Monitoring species diversity using camera traps in Ulu Masen ecosystem, Aceh Province

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Abstract. Camera traps are increasingly used to remotely monitor the population and distribution of a variety of species, including a number of threatened and elusive species over large geographical areas, with little human intervention/disturbance. Between April and September 2017, we deployed 150 camera traps at 75 stations, with two camera traps at each station, to monitor species diversity in the Ulu Masen Ecosystem in Aceh, Indonesia. We identified a total of 33 species that included three ‘Critically Endangered’, one ‘Endangered’, nine ‘Vulnerable’, seven ‘Near Threatened’ and 13 ‘Least Concern’ species over 121 days with a total of 554 trap night/100 km² and Relative Abundance Index (RAI) of 51.93 frames/100 trap nights. Critically endangered species recorded included Panthera tigris sumatrae (three individuals and 17 independent photos), Elephas maximus sumatranus (17 independent photos), and Manis javanica (one independent photo), while Cuon alpinus was the only endangered species (EN) recorded. Our results indicate that the Ulu Masen still harbours a variety of rare and elusive species that need to be protected. Deriving reliable abundance estimates and distribution especially for rare and endangered species from camera traps is an important step in conservation and can be used to guide the management of these ecologically valuable species.

1. Introduction

Aceh forest is one of the largest forests on the island of Sumatra, which has a high biodiversity of fauna and flora, a tropical climate, and a complex geological history. The area of Aceh Forest is 3,557,928 ha, consisting of 2 forest blocks, namely the Leuser Ecosystem (LE) and the Ulu Masen (UM) Ecosystem [1]. The Ulu Masen Ecosystem is a forest area located in the northern of Aceh which has an area of 750,000 ha, which includes the districts of Aceh Besar, Aceh Jaya, Pidie, Pidie Jaya, Aceh Barat and Bireuen [1][2][3].

The Ulu Masen Ecosystem is an important habitat for many fauna and flora species. Research on species is necessary for monitoring the presence of protected species and endangered species based on the IUCN Red list categories [4][5]. The existence of species in the wild maintains the balance of the ecosystem and has its own irreplaceable role. There are two umbrella species namely Sumatran tiger and Sumatran elephant in Ulu Masen. The existence of illegal human
activities in the forest is a threat to the existence of endangered species. This research is to monitor the presence of endangered species in the Ulu Masen Ecosystem in District of Pidie, Aceh Besar and Aceh Jaya. This study uses a camera trap as a tool to record images of species. The use of a camera trap also allows us to minimize the interference with animals that pass through it. Camera traps can be used for long-term monitoring and do not change the behaviour of species that are being observed [6]. This study described the distribution and the abundance of species in the study area.

2. Methods
This survey conducted in the Ulu Masen from April to September 2017. The survey locations were mostly located in Pidie, Aceh Besar and Aceh Jaya districts. We deployed 150 camera traps at 75 stations, with two camera traps at each station (Fig.1). The camera installed on species path with a height of 45-50 cm from the ground, and tied on a tree with a stable camera position. The distance of the camera with the optimal path is 3-4 meters, where it is used to ensure the entire body of the animal is recorded in the photo frame as well as small animals can be recorded by the camera and the camera placement distance between stations is at least 1-2 km [7].

Data from camera traps is stored on the computer using Renamer software. Renamer software is a software that developed to help organize, store and analyze data from camera traps. It allows users to save time and avoid errors when entering data into the computer [8]. Each photos are identified and the number of independent photos of each species are used to calculate the Relative Abundance Index (RAI) [9]. Altitude data is analyzed with ArcGIS version 10.6 using Digital Elevation Maps SRTM 1 Arc-Second Global data and graphics creation using Microsoft Excel 2013.

Figure 1. Study Area
3. Results and Discussion
3.1. Result
The surveyed area is 675 km$^2$ (75 grids x 9 km$^2$) with the closest distance to the camera installation of 1.06 km and the farthest distance of the camera is 45.58 km. The number of trap nights from the survey conducted (for 6 months of study) was 3,740 trap nights (554 trap nights/km$^2$) with 2,095 independent photos. The results of the analysis show the number of photos recorded is 13.8 - 22.6 images per Grid per month with an average of 17.3 images per Grid per month. The number of species recorded every month between 18-31 species with an average of 25.67 species per month. The following (Fig. 2) is a graph of the number of independent photos recorded per month and number of species recorded per month.

Based on the IUCN red list categories, the results of camera trap photos in Ulu Masen found 3 critically endangered species (CR), 1 endangered species (EN), 9 vulnerable species (VU), 7 near threatened species (NT) and 13 least concern species (LC). Critically endangered species are Sumatran tiger (*Panthera tigris sumatrae*), Sumatran elephant (*Elephas maximus sumatranus*) and Sunda pangolin (*Manis javanica*). One endangered species is Dhole (*Cuon alpinus*). In addition, several kind of small cats that are vulnerable and near threatened, such as the Clouded leopard (*Neofelis diardi*), Marbled cat (*Pardofelis marmorata*), Golden cat (*Catopuma temminckii*) and Leopard cat (*Prionailurus bengalensis*). Other vulnerable species are Sumatran serow (*Capricornis sumatraensis*), Sun bear (*Helarctos malayanus*), Pig-tailed macaque (*Macaca nemestrina*), Thomas's Leaf Monkey (*Presbytis thomasi*), Sambar deer (*Rusa unicolor*) and Binturong (*Arctictis binturong*) (Table 1).

![Figure 2. Number of independent photos and species recorded per month](image-url)
Table 1. Detections (N) and relative abundance index (RAI; # independent photos/100 trap nights) of tiger, other wildlife species and human activity (*Homo sapiens*).

| Species                                      | IUCN Status | Independent Photos (N) | Percentage of occurrence (%) | RAI     |
|----------------------------------------------|-------------|------------------------|------------------------------|---------|
| *Arctictis binturong*                        | VU          | 7                      | 0.3341                       | 0.187166|
| *Argusianus argus*                           | NT          | 61                     | 2.9117                       | 1.631016|
| *Canis lupus familiaris*                     | VU          | 1                      | 0.0477                       | 0.026738|
| *Capricornis sumatraensis*                   | VU          | 26                     | 1.2411                       | 0.695187|
| *Catopuma temminckii*                        | NT          | 74                     | 3.5322                       | 1.97861 |
| *Cuon alpinus*                               | EN          | 14                     | 0.6683                       | 0.374332|
| *Elephas maximus sumatranus*                 | CR          | 17                     | 0.8115                       | 0.454545|
| *Gallus gallus*                              | LC          | 1                      | 0.0477                       | 0.026738|
| *Helarctos malayanus*                        | VU          | 93                     | 4.4391                       | 2.486631|
| *Hemigalus derbyanus*                        | NT          | 19                     | 0.9069                       | 0.508021|
| *Herpestes javanicus*                        | LC          | 1                      | 0.0477                       | 0.026738|
| *Homo sapiens*                               | LC          | 93                     | 4.4391                       | 2.486631|
| *Hystrix sumatrae*                           | LC          | 160                    | 7.6372                       | 4.278075|
| *Lophura inornata*                           | NT          | 30                     | 0.1432                       | 0.802139|
| *Lophura ignita*                             | NT          | 3                      | 1.432                        | 0.080214|
| *Macaca fascicularis*                        | LC          | 3                      | 0.1432                       | 0.080214|
| *Macaca nemestrina*                          | VU          | 322                    | 15.3699                      | 8.609626|
| *Manis javanica*                             | CR          | 1                      | 0.0477                       | 0.026738|
| *Martes flavigula*                           | LC          | 48                     | 2.2912                       | 1.283422|
| *Muntiacus muntjak*                          | LC          | 247                    | 11.79                        | 6.604278|
| *Mydaus javanensis*                          | LC          | 23                     | 1.0979                       | 0.614973|
| *Neofelis diardi*                            | VU          | 80                     | 3.8186                       | 2.139037|
| *Paguma larvata*                             | LC          | 66                     | 3.1504                       | 1.764706|
| *Panthera tigris sumatrae*                    | CR          | 17                     | 0.8115                       | 0.454545|
| *Pardofelis marmorata*                       | VU          | 32                     | 1.5274                       | 0.855615|
| *Presbytis thomasi*                          | VU          | 2                      | 0.0955                       | 0.053476|
| *Prionailurus bengalensis*                   | LC          | 3                      | 0.1432                       | 0.080214|
| *Prionodon linsang*                          | LC          | 44                     | 2.1002                       | 1.176471|
| *Ratufa bicolor*                             | NT          | 1                      | 0.0477                       | 0.026738|
| *Rollulus rouloul*                           | NT          | 6                      | 0.2864                       | 0.160428|
| *Sus scrofa*                                 | LC          | 190                    | 9.0692                       | 5.080214|
| *Tragulus sp*                                | LC          | 11                     | 0.5251                       | 0.294118|

The results of analysis indicate that *Macaca nemestrina* has the highest relative abundance value (RAI) of 8.6 frames/100 days with a total occurrence percentage of 15.37%. Then followed by *Rusa unicolor*, *Homo sapiens* and *Sus scrofa*. Each species has RAI values of 6.6, 5.18 and 5.08 (Table 1). Critically endangered and endangered species have RAI value of 0.45 for *Panthera tigris sumatrae* and *Elephas maximus sumatranus*, 0.03 for *Manis javanica* and 0.37 for *Cuon alpinus* with the total occurrence percentage of these four species is 2.34%.
Based on Fig. 3, it shows that the highest value of naïve occupancy is *Sus scrofa* by 76%. In addition, the value of naïve occupancy of more than 50% is *Muntiacus muntjak*, *Macaca nemestrina*, *Hystrix sumatrae* and *Helarctos malayanus*. This shows that most of the animals recorded by cameras spread over more than half of the areas surveyed. However, the critically endangered species occupying the survey area is only 12% of *Panthera tigris sumatrae*, 11% of *Elephas maximus sumatranus* and 1% of *Manis javanica*.

**Figure 3. Naïve occupancy of Species**

**Figure 4.** The Altitude range of species recorded
Based on Fig. 4, it shows that most of the species recorded by cameras spread from lowlands and highlands. Only five species found were only altitude below 1000 m are Manis javanica, Macaca fascicularis, Herpestes javanicus, Lophura ignita and Rollulus rouloul. The Lophura ignita only found at altitudes below 1000 m while the Lophura inornata only found above 1000 m.

3.2. Discussion
Camera trap for species monitoring
Currently, the utilization of camera traps generally used to monitor the existence and population density of Sumatran tiger. But the results of the camera trap can also be used to detect non target species [10][6]. The utilization of camera traps in monitoring the diversity of species in the wild is very important [11][12], especially for endangered and elusive species. The results of the study using a camera trap for 6 months, 33 species identified and 85% of species found from the Mammal, and the rest from Aves. Based on the results obtained, the use of camera traps is very effective in monitoring the existence of species in the wild both rare and elusive species. This can be used to monitor population trends and species occupancy in the area under study.

The existence of rare species in Ulu Masen
The results of the study using camera traps are four animals with critically endangered status (CR) and one with endangered status (EN). Among the four species, there are two key species, the Sumatran tiger (Panthera tigris sumatrae) and the Sumatran elephant (Elephas maximus sumatranus) which are in critically endangered status. The Sumatran tiger has a range of 250 km\(^2\) for male individual [13] while the elephant home range reaches 156 km\(^2\) – 380 km\(^2\) [14]. The results of the study only amounted to 11% and 12% of the survey area occupied by Elephas maximus sumatranus and Panthera tigris sumatrae. Likewise with other critically endangered species, namely Manis javanica, only occupies 1% of the survey area. This shows that the existence of these three species is very rare in the wild. However, the presence of human in the survey area which reached 32% of the survey area. Generally, the human recorded are illegal hunters and NTFPs seekers in the forest. In the conservation of Sumatran tiger and Sumatran elephant, the main threats of decreasing of Sumatran tiger and Sumatran elephant populations in wild mostly by human activity such as human wildlife conflict, habitat loss and fragmentation, trans-boundary issues, illegal hunting and illegal wildlife trade [15][16].

Conservation of rare and protected species in Aceh
The existence of key species in Aceh, especially in the Ulu Masen ecosystem, is of particular concern. Ulu Masen is one of the great habitats for protected species, especially key species, Sumatran tiger and Sumatran elephant. The result of the study is 51% of the findings of species are protected by the state through Ministry of Environmental and Forestry Regulation Number P.106/MENLHK/SETJEN/KUM.1/12/2018 concerning kind of protected plants and animals [17]. It is necessary to have a further study to estimate the population of species that are already in critically endangered and endangered status. Research on rare species in Aceh, especially in the Ulu Masen ecosystems and Leuser ecosystems, should be conducted to monitor the existence and tendency of the species population in the wild, which will become the government's reference in determining regulations. By utilizing camera traps research, it can be a reference for determining important areas and must be protected properly.
4. Conclusion
Based on the results of research, it is very effective to use camera traps to monitor the presence of protected species in the wild especially for secretive and elusive species. Moreover, it can help to estimate the population and occupancy of species in a large area. Presence data from camera trap results can be used to analyze habitat suitability for endangered species. However, monitoring species is not only using camera traps, routine patrols also important activity to identify species threats and prevent the illegal hunting in the wild. Data from camera trap research and routine patrol can be a good reference in determining essential areas for endangered species, especially umbrella species.

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