



Amphibian Mortality on the Roads of Nijhum Dweep National Park in Bangladesh

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Transportation is crucial for the growth and rapid urbanization of regional economies, especially in developing nations (Shyh-Chyang 2007). As transportation networks expand alongside social concern about environmental issues, the interest in studying the relationships between wildlife and roads has also increased (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; Umaphathy et al. 2011). Roads affect wildlife by causing habitat loss, population fragmentation limiting movement and access to food and mates, direct mortality, and behavioral changes (Malo et al. 2004; Jaarsma et al. 2006; Fahrig and Rytwinsky 2009). Although many studies have described the effects of roads on vertebrates, most have focused largely on high-grade highways compared to low-grade highways or rural roads (Gibbs and Shriver 2005; Orłowski 2007) and very few have addressed amphibian species. Therefore, understanding the effects of roads on small vertebrates and the resulting ecological ramifications is imperative (Andrews and Gibbons 2005). For example, amphibians, considered one of the groups most vulnerable to road mortality, tend to suffer direct mortality due to vehicle collisions more than do other vertebrates (Goldingay and Taylor 2006). Several unique behavioral traits, such as seasonal migrations (e.g., from overwintering sites to aquatic breeding sites; Orłowski 2007; Semlitsch et al. 2007), relatively slow movement (Carr and Fahrig 2001; Puky 2006), and the tendency to remain immobile in response to oncoming vehicles (Mazerolle et al. 2005), leave them more prone to road mortality than most other vertebrate species when crossing roads (Hels and Buchwald 2001). Additionally, being small and thus difficult for drivers to see also increases the number of collision events.

Just as few studies have specifically addressed the global impact of road mortality on amphibian populations (van Gelder 1973; Fahrig et al. 1995; Ashley and Robinson 1996; de Maynadier and Hunter 2000; Hels and Buchwald 2001; Cooke and Sparks 2004; Mazerolle 2004; Pellet et al. 2004; Gibbs

and Shriver 2005; Goldingay and Taylor 2006; Elzanowski et al. 2009), no studies have assessed road effects on amphibians in Bangladesh. Forested areas are heavily fragmented by human habitation and roads and railway lines, with only a few forest patches representing about 9.82% of the total land area remaining in the northeast, southeast, and southwest of the country (IUCN Bangladesh 2015). The total length of roads has increased over the last 50 years from 2,500 to 22,096.303 km (Roads and Highways Department 2020), an enormous increase that will certainly have a detrimental influence on animals forced to cross roads. Herein we provide an initial assessment of road mortality on amphibian populations in Nijhum Dweep National Park, Bangladesh, an offshore coastal island in the Bay of Bengal. This park is a tourist site and attracts a large number of local and a limited number of foreign tourists during weekends, largely during the winter season (December to March) and during religious festivals. The aim of our study was to enumerate species composition and encounter rates of amphibians killed on the road, assess the effects of adjacent habitats on roadkills, and identify the factors that contribute to amphibian road mortality in this area.

Nijhum Dweep National Park (21°35'0"N, 92°01'0"E), designated as a protected area under the Bangladesh Wildlife (Preservation) Order 1973 in 2001 (Iftekhar and Takama 2008; Saha et al. 2014), is located in the northern portion of the lower Meghna Estuary and south of Hatiya Island in the Bay of Bengal (Hossain et al. 2016; Sultana et al. 2020). This park is a 163.52-km² coastal island with a planted mangrove ecosystem and is recognized as an important stopover and Important Bird Area (IBA) for migratory birds using the East-Asian Australasian and the Central Asian flyways (Mundkur et al. 2017). Additionally, the island and surrounding waters have been declared the second largest Marine Protected Area (MPA) of Bangladesh (Ministry of Fisheries and Livestock 2019). Of the total landmass of the island, 10% is occupied by humans, 30% is devoted to agriculture (primarily paddy cultivation and seasonal vegetables), and the rest is covered

by forest and planted vegetation (a total of 152 plant species, dominated by *Porteresia coarctata*, *Zoysia matrella*, and *Paspalum vaginatum*) (Uddin et al. 2015; Rabbi et al. 2016).

We conducted our study of amphibian road mortality along a 3-km long stretch of road passing through approximately equal lengths mangrove, agricultural, and human habitats in Nijhum Dweep National Park (Fig. 1) for 35 days in January to March 2020. Each morning between 0600

h and 0730 h we slowly walked along the road looking for dead anurans. Each roadkill was photographed, identified (if possible) using descriptions and photographs in Hasan et al. (2014), and crushed remains were removed to avoid repeated counts (we did not collect or preserve specimens). We recorded ambient temperature (°C) and relative humidity (%). We calculated encounter rates as the number of killed amphibians per km of road surveyed per hour, traffic inten-

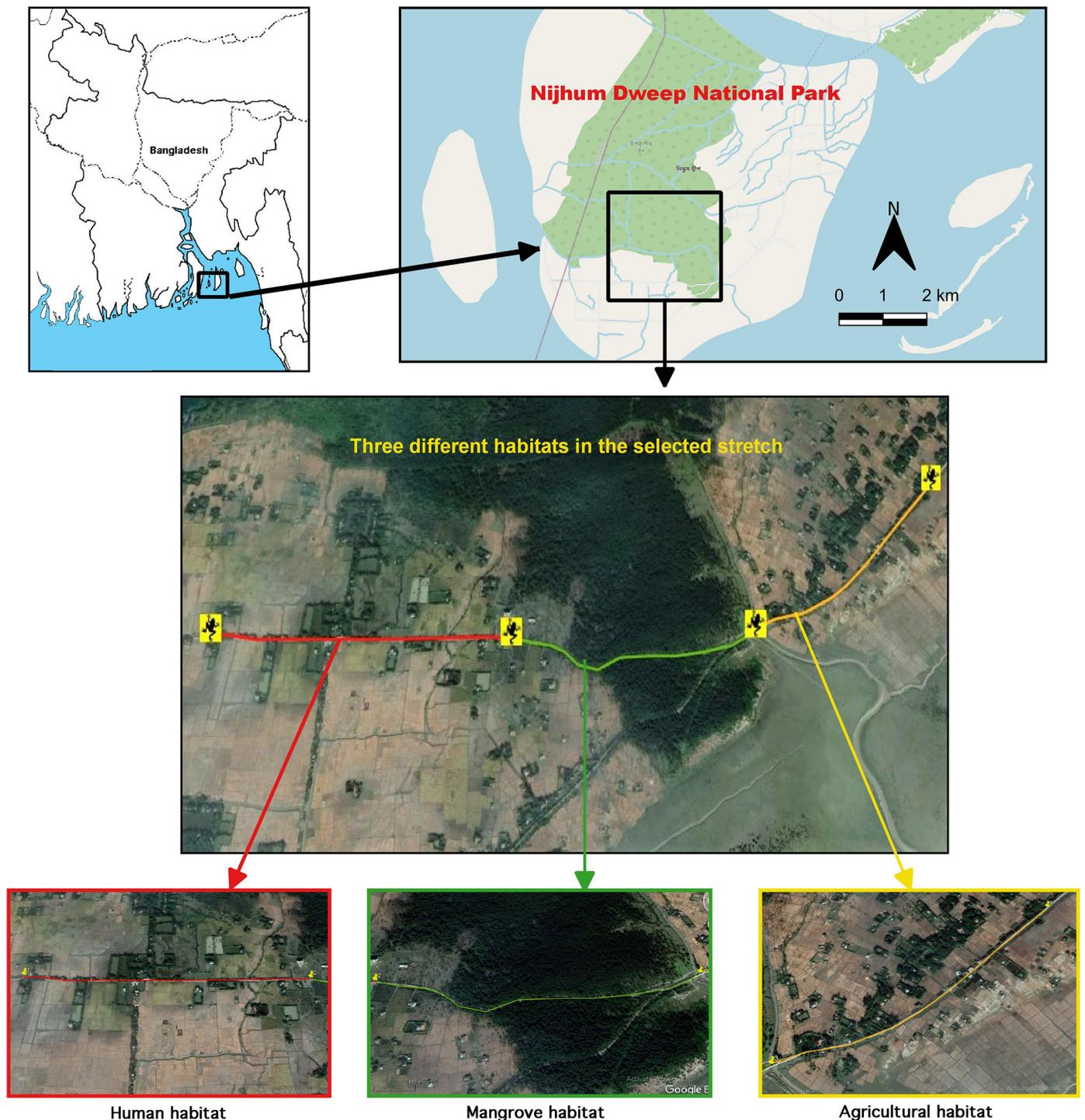


Fig. 1. Map of Nijhum Dweep National Park, Bangladesh, showing surveyed road sections and adjacent habitats.



Fig. 2. Road-killed Common Asian Toads (*Duttaphrynus melanostictus*) in Nijhum Dweep National Park, Bangladesh. Photographs by Naim Khandakar.

sity as the number of vehicles per hour, and vehicular load (in one direction only) between 1900 h and 2100 h, the period during which both traffic and herpetofaunal activity peaked. Pearson correlation tests were used to assess the relationship between traffic intensity and encounter rates.

We recorded a total of 133 dead amphibians, 125 Common Asian Toads (*Duttaphrynus melanostictus*; Fig. 2) and eight unidentifiable anurans, along the 3-km stretch of road, 50.4% in agricultural habitat, 28.6% in mangrove habitat, and 21.0% in human habitat. Not coincidentally, the agricultural habitat contained the most bodies of water. Fifty-five anurans were killed in March (mean temperature 23 °C, mean relative humidity 71%), 43 in February (20 °C, 63%), and 35 in January (19 °C, 65%), suggesting an increase in activity corresponding to increases in temperature and humidity. An average of 1.27 amphibians were killed per kilometer per day at a traffic intensity of 7.17 vehicles per kilometer during the study period. The null hypothesis (no correlation between vehicle numbers/hour and the number of amphibians killed) was rejected (Pearson correlation; $r = 0.63$, $t = 4.70$, $d.f. = 33$, $P = 4.496e-05$, and the 95% confidence interval [0.38–0.80] did not contain 0). A positive correlation existed between numbers of vehicles and amphibian mortality (Fig. 3). In addition to the 133 dead anurans,

we found a Checkered Keelback (*Fowlea piscator*), six Asian House Shrews (*Suncus murinus*), and seven Common House Rats (*Rattus rattus*) dead on the road.

While Feeroz and Uddin (2015) reported that six species of amphibians were found in Nijhum Dweep National Park, SRCWP (2014) assumed that only four amphibian species, the Common Asian Toad (*Duttaphrynus melanostictus*), Indian Skipping Frog (*Euphlyctis cyanophlyctis*), Indian Pond Frog (*E. hexadactylus*), and Indian Bullfrog (*Hoplobatrachus tigerinus*), occur on the island. Of these, the toad was found mainly in the human settlement, especially in the drier portion of the island; the Indian Skipping Frog was found in aquatic habitat, agricultural land, and swampy areas; and the Indian Pond Frog and Indian Bullfrog were found in semi-aquatic habitat, agricultural land, and swampy areas. We found only toads and a small number of unidentifiable anurans dead on the roads of the park. This, we believe, is largely attributable to our study being conducted during the winter period when most anurans are inactive, buried in the mud at the bottom of bodies of water or under logs and leaf litter on the forest floor. The apparent association of higher mortality and higher temperatures in March (late winter in Bangladesh), when amphibians presumably were increasingly active, suggests that road mortality could be even higher and involve more species as the year and seasons progress. However, winter, especially from December to March, also sees increased vehicular traffic from tourism-related activities. Only a longer-term study can determine whether the increase in amphibian activity during warmer and wetter seasons will increase road mortality despite a decline in vehicular traffic.

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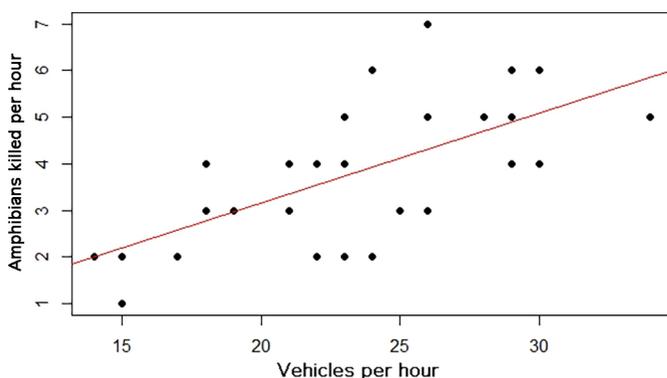


Fig. 3. Correlation between number of vehicles per hour and amphibian mortality in Nijhum Dweep National Park, Bangladesh.

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