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SHORT COMMUNICATION

Mortality of primates due to roads and power lines in two forest patches in Bangladesh

Hassan Al-Razi[1,2], **Marjan Maria**[1,2], **Sabir Bin Muzaffar**[3]

[1]*Faculty of Life and Earth Science, Department of Zoology, Jagannath University. Dhaka, Bangladesh.*
[2]*Bangladesh Slow Loris Research and Conservation Project. 531/2, Shahidbagh, Mosque Road, Dhaka, Bangladesh.*
[3]*Department of Biology, United Arab Emirates University. Al Ain, United Arab Emirates.*
Corresponding author: Hassan Al-Razi (chayan1999@yahoo.com)

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ABSTRACT. Primates are in imminent risk of extinction due to different types of anthropogenic activities. Mortality due to road accidents and electrocution from power lines are among the major direct anthropogenic threats to the survival of primates. We collected primate mortality data from 2015 to 2017 at Lawachara National Park and Satchari National Park in northeastern Bangladesh. We recorded 27 fatalities in five species of primates caused by road accidents (n = 15) and electrocution (n = 12). Most mortality records were for *Trachypithecus phayrei* (Blyth, 1847) (n = 8) while the lowest recorded mortality was for *Macaca mulatta* (Zimmermann, 1780) (n = 3). Ninety percent of primates in Bangladesh are threatened and populations are gradually declining. Our results suggest that roads and power supply lines are major sources of primate mortality that should be managed in these two forests. We strongly suggest avoiding construction of roads and power supply lines inside forests. Furthermore, control of the speed limit of vehicles inside the forests, use of insulated power lines, maintenance of natural canopy bridges and preparation of artificial canopy bridges are strongly recommended.

KEY WORDS. Bengal slow loris, conservation, electrocution, fragmentation, road accident, Phayre's langur.

Primates are one of the largest groups of seed dispersers in tropical forests (Stevenson 2011). They are vital to the reproductive cycles of many plant species (Beaune et al. 2013, Levi and Peres 2013, Arroyo-Rodríguez et al. 2015) and are also central to the livelihood and culture of many societies (Estrada et al. 2017). Although primates are recognized as essential components of ecosystems, about 60% of the primates are globally threatened and an astounding 73% of Asian species are threatened (Estrada et al. 2017). Habitat loss caused by agriculture, logging, wood harvesting, livestock farming and infrastructure development are some of the primary threats to primates (IUCN 2017).

Forest fragmentation associated with forest loss can create small and isolated subpopulations, raising extinction probabilities arising from demographic, environmental, and genetic factors (Frankham et al. 2002, Goosem 2007, Muzaffar et al. 2007). Infrastructure, such as pipelines, roads, railways, and transmission lines have the potential to impact wildlife in many ways, most notably by reducing access to resources and increasing mortality rates (Laurence et al. 2009, Benítez-López et al. 2010, Jenkins et al. 2010, Dean et al. 2019). With rapid development in many developing countries, mortality due to road accidents and electrocution from power lines is among the major direct human causes of mortality of terrestrial animals worldwide (Drews 1995, Fedigan and Zohar 1997, Forman and Alexander 1998, Printes 1999, Chhangani 2004, Lokschin et al. 2007, Parker et al. 2008, Cáceres et al. 2010, Pragatheesh 2011, Umapathy et al. 2011).

Asia as a continent has undergone development at unprecedented rates during the last 50 years (Muzaffar et al. 2011, Islam and Sato 2012, FAO 2015). Within Asia, Bangladesh is a small, densely populated country with a total population of over 160 million. Forested lands are heavily fragmented and few forest patches remain scattered in the northeast, southeast and southwest of the country, representing about 9.82% of the total land area (IUCN 2015). These patches are surrounded by human habitation, roads and railway lines that often pass through these forests. Thus, primates here are at high risk of mortality from road accidents on highways and from electrocution from electric power supply lines that pass through the remaining forest habitats. In this study the threats of primates arising from road accidents and electrocution were characterized.

We selected two forest patches of northeastern Bangladesh, namely Lawachara National Park (LNP) and Satchari National Park (SNP) for this study. Both national parks consist of mixed evergreen forest types planted in the 1930s and 1940s (Kabir and Muzaffar 2002). Lawachara National Park is situated in Kamalganj Upazila, Maulvi Bazar District and covers a 1250 ha area (Mollah and Kunda 2004). The canopy height of the forested areas in LNP varies from 10 to 30 m (Muzaffar et al. 2007). This forest is fragmented by Sreemangal-Bhanugach highway and Dhaka-Sylhet railway line (Fig. 1). In addition, an electric power supply line also passes through the forest approaching the highway. The second site, Satchari National Park, is within Chunarughat Upazilla, Habiganj District and has an area of 243 ha. The current extent of mixed evergreen forest is about 150 ha (Choudhury et al. 2004). The canopy height of this forest varies from 15 to 35 m. This forest patch is dissected by the old Dhaka–Sylhet highway and an electric power supply line that passes through the forest approaching the highway (Fig. 1).

We collected primate mortality data from both primary (direct observation) and secondary sources (published articles, interviews, social media uploads and newspaper reports) from 2015 to 2017 at these two national parks. Firstly, we collected primary data by direct observation during field work from July, 2015 to December 2017 during which we spent a total of 37 days in LNP and 68 days in SNP. Secondly, we collected secondary data from published articles. From March 2018 to April 2018 we searched the internet using Google and Google Scholar to find all related articles regarding primate mortality in SNP and LNP. Thirdly, we searched news published by national and local newspapers, online news portals, wildlife conservation groups and social media outlets. Finally, we collected data from interviews with forest staff, local people, as well as data from the record books of the range offices of SNP and LNP (Table 1). We conducted a questionnaire survey over a seven-day period in February 2018 in SNP. In LNP we conducted the questionnaire survey between May 2018 to June 2018. The questionnaire was developed in advance and approved by the Forest Department prior to the study. After data collection we cross-checked all data to avoid duplication of reports. In order to test possible differences between the types of accidents both within and between

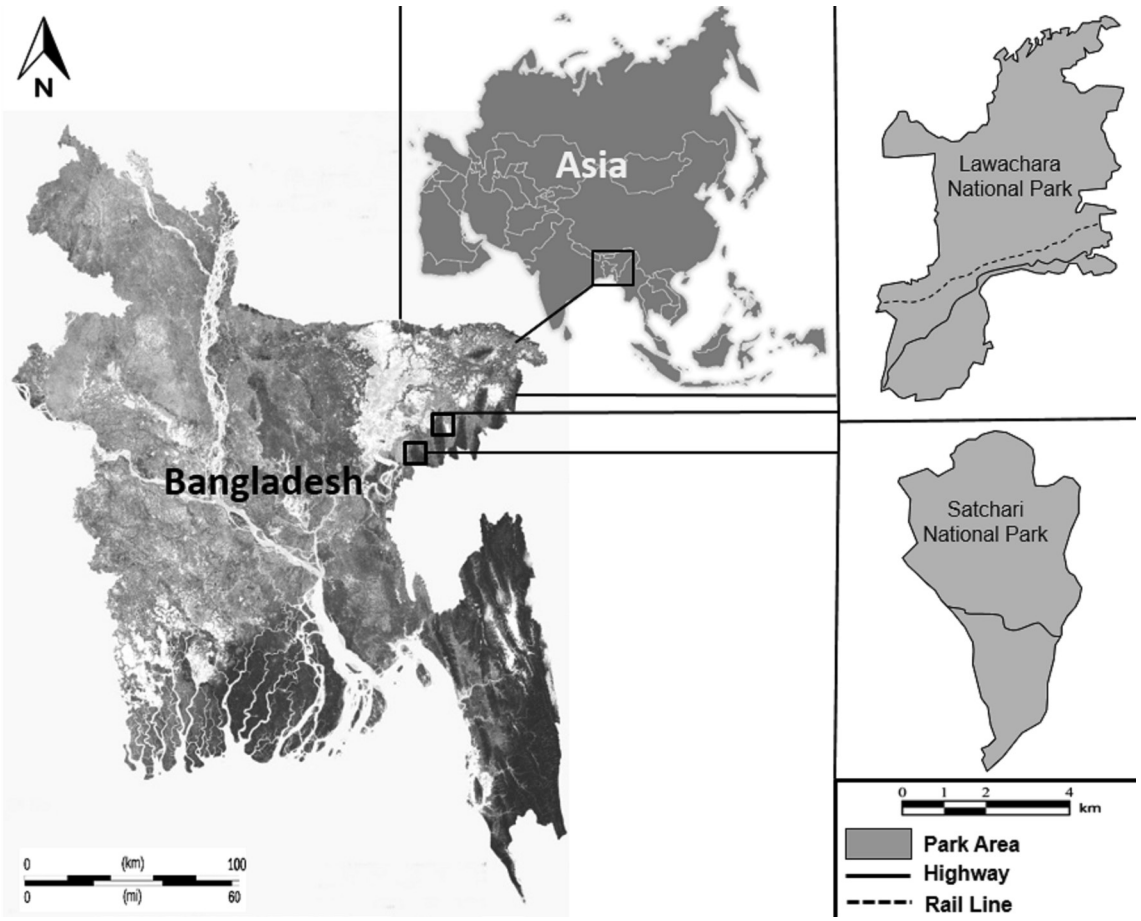

Figure 1. Map of two forest patches in Bangladesh, showing the locations of linear infrastructures inside the forest.

Table 1. Mortality of primates between 2015 and 2017 in Lawachara National Park (LNP) and Satchari National Park (SNP). (Source of data: I, Interview; SM, Social Media; N, Newspaper; PA, Published Article; DO, Direct Observation).

Incidence month	Affected species	Type of incidence	# mortality	Place	Source of data
January, 2015	*Nycticebus bengalensis*	Roadkill	1	SNP	I, SM
March, 2015	*Macaca leonina*	Roadkill	1	SNP	I
August, 2015	*Macaca leonina*	Roadkill	1	LNP	I
October, 2015	*Trachypithecus phayrei*	Electrocution	1	LNP	I
December, 2015	*Nycticebus bengalensis*	Roadkill	1	SNP	N, I
March, 2016	*Trachypithecus phayrei*	Roadkill	1	LNP	N
March, 2016	*Trachypithecus phayrei*	Roadkill	2	SNP	PA, N
June, 2016	*Trachypithecus pileatus*	Electrocution	2	SNP	DO
July, 2016	*Trachypithecus pileatus*	Electrocution	1	SNP	I, DO
August, 2016	*Trachypithecus pileatus*	Electrocution	1	SNP	SM
July, 2016	*Macaca mulatta*	Roadkill	1	SNP	DO
August, 2016	*Trachypithecus phayrei*	Roadkill	1	LNP	N, I
October, 2016	*Trachypithecus phayrei*	Roadkill	1	LNP	N, DO
October, 2016	*Nycticebus bengalensis*	Roadkill	1	LNP	N, I
November, 2016	*Macaca leonina*	Roadkill	1	LNP	I
December, 2016	*Trachypithecus phayrei*	Electrocution	1	LNP	N, I
February, 2017	*Nycticebus bengalensis*	Electrocution	2	LNP	I
May, 2017	*Macaca mulatta*	Roadkill	1	LNP	N, I
May, 2017	*Macaca leonina*	Roadkill	1	LNP	N
June, 2017	*Macaca mulatta*	Roadkill	1	SNP	N
July, 2017	*Trachypithecus pileatus*	Electrocution	1	SNP	I
October, 2017	*Trachypithecus pileatus*	Electrocution	1	SNP	DO
October, 2017	*Trachypithecus phayrei*	Electrocution	1	LNP	SM
December, 2017	*Trachypithecus pileatus*	Electrocution	1	SNP	I

parks we use the chi-square test (with values of significance determined at $\alpha < 0.05$).

A total of 27 (Mean = 9 ± SD 4 per year) individual fatalities of five primate species were recorded, of which 15 were caused by road accidents and 12 were caused by electrocution (Table 1). Most mortality records were for the Phayre's langur, *Trachypithecus phayrei* (Blyth, 1847) (n = 8) while the lowest recorded mortality was for the Rhesus Monkey, *Macaca mulatta* (Zimmermann, 1780) (n = 3). Fourteen individuals of primates died in SNP and 13 individuals in LNP (Table 1). The rate of mortality from road accidents (57.14%) was higher than the rate of mortality from electrocution (42.86%) in LNP, whereas mortality from electrocution (53.85%) was higher than mortality from road accidents (46.15%) in SNP ($\chi^2 = 0.83$, $p < 0.05$). In the case of electrocution, mortality rate of langurs (66.66%) was higher than mortality rates of other primates (16.66%). In contrast, mortality rate of langurs (33.33%) was lower than the mortality rates of other primates (83.33%) due to road accident in both study sites ($\chi^2 = 0.99$, $p < 0.0001$). Between two species of langur, mortality of Capped langur, *Trachypithecus pileatus* (Blyth, 1843), was higher in SNP (n = 6) than in LNP (n = 1) whereas mortality of Phayre's langur was higher in LNP (n = 6) than in SNP (n = 2).

Primate mortality rate appeared to be higher in SNP (13 individuals/2.5 km of road = 5.2 deaths per km of road) compared to LNP (2.15 deaths per km of road). The impact of infrastructure is proportional to its length since this affects the area of the effect zone (Forman 2000, Benítez-López et al. 2010). Furthermore, primate mortality rate in SNP was particularly high in 2016. In 2016, 12 of 18 natural canopy bridges over the highway were cut down to introduce an electric power supply line in the middle of the forest approaching the highway. We suspect that this was the likely cause of the higher mortality of primates in SNP in 2016. Removal of the natural canopy bridges likely forced the primates to use the road or electric power supply wire to cross the road making them vulnerable to road accidents and electrocution. It may be added that there were no records of electrocution of primates in SNP before 2016. Electrocution of primates were recorded only after the installation of electric power supply lines inside the forest, highlighting that such installations constitute a major threat to primates.

Rhesus and pig-tailed macaques were only recorded to have died from road accidents because these two species frequently use the ground for movement (Southwick et al. 1976, Bernstein 1967). Road accidents are considered as one of the major threats for Bengal slow loris as well (Choudhury 1992, Radhakrishna et al. 2006, Kumar and Devi 2010, Das et al. 2015). Only Radhakrishna et al. (2010) reported an incident of mortality from electrocution in this species near Siju Wildlife Sanctuary in Garo Hills, north-

eastern India. In this study, we recorded two incidents of mortality due to electrocution of Bengal slow loris from LNP. Among the two species of langur, mortality of capped langur occurred only due to electrocution. On the other hand, among eight cases of mortality of Phayre's langur, five occurred due to electrocution and three were due to road accidents (Fig. 2). From direct observation and interview of forest staff we found that both Capped langurs and Phayre's langurs frequently use the power supply lines to cross roads. Mortality in langurs occurred primarily due to short-circuiting of two electric parallel power lines connected by overhanging tails. In comparison, the other species have relative short tails (macaques) or almost no tail (e.g. slow loris). This is possibly why the macaques would be less vulnerable to electrocution even if they did use electric lines for movement. However, movement of the slow loris is slow and individuals may move from one wire to the next without releasing their grip on the first wire, causing fatal short-circuiting.

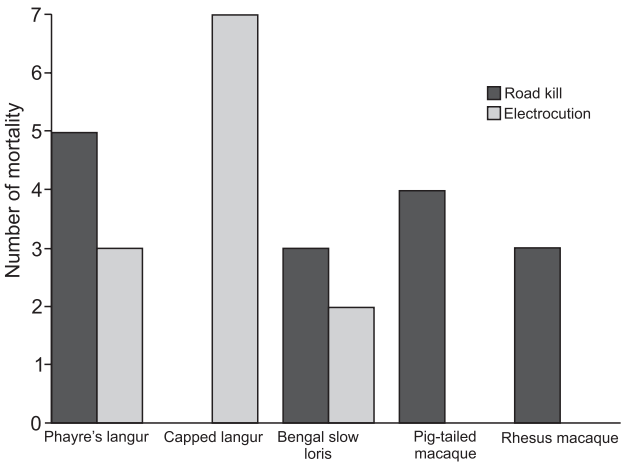

Figure 2. Type of mortality of different primate species in both study sites.

Ten primate species have been recorded from Bangladesh (IUCN 2015). Two species are globally Endangered, three are Vulnerable, and one is Near Threatened (Roos et al. 2014, IUCN 2015). In this study we recorded mortality of one Critically Endangered: *Trachypithecus phayrei*, and three Vulnerable species: *Trachypithecus pileatus*, *Nycticebus bengalensis* (Lacépède, 1800) and *Macaca leonina* (Blyth, 1863). Ninety percent of primates are threatened and the population of most of the primates are gradually declining in Bangladesh (IUCN 2015).

The Phayre's langur is surviving in few semi-evergreen forests of eastern parts of the country in small fragmented populations (IUCN 2015). The total population has declined by more than 80% in the last 20 years making it vulnerable to imminent extinction (Molur et al. 2003, IUCN 2015). Beside habitat destruction, logging, hunting, road accidents and electrocution are major threats of primates in Bangladesh (IUCN 2015). To mitigate the effects of road accidents and electrocution of primates and other wildlife in forest patches in Bangladesh, we strongly suggest avoiding construction of roads and power supply lines inside the last remaining forest patches. However, there is no direct law on the construction of roads and power supply lines inside the forest. As development progresses, roads and electric lines are constructed according to project needs. Stricter control of the speed limit of vehicles inside the forest should be imposed by creating speed breakers. To reduce fatalities from electrocution, we recommend the use of insulated power lines at least in the forested areas. Furthermore, maintenance of natural canopy bridges, and the preparation of artificial canopy bridges over the roads and electric power supply lines could further minimize mortality of primates and other arboreal mammals in forest patches of Bangladesh (Goosem 2004, Thurber and Ayarza 2005, Dean et al. 2019).

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