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Influence of recreational trails on species diversity of tetrapod vertebrates within the Horton Plains National Park, Sri Lanka

Tharanga D.M. Dhananjani, K.M.T. Kalhari, W.A.D. Mahaulpatha*

[1]Department of Zoology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
*Email: mahaulpatha@sjp.ac.lk

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Abstract

Horton Plains National Park (HPNP) is one of the world's best nature reserves and a popular tourist destination in Sri Lanka. This study was conducted to investigate the influence of recreational trails on vertebrate fauna in HPNP. Three 100-meter fixed-length line transects were marked along the recreational trails in each habitat to record species richness and abundance. In addition, three 100-meter fixed control transacts were placed 200 meters away from the existing recreational trails in each habitat. There was a significant difference in the amphibian diversity index of control and trail transects in aquatic habitats ($P < 0.05$). The presence of trails had not influenced the reptile species diversity significantly in the cloud forest and aquatic habitats. There was a significant difference in bird diversity between transects in all habitat types ($P < 0.05$). The mammal species diversity index was not altered significantly in the presence of a trail within all three habitats considered ($P > 0.05$). The presence of recreational trails within HPNP has negatively affected species diversity. It can be concluded that it is necessary to minimize the number of the recreational trail which are to be constructed for most of the other protected areas of Sri Lanka.

Keywords: Habitat, Species diversity, Species richness, Tetrapod vertebrates

Introduction

There are 22 National Parks (NPs) in Sri Lanka which are governed by the Department of Wildlife Conservation (Newsome, 2013) which are leading to provide high levels of protection for wildlife and habitats that are within the national parks. 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 which are rich in both floral and faunal assemblages (Senevirathna

et al. 2013). Despite the economic gains obtained, a number of negative impacts may arise due to heavy visitor arrivals to NPs which keep increasing day by day. It can interfere with the natural behavior of wildlife causing habituation, littering, and damage to vegetation (Herath et al. 1997) which will ultimately affect the ecotourism industry in the long term.

Ecotourism consists only a portion of protected area visitation if some type of recreational activities and their influence on the natural resource composing outdoor recreational activities are considered as overlapping between ecotourism and protected area visitation. One of the best examples is trail use. Hiking and wildlife viewing has been given the best priority in ecotourism and recreational activities that activities commonly happen in the trail, compared with some intensive human uses within protected areas (Farrell and Marion 2001; Wight 1996). The trail is not only given to allow protected area facilities and attractions, and facilitate recreation opportunities, but also access to protect natural resources by focusing on visitor use.

Researchers have examined regarding recreational activities in nature have increased enormously since the last decades (Boyle and Samson 1985; Steven et al. 2011, Monz et al. 2013; Steven and Castley 2013; Hammitt et al. 2015). Researchers and conservationists give the best priority to concern about the potential impact of human recreation on wild animals. Recreational trails disrupt the continuation and prevalence of grasslands and forests. There is evidence that recreational trails can change breeding bird communities in both grassland and forest ecosystems (Miller et al. 1998). Many studies have proved that animals will evade areas if humans are present (Stalmaster and Newman 1978; Burger 1981; Sutherland and Crockford 1993; Reijnen et al. 1995; Gill et al. 1996; Gander and Ingold 1997). When exposed to human presence, animals may react with important changes in their behavior and physiology, most reported disturbances occur around watching wildlife which results in flight (birds) and behavior change in general as a response by the animal.

The study was conducted in Horton Plains National Park due to the most attractive viewing points of people in HPNP are Red Bridge, Chimney Pool, Baker's fall, Small World's End, and Greater World's end (Rathnayake 2015). The first part of the visitor trail is through bare grassland. The grassland leads into a dense expanse of cloud forest as well as aquatic habitats. Hikes to the two mountain peaks are also great opportunities to see some of the endemic wildlife in HPNP. Moreover, a long-time recreational activity has been concentrated on recreational trails within HPNP through the process of ecotourism activities. Therefore, the present study was conducted focusing on the impacts of recreational trails on tetrapod vertebrates within HPNP.

The objective of this study is to determine the impacts of the trails on tetrapod vertebrates fauna in selected habitats within the HPNP. It will also highlight the management and conservation steps that need to be taken in order to conserve recreational trails within protected areas.

Materials and methods

Study sites

The present study was conducted from December 2017 to October 2018 covering three main habitat types in HPNP, including cloud forest, grasslands, and aquatic habitat (Fig. 1). The selected three habitat types were identified, using the baseline survey in HPNP (DWC 2007).

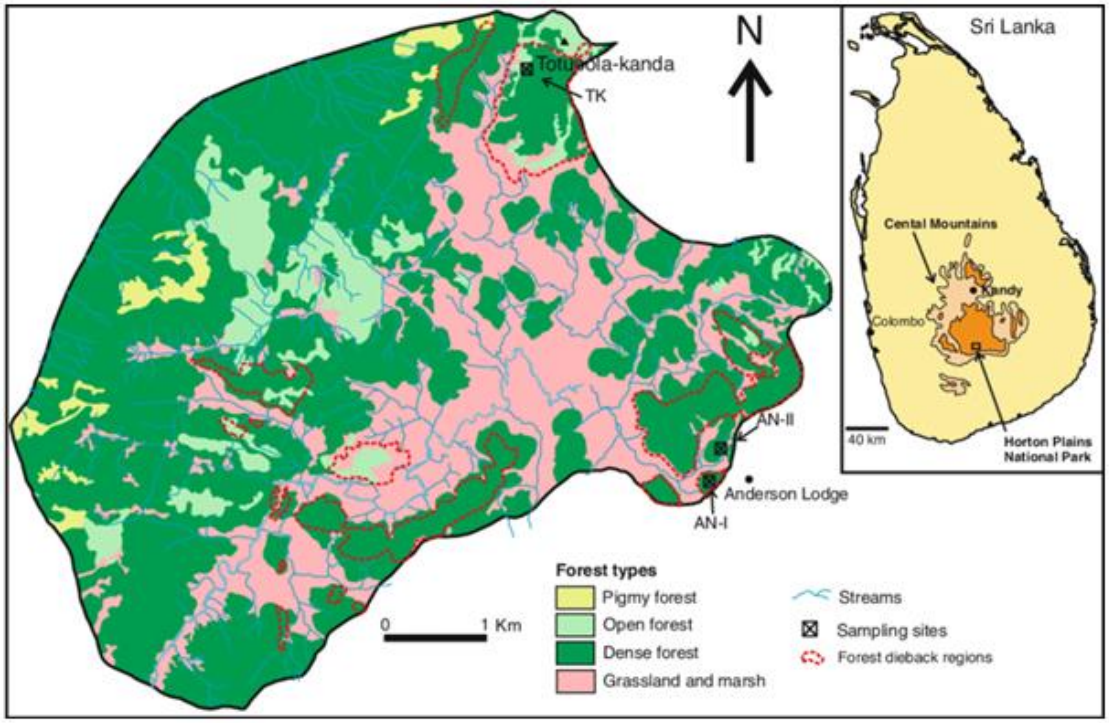

Figure 1. Map of Horton Plains National Park (Chandrajith et al. 2009)

Census of tetrapod vertebrates

Tetrapod vertebrates were surveyed using line transects in the three selected habitats along the nature trails. Control transects were monitored 200m away from nature trails (where no trails existed) within three selected habitats (Hanowski and Niemi 1995). Each transect was 100m in length and the width of the transect line differed according to the tetrapod vertebrate category that was examined. Species richness and abundance were recorded in each habitat type Census of tetrapod vertebrates was carried out in each transect as follows depending on the vertebrate category that was censed for.

Amphibians

The visual encounter surveys (VES) method was used for the observation of amphibians. Amphibians of Sri Lanka: a photographic guide (De silva 2007) was used for identification. Thereby recording all amphibians within a distance of one meter from either side of the transect line (Rödel and Ernst 2004).

Reptiles

Visual encounter surveys were conducted and reptiles observed within two meters on either side of the transects line were recorded using lizards of Sri Lanka – a color guide with field keys (Somaweera and Somaweera 2009). Observations were taken along the transects, walking at a very low speed in order to carefully search the vegetation without disturbing the natural behavior of reptiles.

Birds

A number of individual birds were recorded within a distance of twenty meters on both sides of the path (Hostetler et al. 2001) along the transect line by using the Field Guide to the Birds of Sri Lanka (Harrison and Worfolk 2011).

Mammals

When mammals were sighted within a distance of fifty meters on both sides of the path (Plumptre 2000), the species were identified with the assistance of a photographic guide to mammals of Sri Lanka (Wijeyeratne, 2008). Indirect signs (track and fecal matter) were monitored to estimate the census of mammals (Plumptre, 2000) when direct observations were difficult due to poor visibility in the forest areas, nocturnal behaviors and safety precautions (against carnivores).

Species diversity index was used to measure of the species diversity of tetrapod vertebrates within three habitats in the recreational trails by using Shannon – Wiener diversity index as follow.

$H = - \sum Pi \ln Pi$

Where $Pi = S / N$

S = number of individuals of one species

N = total number of all individuals in the sample

In = logarithm to base e

Results

Species availability in different habitats of roads and nature trails

Most of the species were observed in more than one habitat type. Schmarda' s shrub frog (*Philatus schmarda)*, Sri Lanka jungle fowl (*Gallus lafayetii),* and Giant squirrel (*Ratufa macroura*) were only observed in the cloud forest. However, there were opportunistic observations of Sri Lanka jungle fowl in the grassland habitat as well. Sri Lanka white-eye (*Zosterops ceylonensis)*, Sri Lanka Dull Blue Flycatcher (*Eumyias sordidus),* Sri Lanka Yellow-eared Bulbul (*Pycnonotus penicillatus*), Great Tit (*Parus major),* and Jungle crow (*Corvus levaillantii)* were recorded in all habitats of trail sites. Sri Lanka highland shrew (*Suncus montanus)* and *Zitting Cisticola* were only recorded in the grasslands of the nature trail (Table 1).

Table 1. Species availability in different habitats of roads and nature trails

Common name	Scientific name	Habitats of trails sites
Sri Lankan narrow mouth frog	*Microhyla zeylanica*	CF, AH
Motain frog	*Fejervarya greeni*	CF, AH
Horton Plains shrub frog	*Pseudophilatus alto*	CF, AH
Schmarda' s shrub frog	*Philatus schmarda*	CF
Hourglass forg	*Taruga eques*	CF, AH
Black lipped lizard Rhino horn lizard	*Calotes nigrilabris* *Ceratophora stoddartii*	AH, GH CF
Pygmy lizard	*Cophotics ceylanica*	CF
Common rough-sided snake	*Aspidura trachyprocta*	CF, GH
Sri Lanka Jungle fowl	*Gallus lafayetii*	CF
Alpine Swift	*Tachymarptis melba*	AH, GH
Sri Lanka Wood Pigeon	*Columba torringtoni*	CF
Jungle Crow	*Corvus levaillantii*	CF,AH,GH
Scarlet Minivet	*Pericrocotus flammeus*	CF
Eurasian Blackbird	*Turdus merula*	CF
Sri Lanka Dull Blue Flycatcher	*Eumyias sordidus*	CF, GH
Pied Bushchat	*Saxicola caprata*	AH, GH
Grey-headed canary-flycatcher	*Culicicapa ceylonensis*	CF
Velvet Fronted Nuthatch	*Sitta frontalis*	CF
Great Tit	*Parus major*	CF, AH,GH
Hill Swallow	*Hirundo domicola*	AH, GH

Red-vented Bulbul	*Pycnonotus cafer*	GH
Sri Lanka Yellow-eared Bulbul	*Pycnonotus penicillatus*	CF, GH
Zitting Cisticola	*Cisticola juncidis*	GH
Sri Lanka White Eye	*Zosterops ceylonensis*	CF,AH,GH
Sri Lanka Bush Warbler	*Bradypterus palliseri*	CF
Common Tailorbird	*Orthotomus sutorius*	CF
Sri Lanka Scimitar Babbler	*Pomatorhinus melanurus*	CF
Dark Fronted Babbler	*Rhopocichla atriceps*	CF
Sri Lanka Orange Billed Babbler	*Turdoides rufescens*	CF
Pale Billed Flowerpecker	*Dicaeum erythrorhynchos*	CF
Paddyfield Pipit	*Anthus rufulus*	GH, AH
Yellow wagtail	*Mortacilla flava*	GH
Tricoloured Munia	*Lonchura malacca*	AH, GH
Sri Lanka highland shrew	*Suncus montanus*	GH
Sri Lanka Purple-faced langur	*Semnopithecus vetulus*	CF
Leopard	*Panthera pardus*	
Stripe-necked mongooses	*Herpestes viticollis*	CF
Sambur	*Rusa unicolor*	CF
Dusky-striped jungle squirrel	*Funambulus obscurus*	CF
Giant squirrel	*Ratufa macroura*	CF
Black naped hare	*Lepus nigricollis*	AH, GH

CF; Cloud Forest, AH; Aquatic Habitat, GH; Grassland Habitat

Tetrapod vertebrate species along control transects and trail transects within all three habitats

According to Mann- Whitney U test comparison results, there was only a significant difference between the average number of individuals that were present along control transects and trail transects Motane frog (*Menervarya greeni*) ($P<0.05$). When reptiles were considered, the Black lipped lizard (*Calotes nigrilabris*) and Common rough sided snake (*Aspidura trachyprocta*) were observed to be significantly different in numbers between trail and control transects ($P<0.05$). Sri Lanka white eye, Sri Lanka orange billed babbler (*Turdoides rufescens)*, Common Tailorbird (*Orthotomus sutorius*), Sri Lanka wood pigeon (*Columba torringtoni)*, and Tricolored munia

(*Lonchura Malacca)*, Yellow wagtail (*Mortacilla flava*) and Alpine Swift (*Tachymarptis melba)* were the bird species that were not significantly different in average numbers with the compared trail transects(P>0.05). Sri Lanka highland shrew and Stripe-necked mongooses were the only mammal species that showed a significant difference (P<0.05) (Table 2)

Table 2. The average number of individuals along the control transect and trails transect

Common name	**Control transects**	**Trail transects**	**p Value**
Motain frog	10.42 ±4.98	5.33 ± 3.44	P < 0.05
Schmarda' s shrub frog	0.33 ± 0.49	0.25 ±0.45	P > 0.05
Hourglass forg	5.25 ± 4.43	3.08 ±1.505	P > 0.05
Black lipped lizard	0.58 ±0.79	3.91 ±2.19	P < 0.05
Rhino horn lizard	3.66 ±1.63	2.20 ±1.82	P < 0.05
Pygmy lizard	1.17± 0.80	1.11±0.85	P > 0.05
Common rough-sided snake	1.29 ±1.21	0.41 ±0.50	P < 0.05
Alpine Swift	3.27 ±1.00	2.54 ±0.93	P > 0.05
Sri Lanka Wood Pigeon	0.27 ±0.46	0.45 ±0.52	P > 0.05
Jungle Crow	1.89 ±1.10	3.14 ±1.17	P < 0.05
Scarlet Minivet	2.45 ±1.29	1.09 ±1.04	P < 0.05
Eurasian Blackbird	2.27 ±1.55	1.09 ±0.94	P < 0.05
Sri Lanka Dull Blue Flycatcher	1.54 ±1.40	0.81 ±0.79	P < 0.05
Pied Bushchat	3.72 ±1.00	2.45 ±1.21	P < 0.05
Grey-headed canary-flycatcher	2.36 ±1.28	1.18 ±0.98	P < 0.05
Velvet Fronted Nuthatch	3.00 ±1.00	1.90 ±1.30	P < 0.05
Great Tit	2.45 ±1.10	1.77 ±1.15	P < 0.05
Hill Swallow	0.72 ±0.46	0.36 ±0.50	P < 0.05
Red-vented Bulbul	0.36 ±0.50	0.90 ±0.30	P < 0.05
Sri Lanka Yellow-eared Bulbul	3.81 ±1.07	2.18 ±0.98	P < 0.05
Zitting Cisticola	0.27 ±0.46	0.67 ±0.63	P > 0.05
Sri Lanka White Eye	1.87 ±1.38	1.85 ±1.38	P > 0.05
Sri Lanka Bush Warbler	1.72 ±0.64	1.09 ±0.70	P < 0.05
Common Tailorbird	1.36 ±0.67	0.81 ±0.60	P > 0.05
Sri Lanka Scimitar Babbler	1.81 ±0.40	1.09 ± 0.53	P < 0.05
Dark Fronted Babbler	3.18 ±1.16	1.63 ±1.20	P < 0.05
Sri Lanka Orange Billed Babbler	2.72 ±1.61	1.90 ±1.37	P > 0.05
Pale Billed Flowerpecker	2.36 ±1.12	1.18 ±0.75	P < 0.05
Paddyfield Pipit	2.09 ±0.94	1.27 ±0.46	P < 0.05
Yellow Wagtail	1.09 ±0.53	0.54 ±0.52	P > 0.05
Tricoloured Munia	2.18 ±1.47	1.91 ±3.53	P > 0.05
Sri Lanka highland shrew	0.40 ±0.50	0.81 ±0.39	P < 0.05
Sri Lanka Purple-faced langur	2.36 ±1.62	1.27 ±1.79	P > 0.05
Leopard	0.45 ±0.52	0.27 ±0.46	P < 0.05
Stripe-necked mongooses	0.81 ±0.98	0.36 ±0.80	P < 0.05
Sambur	1.18 ±1.32	0.54 ±1.03	P > 0.05
Dusky-striped jungle squirrel	2.36 ±1.00	1.54 ±1.25	P > 0.05
Giant squirrel	1.54 ±0.52	1.36 ±0.67	P > 0.05
Black-naped hare	1.18 ±0.75	0.63 ±0.67	P > 0.05

Species diversity index of tetrapod vertebrates in the cloud forest of the trails

The highest species diversity index was recorded along control transects laid 200 m away from the cloud forests. Bird diversity was generally higher in cloud forests recording 2.7 and 1.8 diversity indexes respectively along control transects and trail transects. The lowest species diversity index was recorded for reptiles. The species diversity index of amphibians was recorded at 1.0 along the control transect and 0.9 in the trail transect However, the only significant difference in diversity index was recorded for the birds (Hutcheson t-test, $p < 0.05$) when trail and control transect were compared (Fig. 2)

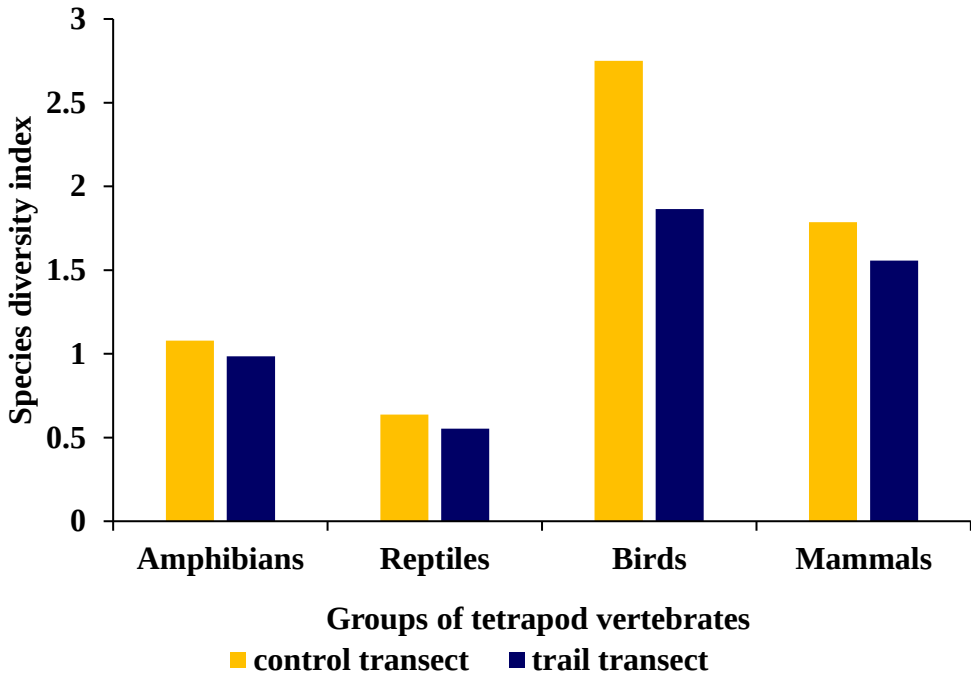

Figure 2. Species diversity index for tetrapod vertebrate groups in the cloud forest

Species diversity index of tetrapod vertebrates in the aquatic habitat of the trails

Being similar to the cloud forests, the bird diversity was higher in aquatic habitats as well. The diversity indexes of both amphibians (trail: 0.7; control 1.0) and birds (trail: 1.5; control: 2.9) were significantly different between control and trail transects (Hutcheson t-test, $p > 0.05$). When mammal (trail: 0.93; control: 0.98) and reptile diversity indexes (trail: 0.67; control: 0.66) were considered, there was no significant difference between control and trail transects (Hutcheson t-test, $p > 0.05$). (Fig. 3).

Species diversity index of tetrapod vertebrates in grasslands habitat of the trails

Interestingly, no amphibians were recorded in the grassland habitat. When birds were considered the diversity index was significantly different between control (1.6) and trails (1.9) transects

(Hutcheson t-test, $p < 0.05$). However, the diversity index for reptiles along trail transect (0.3) was higher than the control transects (0.2) despite being significantly not different (Hutcheson t-test, $p > 0.05$). (Fig. 4)

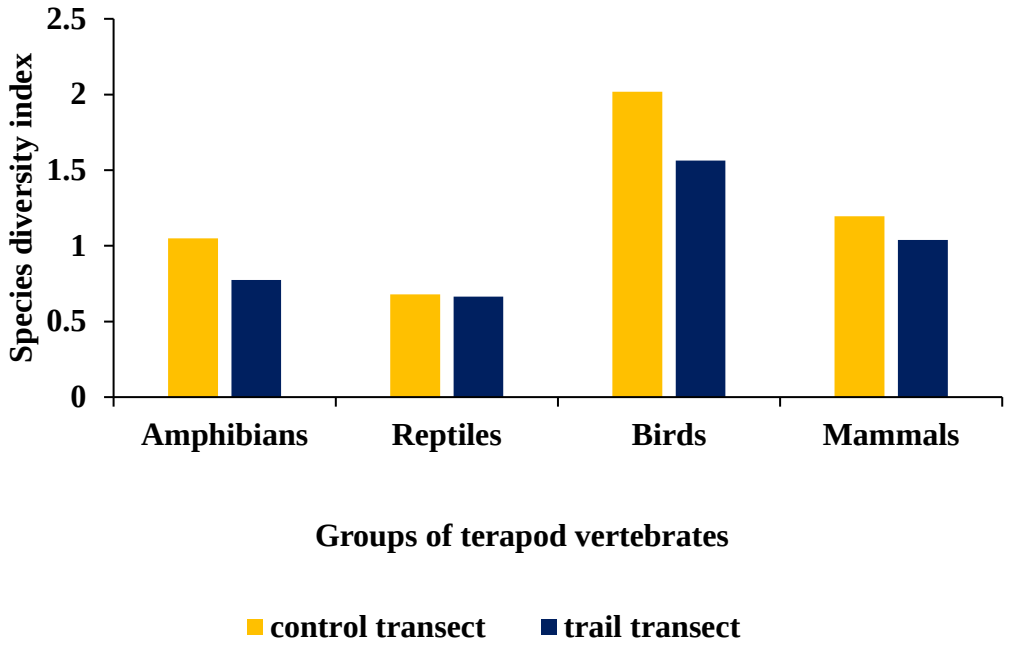

Figure 3. Species diversity index for tetrapod vertebrate groups in aquatic habitat

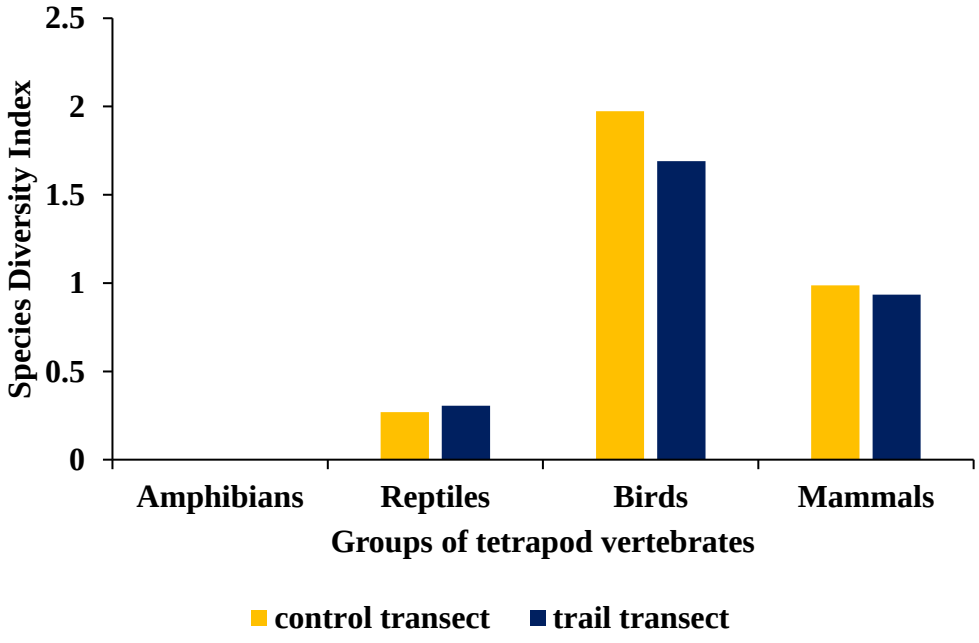

Figure 4. Species diversity index for tetrapod vertebrate groups in grasslands habitat

Discussion

The highest species diversity indexes were recorded along control transects of the nature trails. Therefore, it is evident that tetrapod vertebrates preferred the control transects which were the less disturbed natural habitats within the park. Prominently higher species diversity was recorded for birds when compared to other classes of tetrapod vertebrates. The species diversity of amphibians was higher in aquatic habitats as expected. However, reptiles were identified as the class with the lowest species diversity among all the habitats which was mostly due to the low number of species that are naturally present in these high altitudes. No amphibians were recorded in the grasslands of nature trails. This suggests that grasslands of HPNP are generally a less suitable habitat for this group irrespective of the presence of nature trails. However, the increased visitor pressure (mainly in trampling) due to human visitation may have an indirect impact on this.

The species diversity index depends on the number of individuals. The species diversity index will increase when the number of individuals rises. The number of individuals of amphibians, reptiles, birds, and mammals was higher along control transects than on road and trail transects. A number of individuals and species diversity are altered in the presence of nature trails. A similar observation has been recorded by Miller et al. (1998). However, the only significant difference in diversity index was recorded for amphibians, between control and trail transects in the aquatic habitat but not in the cloud forest of the nature trail site. This result indicates that the presence of nature trails has significantly affected the amphibian diversity index specifically in the aquatic habitats of the trails. Furthermore, the Montane frog was occurring in significantly higher numbers in the undisturbed habitats of trails. Moreover, cloud forests should be given priority in conservation due to the appearance of Schmarda's shrub frog which was identified as a cloud forest specialist.

The presence of nature trails had not influenced the reptile species diversity significantly. However, the Rhino horn lizard was more abundant along control transects than the trail transects and the common rough-sided snake was recorded in significantly higher numbers from control transects of the nature trail site. Therefore, it can be concluded that these two species were more abundant along less disturbed control transects where habitat conditions were good for their survival. However, in the grasslands, there was an exception where the numbers of Black lipped lizards were higher along the trail transects. This preference has been mentioned by Jayasekara et al. (2019) as well. That could be due to the availability of egg-laying areas near nature trails.

The significant difference in bird diversity between control transects and trail transects indicates that they are more sensitive to human disturbances than other tetrapod vertebrate classes. In most cases, the number of individual of birds was higher along control transects than on trail transects.

A similar observation has been recorded by Alwis et al. (2013). Nevertheless, the number of crows was higher along trail transect than on control transects. Hence, they preferred habitats associated along the nature trails mostly due to the availability of garbage generated by visitors. According to the results, the mammal species diversity index was not altered significantly in the nature trail site in the presence of nature trails within all three habitats considered. The present study indicates that most of the tetrapod vertebrate species were more abundant away from nature trails within all three habitat types. It could be highlighted that the presence of nature trails within HPNP has negatively affected the species composition as well as species abundance near the areas of those constructions. This result is applicable to most of the other protected areas of Sri Lanka as well as other parts of the world. According to the results, species diversity was altered due to the presence of nature trails. The present study indicated that the presence of heavily traversed nature trails causes a decline in species diversity within protected areas.

Recommendation

Effective visitor education is crucial in this regard whereby they understand how to protect wildlife while enjoying the wildlife. At the present, a few posters are being displayed by DWC to increase visitor awareness. However, the Number of posters should be increased in habitats of nature where the level of disturbance is high. Previous posters had displayed showing sentences. If pictures are used to convince humans regarding their restrictions within HPNP it will be more effective since people can quickly understand the pictures than sentences (without any language barrier). Furthermore, awareness posters should be displayed regarding reducing noise levels and the prohibition of trampling on nature trails. Moreover, no more trails within the park should be not constructed due to the influence on vertebrates' fauna habitats.

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