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Cover: ***Pipistrellus tenuis*** **recorded during the small mammalian fauna study, Manipur, India. © Uttam Saikia.**

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COMMUNICATION

Effects of visitor disturbance on tetrapod vertebrates in the Horton Plains National Park, Sri Lanka

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Abstract: Effect of visitor disturbances on tetrapod vertebrates was studied from December 2017 to October 2018 in the Horton Plains National Park (HPNP), which is one of the world's best nature reserves and a popular tourist destination of Sri Lanka. Roads and nature trails with cloud forest, aquatic and grasslands habitats inside the HPNP were selected to compare the effect of visitor disturbances. Three 100 meter fixed length line transects were marked along the roads and the nature trails in each habitat. Vehicle noise was measured using sound meter software. Visitor activities that cause disturbance included road kills, photography, trampling and animal feeding. Amphibian and reptile road kills were higher compared to other tetrapod road kills during vacation periods. Behavioral response of species to visitor disturbances included avoidance, habituation and attraction. When the vehicle noise range was from 63±2.11 dB to 69±2.11 dB, habituation behavior was displayed. When the vehicle noise range increased to the range of 70±4.71 dB to 88±4.71 dB, avoidance behavior was displayed. Animals display a propensity to habituation behavior compared to avoidance behavior when vehicle speed was less than 30 kmh/hr. The results of this study can be used to integrate with the future visitor, park and wildlife management practices of the park.

Keywords: Behavioral response, disturbance, habitat, HPNP, nature reserves, road kills, tourist destination.

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Author contributions: DMTD—main researcher on this research findings, field sampling, data collection, data analysis and preparation of the paper were the main contribution. WADM—main supervisor of this research and who gave me the guidance, support and encouragement throughout my research with sharing her valuable experience and knowledge.

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INTRODUCTION

Sri Lanka is an island nation in the Indian ocean, and is considered a global hotspot for biological diversity along with the Western Ghats of India (Myer et al. 2000). Protected areas of the island spread over 1,710,000 ha. There are 22 national parks (NPs) in Sri Lanka governed by the Department of Wildlife Conservation (Newsome 2013). NPs are one of the protected areas to allow in park recreational activities with limited opportunities that are provided for the public to observe and study wildlife within these areas (Senevirathna et al. 2013). Despite the economic gains obtained, a number of negative impacts may arise due to heavy visitor arrivals to NPs which keeps increasing day by day.

According to Knight & Cole (1995) human disturbance is an anthropogenic activity that causes a change in metabolism and/or behavior of an animal. It can produce short-term or long-term effects on individuals, populations, and communities. Many studies have been conducted worldwide related to impact of human disturbance on animal populations (Bélanger & Bédard 1989; Stockwell et al. 1991; Poster et al. 1992; Reijnen et al. 1995; Andersen et al. 1996; Gill et al. 1996).

Behavioral response

Most reported disturbances occur related to viewing of wildlife which results in behavioral change as a response by the animal. Behavioral changes may arise when animals are approached for viewing, touching, feeding, and photographing (Valentine & Birtles 2004; Lemelin & Wiersma 2007). Nineteen out of 27 studies have proven that birds are negatively affected by wildlife observation and photography (Boyle & Samson 1985). However, it is not only birds, other wildlife also gets affected by such activities in varying degrees. Disturbance occurred by photography is greater than that of nature observations (Klein 1993; Tershy 1997).

Road-kills

The greatest non-natural source of vertebrate death is road mortality which is increasing even within protected areas (reserves and parks) (Bernardino & Dalrymple 1992; Kline & Swann 1998). The continuation and prevalence of natural habitats can be disrupted by the presence of trails and roads. There is evidence that recreational trails can change breeding bird communities in both grassland and forest ecosystems (Miller et al. 1998). Width of the road, vehicular traffic and speed level can affect the road kill rates. Mortality of wildlife due to vehicular traffic is among the direct impacts when natural habitats are replaced with roads (Laurance et al. 2009). Despite a number of studies that have been conducted regarding the impact of roads on animals, only two studies have been reported (Maduwage et al. 2003; Amarakoon et al. 2010) from Sri Lanka. Horton Plains National Park (HPNP) was included in the study conducted by Karunarathna et al. (2013) on the impact of road traffic mortality of reptiles.

Noise

Noise is one of the most negatively affecting road disturbance types (Forman & Alexander 1998; Forman et al. 2003; Coffin 2007). Many animals use acoustic communication to communicate with each other via acoustic signals (e.g., amphibians, birds, and mammals). Those acoustic signals get interfered in areas affected by traffic noise (Collins 2004; Marler 2004). The disturbance of anthropogenic noise on wildlife can be quantified (Brumm & Slabbekoorn 2005; Morley et al. 2014). A number of studies highlight the negative and adverse impacts of anthropogenic noise on wildlife (Stone 2000; Barber et al. 2010; Verzijden et al. 2010; Hanna et al. 2011).

At present, Sri Lanka's NPs are becoming prime tourist destinations for both international and domestic tourists. Hence, HPNP was selected to conduct this research which demonstrated the second highest visitor rate within the period concerned. Total number of visitors at HPNP in 2019 was 329,792 (STDA 2019). A total of 109 species of indigenous plants species can be observed in the park. The vertebrate fauna of the park includes five out of 19 mammal species that are endemic, nine mammal species are nationally threatened and five among them are globally threatened, thirteen out of 64 bird species are endemic and three globally threatened species, five out of six species of reptiles are endemic, 13 out of 14 species of amphibians are endemic species; the point endemism within the park is highly remarkable for both fauna and flora (De Alwis et al. 2007). The vegetation consists of cloud forest and wet patana grasslands, with a narrow ecotone belt of shrubs and herbs between them (Gunatilleke & Gunatillke 1990). In HPNP, visitors are allowed to walk along the nature trails in the unique scenic landscape. Road access of 5 km through the park area is also available where visitor vehicles are allowed. Baker's fall, Small World's End, and Greater World's End are popular attractions of the park (Rathnayake 2015). Therefore, over a long period of time, anthropogenic activities have been concentrated within HPNP through the process of ecotourism activities. This research was focused on identifying and quantifying the impact of roads and nature trails from visitors in HPNP. It will also

highlight the management and conservation steps that need to be taken in order to conserve the country's remaining wildlife within protected areas.

Study sites

Present study was conducted from December 2017 to October 2018 covering three main habitats types in HPNP (6.78–6.83 N & 80.76°–80.83 E) including cloud forest, grasslands, and aquatic habitat. The selected three habitat types were identified, based on the base line survey in HPNP (DWC 2007) (Image 1).

METHOD AND MATERIALS

Disturbances were surveyed using line transects in the three selected habitats along the roads and nature trails. For each month, a total of 18 transects were monitored (Appendix 1) with triplicates of survey attempt in the time periods: morning (0800–1100 h), mid-day (1130–1430 h) and evening (1500–1800 h) in an expansion four consecutive days. Each transect was 100 m in length and width of transect line was 20 m, and three such transects were laid in each habitat on the road as well as the nature trail.

Road-kills

On each sampling day, road-kills were recorded while walking in transects. Throughout the survey, in both vehicle road and nature trail, surface and verges (50 cm on either side of the road and nature trails) were scanned. The specimens were identified using field guides (Wijeratne 2008; De silva 2009; Somaweera & Somaweera 2009; Harrison 2011). All specimens were photographed and identifications were verified (Karunarathna et al. 2013). These monthly data were converted for vacation (December, April, and August) and non-vacation periods (February to November).

Visitor activities

Visitor activities were recorded under photography, trampling and animal feeding in the roads and nature trails ((Valentine & Birtles 2004; Lemelin & Wiersma 2007).

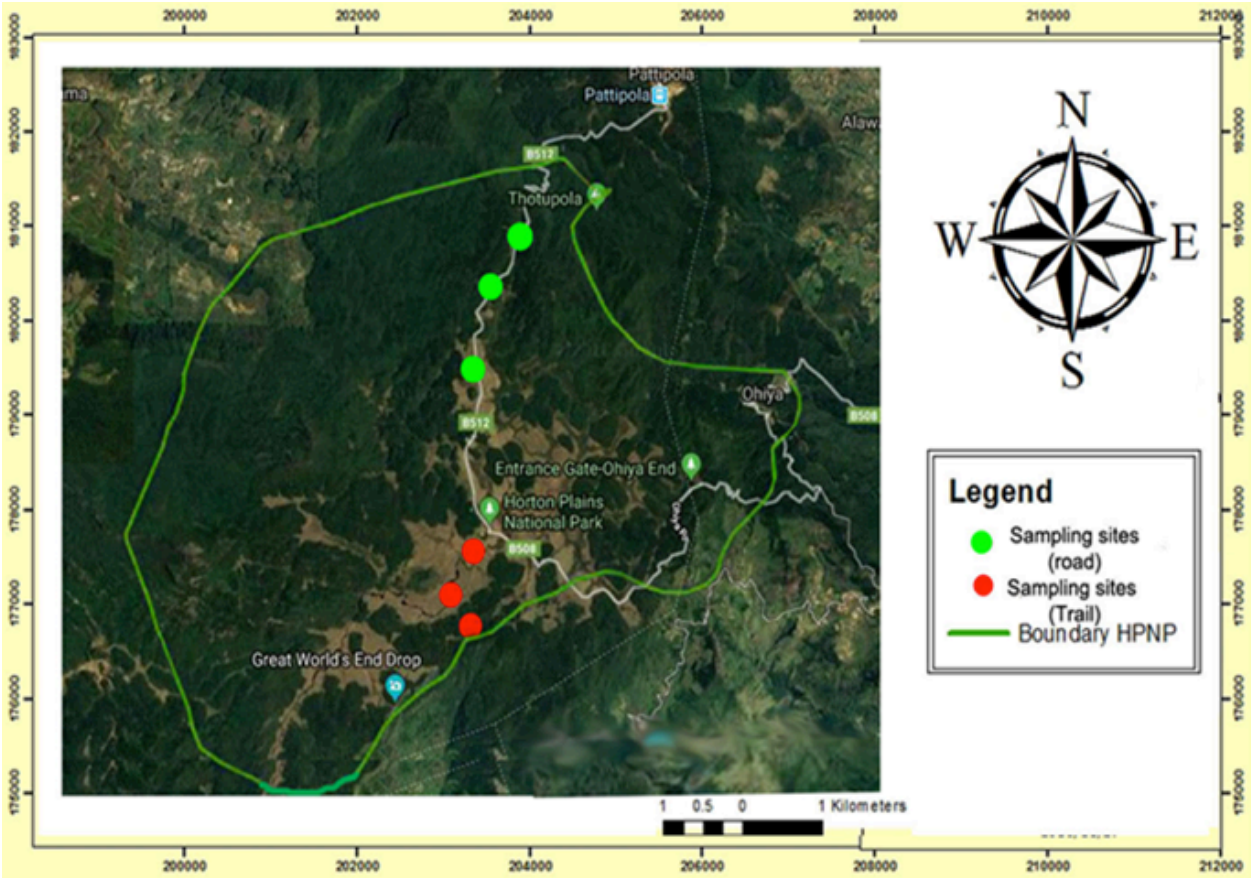

Image 1. Locations of sampling sites within the Horton Plains National Park, Sri Lanka.

Behavioral changes

Animal behavioral changes were monitored under habituation, attraction, and avoidance (Knight & Cole 1995). These behavioral responses were recorded at stopping the vehicles within the sight of animal, then not get out and stopping the vehicle within sight of animal, and then getting out. Habituation is defined as a declining of a response to a repeated stimulus. It does not display either a positive or a negative reward. Attraction is defined as the strengthening of an animal's behavior. It displays positive rewards. Avoidance is defined as moving away from humans. It displays negative reward (Knight & Cole 1995).

Noise

Vehicle noise was measured using sound level meter (UNI-T UT353) along transect lines in all habitat of vehicle road sites (Murphy & King 2016). While measuring noise, animal behavioral response was observed whether it was avoidance or habituation. The noise level was recorded in decibels (dB).

Vehicle speed

Vehicle speed was recorded, using radar gun (Montella et al. 2013) to observe avoidance and habituation behavioral responses of species. Speed level was recorded in km/h.

RESULTS

Amount of tetrapod vertebrate road kills during vacation and non-vacation period in the nature trails

Highest average number of road-kills was recorded in vacation months than non-vacation months. Highest average number (2.67±0.46) of road-kills belonged to reptiles. During the vacation time period, and amphibian road-kills (1.00±0.40) were recorded. No road-kills were recorded for mammals and birds within the trail site habitats (Figure 1A).

Amount of tetrapod vertebrate road kills during vacation and non-vacation period in the roads

Highest average number of road kills was recorded in vacation months compared to non-vacation months for all tetrapods. Birds (0.33±0.12) were the lowest road kills during vacation periods. Highest road kills was recorded for retiles (4.33±0.88) during vacation periods. A value of 2.00±0.14 was recorded of mammals and 2.67± 0.33 was recorded for amphibians during vacation period. No road kills were recorded in non-vacation months for birds (Figure 1B).

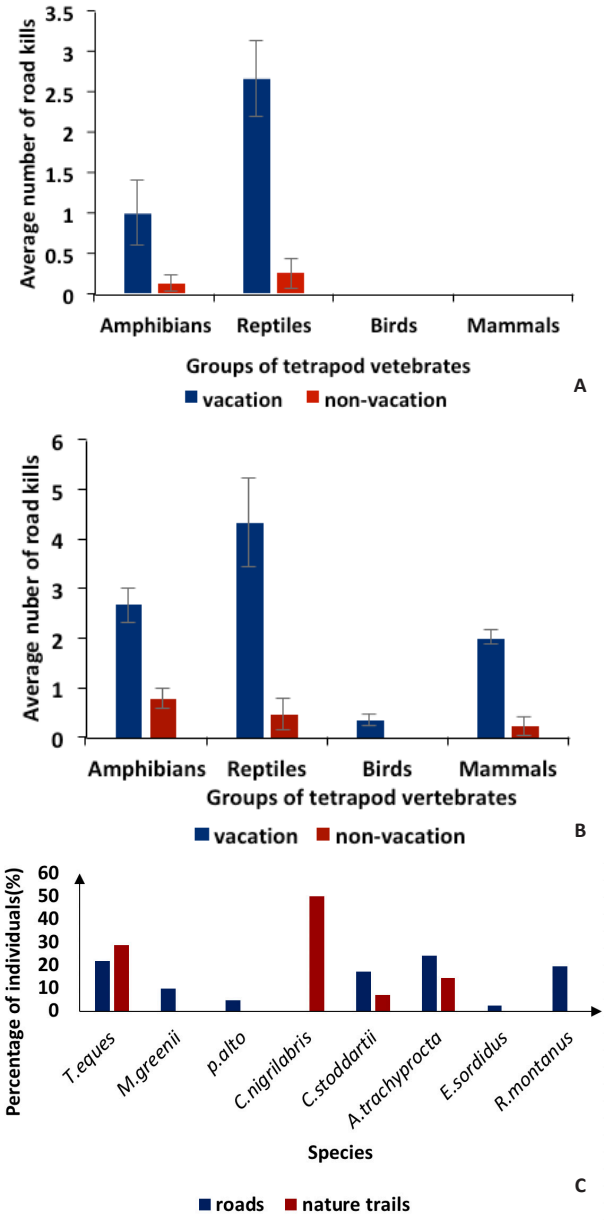

Figure 1. A—Amount of tetrapod vertebrate road kills during vacation and non-vacation period in the nature trails | B—roads | C—recorded road kills species in the nature trails and roads.

Road-kill specimens recorded in the nature trails and roads

Amphibians and reptiles road-kills were generally higher on roads. Taruga eques road-kills were higher in trail site than road site. *Minervarya greenii* road-kills were only recorded in road site. Highest percentage of road-kills recorded were *Calotes nigrilabris*, *Ceratophora stoddartii*, and *Aspidura trachyprocta* road-kills were also recorded. *Eumyias sordidus* and *Rattus montanus*

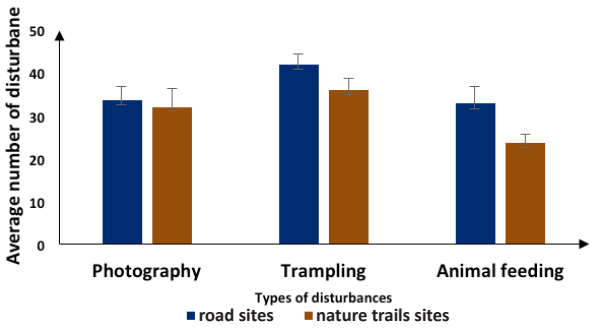

Figure 2. Categories of disturbances in the nature trails and roads.

were two bird and mammal species that were road-killed (Figure 1C).

Categories of disturbance in the nature trails and roads

Photography (33.5±10.72%) followed by animal feeding (32.78±13.25%) were the most prominent disturbance types recorded in roads, whereas, trampling was more common in roads rather than in trails (Image 3). Average percentage of disturbances were significantly higher in roads than in nature trails (Mann-Whitney U test, P >0.05) (Figure 2).

VARIATION OF BEHAVIORAL RESPONSES IN THE PRESENCE OF VISITORS

Behavioral responses of amphibians

All species recorded displayed only avoidance and habituation behavioral responses. Attraction behavioral response was absent in amphibians. *M. greeni* (73%), *T. eques* (82%), and *P. schmarda* (88%) displayed habituation behavioral response as the more prominent response. Avoidance behavioral response was shown in lower percentages despite being shown by all three species (Figure 3A).

Reptiles behavioral response

Only habituation behavioral response (100%) was recorded from *Cophotics ceylanica*. Both avoidance and habituation behavioral responses were observed from *C. nigrilabris* (85–15 %), *C. stoddartii* (88–12 %), and *A. trachyprocta*, avoidance being more prominent (Figure 3B).

Behavioral responses of birds

Only avoidance behavioral response (100%) was observed from *E. sordidus*, *Pericrocotus flammeus, Dicaeum erythrorhynchos, Rhopocichla atriceps, Turdoides rufescens, Pomatorhinus melanurus, Zosterops ceylonensis, Mortacilla flava, Hirundo domicola*, and *Lonchura malacca*. Only habituation behavioral response (100%) was observed from *Gallus lafayetii* (Figure 3C).

Behavioral responses of mammals

A mixture of behavioral responses was observed in most of the animals. *Rusa unicolor* and *Funambulus obscurus* were recorded as the species that showed all three behavioral responses. Attraction behavioral response was observed from *R. unicolor* (78%) and *F. obscurus* (75%) rather than other behavioral responses. Lowest percentage of individuals was recorded showing avoidance behavioral response in both these species (Figure 3D).

Behavioral responses under vehicle noise

Average values of vehicle noise were 66.5 dB and 79.0 dB for habituation and avoidance respectively. The vehicle noise recorded was in the range of 63±2.11 dB to 69±2.11 dB under habituation behavior. It ranged from 70±4.71 dB to 88±4.71 dB where avoidance behavior was observed (Figure 4).

Behavioral response of tetrapod vertebrates under vehicle speed

When tetrapod vertebrates show behavioral responses to vehicle speed, the average values of vehicle speed for habituation and avoidance behaviors were 18.73 km/h1 and 38.45 km/h, respectively. Vehicle speed range was from 11±6.07 km/h to 29±6.07 km/h under habituation behavior. Vehicle speed range was from 30±5.01 km/h to 45±5.01 km/h under avoidance behavior (Figure 5).

DISCUSSION

Most studies of the effects of roads on wildlife emphasize upon traffic mortality which has revealed that roads act as complete or partial barriers to movement for some species (Rondinini & Doncaster 2002; Shine et al. 2004; Whittington et al. 2004). Average number of road-kills recorded was higher during vacation period in nature trails as well as roads than in non-vacation period. However, road-kills were greater on roads than nature trails. The reason for this is obviously the speed of the vehicles which have a higher probability of colliding with animals when compared to the slow-moving human visitors. However, the occasional road-kills were observed even on the nature trails due to the faults of unaware visitors.

Amphibian road-kills were higher on the roads as well

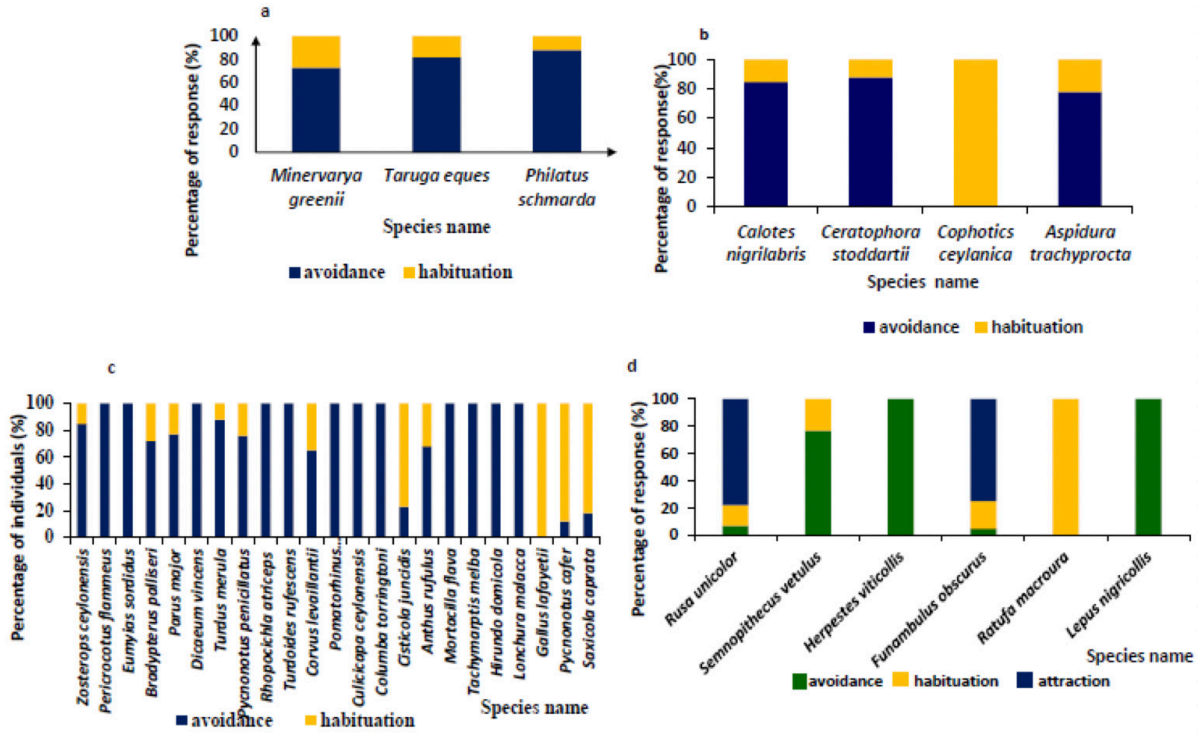

Figure 3. A—behavioral response of amphibians | B—behavioral response of reptiles | C—behavioral response of birds | D—behavioral response of mammals.

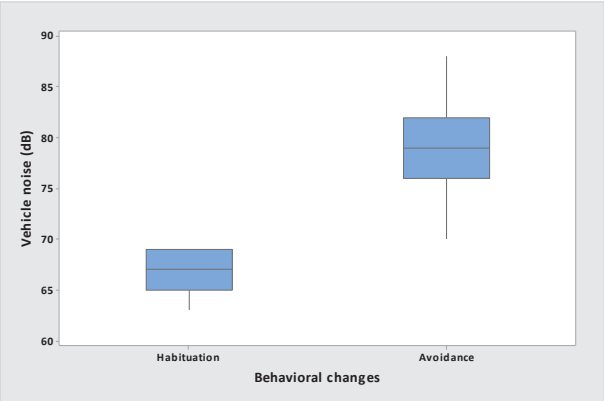

Figure 4. Behavioral responses against vehicle noise.

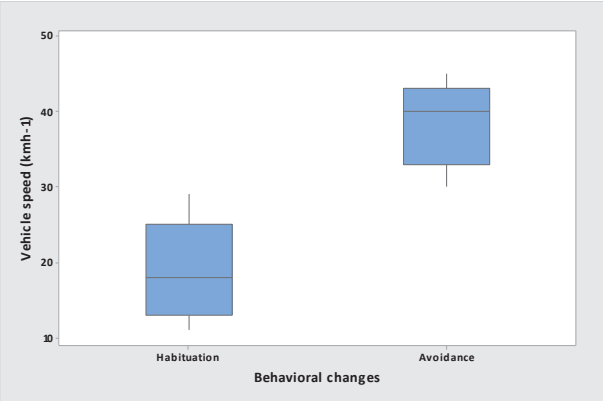

Figure 5. Behavioral responses against vehicle speed.

as nature trails adjacent to aquatic habitats than in other areas. Immobilization behavior of amphibians (Mazerolle et al. 2005) on road and nature trails leads to increased mortality rate. Pond-breeding amphibians (*Rana arvalis*) that migrate in large numbers to and from breeding sites, are particularly vulnerable to ''collisions'' with vehicles (Fahrig et al. 1995).

Reptile road-kills were also recorded in nature trails and roads. The possible reason could be snakes and lizards getting attracted to open patches created by roads to use as basking sites (Bambaradeniya et al. 2001; Karunarathna & Karunarathna 2005) which consequently improves foraging efficiency. Road-kills of birds were only recorded nearby the cloud forest of road site. Throughout the survey, the only recorded road-kill was of a Dull Blue Fly Catcher during its breeding months. Their nest sites being located in road banks and tree holes (Dharmarathne 2018) become a possible threat to this species, particularly by the visitor vehicles. Present study indicates that all road killed specimens of mammals were of small mammals.

Most amphibian and reptile road-kills were not

identified to the species level due to rapid deterioration of carcasses by travelling vehicle and weather conditions. Present study indicated that *C. nigrilabris* has the highest average percentage of nature trail mortality compared to other lizards species in HPNP. The results highlight that road-kills occurred on road and nature trails are a threat to endemic species vertebrate fauna of HPNP, especially the amphibians and reptiles.

Highest photography disturbance was recorded on the nature trails. A lot of visitors preferred to take photographs in aquatic habitat and cloud forest of nature trails. Visitors were interested in taking photographs of chimney pool associated habitats and tetrapod vertebrates that lived in there. Visitors often involve in close approaches to wildlife for purposes of identification or photography (Green & Giese 2004), hence there is potential negative impact on animals, especially if flashes are used. Klein (1993) identifies photographers as the most disruptive disturbance. Display of attraction behavior of sambar was noticed due to animal feeding. Animal feeding was more prominent disturbance on roads than in nature trails.

All amphibians were displaying high amount of avoidance behavior indicating their high sensitiveness for the human presence. Black-lipped lizards, Rhino horn lizards and Common rough sided snake showed both avoidance behavior and habituation behavior. Habituation behavioral response was mostly recorded from Pygmy lizard which is a cryptic species that depends highly on its camouflage (Keerthiratne 2019). However, except for the Red Vented Bulbul, Pied Bush Chat, and Sri Lanka Jungle Fowl, most other species more frequently avoid the approaching visitors. Therefore, in general birds were one group that were highly disturbed by the human presence in these habitats. Dusky striped squirrel and Sambar displayed habituation, avoidance as well as attraction behavioral responses. These two species were frequently fed by visitors in the nature trail and could be identified as two species that prefers human feeding over their natural foraging. Certain individuals of these species could be observed habituated to sites where more visitors gather.

Avoidance behavior was recorded at high traffic noise level. High traffic noise poses a large impact on birds, making it difficult for them to establish and maintain their territory and attract mates. Moreover, Parris & Schneider (2009) suggest that it reduces their reproductive success. Due to the inability of detecting low frequency songs under traffic noise interference, they tend to sing at high frequencies (Slabbekoorn & Peet 2003).

Trampling disturbance was posing more danger to

Image 2. Road-kills in the study areas in HPNP: a—Endangered *Ceratophora stoddartii* | b—*Rattus montanus* | c—Endangered *Taruga eques* | d—Endangered *Calotes nigrilabris* | e—Near Threatened *Eumyias sordidus* © Tharanga Dasanayaka, Dulan Jayasekara, Chathuranga Dharmarathne.

Image 3. Photos of disturbances in the study areas in Park: a—Photography of cloud forest | b—Trampling of grassland | c—Animal feeding.

C. nigrilabris which more often have their nest sites in the grassland habitat. Natural grazing ecosystem of *R. unicolor* was also damaged by trampling of grassland habitat. Egg masses of amphibians and some amphibians may be destroyed while trampling in aquatic habitat and cloud forest.

Management implications

Since HPNP is a national park, visitor disturbance and vehicle disturbance are always present in different levels in cloud forest, aquatic habitat and grassland of nature trail and road within HPNP. Effective visitor education is crucial in this regard whereby they understand how to protect wildlife while enjoying wildlife. Previous posters had displayed only sentences. If pictures are used to convince the humans regarding their restrictions within HPNP it will be more effective since people can quickly understand the pictures than sentences (without any language barrier). According to present data, a maximum vehicle speed limit of 30 km/h is recommended within HPNP. Road signs can be used to indicate that amphibians are crossing a road and indicate the vehicle drivers to drive carefully and slowly around aquatic habitats. If these measures do not reduce road mortality effectively, a shuttle service should be established especially during vacation periods. It can reduce the number of vehicles that enter HPNP. If medium sized buses are used as shuttles, a group of visitors could be served at one round. Moreover, some implementation should be applied in the vacation period to reduce vehicular disturbances such as parking reservations for private vehicles outside of the park. Animal feeding and trampling should be strictly prohibited within the park and if people contravene this rule that could be fined by department of wildlife conservation.

Appendix 1. Lat.-long. of starting to ending point within each transect of habitats.

Study sites		Cloud forest			Grasslands			Aquatic habitat		
Nature trails	Transect	A	B	C	D	E	F	G	H	I
	Start points	6.793160° 80.805249°	6.792020° 80.805369°	6.790795° 80.805298°	6.796226° 80.805046°	6.795560° 80.805128°	6.794735° 80.804905°	6.793655° 80.802986°	6.793006° 80.802009°	6.792414° 80.801383°
	End points	6.792394° 80.805579°	6.791502° 80.805230°	6.789718° 80.805417°	6.795560° 80.805128°	6.794735° 80.804905°	6.793867° 80.804257°	6.793086° 80.802415°	6.792409° 80.801318°	6.791904° 80.800601°
Roads	Start points	6.826310° 80.805438	6.826915° 80.806135°	6.829553° 80.806104°	6.806246° 80.805426°	6.808065° 80.804211°	6.810245° 80.802119°	6.830929° 80.806961°	6.832925° 80.807812°	6.838810° 80.811630°
	Ends points	6.826915° 80.806135°	6.827565° 80.806488°	6.830460° 80.806806°	6.807325° 80.805243°	6.808932° 80.803578°	6.811071° 80.801873°	6.831927° 80.807382°	6.833247° 80.808554°	6.839460° 80.812393°

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