{N} log_2 \frac{n_i}{N}\right]$$

where:

D = Diversity index;

s = number of taxa;

ni = number of individuals of the i^{th} species (taxon); and

N = total number of individuals of all species of the sample

Equitability Index

This index measures the degree of evenness with which sampled individuals are distributed among taxa represented in a community (Pielou 1966).

$$J = \frac{D}{\log_2 s}$$

Where:

J = Equitability index;

D = Shannon-Weaver diversity index; and

s = number of species (taxon) in the sample

Richness Index

The richness index is a measure of the "taxonomic wealth" in a faunal community (Margalef 1958). The higher the richness in a community, the more organisms (taxonomically) that exist, which in turn reflects habitat complexity (i.e., a greater the number of habitat niches available for biological use will generate a greater variety of fauna able to colonize, survive, and reproduce in a given area).

$$R = \frac{s-1}{\log_e N}$$

Where:

R = Richness index;

s = number of taxa in the sample; and

N = total number of individuals of all species of the sample

Mammal survey result is analyzed descriptively according to the species protection status which refers to IUCN (www.iucnredlist.com), CITES (Appendices of CITES), and Indonesian government protection (Permenlhk No.92 Tahun 2018).

All mammals species in the study area were recorded and then identified, mammals's diversity values and ecosystem services to the species. Species of concern, the Sulawesi's endemic and uniques species including anoa (*Bubalus depressicornis*, *B. quarlesi*), bear cuscus

(*Ailurops ursinus*), Sulawesi dwarf cuscus (*Strigocuscus celebensis*), tarsius (*Tarsius* sp), Sulawesi' tonkean macaque (*Macaca tonkeana*), Sulawesi civet (*Macrogalidia muschenbroekii*) were given more attention in the context of habitat, development and land uses including distribution and important and/or critical habitat of the species.

Results and Discussion

General description of the habitats

Eight stations were surveyed along the Saddang Rover's catchment area, covering many habitat types. Stations 1,2,3,4 are situated at the dowmstream, whereas the stations 6, 7,8, representing habitats at the ustream of the proposed dam site at station 5. In general, most of the habitats have been modified mainly agricultural activities by the local people, either monoculture or mixed-plantations, paddy field, and settlements. The habitat types include schrubs, secondary forests riverine forest, secondary forests. Patchy primary forests could only be found at inaccessible parts of the catcment area that are in the remote and at the extremely high slopes at the river banks and at the tops of the mountains and hills. At station 01 to 04, the dryland agriculture (monoculture) is dominated by corn plantations, while mixed drylang agriculture are combination of pepper, chili, coffee, cacao, clove, durian and *Aleurites moluccana* (kemiri) plantations. Shrubs and secondary forests are located at the riverine forest and at the abandoned dryland agriculture, and at low accessibility areas. Paddy fields are agricultural areas that are watered or inundated using simple irrigations built by the villagers by facilitating the water runnning from the higher ltitudes, rivers and tributaries which are mostly permanent water supply. The paddy fields are characterized by a bundling pattern, planted with short-living food crops (paddy). The sugar palm *Arenga pinnata* grow naturally at steep slopes along the riverine belts and the endemic palm *Pigafetta elata* characterized the landscape at the hills and were pioneer species at eroded soils at steepy slopes. The sugar palm has high economic value since its extract is used as drink and has been traditionally processed for aren sugar or red sugar.

Mammals habitat in the study area are characterized by secondary foresty, shrubs, riverine forest, dryland agriculture, patchy old secondary and primary forests at station 01 to 05, and additional of paddy field along the river bank at station 05 to 08. The most elusive megafauna on this island, anoa, body weight 60-100 kg, and babirusa, body weight 40 kg, based on direct

and indirect obsevations based on foot prints, faeces, and other tracks, and discussion with the locals indicating that these iconic species have now absent a along the riverine and settlement. Long history of human activities along of the catchment area vanished the primary forests and the habitats used by the Sulawesi's secretive and elusive mammals such as anoa and babirusa. Discussion with the local people confirmed that anoa could be found in this area during 1970s and 1980-s, almost 40 years ago, before the intensive settlements, plantations, and the construction of Bakaru Dam of Saddang River.

Habitat condition at each of the stations

Stasiun 1

This station is located near the Bakaru Dam, Pinrang, characterized by mixed plantation of corn, cacao, coffee, and *Aleurites moluccana*. Pine stands could be found at the higher altitude dominated the tops of hills that nearby planted during the 1980s of the forest rehabilitation shortly after the dam construction. Natural plant species could be found along the riverine belts such as sugar palm (*Arenga pinnata*), banga (*Pigafetta elata*), gattungan (*Diospyros* sp.), buangin (*Casuarina junghuniana*), kondang (*Ficus variegata*), *Ficus drupace*, and *Ficus benjamina*. At the plain terrain, the local people have used as feeding ground of cattle, buffaloes, and horse. There are several rivers and tributaries running to the Saddang River. the temperatur ranges from 22,2 to 29,7 ^{o}C, and relative air humidity ranges ranges from 84 to 87%. Among the mammals species recorded recorded in this area are Malay palm civet (*Viverra tangalunga*), the endemic white-tailed rat (*Maxomys hellwandii*), Sulawesi warty pig (*Sus celebensis*), macrochiroptera (*Cynopterus* sp.) dan *Myotis* sp.

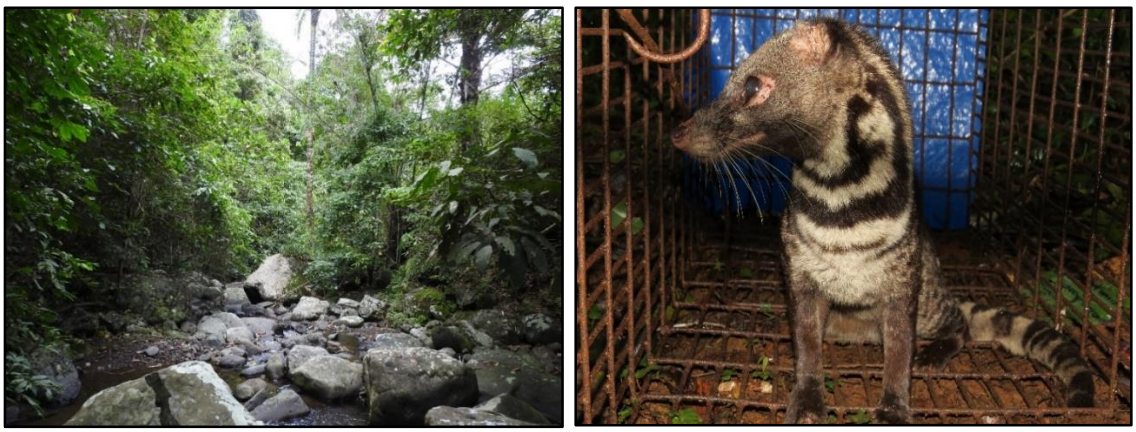


Fig 1. Mammals habitat at station 1 (Photo:Abdul Haris Mustari)

Stasiun 2

This station is situated at the upper of Bakaru Dam, Pinrang, charecaterized by rugged terrains, hill and mixed plantations of corn, coffee, cacao, cloves, durian, and secondary forests. Primary forest remains could be found forming narrow belts along the river, where vegetation dominated by buangin (*Casuarina junghuniana*), nato (*Palaquium* sp.), lilatin bulan (*Dendrocnide* sp.), sugar palm (*Arenga pinnata*), tarra (*Artocarpus* sp.), luaje (Ficus variegata), gattungan (*Diospyros* sp.), bayur (*Pterospermum celebicum*), and pulai (*Alstonia* sp.). Mammals species recorded in this area are Sulawesi warty pig (*Sus celebensis*), tonkean macaque (*Macaca tonkeana*), tinggalung (*Viverra tangalunga*), dou (Rubrisciurus rubriventer), kuse (*Ailurops ursinus*), and feces of the endemic Sulawesi palm civet (*Macrogalidia musschenbroekii*). Of the rodents, Polynesian rat (*Rattus argentiventer*) are common in the corn plantation and the white tailed rat (*Maxomys hellwandii*) recorded in the mixed plantations. Of the volant mammals, Chiroptera, brachyotis,

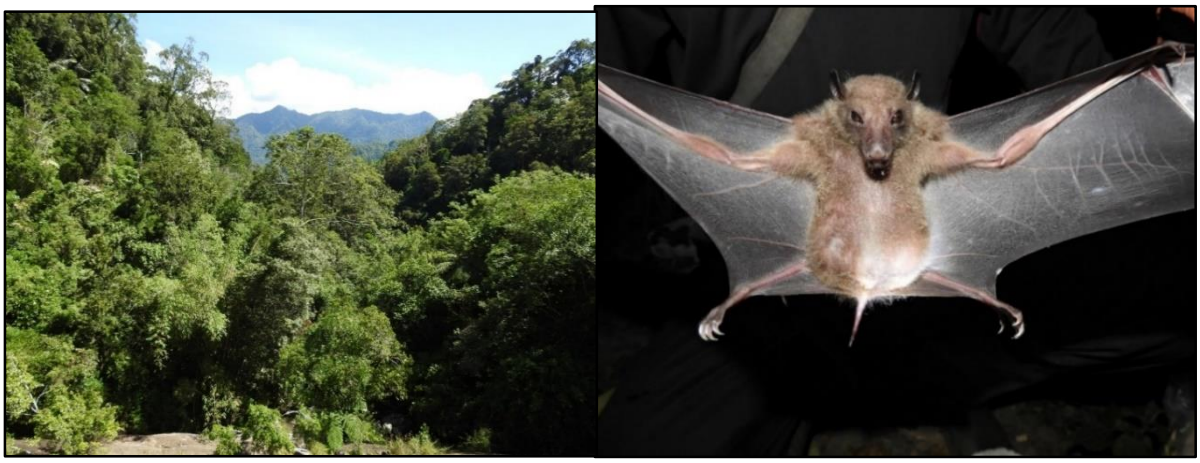


Fig 2. Mammals habitat at station 2 (Photo:Abdul Haris Mustari)

Stasiun 3

This station is located at Salimbongan of Ulu Saddang village, Pinrang, near the locals' settlement. Stasiun 3 berada di desa Ulu saddang. This habitat is characterized by heavy terrain, modified habitats, secondary forests and primary forests at the tops of the hills and at the extremely heavy terrains. A small river from the forested area running along the lowest contours at the foot of the hills and crossed the main settlement of Salimobngan. The temperature ranges from 21, 9 to 26,7 ^{o}C, and the relative humidity was 72 - 90%. At the secondary, lumassang (*Macaranga* sp), pute mata (*Macaranga gigantea*) are common species,

whereas in the primary protected forests, the dominant species are sugar palm (*Arenga pinnata*), kabutu (*Evodia celebica*), pulai (*Alstonia* sp), simmi (*Albizia procera*), luaje (*Ficus variegata*), lebani (*Ficus septica*), lelatin bulan (*Dendrocnide* sp.), bayur (*Pterospermum celebicum*), bakan (*Cordia myza*), buangin (*Casuarina junghuniana*), beringin lamba (*Ficus drupacea*). The endemic palm, banga (*Pigafetta elata*) is the pioneer species at the frequently slide soils at the extremely heavy slopes. The *Cycas* sp. is common is this area. Of the undergrowth, the thorny liana, *Rubus moluccanus*, *Eupathirium* sp., and *Mikania cordata* dominated the modified habitats. At the modified habitats and the plantations, the local people grow corn, cacao, coffee, clove, durian, jack fruit, etc. Among the mammals spesies rerorded in this area are two groups of tonkean macaque, 15 and 7 individuals respectively, observed at the primary forests, old seconadry forests, riverine forests. Since the plantations and the forested area share borders, the omnivore macaques are reportedly entering the planations raiding the crops, such as coffee, cacao, bananas, and corns. Other mammals in this area are Sulawesi warty pig (*Sus celebensis*), tinggalung (*Viverra tangalunga*), tonkean macaque, sulawesi giant squirrel (*Rubrisciurus rubriventer*).

Fig 3. Mammals habitat at station 3 (Photo:Abdul Haris Mustari)

Stasiun 4

Situated at Rampusa of Betteng village, Pinrang, the landscape is dominated by heavy terrain with scattered settlements, mixed plantations and old secondary forest along the clean rivers that used by the villagers for microhydro. The dominant species at the secondary forests are sugar palm (*Arenga pinnata*), uru (*Elmellrillia ovalis*), gattungan (*Dispyros* sp), *Ficus drupace*, *Ficus variegata*, nato (*Palaquium* sp.) palli, bakan (*Cordia myza*), pulio, kumea, lilatin bulan (*Dendrocnide* sp.) and banga (*Pigafetta elata*). The mixed plantations are dominated by

Aleurites moluccana, durian, and coffee, cacao, and clove. Scattered monoculture of corn plantattion could be found at the lower altitude and the relatively plain areas. The local termperature ranges from 21, 9 to 26,7 ^{o}C, and relative humidity was 72 - 90%. Mammals species recorded in this habitat were Sulawesi warty pig (*Sus celebensis*), tonkean macaque (*Macaca tonkeana*), Malayan palm civet (*Viverra tangalunga*), Sulawesi palm civet (*Macrogalidia musschenbroekii*), ledo, paniki, white tailed rat (*Maxomys hellwandii*), bear cuscus (*Ailurops ursinus*), tarsier (*Tarsius tarsier*).

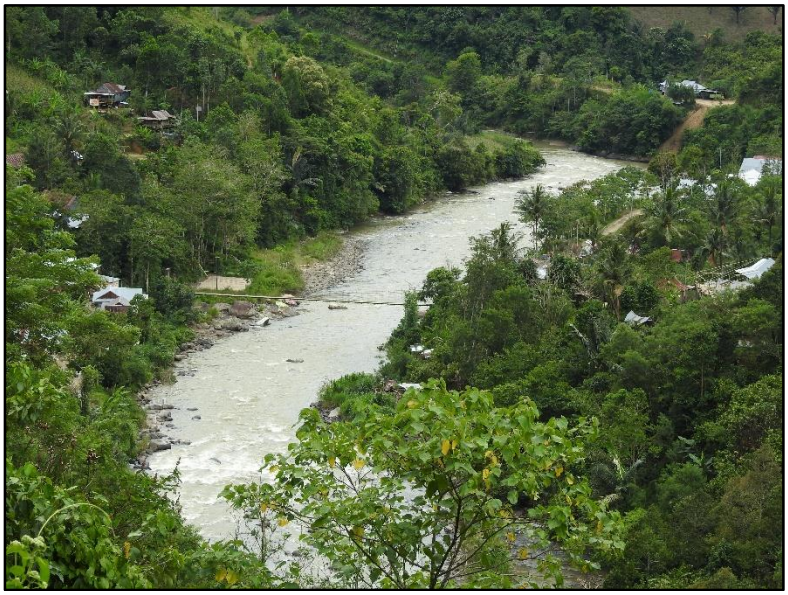


Fig 4. Mammals habitat at station 4 (Photo:Abdul Haris Mustari)

Stasiun 5

This is the proposed dam site, situated at Londe of Lembang Mesakada Village, Pinrang. This site is the most heavy terrain among the eight stations, where the river is siatuated in between the two hills. Mammals habitat in this area is characterized by dry-land agriculture, riverine forest, secondary forest, mixed plantation, paddy field, and secondary forests dominated by *Casuarina junghuniana, Dendrocnide* sp., *Pigafetta elata, Alstonia scholaris, Arenga pinnata,* and *Palaguium* sp. The riverine vegetations and mixed plantations along the river banks is the main features of the landscape. The riverine vegetations are sugar palm (*Arenga pinnata*), gattungan (*Diospyros* sp.), lawirri, libarrang, libani (*Ficus* sp.), bakan (*Cordia myza*), simmin (*Albizia procera*), tarra (*Artocarpus* sp.), buangin (*Casuarina junghuniana*), lilatin bulan (*Dendrocnide* sp.), bittasu, uru (*Elmerrillia ovalis*). Similar with the other stations, scattered pine stands could be found at the tops of the hills, the tree of which is now frequently logged by the local people which is illegal. The local people have used the area for either monoculture or mixed plantations of coffee, cacao, Aleurites moluccaca, and cinnamomum. A small village

of Londe and Tekkoan could be found in this site. Paddy field of approximately 5 ha could be found at the riverine of Londe village functioning as rice field during the raony season and corn and and vegetables during the dru season. ekitar 5 ha. The temperatur ranged from 21, 9 to 26,7 ^{o}C, and the relative humidity was 72 - 90%. Mammals species could be found in this area were Sulawesi warty pig, malay palm civet, Sulawesi giant squirrel, tarsier, white tailed rat, and several species of bats. The sulawesi palm civet, and tonkean macague were infromed by the local people, yet their poplations are away from the settlements and plantations since they were hunted.

Fig 5. Mammals' habitat and landscape at station 5, where extremely heavy terrain, riverine forest, and mixed plantationa are the main characteristics of this area (Photo:Abdul Haris Mustari)

Stasiun 6

This station is located in Suppiran Village of Pinrang. Paddy fields are at the plain area along of the riverine. The paddy field turned into corn and aother short-term commodities, mainly vegetables in the dry season. At the higher altitude, mixed plantations of coffee, cacao, clove, Aleurites moluccana, durian, and cinnamomum dominated the landscape. The riverine habitats are also dominated by natural vegetatios such as sugar palm, four species of bamboo (*Bambusa* spp.), and the sedges *Sacharum spontaneum*. Not many mammals species recorded in this area, except malay palm civet, white taolet rat, sulawesi giant squirrel, sulawesi warty pig. While tarsier, and tonkean macaque were recorded based on infromation from the local people, yet their population is rare. Other mammals of Chiroptera, *Cynopterus brachyotis*, was observed from the individual captured using the mist net. Of the rodent, two rat species, Polynesian rat (Rattus exulan), *Rattus argentiventer* were trapped in the riverine habitat.

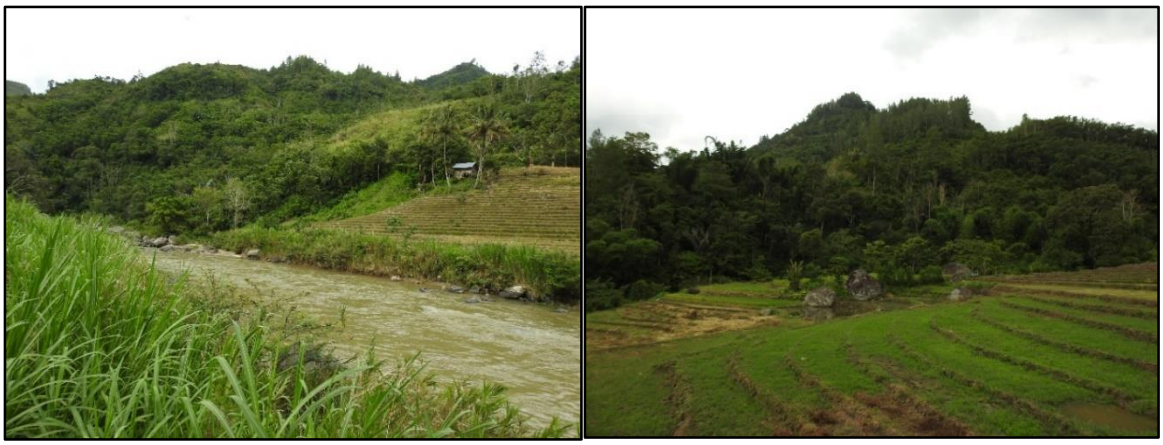


Fig 6. Mammals habitat and lanscape at station 6, charactrized by riverine vegetation, paddy field, schrubs and secondary forest (Photo:Abdul Haris Mustari)

Stasiun 7

Station 7 is located in Sepang Village of Mamasa, a combination of paddy field, mixed plantation, secondary forest and schrub, and riverine. Paddy fields are ssituated along of the river banks, whereas mixed plantations are at the higher altitude of the rugged terrain. Coffee, cacao, cinnamomum, durian, Aleurites moluccana, and clove are the main commodities in this area. Other commodities are cassava, Ipomoea batatas, banana could also be found mixed with the main commodities. Small rivers and tributaries starting at the top of the hills and running accross the mixed plantations and the paddy fields, and finally to the Mamasa main river. The local people use the clean water from the small rivers and springs, which are permanent water supply, for irrigation of the paddy field. Mammals species could be observed in this stationa were bats and rats, while Sulawesi warty pig, bear cuscus, malay palm civet and tonkean macaque recorded based on information from the villagers. Temperature in this station was $28,7^0$C and relative humidity was 69%.

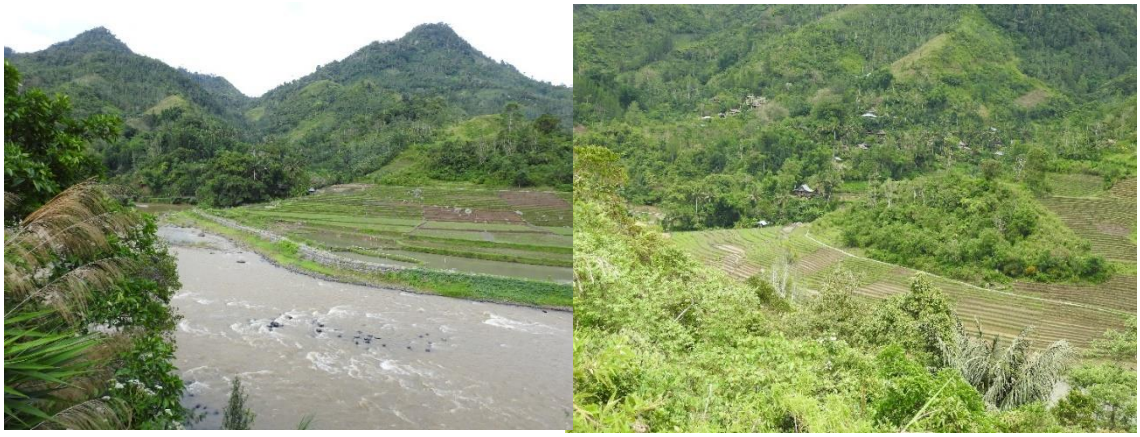


Fig 7. Habitat and landscape at station 7 (Photo:Abdul Haris Mustari)

Stasiun 8

This station is located in Matande Village of Mamasa. Mammals' habitats are characterized by settlements and paddy fields along the river banks, and mixed plantations of cacao, coffee, clove and *Aleurites moluccana* and secondary forests dominated the higher altitude having rugged and heavy terrains. Similar with the other stations, clean water is available all year round supplied by the rivers, tributaries and springs. The temperature ranges from 18 to 24 ^{0}C and the relative humidity was 80 – 94%. Mammals species inhabiting the mixed plantations and secondary forests are white-tailed rat (*Maxomys hellwandii*), tonkean macaque (*Macaca tonkeana*), bear cuscus (*Ailurops ursinus*), sulawesi warty pig (Sus celebensis), sulawesi giant squirrel (*Rubrisciurus rubriventer*), and tarsier (*Tarsius tarsier*), malayan palm civer (*Viverra tangalunga*). Wildlife hunting and bushmeat consumption by the local people have been forcing the wildlife, especially sulawesi warty pig and tonkean macaque are away from the settlement and mixed plantations, yet the small mammals such as white-tailed rat and bats could still be found inhabiting the plantations and secondary forests nearby the villagers' settlements.

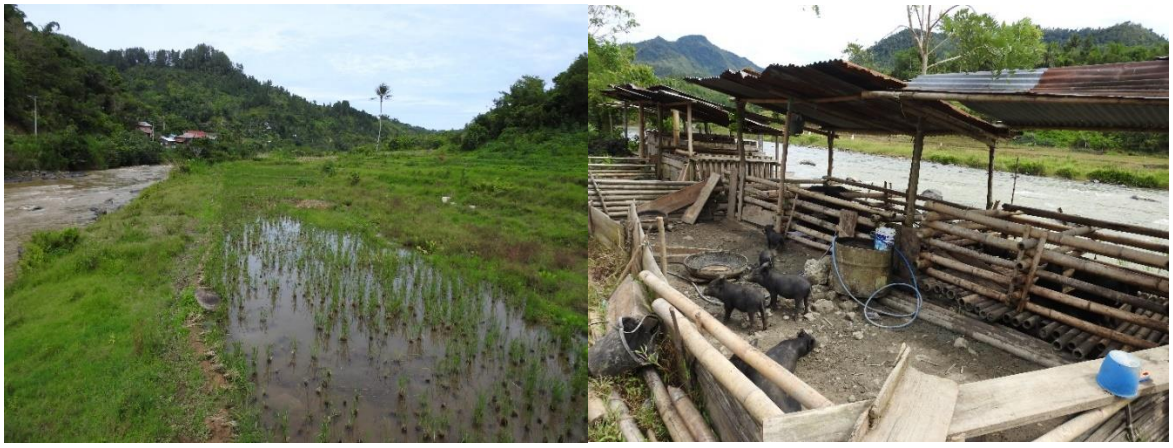


Fig 8. Domestic pig's enclosures of the local people, situated along the Mamasa River banks. Feces and urine of the domestic pigs were directly disposed to the river (Photo:Abdul Haris Mustari)

Bench Mark

The bench mark site representing the primary forest in the catcment area, yet parts of this area has been modified mainly for coffee and cacao plantations. The only undisturbed habitat are at the top of the hill that dominated by uru (*Elmerrillia ovalis*) and the endemic palm, banga (*Pigafetta elata*). A small year round river is one of the focal habitat in this area inhabited by many species of mammlas, birds, and amfibians. Mammals found in this forest were sulawesi warty pig, tonkean macaque, bear cuscus, white tailed rat, malayan palm civet, tarsius, and Sulawesi palm civet.

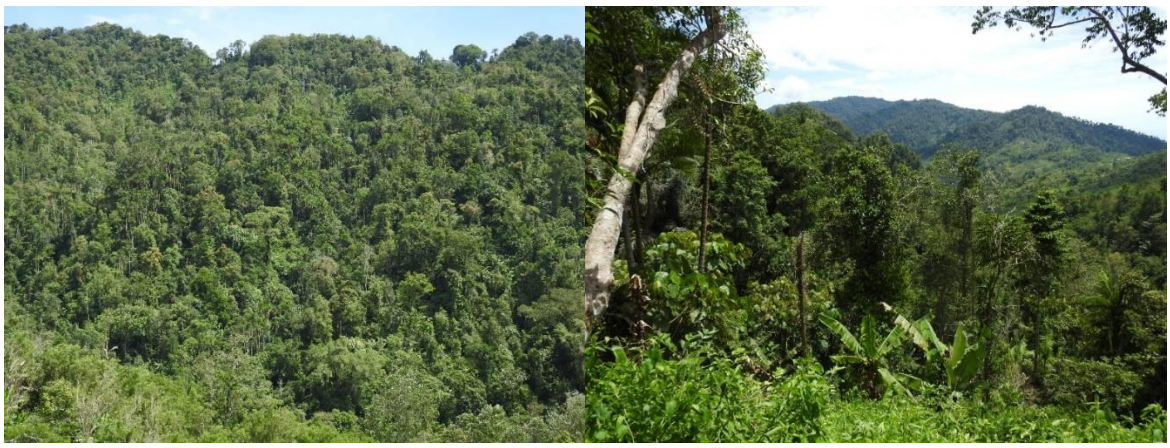


Fig 9. Mammals" habitat and vegetations of the Bench Mark (Photo:Abdul Haris Mustari)

Diversity of mammals species

Mammals species observed in this area are dominated by small and medium size species, including Rodents (rats), Chiroptera (bats) ,Marsupials (bear cuscus and dwarf cuscus),

Primate (tonkean macaque and tarsier), and Viverridae (civets). These species inhabiting the remaining secondary forests, schrubs, patchy primary forests along the riverine, riverine forests, dryland agriculture, forest margins and modofied habitats. The mammals are maainly arboreal and semi-arboreal.

A total of 19 mammals species recorded in the study area which are belonging to 19 generas of 10 families. Eleven species were directly encountered and 7 species were confirmed by the local people and from the tracks (feces and foot prints). Mammals species of conservation significance based on Indonesian Permen LHK No.P.106/2018, IUCN and CITES (Table 1). Five out of the 19 species are protected based on PermenLHK P.106/2018, including tonkean macaque (*Macaca tonkeana*), tarsier (*Tarsius tarsier*), Sulawesi dwarf cuscus (*Strigocuscus celebensis*), Sulawesi civet (*Macrogalidia muschenbroekii*), and rusa deer (*Rusa timorensis*). Based on IUCN Red List 3.1, six of the mammals species are classified as Vulnerable including bear cuscus (*Ailurops ursinus*), sulawesi dwarf cuscus (*Strigocuscus celebensis*), tonkean macaque (Macaca tonkeana), tarsier (*Tarsius tarsier*), Sulawesi civet (*Macrogalidia muschenbroekii*), and the introduced timor deer (*Rusa timorensis*). Sulawesi warty pig is classified as Near Threatened.

The secretive and the only native carnivore on the island, Sulawesi palm civet, called Malo by the locals could be found in the study area from faeces found at station 02 and at station 4. The middle-sized carvivore, its presence, however, reported by the local people at each of the stations, yet, its population is very low and was rarely encountered. Hhair tubes and skeleton remains of rodents could be identified from the faeces.

Eight species of the mammals are endemic to Sulawesi, including bear cuscus, sulawesi dwaf cuscus, white-tailed rat, sulawesi giant squirrel, sulawesi civet, tonkean macaque, tarsier, and sulawesi warty pig. The tonkean macaque's habitat and distrubution are limited in the central and western parts of this island (IUCN).

Most of the mammlas species were encountered at station 01,02,03,04, and 05, which are schrubs, secondary forest and patches or remnants of primary forests, and mixed plantation of coffee, cacao, durian and *Aleurites moluccana* habitats. This habitat could still facilitate the arboreal and semi-arboreal mammals food and cover. Additionally, local people living in this area have rarely hunted the wildlife, yet they only considered some of the species as pest such as tonkean macaque and sulawesi warty pig, both of which are regarged as main pests for the

dryland agricultural commodities. Cultural and religion (Moslem) background of the people in this stations might be the main factor affecting the existence of the mammals. In contracts, at villages with relatively intensive agriculture acftivities, paddy field, people living along of riverine forest at station 06,07 and 08, might affect the habitat of the forest-dependent species and of the arboreal and semi-arboreal mammals.

Of the forest ungulates, Sulawesi warty pig could be observed in the study area. Meanwhile, the dwarf buffaloes, anoas, and babirusa, all of which are endemic to the island could not be observed in the study area at all of the stations, based on direct and indirect observation and information from the community. These forest-dependent ungulates are secretive, avoiding habitats frequented by human activities (Mustari 1995; 2003).

The recent study indicated that minimum wild biomass harvested from ilegal hunting across Sulawesi was 742 tonnes per year, 90% of which was composed of Sulawesi warty pig, followed by anoa (4%, 284 individuals), rusa deer (3,7%), babirusa (1%), and sulawesi macaques (0,5%) (Rejeki 2018). This study indicated that Sulawesi warty pig is still the most preferred species for hunting on the island.

Tonkean macaque could be observed at stations 01 to 04 within, whereas at station 05 to 08, this black macaque was absent within the distance 0 – 3 km from the river. Descussion and interview with the local people confirmed that *Macaca tonkeana* and *Sus celebensis* had been seriously hunted in the past. Cultural and religion backgrunds might influenced the hunting activities and the local extintion of these species in villages of stations 5 to 8. These species are hunted and consumed by the Christian community, causing these species were very difficult to be found near the settlements and/or the river. At station 01 to 04, *Macaca tonkeana* and *Sus celebensis* could be found inhabiting secondary and remnants of primary forest, and mixed hard wood plantation. These maammals are considered as main pests of the crops, and groups of the macaque have continuously approached the plantations, especially corn, bananas and cacao plantations.

The native range of the Malay civet is Indoensia, Malaysia, Brunai, Philippines and Singapore. This species was introduced to Sulawesi along with the Paradoxurus hermaphroditus. This civet could be easily determined by its tail that ringed black and white on the lower side. The local people know this species well, known as Tingkalung in local languange Their upperparts are greyish with numerous black spots and about 15 black bands in the tail. It inhabits a wide

variety of habitats including forest, secondary and modified habitats, cultivated land and the outskirts of villages. Malay civets are solitary, nocturnal, and primarily terrestrial. It is omnivorous, feed on vertebrates and invertebrates. This species is considered as a pest, prey small livestock mainly chickens.

Sulawesi warty pig is one of the endemic forest ungulates of Sulawesi. Head and body lenght 80 – 130 cm, Body weight 40 – 70 kg, and its shoulder heigyt is 60- 70 cm. Its social group is *matriarchal*, a group lead by an adult female. A group of 3 -5 individuals consisting adult female, youngs and babies and frequently found. Adult male live solitarily, and join the female groups only during mating seasons. This oppotunistic omnivor inhabit many habitat types from primary forest, secondary forest, schrubs, to riverine forests. Its food items cover many species of plants such grasses, roots and succulent tubers, fallen fruits such as many species of fig fruits, *Pangium edule*, *Arenga pinnata*, *Drancontomelon dao* and *D.mangiferum*. Local people and farmers has positioned this endemic sepcies as main pest of the crops, frequnted entering the plantation looking for food, visiting the beach and mangrove forests searching for food including molusca, crabs, and sea grasses during low tides (Mustari 2003)

Males are larger than females, but both sexes have short legs, a rounded back, and a long tufted tail. Adults are gray-black in color, sometimes with an infusion of red or yellow on the flanks. There is a short crest of thick black bristles on the crown of the head (and sometimes the nape of the neck), which extends into a dark dorsal stripe. The short face is generally dark, with a prominent band of yellow hair which crosses the snout in front of the eyes and a tuft of pale bristles on each cheek. Both sexes have three pairs of facial warts, but they are much more pronounced in males, and may dominate the faces of older animals. The ears are relatively small.

Sulawesi warty pigs are most active in the morning (06:00-11:00) and afternoon (14:00-18:00), often spending the midday wallowing in mudholes which they dig up with their snouts. Dried mud is often rubbed off on tree trunks, which likely helps with skin care. Night is usually spend resting, but in areas with human activity this species often shows nocturnal activity. While on the move, groups are generally led by the dominant male. This species uses a halting gait when in open spaces (like salt licks), taking several steps and then freezing in position to assess their environment, breaking into a run if alarmed. Males may scent mark using secretions from facial glands, but the function of this behavior is unknown. Population densities in Sulawesi are highly variable, with estimates in the north (Panua Nature Reserve) being as low as 0.4 animals

per km² but in parts of the southeast (Tanjung Peropa) densities of 23.5-34 animals per km² have been recorded.

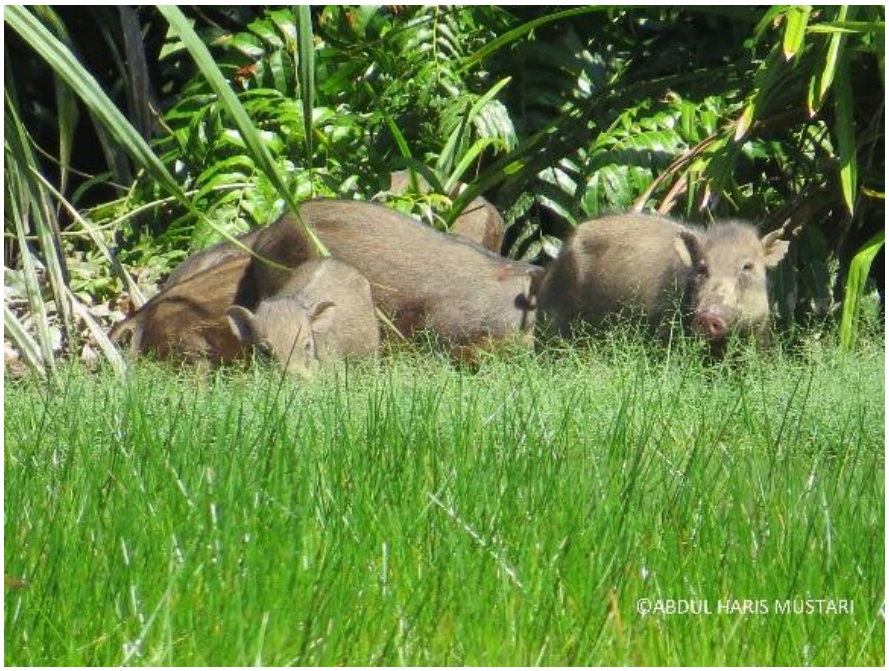


Fig 10. Sulawesi warty pig (*Sus celebensis*) (Photo:Abdul Haris Mustari)

Table 1. Mammals species in the study area, conservation status and general behaviour

No.	Family/Species Name	Common name	General behaviour	Conservation status		
				IUCN	CITES Appendix	Permen LHK No. P 106/2018
1	*Ailurops ursinus*	Bear cuscus	Arboreal, solitary, diurnal	VU	II	
2	*Strigocuscus celebensis*	Sulawesi dwarf cuscus	Arboreal, solitary, nocturnal	VU	II	Protected
3	*Rubriscurus rubriventer*	Sulawesi giant squirrel	Arboreal, solitary, pairs, diurnal	DD		
4	*Maxomys hellwaldii*	Hellwad's spiny rat	Arboreal, solitary, nocturnal	LC		
5	*Rattus tanezumi*	Japan's House rat	Semi arboreal, solitary, nocturnal	LC		
6	*Bunomys penitus*	Montane Bunomys				
7	*Dobsonia exoleta*	Sulawesi naked-backed bat	Arboreal, nocturnal	LC		
8	*Rousettus celebensis*	Celebes Rousette	Arboreal, nocturnal	LC		
9	*Cynopterus luzoniensis*	Sulawesi Dog-faced fruit bat	Arboreal, nocturnal	LC		
10	*Eonycteris spelaea*	Cave nectar bat	Arboreal, nocturnal	LC		
11	*Arielulus sp*		Arboreal, nocturnal	LC		
12	*Murina florium*	Flores Tube-nosed Bat				
13	*Macrogalidia muschenbroekii*	Sulawesi civet	Semi arboreal, solitary, nocturnal	EN	II	Protected
14	*Paradoxurus hermaphroditus*	Common palm civet	Semi arboreal, solitary, nocturnal	LC	III	
15	*Viverra tanglunga*	Malayan civet	Semi arboreal, solitary, nocturnal	LC	III	
16	*Tarsius tarsier*	Spectral tarsier	Arboreal, live in pairs, small group, nocturnal	VU	II	Protected
17	*Macaca tonkeana*	Tonkean macaque	Semi arboreal, live in groups, diurnal	VU	II	Protected
18	*Rusa timorensis*	Timor deer	Terrestrial, small group of 4-5 individuals, diurnal and nocturnal	VU	II	Protected
19	*Sus celebensis*	Sulawesi warty pig	Terrestrial, matriarchal group 3-5 individuals, crepuscular, dirnal, nocturnal	NT		Endemic

Note: VU Vulnerable, LC Least Concern, DD Data Deficient, NT Near Threatened, E Endemic

Table 2. Index of diversity of mamals in the study area

No.	Species Name	Common name	Index					
			n	(ni/N)	Ln (ni/N)	*H'*	D Mg	E
1	*Maxomys hellwaldii*	Hellwad's spiny rat	19	0.15	-1.92	-0.28		
2	*Rattus tanezumi*	Japan's House rat	11	0.09	-2.46	-0.21		
3	*Bunomys penitus*	Montane Bunomys	1	0.01	-4.86	-0.04		
4	*Dobsonia exoleta*	Sulawesi naked-backed bat	2	0.02	-4.17	-0.06		
5	*Rousettus celebensis*	Celebes Rousette	11	0.09	-2.46	-0.21		
6	*Cynopterus luzoniensis*	Sulawesi Dog-faced fruit bat	5	0.04	-3.25	-0.13		
7	*Eonycteris spelaea*	Cave nectar bat	11	0.09	-2.46	-0.21		
8	*Arielulus sp*		5	0.04	-3.25	-0.13		
9	*Murina florium*	Flores Tube-nosed Bat	6	0.05	-3.07	-0.14		
10	*Macrogalidia muschenbroekii*	Sulawesi civet	2	0.02	-4.17	-0.06		
11	*Viverra tanglunga*	Malayan civet	1	0.01	-4.86	-0.04		
12	*Macaca tonkeana*	Tonkean macaque	43	0.33	-1.10	-0.37		
13	*Ssus celebensis*	Sulawesi warty pig	12	0.09	-2.37	-0.22		
		Total (N)	129			**2.10**	**2.68**	**1.04**
		Total Jenis (S)	13					

Shannon index, D Mg Margalef Index of Richness, E Index of Evenness

Based on finding locations, most of the mammals species were recorded at station 1, 2, 3, 4, and 5. Stations 1 to 4 are situated at down of the proposed dam construction, whereas the station 5 is at the dam site and its surrounding area. Landuse and socio-cultural backgroud of people living along the riverside and the stations are main factor causing the different of the mammals spesies and composition. Mixed plantation, secondary and remnant of primary forests could still be found at stations 1 to 4, and the local people are mainly moslem that are more selective in bushmeat consumption. In contrast, people living at station 5 to 8 are mainly Christian, that alsmost no restriction for bushmeat consumtion, including warty pig, macague, squirrel, bats and other mammal species. Additionally, paddy field and monoculture platation are more intensive at station 5 to 8 and the absent of even scattered primary forests that might support the mammals life.

Table 3. Mammals species based on finding locations

No.	Species Name	Common name	Diet	Station (Finding Location)								
				1	2	3	4	5	6	7	8	Bench Mark
1	*Ailurops ursinus*	Bear cuscus	Leaves,fruits,flowers, buds									√
2	*Strigocuscus celebensis*	Sulawesi dwarf cuscus	Leaves, mainly fruits	√	√	√		√				
3	*Rubriscurus rubriventer*	Sulawesi giant squirrel	Fruits									
4	*Maxomys hellwaldii*	Hellawad's spiny rat	Omnivore	√	√	√	√	√	√	√	√	v
5	*Rattus tanezumi*	Japan's House rat	Omnivore						√		√	
6	*Bunomys penitus*	Montane Bunomys	Omnivore						√			
7	*Dobsonia exoleta*	Sulawesi naked-backed bat	Fruits	√								
8	*Rousettus celebensis*	Celebes Rousette	Fruits			√				√		
9	*Cynopterus luzoniensis*	Sulawesi Dog-faced fruit bat	Fruits						√			√
10	*Eonycteris spelaea*	Cave nectar bat	Fruits		√		√	√		√		
11	*Arielulus sp*		Small insects								√	
12	*Murina florium*	Flores Tube-nosed Bat	Small insects	√	√	√						
13	*Macrogalidia muschenbroekii*	Sulawesi civet	Fruits, palm fruits,small mammals, birds, small reptiles				√					
14	*Paradoxurus hermaphroditus*	Common palm civet	Fruits, Palm fruits,small mammals, birds, small reptiles	√	√	√	√					
15	*Viverra tangalunga*	Malayan civet	Fruits, Palm fruits,small mammals, birds,small reptiles	√								
16	*Tarsius tarsier*	Spectral tarsier	Living insects	√	√	√	√	√				
17	*Macaca tonkeana*	Tonkean macaque	Fruits, leaves, flowers, buds	√	√	√	√					√
18	*Rusa timorensis*	Timor deer	Grasses, herbs				√					
19	*Sus celebensis*	Sulawesi warty pig	Omnivore	√	√	√	√	√				√

Mammals species inhabit many habitat types, at least eight habitat and vegetation types could be determined in the srudy area incuding mix plantation, riverine forest, secondary and primary forests and monoculture habitats of paddy field, dry-land agriculture and pine forest. Most of the mammals encountered inhabited mix plantation, riverine forest, secondary and primary forests indicating that the mammals were mainly arboreal and semi-arboreal species. Vegetation types that provide food and cover, breeding and nesting and for social interactions are essential for the mammals. The habitat lost and habitat fragmentation will certaintly affect the mammals. Many species of plants provide food for the mammals, encluding leaves, buds, flower, fruits, and grain. Vegetations are also important as cover, escaping from predators for preys and for hiding and ambushing for predator to catch their preys.

Table 4. Mammals species based on vegetation types

No.	Species Name	Common name	Vegetation Types							
			Paddy Field	Dry-Land Agricultural	Mixed Plantation	Riverine forest	Shrub	Secondary Forest	Primary Forest	Pine Forest
1	*Ailurops ursinus*	Bear cuscus			√	√		√	√	
2	*Strigocuscus celebensis*	Sulawesi dwarf cuscus				√			√	
3	*Rubriscurus rubriventer*	Sulawesi giant squirrel			√	√		√	√	√
4	*Maxomys hellwaldii*	Hellawad's spiny rat			√	√		√	√	
5	*Rattus tanezumi*	Japan's House rat	√	√	√	√	√			
6	*Bunomys penitus*	Montane Bunomys	√	√			√			
7	*Dobsonia exoleta*	Sulawesi naked-backed bat			√	√		√		
8	*Rousettus celebensis*	Celebes Rousette			√	√		√		
9	*Cynopterus luzoniensis*	Sulawesi Dog-faced fruit bat			√	√		√		
10	*Eonycteris spelaea*	Cave nectar bat			√	√		√		
11	*Arielulus sp*				√	√		√		
12	*Murina florium*	Flores Tube-nosed Bat			√	√		√		
13	*Macrogalidia muschenbroekii*	Sulawesi civet				√		√	√	

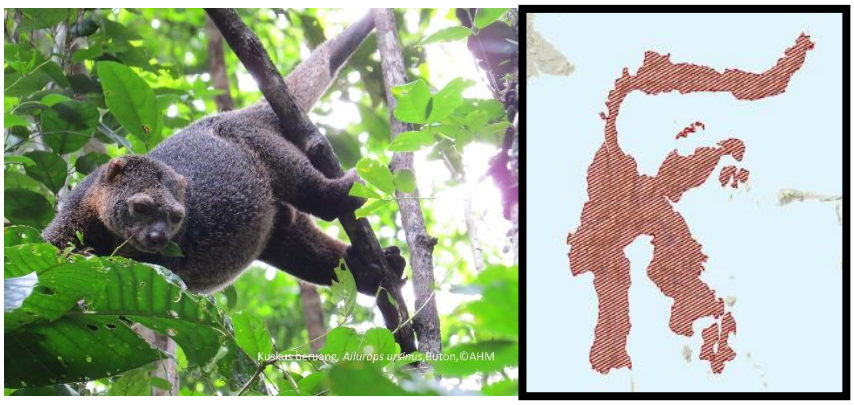
No.	Species Name	Common name	Vegetation Types							
			Paddy Field	Dry-Land Agricultural	Mixed Plantation	Riverine forest	Shrub	Secondary Forest	Primary Forest	Pine Forest
14	*Paradoxurus hermaphroditus*	Common palm civet				√		√	√	
15	*Viverra tanglunga*	Malayan civet				√		√	√	
26	*Tarsius tarsier*	Spectral tarsier				√		√	√	
17	*Macaca tonkeana*	Tonkean macaque				√		√	√	
18	*Rusa timorensis*	Timor deer						√	√	
19	*Sus celebensis*	Sulawesi warty pig			√	√		√	√	

Species of Concern

Bear cuscus (*Ailurops ursinus*)

Bear cuscus is Vulnerable, Appendix II CITES, endemic to Sulawesi. The marsupial's mammals, bear cuscus (Ailurops ursinus) is arboreal, solitary or in pairs, and active in the day time (diurnal). Bear cuscus inhabits lowland moist tropical rainforests, up to 600 metres above sea level. This species is found on the island of Sulawesi mainland, and the neighbouring islands of Sangihe, Butung, the Peleng Islands, the Togian Islands whereas its sibling *Ailurops melanotis* inhabits Talaud and sangir islands of Salibabu (Repi).

Body weight is 7 – 10 kg, head and body length 61cm, and tail length up to 58 cm.. The female has pouch on its belly, in which the poorly developed young suckle. Food item of this slow-moving mammal are leaves (foliavore) and fruits of many species including *Garuga floribunda*, *Syzygium* spp., *Melia azedarach*, *Cananga odorata*, *Dracontomelon dao* and *Dracontomelon mangiferum*. Its tail is frequently used as *fifth-leg* when trying to get leaves and shoots or flowers at the tips of the branches, called prehensile. This marsupial inhabit many habitat types, mainly primary forest, old secondary forest and forest margins near plantations and settlements. A total of 80 plant species have been recorded consumed by this species in their natural habitat in Tanjung Peropa Wuldlife Reserve (Nugraha and Mustari 2017).

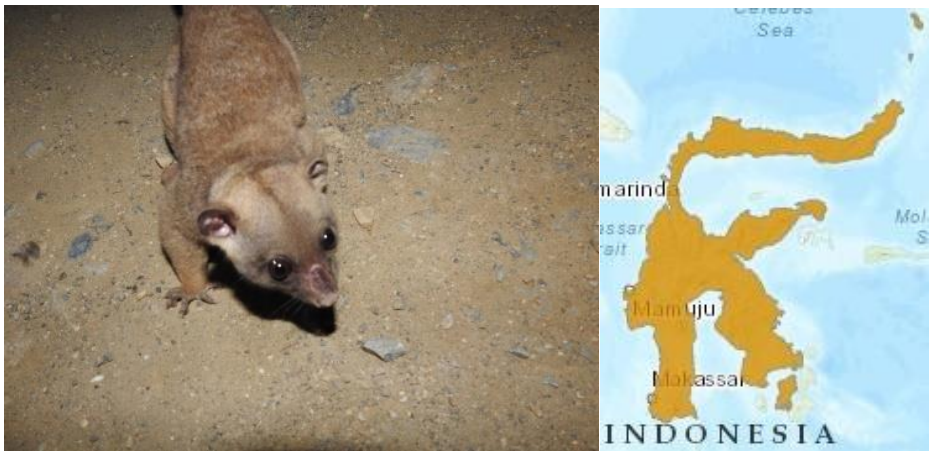


A B

Fig 11. Bear cuscus, *Ailurops ursinus* (A) and its distribution accross Sulawesi (IUCN) (B) Photo:Abdul Haris Mustari

Sulawesi dwarf cuscus (*Strigocuscus celebensis*)

With the body weight is only 1 kg, categorizing this cuscus as dwarf cuscus; body lenght 29 – 38 cm, and tail lenght 27 – 37 cm. This nocturnal cuscus, live solitarily or in pairs, and fully arboreal. Strigocuscus celebensis occurs in rainforests and in secondary forests and gardens around human dwellings. Its main food are fruits, flowers, barks, fungis, and young leaves of many species. Its habitats are primary forest, secondary forest, forest edges, mixed plantations. In villages close to the forest, this species could also be found in the coconut plantation, feeding flowers of the cocos, one of its preferred food item.



A B

Fig 12. Sulawesi dwarf cuscus (*Strigocuscus celebensis*) (A),
and its distribution accross Sulawesi (IUCN) (B) (Photo:Abdul Haris Mustari)

Tonkean macaque (*Macaca tonkeana*)

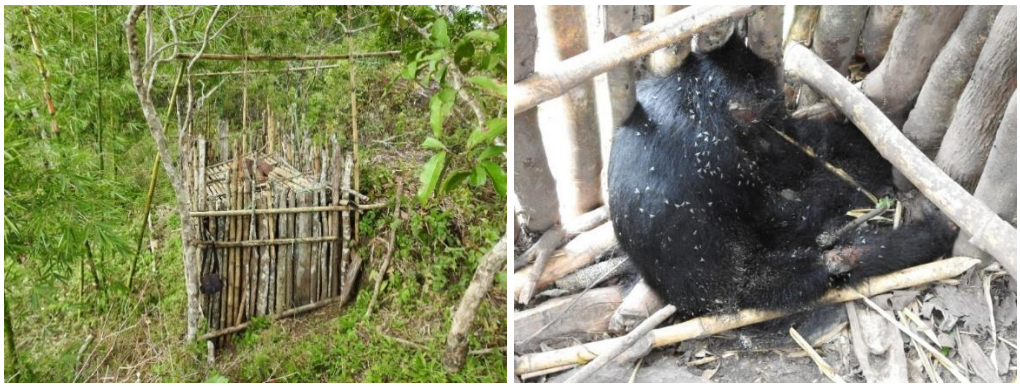
Macaca tonkeana is Vulnerable in IUCN Red List, and on Appendix II of CITES. Its natural distribution is in the centeal and western parts of Sulawesi, therefore this macaque is not only endemic to Sulawesi, but endemic to the very limited area. Moreover, this macaque is ,unfortunately, regarded as main pest of the farmers' crops and enemy of the communities. This species have been hunted, trapped, killed, tortured, and poisoned. Its habitat is mainly primary forests, yet this macaque could also be found at secondary forests, forest margins and frequnted the plantations surrounding the forests. This species is territorial, live in gropus of 10 – 30 individuals consisting an alfa-male as leader of the group, adult females, co-dominants, youngs, juvenile and infants. Active feeding and foraging during day time (diurnal), semi-terrestrial (active both in the canopy and forest floor). Their natural food item are many species of fruits, young leves, shoots and flowers of many species of plants, thus they are mainly herbivore (foliavore and frugivore). As a group, it needs certain home range and territory to maintain the group, in supplying food, water and cover. Key foctors for conservation of this species in the existance of its habitat that quarantee in providing food, water and covers for the species. The secondary forests, schrubs, and riverine forests along the river need a corridors connecting the fragmented habitats and a quarantee that tonkean macaque groups could move freely in their habitats for foraging and other social activities.

This study indicated that this species could be found at station 01to 05. Stations 01 to 04 are at down streams of the proposed build-up area, whereas station 05 is at the proposed built up area. The main characteristis of the proposed build-up area is heavy terrain, mixed plantation mainly corn, coffee and cacao, old secondary forest, and pine forest.

The increasing population and area of the settlements, agriculture activities, habitat degradation and habitat shrinking have been forcing this species into human-wildlife conflict, since the macaque is, unfortunately, considered as pest of the crops.

A B

Fig 13. Tonkean macaque (*Macaca tonkeana*) (A)
and its distribution accross Sulawesi (IUCN) (B) (Photo:Abdul Haris Mustari)



A (B)

Fig 14 . Captured using live trap of bamboo's enclosure (A), the death of an alfa-male of Tonkean macaque at station 02 (B), and distribution of Macaca tonkeana in the central part of Sulawesi (IUCN) (C). The live traps were set up by the community preventing the monkeys entering and riding their crops. The monkey dead after ten days trapped in the live trap without food and drink (Photo:Abdul Haris Mustari)

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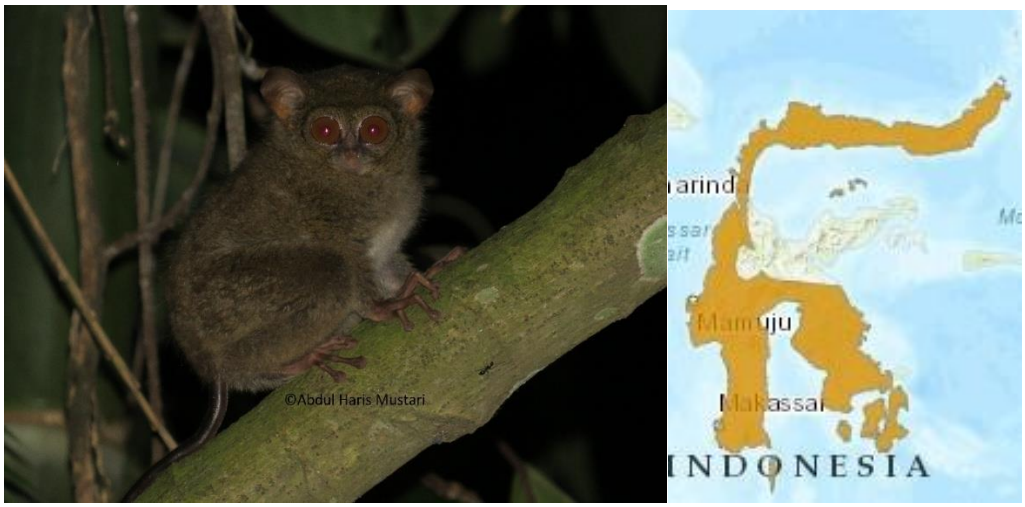
Tarsier (*Tarsius tarsier*)

Tarsier (*Tarsius tarsier*) is endemic The smallest living primate, *Tarsius tarsier* is nocturnal, insectivore, live in pairs or in small groups consisting 2-7 individuals (Mustari et al., 2016). The night and dawn calls of the species could be detected and recorded at stations 01 and 05. Based on the habitat types and the Tarsius habitat need, we are sure that the species should also inhabited the other station, since the tiny primate is not hunted and not considered as pest of the crops, and additionally the species is nocturnal, where local people are very often do not

aware of its presence, yet, night calls and/or direct encounter on the canopies and plantations near the settlement could be detected.



A B

Fig 15. *Tarsius tarsier* (A) called Lappa by the local people in Mamasa and Pinrang, endemic to Sulawesi, and its distribution accros Sulawesi (IUCN) (B) (Photo:Abdul Haris Mustari

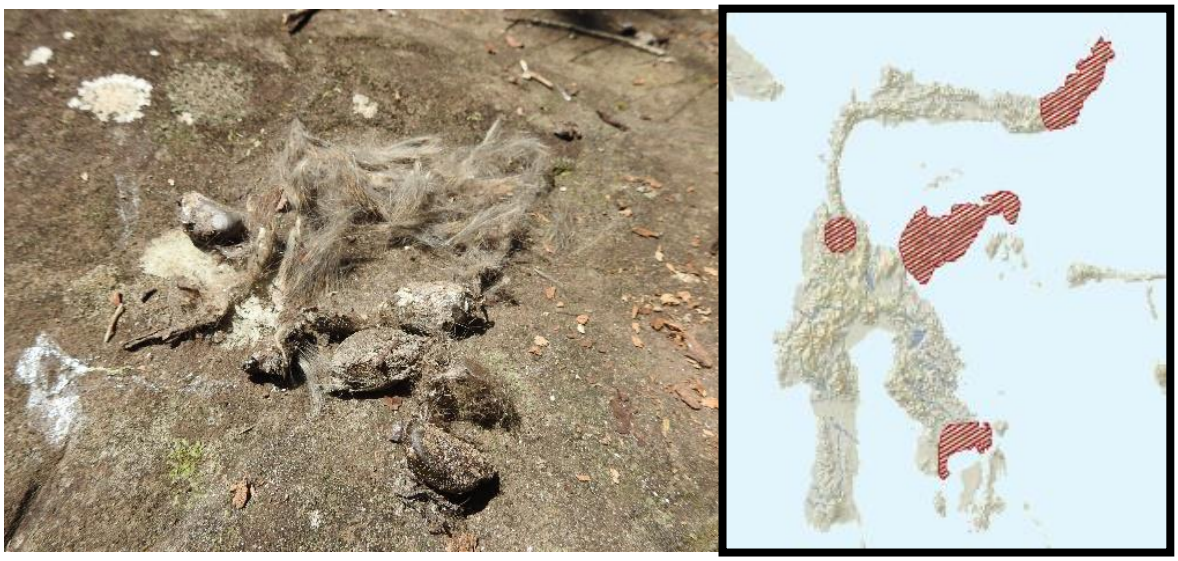
Sulawesi Palm Civet (*Macrogalidia musschenbroekii*)

The most secretive mammals on Sulawesi, and is the only native civet predator on the island is Sulawesi Palm Civet (*Macrogalidia musschenbroekii*). The local people know this species well, known as Malo in local languange. This species is protected, catagorized as vulnerable by IUCN Red List, and on Appedix II of CITES. Its body weight 3,8 - 6,1 kg, body lenght 650 - 715 mm, and tail lenght 445 - 540 mm. This nocturnal mammal live solitarily, largely arboreal in habits, food items icluding small rodents, birds and eggs, reptiles, insects and its preferred palm fruit of *Arenga pinnata*. Local people living in the remote villages with forest and mixed plantation, schrubs, mountanious and heavy terrain habitats, are quite familiar with this rare, endemic species. This civets could also be easily differentiated from the other two-introduced civets, *Paradoxurus hermaphroditus* and *Viverra tangalunga*, from its brown hairs and tail lenght. In the daytime, this civet spends its time in the hollow of big trees in the forest, crevices, and caves that are not frequented by people entering the forests.

This species appears to be rare and its distribution is patchy: it appears to be largely restricted to old-growth, primary forest from sea level to 2600 metres elevation, but is known to stray

beyond the confines of such forest and venture into agricultural areas.It appears to be mainly nocturnal and largely arboreal in habits, which may account for the paucity of sightings. It is omnivorous, consuming a variety of palm fruits as well as vertebrate prey such as rodents and small birds.This relatively large civet has short, brownish-grey fur with darker markings on the posterior part of the back. The tail is patterned with light and dark rings. Its head and snout are pointed and its ears are rounded and erect.The main threat to the survival of this species is continued forest loss. Individuals are sometimes killed by farmers in retaliation for the loss of livestock (presumably chickens).

The Sulawesi Palm Civet is known from the northern, central and southeastern parts of the island. In 2018 its continued presence in the Bogani Nani Wartabone National Park of North Sulawesi was confirmed.



(A) (B)

Fig 16 . Feces of a civet, is more likely of *Macrogalidia muschenbroekii* , with hair tubes and skeletons remains of small mammals of rodents found at station 02 (A), and distribution of Sulawesi civet in Sulawesi (IUCN). This map indicated that this endemic civet was absent in the western and southern parts of the island, yet this study suggested that the protected and rare species inhabit the forested areas in these regions (B) (Photo:Abdul Haris Mustari).

Other species

White tailed rat (*Maxomys hellwandii*)

White tailed rat is endemic to Sulawesi (van der Zon 1979), mainly fpund in north and central parts of the island. There are many local names of this species where people in the north Sulawesi call it as Turean, while in the central and western parts, the local people know this species as Balau Palele (Patinjo dan Toraja People). The body lenght is 20 cm, and the tail lenght is 30 cm. Its food items are mainly fruits of many species including fruits of figs (Ficus spp.), and young leaves, shoots, and flowers of plants. This species is frequently observed in the mixed plantations of cacao, coffee, near the settlement and in the forest margins feeding on fruits of many specie sof plants. People in the north and partly in the central and west Sulawesi, this species is highly appreciated since it has become favourite food for the people.

Fig 17. Hellwad's spiny rat (*Maxomys hellwandii*) (Photo:Abdul Haris Mustari)

Fig 18. Japan's House rat (*Rattus tanezumi*) (Photo:Abdul Haris Mustari)

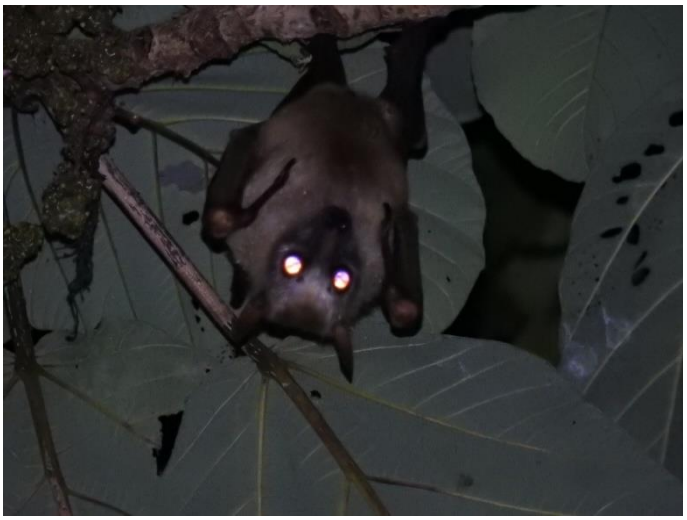


Fig 19. Sulawesi naked-backed bat (*Dobsonia exoleta*) (Photo:Abdul Haris Mustari)

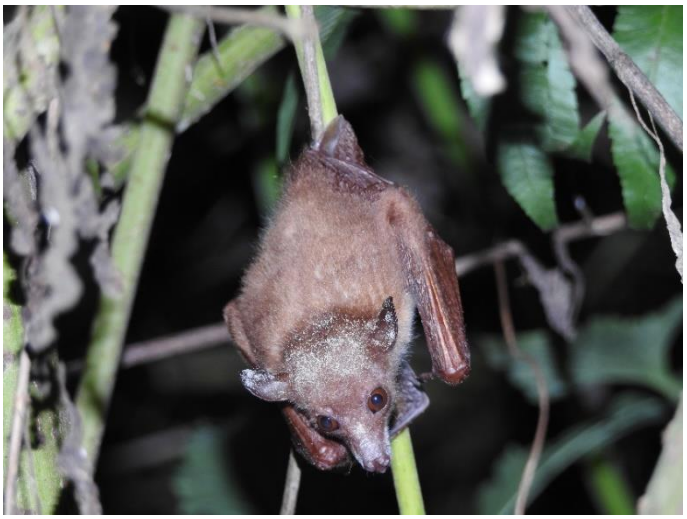


Fig 20. Cave nectar bat (*Eunycteris spelaea*) (Photo:Abdul Haris Mustari)

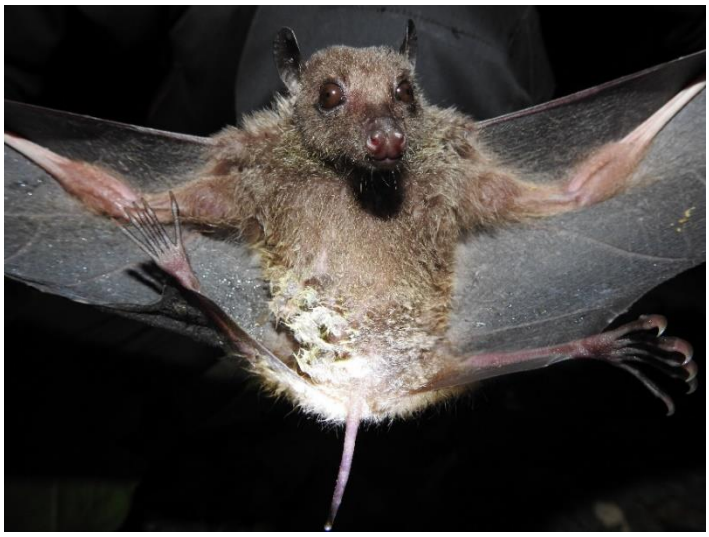


Fig 21. Celebes Rousette (*Rousettus celebensis)* (Photo:Abdul Haris Mustari)

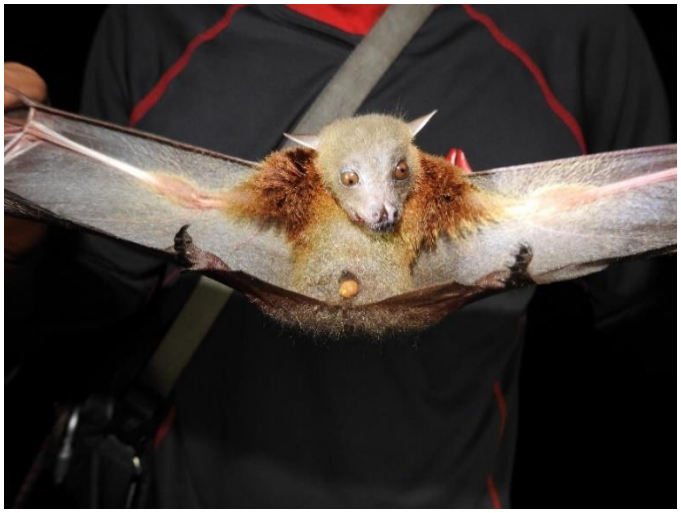


Fig 22. Sulawesi Dog-faced fruit bat (*Cynopterus luzoniensis*) (Photo:Abdul Haris Mustari)

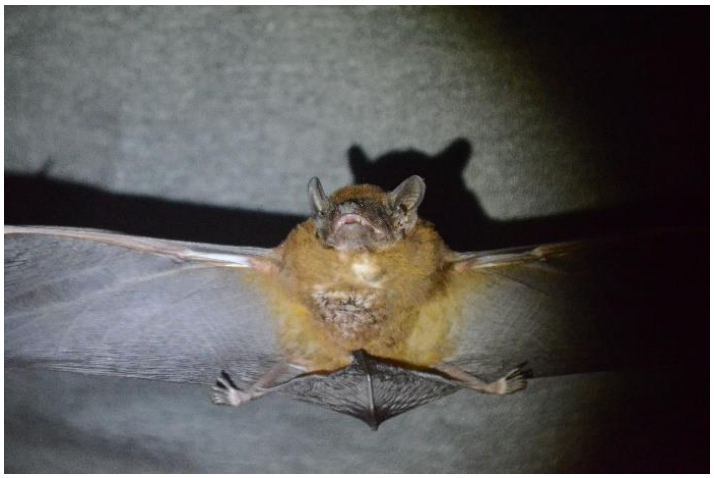


Fig 23. Ripo flores (*Murina florium*) (Photo:Abdul Haris Mustari),

Fig 24. *Ficus flavostipulata* called Popong by the local people is one of the favourite fruit eaten by many mammls's species, including bear cuscus, tonkean macaque, sulawesi giant squirrel, and its fallen fruit eaten by terrestrial mammals such as sulawesi warty pig, and at the primary undisturbed habitats, this fruit is favourite food for anoa and babirusa. This species is common along the riverine forest of Mamasa and Saddang rivers (Photo:Abdul Haris Mustari)

Conclusion

A total of 18 mammals species recorded in the study area, of wich five species are protected, one species is catagorized as Endangered, and five species are Vulnerable. Most of the mammals are arboreal and semi-arboreal species emphasizing that vegetations are key components of their habitats for food, water and cover that will quarantee their population sustainability. The target species are tonkean macaque, bear cuscus, sulawesi dwarf cuscus, tarsier, Sulawesi palm civet, ogically significant. Among the target species, tonkean macaque has the highest risk of extinction and the dam contruction will has significant impact since the species is medium sized primate, live in social gruop, dirnal, and semi arboreal meaning that the inundation of the area will directly has impact both to habitat and population of the black macaque. Additinally groups of this omnivore species are relatively easy to be detected and/or targeted by the hunters and in pest eradication using poisoned baits, live traps, torture and direct killing.

References

Burton J, Mustari AH, Rejeki IS. 2018. Sulawesi Warty Pig *Sus celebensis* (Muller & Schlegel, 1843) in Melleti M, Meijard (eds), Ecology, Conservation and Management of Wild Pigs and Peccaries. Cambridge University Press

Clark AB. 1991. Individual Variation in Responsiveness to Environmental Change. Dalam: Primate Responses to Environmental Change. HO Box (Editor). Chapman and Hall, London. Him 92-110.

Fairuztania ZZ, Mustari AH. 2017. Karakteristik Habitat dan Populasi Monyet Butung (*Macaca ochreata*) di Suaka Margasatwa Tanjung Peropa, Sulawesi Tenggara. *Jurnal Wasian* 4(2):97-108

Heywood VH and Stuart SN. 1992. Species Extinction in Tropical Forests. Dalam: Tropical Deforestation and Species Extinction. TC Whitmore and JA Sayer (Editor). Chapman and Hall, London. Him 91 - 117.

IUCN. 2018. The IUCN Red List of Threatened Species. (www.iucnredlist.org). Access date 26 February 2019

Jamaludin M. 2007. Studi populasi dan penyebaran babi hutan sulawesi (*sus celebensis*, muller dan schlegel 1843) di suaka margasatwa tanjung peropa, sulawesi tenggara. Skripsi. Institut Pertanian Bogor. Bogor.

Krebs CJ. 1978. *Ecological Methodology*. New York (US): Haper *and* Row.

Kurniawan I. 2010. Keragaman morfometris tengkorak anoa (*Bubalus* spp.) dari berbagai region di Sulawesi. Skripsi. Institut Pertanian Bogor. Bogor.

Lee PC. 1991. Adaptations to Environmental Change: An Evolutionary Perspective. Dalam: Primate Responses to Environmental Change. HO Box (Editor). Chapman and Hall, London. Hlm 39-56.

Ludwig JA, Reynold JF. 1998. *Statistical Ecology*: *A Primer on Methods and Computing*. New York (US): J Wiley.

MacKinnon K. 1987. Conservation Status of Primates in Malaysia, With Special References to Indonesia. Primate Conservation, 8, 175-183.

Mansyur, FI, Mustari AH, Prasetyo LB. 2016. Karakteristik habitat tarsius (*Tarsius* sp.) berdasarkan lokasi tidur di hutan Lambusango Pulau Buton Provinsi Slawesi Tenggara. Media Konservasi 21 (2):135-142

Mustari AH, Amnur NA, Kartono AP. 2015. Karakteristik Habitat Preferensial Tarsius (*Tarsius Fuscus*) di Taman Nasional Bantimurung Bulusaraung. *Media Konservasi* 20 (1): 1 – 8

Mustari AH, Mansyur FI, Rinaldi D. 2013. Karakteristik habitat dan populasi tarsius (*Tarsius fuscus* Fischer 1804) di resort Balocci, Taman Nasional Bantimurung Bulusaraung Sulawesi Selatan. *Media Konservasi* 18 (1):47 - 53

Mustari AH, Surono H, Mansyur FI. 2011. Keanekaragaman jenis mamalia di Taman Nasional Bantimurung Bulusaraung, Sulawesi Selatan. Jurnal Media Konservasi. Vol.16 : 156-161.

Mustari AH. 1995. Population and behaviour of lowland anoa (*Bubalus depressicornis*) in Tanjung Amolengo Wildlife Reserve, Southeast Sulawesi, Indonesia. MSc. Thesis, Georg-August University, Gottingen, Germany.

Mustari AH. 2003. Ecology and conservation of lowland anoa (*Bubalus depressicornis*) in Sulawesi, Indonesia. PhD Dissertation. University of New England. Australia.

Mustari AH., Kurniawan I. 2011. Manual identifikasi beberapa spesies kunci di Sulawesi.Kementerian kehutanan Republik Indonesia.

Nugraha R, Mustari AH. 2017. Karakteristik Habitat dan Jenis Pakan Kuskus Beruang (*Ailurops Ursinus*) di Suaka Margasatwa Tanjung Peropa, Sulawesi Tenggara. *Jurnal Wasian* 4(2):55-68

Pearce J, Vernier L. 2005. Small mammals as bioindikator of sustainable boreal forest management. *Forest Ecology and Management*. 208: 153-175.

Prasetyo AA. 2018. Dampak pembangkit listrik tenaga air terhadap lingkungan masyarakat. Jurusan Teknik Elektro Fakultas Teknik Universitas Tidar.

Prasetyo PN, Noerfahmy S, Tata HL. 2011. *Jenis-jenis Kelelawar Khas Agroforest Sumatera*. Bogor (ID): World Agroforest Centre – ICRAF.

Rejeki IS. 2018. Wildlife conservation strategy: an assessment of wildlife hunting activities in Sulawesi. PhD Dissertation. Bogor Agricultural University.

Riley EP, Suryobroto B, Maestripieri D. 2007. Distribution of *Macaca ochreata* and identification of mixed *ochreata-tonkeana* groups in South Sulawesi, Indonesia. Primate Conserv 22: 129-133.

Santosa Y, Ramadhani EP, Dede AR. 2008. Studi keanekaragaman mamalia pada beberapa tipe habitat di stasiun penelitian pondok amabung taman nasional tanjung puting Kalimantan tengah. Jurnal Media Konservasi. Vol.13(3): 108 – 114.

Supriatna J dan Wahyono EH. 2000. Panduan lapangan primata Indonesia. Yayasan Obor Indonesia. Jakarta.

Wheeler PM, Mustari AH, Burton J. 2014. Anoas *Bubalus depressicornis* (C.H.Smith, 1827); Bubalus quarlesi (Ouwens, 1910) in Melleti M, Burton J (eds). Ecology, Evolution and Behaviour of Wild Cattle Implications for Conservation. Cambridge University Press

Whitten AJ, Mustafa M, Henderson GS. 1987. *The Ecology of Sulawesi*. Yogyakarta: Gadjah Mada Univ Press.