Landscape transformation and wildlife: road mortality in Rawa Aopa Watumohai National Park, Southeast Sulawesi, Indonesia

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Abstract. The development of high way that crosses wildlife habitat will inevitably cause wildlife casualties. The purpose of this study was to identify wildlife road mortality in Rawa Aopa Watumohai National Park, Southeast Sulawesi (mostly consisted of savanna). Road kill data was collected by driving along the 22.4 km highway in February and March 2020 (n=28). Traffic volumes were recorded by taking traffic samples in 5 different times of the day, an hour duration each (totaling 70 h). There were 37 species being killed (totaling 529 individuals, of which 49.3% happened along km 0-10), consisted of 19 bird species, 3 small mammal species, 10 reptile species, and 5 amphibian species. Based on taxa, the highest number of road mortality was amphibians (dominated by Ingerophrynus biporcatus), followed by birds (mostly Lonchura malacca), mammals (dominated by Rattus argentiventer), and reptiles (dominated by Varanus salvator). Among mammals, no big mammal (booted macaque Macaca ochreata, wild boar Sus scrofa) was killed. Landscape transformation clearly has impacted wildlife in the study area. To reduce the occurrence of road kills, it is recommended to create corridors for wildlife crossings, limiting vehicle speed in the hot spots locations, create speed bumps, as well as adding more signage and road signs along the highway.

Keywords: amphibians, road kills, savanna, traffic, wildlife crossing.

1. Introduction

Economic development has driven changes of landscape in various regions. To improve access in remote areas, roads and highways are constructed and often crosses natural landscapes. The existence of the road has created a problem for wildlife that usually moves among various habitat, as the habitat become fragmented, and might cause mortality or injured while trying to cross the road. Wildlife road mortality has become a leading cause of population decline in some areas, i.e. in East Africa, India and Taiwan [1], [2], [3].

Rawa Aopa Watumohai National Park in Southeast Sulawesi (Indonesia) has been known as its tropical savanna habitat. In 2009, a provincial highway funded by the Australian project “The Eastern Indonesia National Road Improvement Project (EINRIP)” was built, which separated the northern and southern part of the savanna of the Park [4]. Considering that there are at least 321 species of fauna consisting of 28 species of mammals, 218 species of aves [5], 10 species of amphibians and 32 species of reptiles [6], the existence of this highway might become a problem for wildlife. The discovery of carcasses of Amboina box turtle (Cuora amboinensis) along the highway indicates the possibility that the road could affects the population of this turtle [7]. Although the species is not protected, it is categorized as Vulnerable by IUCN Red List [8] and listed in CITES Appendix II.

Report on the impact of highway to wildlife in the Indonesia is scarce. Only one report in grey publication on roadkill available, which refers to road kill between Sanggi – Bengkunat.
at Bukit Barisan Selatan National Park in Sumatera [9]. Thus, research on road mortality in Rawa Aopa Watumohai National Park is important. The purpose of this study is to identify the wildlife road mortality in Rawa Aopa Watumohai National Park.

2. Methods
The Rawa Aopa Watumohai National Park (105,194 ha) was established on 17 December 1990 and lays in four regencies: East Kolaka Regency, Konawe Regency, South Konawe Regency and Bombana Regency [5] (Figure 1). Surveys in the Park were carried out along the 22.4 km provincial highway, starting from the entrance gate of Konawe Selatan to the exit gate of Bombana. The road passed through several ecosystems, i.e., savanna, lowland forest, swamp, and mangrove, with savanna (22,963 ha) as the dominant ecosystems (Figure 2).

**Figure 1** Study area in Rawa Aopa Watumohai National Park (Southeast Sulawesi, Indonesia), showing position of highway surveyed
Data were collected for 28 days (15-28 February; 15-28 March 2020) by driving along the 22.4 km road as the main transect where observer travel at a constant speed [10] similar to research elsewhere [11]. Observations were made by two-person travelling with motorbike with a constant speed of 20-40 km/hour, 2 times a day in the morning (6am local time), and the afternoon (4pm). Observers will stop on the road shoulder whenever wildlife carcasses were sighted. The starting point for the observation were either the entrance gate in Konawe Selatan Regency or the entrance gate in Bombana Regency, with the same number of repetitions, totaling 627.2 km. All carcasses spotted were recorded with Global Positioning System (GPS) and marked using spray paint. Carcasses were measured and recorded and removed afterward from the road using shovels and latex gloves to avoid subsequent recounts. Species were identified at least to family level. Wildlife roadkill diversity was estimated as the number of species found dead on the surveyed.

3. Results and Discussions

3.1 Roadkill diversity
Roadkill during the study period was 529 cases from 37 species, with only 453 cases identified to genus and species, as some could not be identified due to the deteriorated conditions (Figure 3). The number of roadkill consisted of 263 amphibians (51%), 120 aves (23%), 63 mammals (12%), and 69 reptiles (14%). The daily average of roadkill in this study was 37.8 cases with a range of 18–69 cases. The number of roadkill in this study was quite high and diverse. The annual roadkill was estimated to reach 13,797 (6,570-25,185). No previous report on the number of roadkill in this Park and the high number of road mortality in this study showed that road mortality in this Park has been overlooked. Overall from the above data, many roadkills occur near the main gate of Bombana Regency.
In term of diversity, the number of species killed included at least 19 species of aves (Table 1), 3 species of mammals (Table 2), 10 species of reptiles and 5 species of amphibians (Table 3). The number of species was higher compared to report by [9] which only reported 4 species of mammals, 1 species of birds, and 6 species of reptiles. Other research outside Indonesia mostly reported specific classes of animals. For example, [12] recorded roadkill of 18 species of mammals from 10 families on major roads in Brazil. Meanwhile, [13] reported roadkill of 8 herpetofauna species on the road, consisting of 180 amphibians and 72 reptiles. During 6 years of observation from 2010-2015, [14] recorded 102 (80.3%) Cuora amboinensis and 25 (19.7%) Cyclomys dentata roadkill in Palawan, Philippines.

For bird (aves), Lonchura malacca was killed the most compared to other birds (Figure 2b). This bird species lives mostly in lowland ecosystems including savanna [15], often seen flying low and crossing the highway from one side to the other, which caused this species vulnerable to being hit.

Roadkill mammals are dominated by rats (Rattus argentiventer) and civets (Viverra tangalunga; Figure 2c) which have been known to adapt with human settlements [16], [17]. There were no incidents of road kill of big mammals such as Macaca ochreata and Sus scrofa at the time of the study, although both species were often seen around the highway.

The highest roadkill among wildlife were amphibians (n = 263) with 143 cases of crested toad Ingerophrynus biporcatus, of which 99% of cases occurred near the savanna. Savannas are one of the main habitats of this species [6] and during the survey, the toad were often found hopping in the asphalt in the middle of the road at night, increasing the possibility of getting hit by vehicles (Figure 2). Although the toad is endemic to Indonesia, its original distribution confines to Sumatra, Java, Madura, Bali, Lombok, and Kalimantan. The toad has been introduced to Sulawesi and able to lives in lowland forests, degraded forests, and nearby settlements [18], [19].

As expected, the Amboina box turtle was also recorded as road kill. Six species of snake were recorded as roadkill with the highest number of snake killed was Hypsicopus matannensis, an endemic species of Southeast Sulawesi. Varanus salvator was the highest number of reptile killed on the road (Table 3, Figure 3d). This species was often found basking on the side of the road during afternoon and late afternoon. The higher number of this species killed in the road might be caused of its feeding habits as scavengers [20]. The high number of carcasses in the road might attract the monitor to eat the carrion and increase the possibility of getting hit by a vehicle while eating.

Table 1 Diversity of avian road kill and mortality rate in Rawa Aopa Watumohai National Park during February-March 2020, listed based on alphabetical order

| No | Species                     | Family    | Number | Mean mortality/10 km |
|----|-----------------------------|-----------|--------|----------------------|
| 1  | Aerodramus fuciphagus       | Apodidae  | 2      | 0.9                  |
| 2  | Amaurornis phoenicurus      | Rallidae  | 1      | 0.4                  |
| 3  | Caprimulgus affinis        | Caprimulgidae | 1  | 0.4                  |
| 4  | Centropus bengalensis      | Cuculidae | 13     | 5.8                  |
| 5  | Cisticola exilis            | Passeridae | 5      | 2.2                  |
| 6  | Cisticola juncidis         | Passeridae | 13     | 5.8                  |
| 7  | Cisticola sp.               | Passeridae | 10     | 4.5                  |
| 8  | Gallirallus torquatus       | Rallidae  | 4      | 1.8                  |
| 9  | Hirundo tahitica           | Hirundinidae | 1  | 0.4                  |
| 10 | Ixobrychus sinensis        | Ardeidae  | 2      | 0.9                  |
### Table 2: Diversity of mammal road-kill and mortality rate in Rawa Aopa Watumohai National Park during February-March 2020, listed based on alphabetical order

| No | Species                  | Family       | Number | Mean mortality/10 km |
|----|--------------------------|--------------|--------|----------------------|
| 1  | *Rattus argentiventer*    | Muridae      | 33     | 14.7                 |
| 2  | *Rattus sp.*              | Muridae      | 22     | 9.8                  |
| 3  | *Viverra tangalunga*      | Viverridae   | 2      | 0.9                  |
| 4  | Unidentified              |              | 6      | 2.7                  |
|    | **Mammals**               |              | **63** | **28.1**             |

### Table 3: Diversity of herpetofauna road-kill and mortality rate in Rawa Aopa Watumohai National Park during February-March 2020, listed based on alphabetical order

| No | Species                  | Family       | Number | Mean mortality/10 km |
|----|--------------------------|--------------|--------|----------------------|
| 1  | *Calamaria nuchalis*     | Colubridae   | 1      | 0.4                  |
| 2  | *Cuora amboinensis*      | Goemydidae   | 3      | 1.3                  |
| 3  | *Dendrelaphis pictus*    | Colubridae   | 8      | 3.6                  |
| 4  | *Gekko gecko*            | Gekkonidae   | 1      | 0.4                  |
| 5  | *Hypsiscopus matannensis*| Homalopsidae | 17     | 7.6                  |
| 6  | *Lycodon capucinus*      | Colubridae   | 10     | 4.5                  |
| 7  | *Ophiophagus hannah*     | Elapidae     | 1      | 0.4                  |
| 8  | *Ramphotyphlops braminus*| Typhlopidae  | 1      | 0.4                  |
| 9  | *Varanus salvator*       | Varanidae    | 19     | 8.5                  |
| 10 | *Xenopeltis unicolor*    | Xenopeltidae | 1      | 0.4                  |
| 11 | Unidentified reptile     |              | 7      | 3.1                  |
|    | **Reptiles**              |              | **69** | **30.8**             |
|    | **Amphibian**             |              | **263**| **117.4**            |
| 1  | *Fejervarya cancrivora*   | Dicroglossida| 7      | 3.1                  |
| 2  | *Fejervarya limnocharis*  | Dicroglossida| 28     | 12.5                 |
| 3  | *Fejervarya sp.*          | Dicroglossida| 49     | 21.9                 |
| 4  | *Ingerophrynus biporcutus*| Bufonidae    | 143    | 63.8                 |
| 5  | *Polypedates iskandari*   | Rhacophoridae| 17     | 7.6                  |
| 6  | Unidentified amphibian    |              | 19     | 8.5                  |
Conservation implication
The development of highway in the middle of a national park area is a major problem for the existence of wildlife in this area. The construction of road infrastructure in forest areas might cause several negative impacts, such as physical changes, pollution, invasion of alien species and the roadkill [21]. Lack of signs stating animal crossing areas and maximum speed limit of 80 km/hour increases the likelihood of an animal being hit. Even though about 150 m from the direction of South Konawe Regency there are animals crossing sign, but these signs are not clearly visible (Figure 4).
There is another project within the Park area in progress, namely the 150 kV Andolo-Kasipute Sutt Electricity Infrastructure Acceleration Project. Geothermal power plants is an environmentally friendly energy [22], however there might be negative impact of the project, especially during the construction phase with high mobility of construction’s vehicle. There are several steps to reduce roadkill by construction of corridors for wildlife crossings, reducing speed limit of vehicles in "hot spots" area, and adding more signboards and road signs.

Corridors have an important function as connecting routes between a different type of land cover and neighbors on both sides [23]. The highway has divided the savanna into two parts, and ponds are found in both sides. These ponds are very important and wildlife will move to puddles on other sides when ponds dried up. To enable this wildlife species, especially amphibian and reptiles, to cross the road safely, there is a need to develop a tunnel as a corridor for the species’ movement. Corridor construction can be carried out near the Bombana’s Gate, but must spend high funds. Previous study showed suitable types of tunnels for frogs are the one mostly made by concrete but lined with soil [24].

Speed restrictions need to be put in place so that animals have the opportunity to run when vehicles approach. At high speed, drivers and animals have limited time to avoid each other [25]. Lowering speeds not only reduce collisions but also lowering noise intensity. Tall and dense roadside trees can increase the likelihood of collisions with animals, so tall and medium vegetation should be avoided [26].

It is necessary to install notification boards or road signs. Road sign along the highway are mostly in poor condition and the number is too few. Signs must be made every 1 km to enable drivers to read the signs. Creating speed bumps in hot spot area might be needed to reduce speed, especially at km 1-10 of Bombana Gate.

With the development of other infrastructure in the area, it is necessary to ensure that an environmental impact analysis has been carried out to identify the potential effects of this development on the ecology and wildlife in the national park. Local and international stakeholders as well as the government need to take strategic steps to protect the Rawa Aopa Watumohai National Park and its wildlife.

4. Conclusions
Based on the research, the highway of Rawa Aopa Watumohai National Park might negatively affect animal that live in the park. There were 529 cases of roadkill consisted of 37 species. The animals most frequently hit are amphibians (*Ingerophrynus biporcatus*), aves (*Lonchura malacca* and *Centropus bengalensis*), mammals (*Rattus argentiventer*), and reptiles (*Varanus salvator*). It is necessary to consider the construction of corridors in the form of flyovers and improvement of several tunnels along the road, renewing and adding road signs on animal crossing areas, and reduce maximum speed limit to reduce roadkill.

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