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Morphometry and habitat selection of the Mountain Hourglass Treefrog [*Taruga eques* (Günther, 1858)] (Amphibia, Rhacophoridae) in the Horton Plains National Park, Sri Lanka

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ABSTRACT

Many amphibian species in Sri Lanka have become endangered with extinction. The endemic, Montane Hourglass Tree Frog (*Taruga eques*) is an endangered species that is restricted to the central hills in Sri Lanka, elevations above 1,270 m. This article discusses the population status, habitat utilization, foam nest construction, and threats to this species within the Horton Plains National Park, Sri Lanka. The study on which this article was carried out in five locations for one week per month over a period of five months. Randomly placed transects were used in the study. The density of *Taruga eques* was recorded as 5 individuals/100km^2 within the park. The abundance of males was significantly higher than females indicating a male-biased pattern (M: F= 9:1). Herbs were the preferred microhabitat (33.6 %), whereas the most frequently recorded behavior was perching (92.1%). Nest construction occurred between herbs in 56.5% of cases. Hence, the entire life cycle of the species is dependent on the conditions of these microhabitats. Females possessed color patterns distinct from males, which may be useful in separating the sexes in visual observations. They had different color patterns which changed from individual to individual, and the hourglass mark was not prominent. Several putative threats were noted during the survey including road kills, over visitation, parasite attacks, predator pressure, and anthropogenic pressure. These findings provide pragmatic insights relevant to the conservation of *Taruga eques* in Sri Lanka.

KEYWORDS:
Foam nest, microhabitat, montane, *Taruga eques*, habitat selection

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Introduction

Sri Lanka is a tropical continental island that contains remarkable amphibian diversity and endemism (Meegaskumbura et al., 2002; Bossuyt et al., 2004; Gunawardene et al., 2007). The island is considered a global amphibian hot spot (Meegaskumbura et al., 2002). The majority of endemic and threatened amphibians are confined to wet zone ecosystems, especially in the montane region (Kottawa-Arachchi & Wijeratne, 2017). One-hundred and twenty amphibian species are believed to inhabit the island of which 107 are endemic (Meegaskumbura & Manamendra-Arachchi, 2005, 2011). Nevertheless, many species are yet to be described (Meegaskumbura & Manamendra-Arachchi, 2005). Amphibians in Sri Lanka face many threats including deforestation (Pethiyagoda, 2012a), environmental pollution, climate change, and road traffic (Meegaskumbura & Manamendra-Arachchi, 2005). Some twenty species are known only from museum specimens: they may be extinct (Gunawardene et al., 2007; Ministry of Environment, 2012; Kottawa-Arachchi & Wijeratne, 2017).

The Montane Hourglass Tree Frog, or Guther's Whipping Frog [*Taruga eques* (Günther, 1858)], is a species endemic to Sri Lanka (Meegaskumbura et al., 2011b). The *Taruga* genus consists of three species *viz*., *Taruga eques, Taruga fastigo,* and *Taruga longinasus* (Meegaskumbura et al., 2011b). Two genera contain five foam-nesting species, four of which are endemic species (Meegaskumbura et al., 2011b). *Taruga eques* is found in the higher regions of the Central Hills at altitudes between 1,270 m and 2,140 m above sea level (Dutta & Manamendra-Arachchi, 1996; Manamendra-Arachchi & Pethiyagoda, 2001; Pethiyagoda, 2012b), including Horton Plains National Park and the Knuckles Forest Range in Sri Lanka (Meegaskumbura et al., 2011a, 2011b). This is the only member of a foam-nesting tree frog in the Horton Plains National Park (Pethiyagoda, 2012b).

Taruga eques is usually found on trees adjacent to water ponds and streams in exposed and shaded areas (Pethiyagoda, 2012b). This frog is large in size. Females may reach over 70 mm in snout-vent length while males are much smaller, seldom more than 40 mm (Dutta & Manamendra-Arachchi, 1996; Pethiyagoda, 2012b). They have a long sharp triangular snout (Dutta & Manamendra-Arachchi, 1996), with a dorsally brown coloration, and the underside is white to creamish-yellow (Pethiyagoda, 2012b). *Taruga eques* produces a characteristic white foam nest (Pethiyagoda, 2012b), which usually hangs on trees and shrubs beside pools. At breeding time, the female selects a calling male. She allows him to mount her and climbs onto an object which is usually overhanging a pool of water (Meegaskumbura et al., 2011b). Afterward female secretes mucus that she then beats into a thick foam with her hind limbs (Crump, 2010). Meanwhile, the male fertilizes the eggs which are deposited into the foam nest by the female (Pethiyagoda, 2012b). Following hatching, tadpoles fall into the water where they continue to develop (Crump, 2010; Pethiyagoda, 2012b).

The amphibian is a highly threatened taxon compared to birds and mammals and is rapidly declining all over the world (Stuart et al., 2004). Although many amphibian declines

are due to overpopulation, there are many other unidentified processes driving them to extinction in many places (Stuart et al., 2004). Many amphibian species recognized from Sri Lanka are possibly threatened or near threatened (Stuart et al., 2004; Meegaskumbura & Manamendra-Arachchi, 2005). However, the status of the majority has not been evaluated due to a lack of knowledge. Hence, assessing the status of this species will be helpful for understanding the ecological status and vulnerability of its habitats, so as to contribute to future conservation. Moreover, *Taruga eques* is already listed as endangered by the International Union for Conservation of Nature due to the reduction of their area of occupancy and the quality of their habitat (Ministry of Environment, 2012). The attention and conservation measures which have been implemented hitherto are, therefore, limited to this species.

The Study

This article is based on a survey which assessed habitat utilization, nesting strategies and threats faced by the *Taruga eques* within the Horton Plains National Park in Sri Lanka. The survey was conducted from 22nd October 2016 to 25th February 2017 in the Horton Plains National Park (HPNP) which is located in the Central Highland of Sri Lanka. The Horton Plains was declared a national park in1988 (Department of Wildlife Conservation, 2007). The National Park is about 3,160 ha and is situated in the Nuwara-Eliya district. It is contiguous with Peak Wilderness Nature Reserve to the west (Department of Wildlife Conservation, 2007). HPNP is a part of the recently declared World Heritage Sites (Peak Wilderness Protected Area, Horton Plains National Park, and Knuckles Conservation Forest) of the Central Highland of Sri Lanka. HPNP's altitude ranges from 1,500 m to 2,530 m above sea level which comprises upper montane rain forests (Department of Wildlife Conservation, 2007). The mean annual temperature is 15°C and the mean annual rainfall is about 2,150 mm (Department of Wildlife Conservation, 2007). The weather is dominated by prominent cloud cover and strong winds, and at times, gale-force is common during the southwest monsoon (Department of Wildlife Conservation, 2007). HPNP is a significant catchment for several major rivers in Sri Lanka including the Mahaweli River, Kalani River, and the Walawe River. Based on early reconnaissance surveys within the study area, *Taruga eques* was found in association with still water bodies.

The *Taruga eques* survey was conducted in five consecutive water bodies (Figure 1) for a week per month and included five visits to the study areas. Among the five sites, sites A, B, and C were located by the side of the main road, and sites D and E were located outside the road network. The latter were smaller and seasonally abandoned gem pits. The time of the sampling fell between 6.00 a.m. to 9.00 a.m. and 4.00 p.m. to 12.00 p.m.

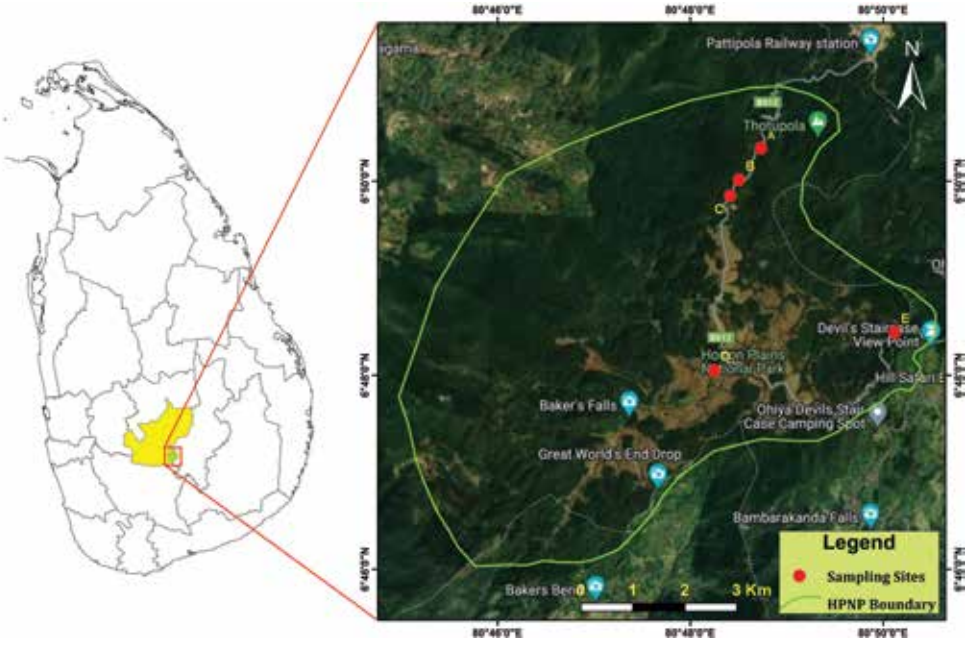


Figure 1: The map of the study area showing sampling locations within the boundaries of HPNP (**A**- 6° 50' 20.33" N/80° 48' 42.87" E, **B** - 6° 50' 1.11" N/80° 48' 32.52" E, **C** - 6° 49' 52.20" N/80° 48' 25.60" E, **D** - 6° 48' 3.12" N/80° 48' 15.00" E, **E** - 6° 48' 26.57" N/ 80° 50' 6.83" E).

Material and Methods

The stratified random sampling technique was employed to investigate *Taruga eques* in Horton Plains National Park. Primarily transects surveys were conducted and opportunistic observations were employed when walking along transects at a constant speed (Rödel and Ernst, 2004). 100 m × 2 m belt transects were placed along the still water bodies covering all habitats such as grassland, forest, and aquatic habitat (Rödel & Ernst, 2004). The plots were surveyed in the morning (6.00 a.m. to 9.00 a.m.), and at night (4.00 p.m. to 12.00 p.m.). Two persons walked at a constant speed along transects while actively searching and visually scanning for amphibians, at night using headlamps and spotlights.

Activities for active searching included examining leaf litter on trees and tree trunks, understory vegetation, turning rocks, and moving some movable debris (Karunarathna et al., 2017a). Water pools were sampled using the same transects for the foam nest counting. The nest size, nest height from the ground/water surface, the habitat, and condition of the nests were recorded. Along the transects time, ambient temperature (°C) one meter above the ground/water surface, and relative humidity one meter above the ground/water surface were recorded using a portable weather meter (United States of America). Water quality parameters such as conductivity, total dissolved solids, and pH were obtained using a portable standard water quality meter (Water Quality Monitoring Instrument-YSI-PRO-PLUS). Rainfall data was obtained from Nuwara Eliya which was the nearest weather station to the national park.

Taruga eques was identified using the keys of Duatta & Manamendra-Arachchi (1996), and Pethiyagoda, (2012b). Randomly picked individuals of *Taruga eques* were captured to record morphometric measurements to the nearest 0.1 mm using a digital venire caliper (Manamendra-Arachchi & Pethiyagoda, 2001). Sex (excluding juveniles) and the maturity state of the frogs, behavior, and habitat use were recorded at the time of observation (Rödel & Ernst, 2004). Frogs were assigned to age classes based on snout to vent length: mature males-32-42 mm, gravid females-62-71 mm, and juveniles <20 mm (Dutta & Manamendra-Arachchi, 1996). The frogs' microhabitat was categorized into seven types including "in grasses", "on grasses", "on tree", "in herbs", "on herb", "on shrub", and "in water". Behavioral acts were also categorized into "perching", "swimming", "mating", and "jumping". The microhabitat of nests was categorized into five types including "hanging in trees", "in grasses", "between herbs", "on grasses", and "between grasses".

Other species of amphibians which were sympatric with *T. eques* were also recorded. Adult males and females were identified based on external morphology which is the presence of the nuptial pad (Dutta & Manamendra-Arachchi, 1996) on the male forelimb first digit, and the presence of the vocal sac (Dutta & Manamendra-Arachchi, 1996; Manamendra-Arachchi & Pethiyagoda, 2001). The individuals that were captured were temporarily held in a container to avoid double-counting. A standardized data sheet was used to record data and all captured amphibians were released after recording data at the point of capture.

Results and Discussion

A total of 20 transects were conducted that covered a total area of 0.002 km^2. A total of 101 individuals comprising 72 males, 8 females, and 21 juveniles were recorded. The overall population density was 5 individuals/100 km^2. The abundance of males was significantly higher than that of females (male: female = 9: 1). Moreover, their activities were absent in fast-flowing rivers, perhaps due to the introduction of exotic Rainbow Trout *(Oncorhynchus mykiss)* as observed by Prabhath et al. (2018). However, studies assessing the impact of invasive alien fish species on amphibians in Sri Lanka are limited, except for studies conducted by Bambaradeniya (1999) that showed Guppy fish (*Poecilia* spp.) feeding on amphibian eggs. Hence, it is very important to take conservation action on species such as the narrow-ranging endangered frogs in Sri Lanka including the critically endangered Kandyan Torrent Toad *(Adenomas kandiaunus)* (Karunarathna et al., 2017a).

Behavioral acts that were observed included perching on a variety of microhabitats, swimming, mating, and jumping. Behavioral acts were not uniform among the frogs. While perching was the most commonly observed behavioral act among all the age-sex groups (92.1%), other types of behaviors such as swimming (2.9%), mating (1.9%), and jumping (2.9%) were observed much less, perhaps due to mating which occurs only during a particular season. Mating (Amplexus) was recorded only a single time during the entire survey (See Figure 2). The behavior did not substantially change among the age-sex groups.

The morphometric parameters significantly differed among males and females ($F=116.67$, $P < 0.05$). The females were normally larger than the mature males with an average length (Snout to vent length) of 61.93 cm (SD ± 4.22), while the males' average

length reached 39.26 cm (SD ± 1.50). The largest female and male measured were 42.45 cm and 66.41 cm respectively (Table 1). Females were larger than males and they showed prominent sexual dimorphism. Hence the mean body size (snout to vent length) of females is significantly larger than that of males. Therefore, size is a pragmatic factor for distinguishing them in the field.

Table 1: Morphometric measurements for *Taruga eques* (measurements in cm)

	Males (n=14)				Females (n=3)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
SVL	39.26	1.50	37.22	42.45	61.93	4.22	58.04	66.41
HL	15.20	1.05	13.35	16.87	23.71	1.65	22.22	25.49
HW	12.43	0.69	11.58	14.44	21.21	0.78	20.72	22.12
IOD	4.92	0.57	4.10	5.86	9.19	0.86	8.26	9.97
IND	3.60	0.44	2.73	4.43	5.25	0.48	4.79	5.75
ED	4.64	0.38	3.91	5.52	6.34	0.44	5.84	6.66
TD	2.83	0.44	1.92	3.60	4.77	0.46	4.25	5.14
LHU	7.91	1.30	5.58	9.65	14.80	1.09	13.92	16.03
FOL	10.88	2.45	7.91	18.12	17.80	1.67	16.36	19.64
THL	17.50	2.25	10.58	20.39	29.70	1.68	28.6	31.64
TL	18.54	1.42	14.40	19.96	32.13	1.86	29.98	33.23
FL	24.87	1.53	21.64	27.06	42.20	2.28	40.06	44.59

***SVL:** snout-vent length, HL: head length, HW: head width, IOD: inter orbital diameter, IND: inter-nostril distance, ED: eye diameter, TD: tympanum diameter, LHU: length of the humerus, FOL: forearm length, THL: thigh length, TL: tibia length, FL: foot length.

Figure 2: Mating Amplexus of *Taruga eques*, the male mounted on the female

The frogs were observed in seven different microhabitats including (1) in grasses, (2) on grasses, (3) on trees, (4) in herbs, (5) on herbs, (6) on shrub, and (7) in water (Table 2). The most used microhabitats among all the age-sex groups were perching on herbs (33.6 %) and in herb (23.7%). Most of the adult and juvenile frogs were observed associating with *Juncus effusus* herbs adjacent to still water bodies. The use of in water (1.9%), and on grasses (3.9%) was less frequent (Table 3). During the daytime, they hid in herbs and grasses and slowly started to emerge from their refuge after 4.00 p.m. in the afternoon. A substantial amount of individuals were also found in grasses (18.8%). Their microhabitats selection was based on the maximum cover to prevent desiccation (Prabhath et al., 2018). This is very important because the observed still-water pools are located along the main road to the national park and are subjected to human-related threats. Hence protecting grasses and vegetation around these pools is significant for the life cycle of these frogs.

Table 2: Microhabitat types used by *Taruga eques* within the Horton Plains National Park

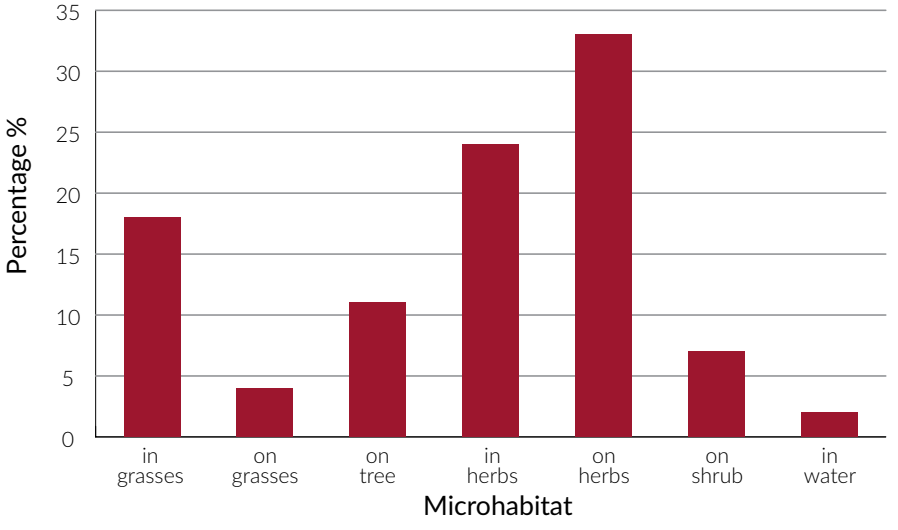
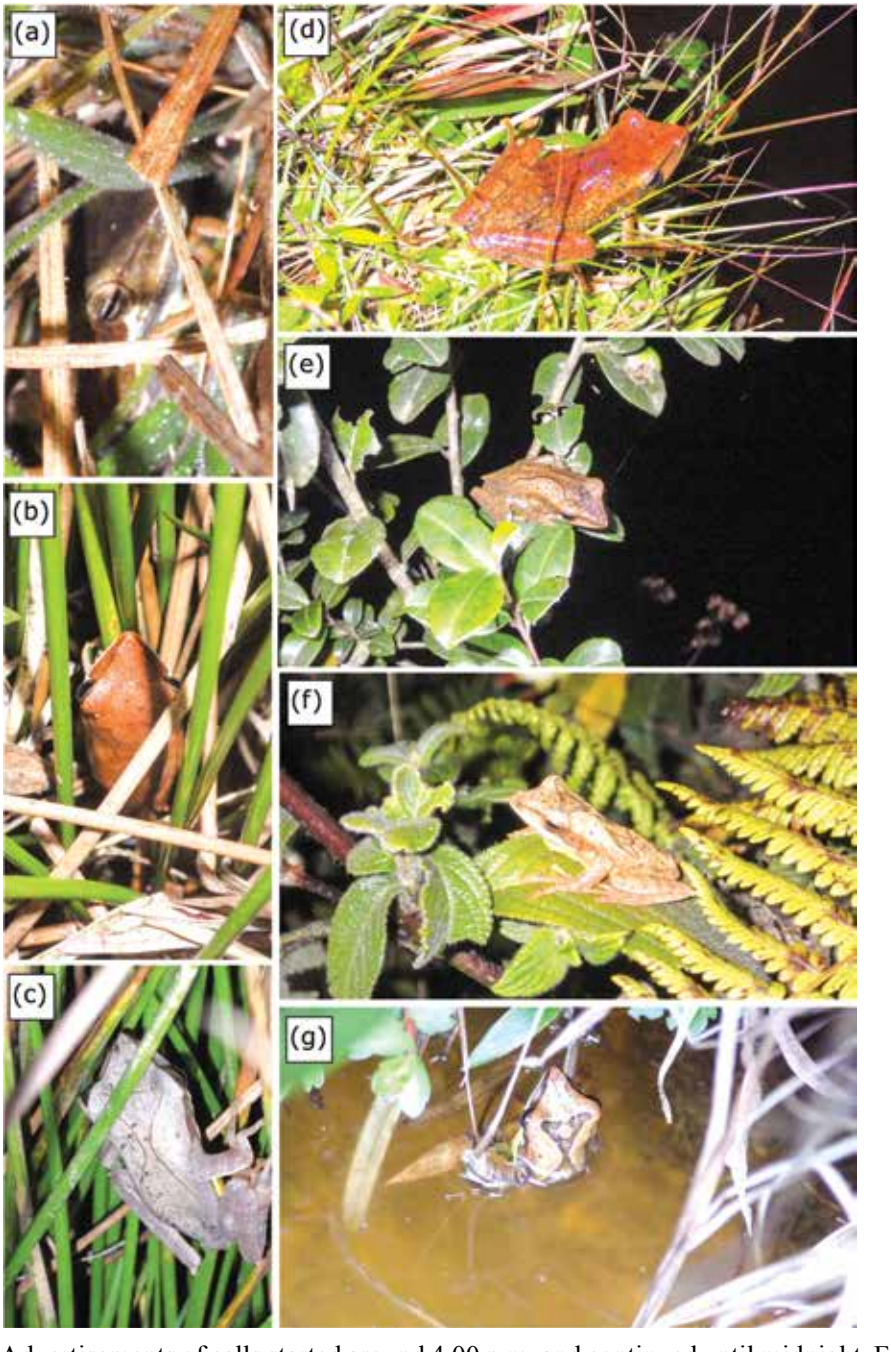


Table 3: Percentages of microhabitats used by *Taruga eques.*

Microhabitat	in grasses	on grasses	on tree	in herbs	in herbs	on shrub	in water
Individuals	19	4	11	24	34	7	2
Percentage (%)	18.8	3.9	10.8	23.7	33.6	6.9	1.9

There were also several other species of amphibians that were sympatric with the *T. eques* including the Mountain Frog *(Fejevarya greenii)* (n=13), Small Eared Frog *(Pseudophilautus microtampanioum)* (n=2), Red Eyed Shrub Frog *(Pseudophilautus alto)* (n=5), and several other shrub frogs (*Pseudophilautus* spp.) (n=22), most of whom have not yet been identified scientifically in Sri Lanka. Among them, *Fejevarya greenii* is one of the endangered frogs living in this habitat (Ministry of Environment, 2012).

Figure 3: Different microhabitat types used by *Taruga eques,* (a) in grass, (b) in herb, (c) on herb, (d) on grass, (e) on tree, (f) on shrub, (g) in water.



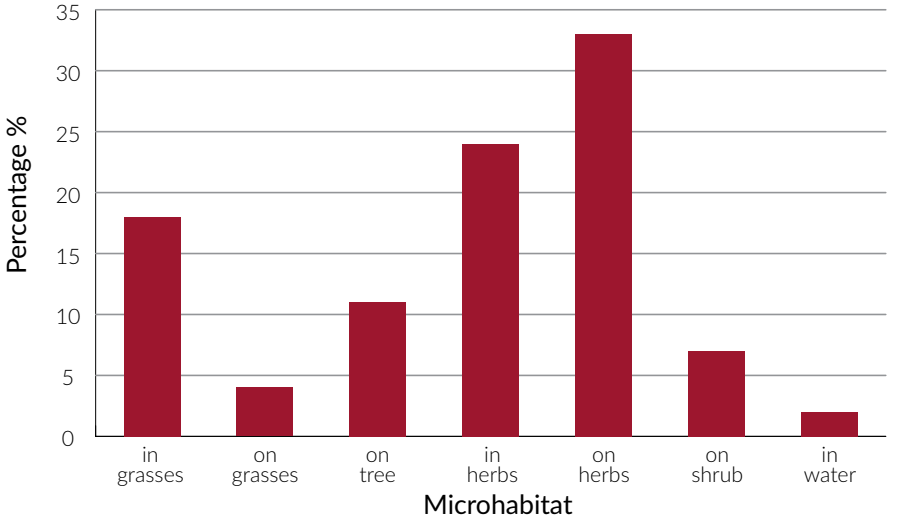
Advertisements of calls started around 4.00 p.m. and continued until midnight. Frogs called while perching on microhabitats (the majority on herbs). The environmental variables indicated higher humidity (>65%), and cooler temperature (<16°C) preferred by *T. eques*. They also preferred water in pools with cool temperatures (<16.5°C), still water with near-

natural pH (5.99), low conductivity (18.4 µS/cm), and low total dissolved solids (TDS) (9.1 ppm). Pools which contained still water in a waterlogged condition had accumulated organic matters, silt, and sediment over the years resulted in low TDS in water.

Nesting Patterns

A total 76 of foam nests were counted during the surveys. Foam nests were only observed in sites A, B, and C due to year around water availability. Site D and E are seasonal, and the water level was lower at the beginning of the survey and by the end, they were completely dry. According to the ANCOVA test, nest size and nest height were not significant ($F=0.87$, $P = 0.353$). Pond sizes did not significantly affect the number of nests (> 0.05). The maximum number of nests (n=37) was recorded from site B. The mean nest height was 15.24 ± 24.73 cm with a maximum of 200 cm. The maximum nest size was 195 cm^2 with a mean of 48.72 ± 26.7 cm^2. Nest height correlated significantly with water temperature, pH, conductivity, TDS, and ambient temperature (Pearson correlation <0.05), while nest size correlated with water temperature and ambient temperature (<0.05). Nest heights ranged between 1-200 cm, while nest sizes varied between 12-195 cm^2. Nests were constructed in five different microhabitats including (1) hanging in trees (2) in grasses, (3) between herbs, (4) on grasses, and (5) between grasses (Table 4). Among them between herbs (56.5%) was the most observed microhabitat for nest construction, while hanging in trees (3.9%) and in grasses (6.5%) were the least. However, most nests were recorded from site B which is smaller than other pools. It is clear that the place for nest construction is pragmatic as it is directly related to the post-metamorphism of tadpoles. If a suitable place is not selected survival would be highly threatened. The frogs constructed nests close to the water surface, but not too close because if high rainfall occurred, the nest could be inundated.

Table 4: Microhabitat of foam nests by percentage.



All the observed foam nests were bright white in color (Figure 4). However, Fernando and Dayawansa (1995) recorded that *T. longiginasus* nests were brownish-white in color. They also recorded that *T. longinasus* nests were located between 15-200 cm above the water surface. Meegaskumbura et al. (2011a) recorded that *Polypedates crucigur* nests are blue in color due to copper iron. *P. crucigur* also selects specific microhabitats for the nests' construction (Meegaskumbura et al., 2011a).

T. eques is a terrestrial foam nesting species that shows partial aquatic development with eggs laid on vegetation or rocks in a foam nest above water, and completes development as free-living forms in water (Meegaskumbura et al., 2011b). The thick foam nest protects the eggs and developing larvae from sunlight and desiccation. The function of the foam nest is to provide protection. The outermost layer of foam dries quickly and provides some protection against desiccations and predation (Crump, 2010). Hence it is evident that *T. eques* selects places with high coverage to construct nests in order to avoid desiccation and predation. Therefore, microhabitats are important for their entire life cycle. Moreover, they frequently construct nests between *Juncus efficus* herbs. Hence, protecting this herb and other grass vegetation is important for their spatial distribution and reproduction and future survival (Meegaskumbura et al., 2011a). However, further studies should be undertaken to test the composition of foam nests as well as their anti-bacterial and anti-fungal property in both *Polypedates* and *Taruga* genera (Meegaskumbura et al., 2011a).

Figure 4: Characteristic white color foam nest of *T. eques*

The female color pattern differed from that of males. Females showed more reddish-orange coloration while males showed brown body coloration on the dorsum. However, most of the time both showed the same creamy white color in the ventral aspect. Hence the hue rapidly changed from individual to individual. Most of the male individuals showed a brown dorsal while the underside was white to creamish-yellow in color. However, a few

males showed a greyish color pattern with a white underside. In males, the color changed from brown to dark brown, and grayish color dorsally. An hourglass mark was not common for all individuals and some individuals lacked a mark - instead they had brown spots. All females showed red, orange, yellow, and yellowish-orange, while the underside was creamish-yellow and white with dark spots. Both males and females had dark stripe patterns on the hind legs.

Hence, females show a prominent color difference in comparison to males. Therefore, the color difference is one of the reliable factors, except for body length, nuptial pad, and gular sac, to differentiate them in the field. Further, it is easily observable from a distance without disturbing the individual. As Dutta and Manamendra-Arachchi (1996) note, the dark hourglass mark on the dorsal surface is not common for all individuals - instead they have dark spots on the durum. However, it is doubtful whether other members of this genus such as *T. longinasus,* and *T. fastigo* show such color pattern differences since studies have not been conducted.

There are several threats to amphibians, even to extinction, such as climate change (Meegaskumbura et al., 2011a), predator attacks, parasite attacks (leach, dragonfly and damselfly larvae, and freshwater crabs), road kills (Karunarathna et al., 2017b), and human-related pressure (Batuwita et al., 2019). During the surveys, several threats were recorded that were detrimental to this species. Among them dragonfly larvae in still-water pools (Figure 5) which are macroinvertebrates that could pose a threat to the early life stage of *T. eques*. This could lead to higher mortality among tadpoles and juveniles. Parasite attacks including leaches can lead to abnormalities in amphibians. This can cause missing limbs or parts of limbs (Johnson et al., 2001). Silva et al. (2019) reported that *T. eques* had the most number of abnormalities in the Horton Plain National Park. They also reported that an unidentified cestode attack caused infection of the ventral side of the thigh of *T. eques*. During our field observation, several potential predators were recorded from the area such as the Indian Pond Heron *(Ardeola grayii),* Indian Black Bird *(Turdus simillimus),* Mongoose (*Herpestes* spp.), and Eurasian Otter *(Lutra lutra)*.

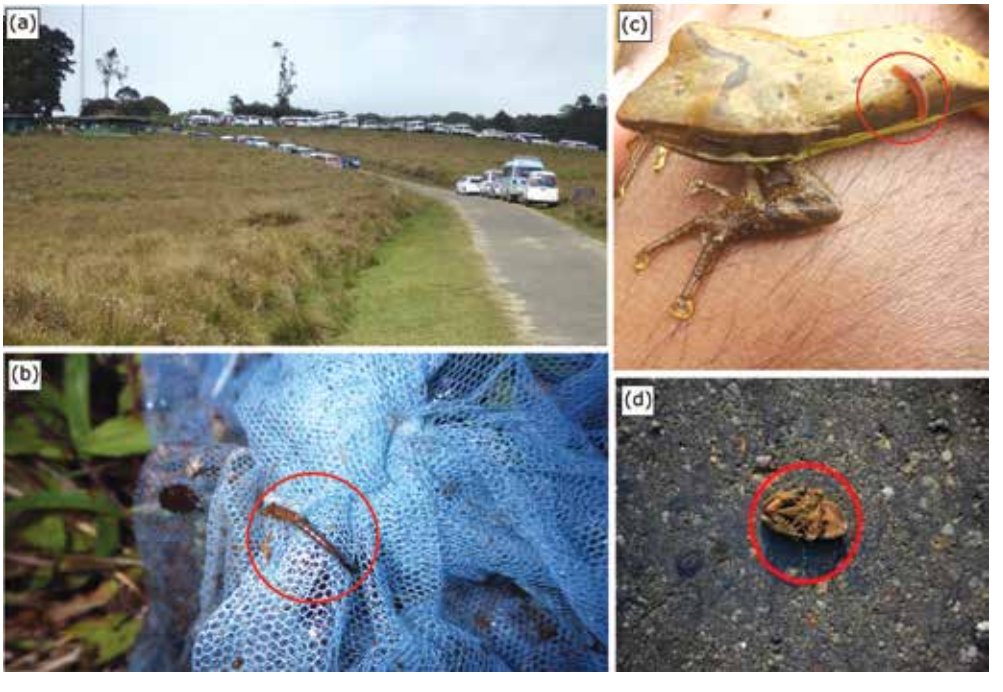
Over visitation is also a major threat, not only to the amphibians but also to the entire ecosystem of the park. Moreover, during peak tourist season within the part, littering and air pollution increase. Therefore, these anthropogenic activities create even more pressure on the amphibians, leading to extinction. Cloud forest habitats are especially, vulnerable to the effects of global climate change due to their pristine nature (Stuart et al., 2004). Pressures from habitat loss and fragmentation will cause many species to lose their optimal microhabitats over the next decades (Meegaskumbura & Manamendra-Arachchi, 2005). The forest dieback may be a cumulative effect of these anthropogenic activities and natural causes although the exact reason is yet to be found.

Although several invasive plant species have been found within the park including in the pond habitats, no studies have yet been conducted to find out the detrimental impact of these invasive species on amphibians. Hence studies should be conducted to find whether there is an adverse effect, or not, on amphibian populations. Meegaskumbura et al. (2011a) reported that nests of *Pholypedates cruciger* have been attacked by certain fly species by

which entire foam nests were destroyed. They reported, however, that fly attacks were not observed in *T. eques* nests. Our study confirms this such a fly attack was not observed during the nest surveys. According to Meegaskumbura et al. (2011a) this may be due either to the absence of flies in *T. eques* habitats, or nests which can tolerate such fly attacks.

Moreover, this is the only national park in Sri Lanka where tourists are allowed to go inside with their personal vehicles and walk inside. That could be further detrimental to the habitat and species. It has been recorded the HPNP supports around 15 species of amphibians (Karunarathna et al., 2017b). Hence it is important to take the necessary steps to control the over-visitation since this is the only tropical montane cloud forest habitat in Sri Lanka with less than 30 km^2 in extent. Given this narrow distribution range, it is advisable to implement studies beyond the park boundary to assess *T. eques*'s population status, breeding patterns, population trends and interesting color variations.

Figure 5: Potential threats to *Taruga eques* within the HPNP ;(a) Vehicular traffic congestion during the peak time, (b) A damselfly larvae captured from sampling locations, (c) an ecto-parasite (leach) feeding on a male *T. eques,* (d) A road kill of *T. eques.*



Conclusions

The survey of *T. eques* nests revealed that there should be a substantial number of females within the study area, assuming one individual produces one foam nest at a time. The distinct color pattern of females would be one of the best clues to distinguishing males from females in the field, among other characters such as snout to vent length and

nuptial pad. The overall population density was satisfactory within the park but studies that extend outside the park are necessary. Sites A, B, and C can be considered as *Taruga eques* hotspots that are significant to their life cycle though they are highly vulnerable to threats. The *Juncus efficus* herb is very important to their nest construction and provide the best microhabitats for their life cycle. Hence, protecting this herb and vegetation around the pools must be a priority.

Like other amphibians, *T. eques* faces a substantial risk of extinction because of their narrow range and habitat specialization, poor dispersal ability, and high fidelity. All three members of the *Taruga* genus have been classified as threatened in the IUCN Red list, while *T. fastigo* is listed as critically endangered. Hence the conservation priorities should be focused at the genus level. Even though *T. eques* is listed as endangered on IUCN Red List it has not been listed on the Convention on International Trade in Endangered Species appendices, and this can make them vulnerable to the illegal international pet trade. Further, amphibians are the most vulnerable group to road kills in the HPNP due to their slow-movement. This is a major threat to them during the peak tourist season. Limiting the vehicle speed and the number of vehicles taken into the national park should be implemented to avoid roadkill mortality. Finally, the findings of this study would support future conservation planning on this endangered species.

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