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Pugmark and scat evidence of elusive mammals at Maduru Oya, Sri Lanka: A preliminary study

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Abstract

Pugmark and scat identification are indirect methods of mammal observation in the wild less popular than camera trapping and GPS collaring and is an understudied field of research in Sri Lanka with limited reference resources and no research publications so far. However, this is not the same in many other countries where mammals are studied in the wild. Therefore, we conducted a preliminary study in February and March 2021 at a selected location in the dry zone of Sri Lanka with the aim of identifying elusive mammals by pugmarks and scat evidence. We identified a total of 13 mammals, 9 by pugmarks of which 8 belonged to the family Carnivora and 1 Proboscidea. We also identified 4 mammals by scat of which 2 belong to the family Carnivora, 1 Proboscidea, and 1 Lagomorpha. Among them are 4 nationally endangered and 1 nationally vulnerable species. We report the presence of the nationally endangered *Prionailurus viverrinus* (Fishing cat) both by pugmark and scat evidence previously not recorded at our study site. We also report pugmark evidence of *Viverricula indica* (Small Indian civet) which has not been previously reported at our study site. In addition, we report the visual observation of the nationally vulnerable and rare *Rhinolophus beddomei* (Lesser woolly horseshoe bat) also previously not reported at our study site.

Keywords: Animal feces, Maduru Oya, Mammals, Pawprints, Sri Lanka

Introduction

At present Sri Lanka is home to 127 species of mammals (96 terrestrial & 31 marine) of which 22 are endemic (17%) (Ministry of Environment, 2012; Yapa & Ratnavira, 2013; Miththapala, 2018; Edirisinghe et al., 2018; Kotagama, De Alwis Goonathilake and Rathnavira, 2019; De Silva Wijeyerathne, 2020). The island provides habitat to charismatic mega-mammals such as the Sri Lanka Elephant, Sri Lanka Leopard,

Sloth bear, and old-world monkeys. However, the majority of mammals are small to medium-sized (Edirisinghe et al., 2018). Meso-mammals are those that are medium-sized roughly larger than rodents and smaller than Jackal and they play keys roles in the ecosystems as predators, seed dispersers, the influence of community structures, and maintaining biodiversity (Jayasekara, Mahaulpatha & Miththapala, 2021).

Elusive mammals are those that are difficult to visually observe in the wild, the reason could be that they are shy, solitary, rare, or uncommon, especially those mammals that are nocturnal or crepuscular. Nevertheless, there are several other ways of observing these mammals indirectly in the wild. The most popular method is the use of camera traps to capture photos or videos of mammals as they go about their daily routine and these data can be used to make checklists, determine species abundance, density estimations, population monitoring, behavioral studies, and wildlife management (Jayasekara et al., 2019; Jayasekara, Mahaulpatha & Miththapala, 2021; Jayasekara & Mahaulpatha; 2021a; Jayasekara & Mahaulpatha, 2021b). A second method would be to capture them using walk-in cage traps baited with visual, scent, or audio lures and then fitting them with a GPS collar which will enable them to track and map their movements over a long period of time and even help to establish home ranges (Taylor et al., 2016; Rathnayake et al., 2021).

A less popular method would be to look for evidence of remnants such as pugmarks or scat of these mammals. These remnants are unique to each species and can be used for the identification, census, and tracking of animals (Thakur, Yadav & Jhariya, 2016). Tracks, spoor, footprints, paw prints, or pugmarks all refer to the foot imprints an animal leaves on mud or sand. In countries such as the USA where hunting is widely practiced tracking animals by studying these remnants is a sub-science, meriting entire publications devoted to the subject. However, in Sri Lanka pugmark and scat identification of mammals are an understudied field of research and a rare science these days (Yapa & Ratnavira, 2013; Miththapala, 2018). Pugmark analysis can reveal a lot of information about the animal it belongs to, including direction of travel, age, general physical conditions like size and weight (Sanei et al., 2011; Jhala, Qureshi & Gopal, 2011; Taylor et al., 2016; Thakur, Yadav & Jhariya, 2016; Bhagat, Yadav & Jhariya, 2017; Kabir, Ahsan & Khatoon, 2017), sex (Sharma, Jhala, & Sawarka, 2003; Gu et al., 2014; Singh et al., 2014) and even individual identity in some instances (Sharma & Wright, 2005; Sharma, Jhala, & Sawarka, 2006; Dhande & Gulhane, 2016). Scat or dropping are feces left behind by animals. Scat identification and analysis can also relieve a lot of information about an animal's diet (Jhala, Qureshi & Gopal, 2011), DNA can also be recovered from Scat and can be used to identify or verify species, determine sex, and even can be used for individual identification (Hájková, et al., 2009; Borthakur et al., 2011).

The North-Central and Eastern regions of Sri Lanka remained relatively unexplored due to the 30-year (1976-2009) civil war (Gabadage et al., 2015). The Batticaloa district is situated in the Eastern province and bioclimatic lowland dry zone of Sri Lanka. The habitat comprises of diverse mosaics including woodlands, scrublands, grasslands, marshlands, rocky outcrops, rock mountains scattered throughout the area, abandoned land, agricultural land, home gardens, a variety of built-up areas and various water sources like rivers, streams, ponds, lakes, tanks, and reservoirs. The main vegetation type is dry tropical mixed evergreen forests. In addition, some thorn forests and riverine forests are found (Edirisinghe et al., 2018). Various biodiversity studies have already been conducted inside the Maduru Oya National Park (MONP) including, avifauna (Gabadage et al., 2015; Dilrangi, De Silva & Mahaulpatha, 2021), bats (Edirisinghe et al., 2018), butterflies (Silva et al., 2020; Silva et al., 2021) and mammals (Jayasekara et al., 2019; Jayasekara, Mahaulpatha & Miththapala, 2021; Jayasekara & Mahaulpatha; 2021a; Jayasekara & Mahaulpatha, 2021b) but not outside the immediate boundary of the national park. No studies on pugmark and scat identification of mammals of Sri Lanka were not found in the literature. Therefore, we conducted a preliminary study at the selected study site to identify elusive mammals in the dry zone of Sri Lanka. The main objective of this study was to record pugmarks and scat evidence of mammals and identify them. Secondly, to record any other type of indirect evidence such as skeletal remains of mammals, and lastly to record any direct observations of elusive mammals.

Materials and Methods

Study area

The selected study site for our research was the proposed Maduru Oya right bank development project (MORBDP) site of 180km^2 (Fig 1) which is to be initiated with the purpose of providing irrigation facilities to settle farmers along with improvement to drinking water and sanitation. The water that will be used in the irrigation project is to be obtained from the Maduru Oya Reservoir located within the MONP. This is the closest national park to our study site located about 20km due South-West, hence the importance of the location of our current study site. As a statutory requirement under the National Environment Act No. 47 (1980) an Environment Impact Assessment (EIA) was conducted in compliance with the Central Environmental Authority. During this EIA the fauna and flora at the study site has been previously documented (Mahaweli Consultancy Bureau, 2017).

Data collection

Field visits were conducted for a total of 7 days between 20 February 2021 and 7 March 2021. Surveys were conducted during the daytime only, for 10 hours between 8.00 am and 6.00 pm. The opportunistic

visual encounter survey method was used for surveying and observations of pugmarks and scat were recorded. A ballpoint pen of 14cm was used as a scale and placed next to the pugmarks and scat when photographs were taken using a Nikon D3500 camera with AF-S Nikkor 18-55mm f/3.5-4.5G VR II lens. Yapa & Ratnavira, 2013 and Miththapala, 2018 were used to identify pugmarks and scat. In addition, we enlisted the help of mammal experts to confirm our identifications. Some scat samples were processed on-site. The samples were washed with clean water and left in the sun to dry and then photographed and analyzed. Once pugmarks or scat were encountered GPS coordinates were taken using a Garmin eTrex Vista device.

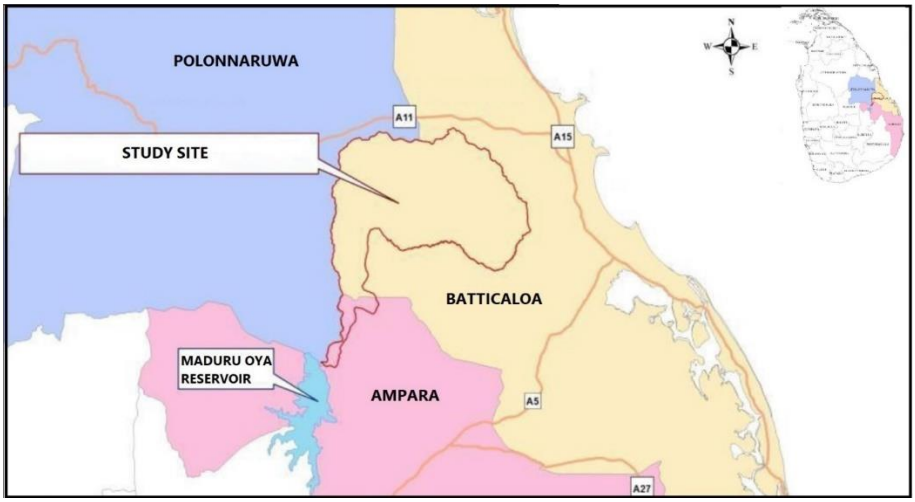

Figure 1. Location of the study site

Results

Pugmarks

Observations of pugmarks during the field visits were recorded and are described here along with their locations which are shown in figure 2. On 20 February at around 11.30 am several pugmarks were observed on the bank of a shallow stream at location figure 2A These were photographed and later identified to be of *Prionailurus viverrinus* (Fishing cat), *Hystrix indica* (Porcupine), and *Lutra lutra* (Eurasian otter) (Yapa & Ratnavira, 2013; Miththapala, 2018) (Fig. 3A, 3B and 3C) respectively). All these pug marks were found more or less in the same vicinity indicating high animal traffic across and around this water source. Several canine pugmarks were also observed on the bank but not photographed and assumed to belong to *Canis lupus familaris* (domestic dog) as there were some houses in the close vicinity with pet dogs during the time of photography. The following day (21 February) at around 3.30 pm large pugmarks (Fig. 3D) were observed on either side of a stream at location figure 2B which were identified to be of *Elephas maximus* (Sri Lanka elephant) (Yapa & Ratnavira, 2013; Miththapala, 2018). In the same vicinity, many pugmarks of the canine family were also observed (Fig. 2B). These were identified to be *Canis aureus naria* (Sri

Lanka Jackal) (Fig 3E) (Yapa & Ratnavira, 2013; Miththapala, 2018). On 26 February at around 12.45 pm a pugmark was observed in a rock cave-dwelling at location Fig 2C and locals identified them as that of *Melursus ursinus* (Sloth bear) (Fig. 3F) (Yapa & Ratnavira, 2013; Miththapala, 2018). This rock cave dwelling was also identified to have archaeological significance (Mandawala, 2021). The following day (27 February) at around 12.15 pm several pugmarks were observed on the bank of a pond on a rocky outcrop of elevation 91.48m at location figure 2D. These were later identified to be a fishing cat, porcupine, *Viverricula indica* (small Indian civet) (Fig. 3G), and *Herpeste sp*. (mongoose) (Fig. 3H) whose species identity was unable to be determined (Yapa & Ratnavira, 2013; Miththapala, 2018). On 6 March at around 1.45 pm several pugmarks were observed on the bank of a pond on a rocky outcrop of elevation 85.07m at location figure 2E. These were later identified to belong fishing cat, *Herpeste sp*. (mongoose) whose species identity is unable to be determined, and a third pugmark whose identity was inconclusive (Yapa & Ratnavira, 2013; Miththapala, 2018).

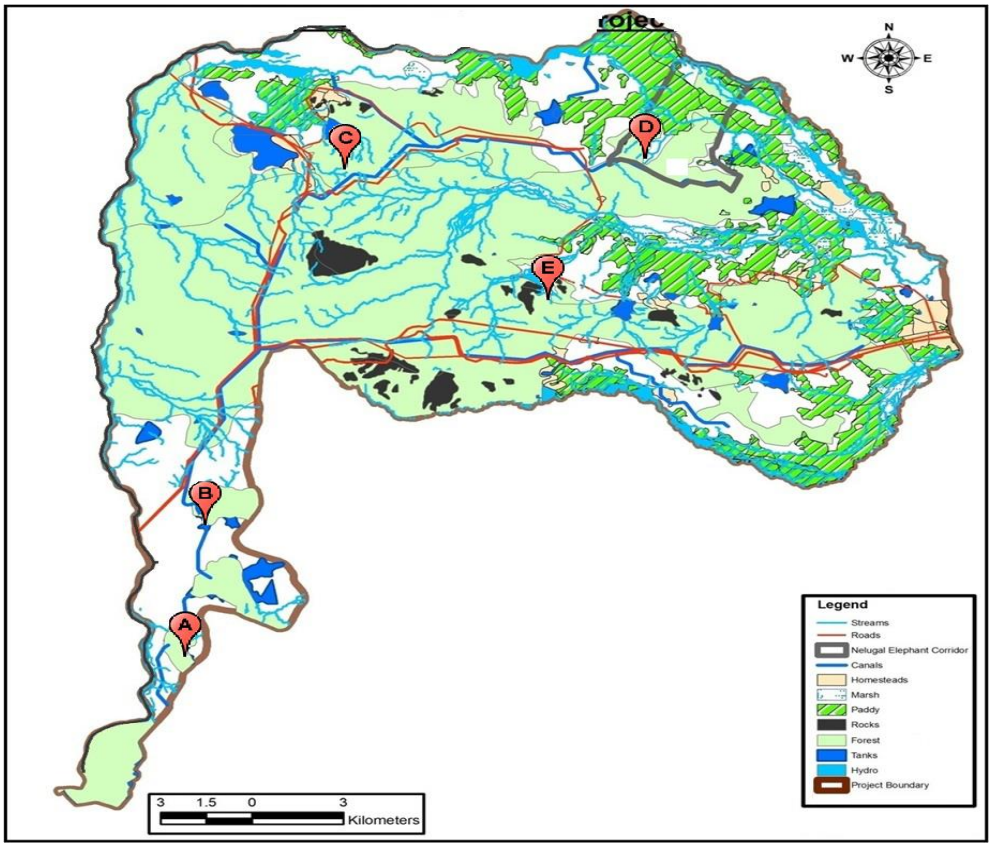

Figure 2. Locations of pugmark evidence. **A.** Fishing cat, porcupine and otter. **B**. Elephant and Jackal. **C**. Sloth bear. **D.** Fishing cat, Porcupine, Small Indian civet and Mongoose. **E**. Mongoose, Fishing cat and unidentified pugmark

Figure 3. Pugmarks of **A.** Fishing cat. **B**. Porcupine, **C.** Eurasian otter, **D.** Elephant, **E.** Jackal, **F.** Sloth bear, **G.** Small Indian civet, **H.** Mongoose

Scat

Similarly, observations of scat during the field visits were recorded and details are described here along with locations which are shown in figure 4. On 20 February at around 3.30 pm three sets of scat were observed at location figure 4A of which two sets were later identified to be porcupine (Fig. 5A) and *Lepus nigricollis* (Black napped hare) (Fig. 5B) (Yapa & Ratnavira, 2013; Miththapala, 2018). On a nearby rocky mountain called Weheragodella just next to a pond on a rock plateau, a scat sample was observed (Fig.

5C). The pond was a 10m long and 5m wide natural pond at an elevation of 142.53m above mean sea level. The scat sample appeared to be fresh and green in color with white fragments embedded in it. These fragments appeared to be bone fragments (Fig. 5D).

This sample was processed on-site. It was washed with clean water and then laid in the sun to dry and then photographed. On analysis, we found fish scales, thin fish bones, fur, small mammal bones, and the calamus of features (Fig. 5E) This led us to believe this sample belonged to a fishing cat (Yapa & Ratnavira, 2013; Miththapala, 2018). At the top of this Weheragodella mountain, we found the ancient ruins of a stupa and a rock cave-dwelling and identified to have archaeological significance (Mandawala, 2021).

On the following day (21 February) at around 5.45 pm elephant dung (Fig. 5F) was observed at the bank of a small tank at location figure 4B. This manmade tank was identified to have archaeological significance (Mandawala, 2021). Another scat sample was observed at location figure 4C on 26 February at around 1.00 pm next to a pond of dimensions 5m long and 2.1m wide at elevation 64.22m on a rock plateau. This sample was identified to belong to the porcupine. (Yapa & Ratnavira, 2013; Miththapala, 2018).

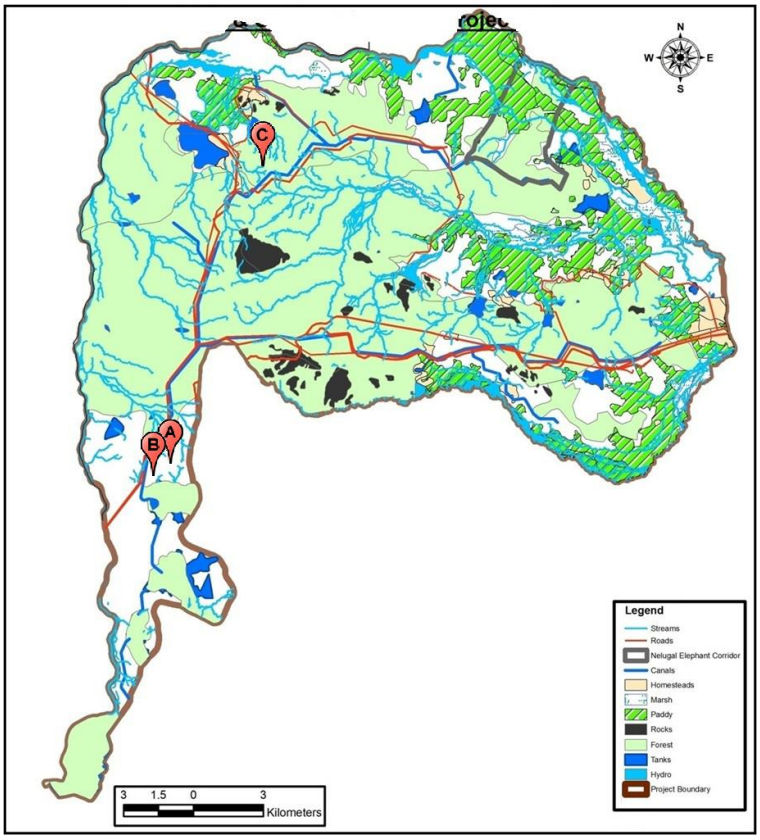

Figure 4. Locations of scat evidence. **A**. Porcupine, Black-naped hare and Fishing cat. **B**. Elephant **C**. Porcupine

A

B

C

D

E

F

Figure 5. Scat of **A.** Porcupine, **B**. Black napped hare **C.** Fishing cat **D.** Same sample with the pond in the background, **E.** Scat sample after processing, **F.** Elephant dung.

Skeletal evidence

In addition to pugmarks and scat, other indirect evidence of elusive mammals such as skeletal remains were also recorded and details are described here with locations shown in figure 6. On February 26 at around 12.00pm a skull of an animal was observed at location figure 6A and was identified to be of *Sus scrofa* (wild boar) (Fig. 7A). The cranium and the mandible were found about 50m from each other. No other

bones were found in the near vicinity. This skull was found in close proximity to a rock cave dwelling with brick walls which was identified to have archaeological significance (Mandawala, 2021). On the same day at around 2.00 pm, the pelvis bone of an elephant (Fig. 7B) was found at location figure 6B. On 6 March at around 1.00 pm the skull of *Axis* (Spotted deer) (Fig. 7C) was observed close to Baron's Caprock at location figure 6C. No other deer bones were found in the near vicinity. A molar tooth (Fig. 7D) and a few other bones of an elephant near a site with several archaeological ruins (Mandawala, 2021) were observed on 7 March 2021 at around 10.15 am at the location (Fig. 6D). In addition to wildlife, some domestic animal skeletal remains were also observed. These were exclusively *Bos Taurus* (domestic cattle) which were not recorded.

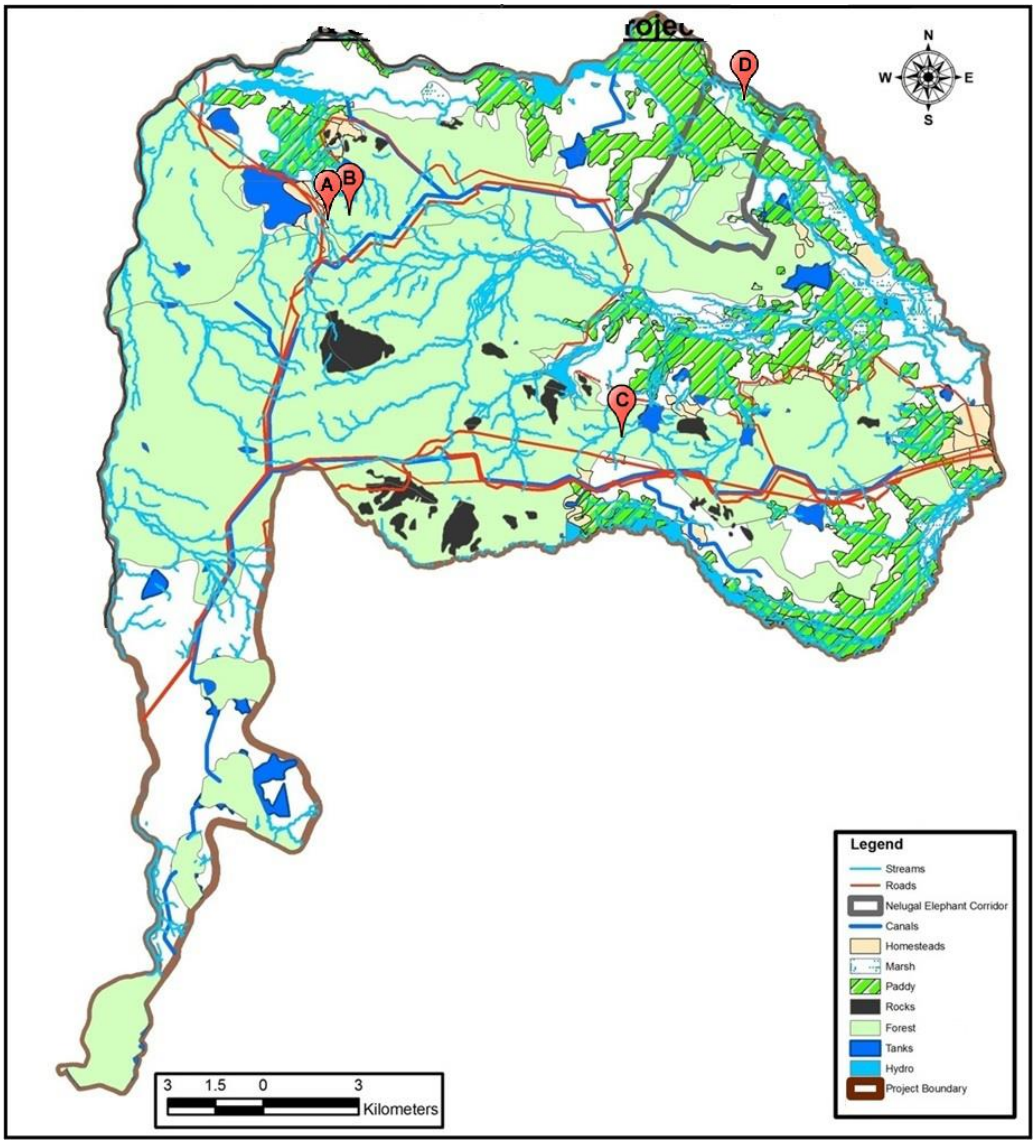

Figure 6. Locations of skeletal evidence **A.** Skull of wild boar. **B.** Pelvis bone of elephant. **C.** Skull of Spotted deer. **D**. Molar tooth of elephant

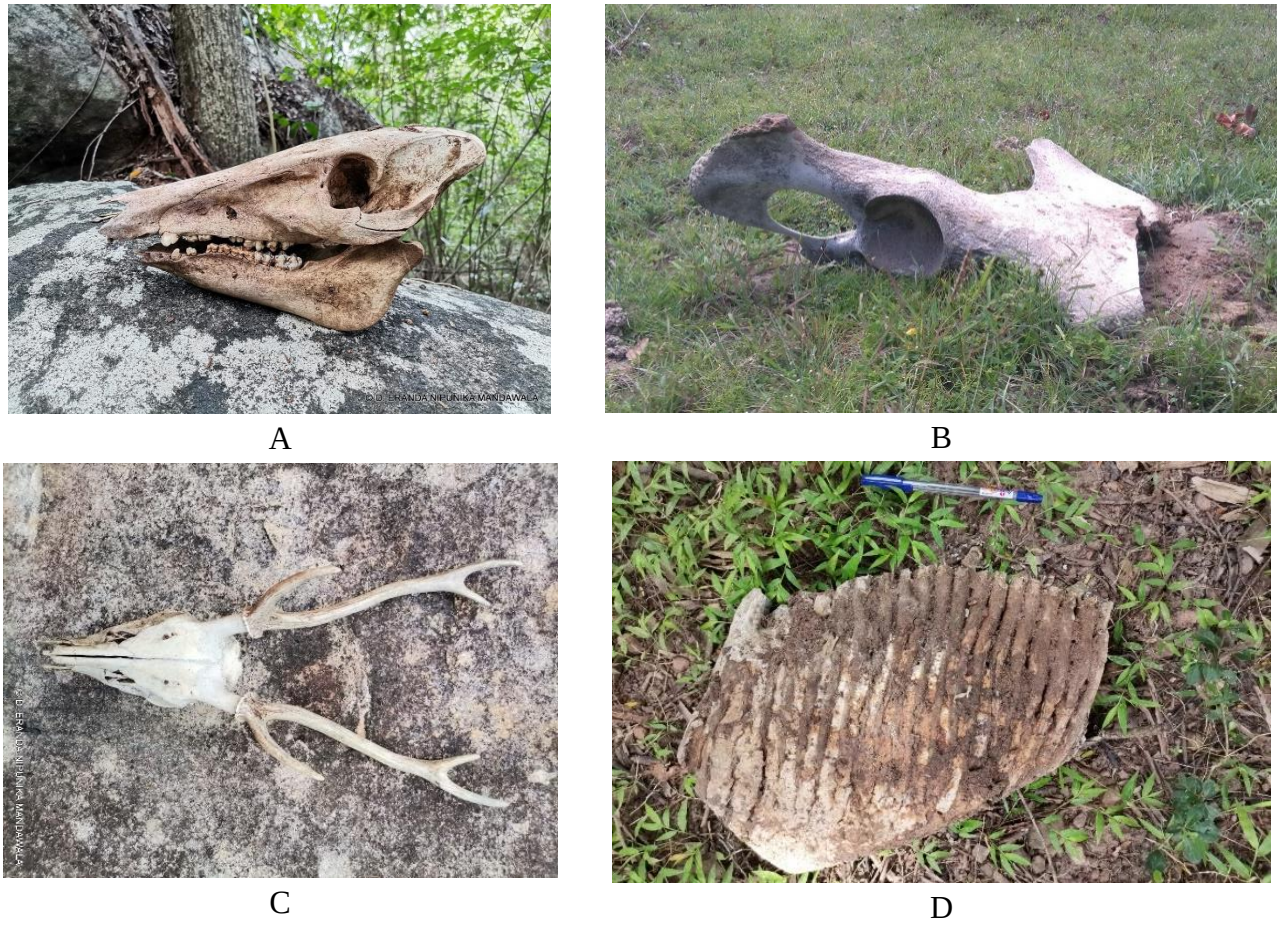

Figure 7. A. Skull of wild boar, B. Pelvis bone of an elephant, **C.** Skull of Spotted deer, **D.** Molar tooth of an elephant

Discussion

19 mammals (2 endemics, 3 Endangered, 1 Vulnerable, and 3 Near Threatened) have been recorded at our study site by Mahaweli Consultancy Bureau, 2017. Our study reports 9 of these mammals previously reported (Jackal, spotted deer, elephant, mongoose, porcupine, black napped hare, otter, wild boar, and sloth bear) based on either pugmark, scat, or skeletal evidence, with 4 mammals by visual observation (palm squirrel, giant squirrel, toque macaque, and grey langur). 5 mammals previously reported were not recorded in our study (Barking deer, Sambar deer, Leopard, Pangolin, and Sri Lanka mouse-deer). Future investigation will confirm their presence.

All pugmarks observed during the field visits belonged to mammals except one which belonged to a *Geochelone elegans* (Star tortoise) which is not reported here. All pugmarks were found near different types of water sources like streams, lakes, and ponds except the sloth bear paw print which was found in a rock cave dwelling. This may suggest that mammals use these water sources most likely to hydrate themselves and as hunting grounds. Only the leopard from the Felidae family was previously recorded at

our study site by Mahaweli Consultancy Bureau, 2017. We report herein our survey evidence of the rare and nationally endangered fishing cat by pugmark and scat evidence previously reported at our study site (Ministry of Environment, 2012). However, reported at the MONP by Jayasekara et al., 2019; Jayasekara, Mahaulpatha & Miththapala, 2021; Jayasekara & Mahaulpatha; 2021a; Jayasekara & Mahaulpatha, 2021b thus confirming our findings.

We did not find evidence of *Felis chaus* (Jungle cat) and *P. rubiginosus* (Rusty-spotted cat). Nevertheless, it has been reported at MONP by Jayasekara et al., 2019; Jayasekara, Mahaulpatha & Miththapala, 2021; Jayasekara & Mahaulpatha; 2021a; Jayasekara & Mahaulpatha, 2021b. Therefore, the possibility of them inhabiting the current study site is present. Future exploration may confirm this. Since the fishing cat and otter diet predominantly consists of fish and the pugmarks found near a stream (Fig 2A) and the scat found at location figure 4A suggests that they use these water sources as hunting grounds as well. It will be worthwhile to set up a few camera traps at this location to confirm this behaviour. The sloth bear has only been recently observed at MONP (Jayasekara et al., 2019) and previously recorded at our study site by Mahaweli Consultancy Bureau, 2017. Our observation of a sloth bear paw print in a rock cave-dwelling may suggest that it uses it as a den. Fixings camera traps at this location may confirm this.

We report pugmark evidence of small Indian civet that has not been previously reported by Mahaweli Consultancy Bureau, 2017 at our study site but reported at MONP by Jayasekara, Mahaulpatha & Miththapala, 2021; Jayasekara & Mahaulpatha, 2021b. The locations of figure 2D and figure 2E were both near a pond on a rocky outcrop. Pugmarks of 4 meso-mammal carnivore species were observed at locations figure 2D and 3 at location figure 2E with multiple overlapped tracks of each species in both locations. This shows heavy mammal traffic at both locations. This suggests that they use these two water sources quite often and frequently show good assemblage. It also shows evidence of the coexistence of these meso-mammal carnivore species at both locations. As such both these locations are suitable to set up camera traps to observe these mammals. In addition, we also report a visual observation of *Rhinolophus beddomi* (Lesser woolly horseshoe bat) (Fig. 8) in a rock cave previously not reported by Mahaweli Consultancy Bureau, 2017 at our study site but found at MONP (Edirisinghe et al., 2018). This bat species is rare and nationally vulnerable (Ministry of Environment, 2012; Edirisinghe et al., 2018). Many rock cave dwellings almost all with archaeological significance were observed at our study site (Mandawala, 2021). A high species richness (15 species) of bats was identified at MONP by Edirisinghe et al., 2018 and as such similar richness may be found at our study site. A separate project similar to Edirisinghe et al., 2018 to identify bat species at our study site will be beneficial.

Figure 8. Lesser woolly horseshoe bat (*Rhinolophus beddomei*) – nationally vulnerable

Visual observation of farm animals such as domestic cattle, water buffalo, and goats as well as domestic pets such as dogs was observed during the field visit. Cattle were also observed by Mahaweli Consultancy Bureau, 2017. Since the mid-90s for the past 30 years, no development has occurred in the Maduru Oya area due to the civil war, as such a significant area coming under the proposed development project had been taken over by the Forest Department. However, the Forest Department has agreed to release approximately 180km^2 of land for the irrigation development project after leaving out the elephant corridors and dense forest areas. Hence the current study site is not a protected area. This proposed development site is surrounded by 4 national parks (MONP to the South, Wasgamuwa National Park, Floodplains National Park, and Angammedilla National Park to the West, and Somawathiya National Park to the North) and 2 nature/forest reserves to the North (Trikonamadu Nature Reserve and the Nelugala Forest Reserve), the closest being the MONP, hence the importance of this location for wildlife.

Our finding shows a good assemblage of dry zone mega and meso-mammals all of which are found at the closest National Park (MONP) some of whom are nationally vulnerable or endangered (Ministry of Environment, 2012). However, EIA has reported that the proposed project will not result in a significant loss of wildlife habitat as the areas identified for cultivation and settlement of people are already under human use (Mahaweli Consultancy Bureau, 2017). At present, the Maduru Oya area is listed as having moderate human-elephant conflict with most lands used by elephants as their feeding grounds since they are not cultivated. The proposed development it may lead to an escalation of the present level of human-

elephant conflict in this area. This is to be mitigated by erecting permanent and temporary electric fences around permanent and seasonal cultivations respectively (Mahaweli Consultancy Bureau, 2017).

We found two reference resources (Yapa & Ratnavira, 2013; Miththapala, 2018) which had some details on pugmark and scat identification of mammals of Sri Lanka and detailed field guide manuals (Rogers, 1991; Singh, 1999; Talwar & Usamani, 2005) and research publications on pugmark and scat identification of Tigers, Leopard, Fishing cat and Elephant in India (Sharma, Jhala, & Sawarka, 2003; Sharma, Jhala, & Sawarka, 2006; Jhala, Qureshi & Gopal, 2011; Singh et al., 2014; Taylor et al., 2016; Thakur, Yadav & Jhariya, 2016; Bhagat, Yadav, & Jhariya, 2017; Kabir, Ahsan & Khatoon, 2017). However, such a detailed field guidebook on pugmark and scat identification of mammals of Sri Lanka was not found. This lack of sufficient reference sources may suggest why no research publications on this topic in Sri Lanka were found. However, field knowledge on pugmark and scat identification gained by mammal experts, wildlife rangers, indigenous community (*Veddas*), and even some locals who explore the forests to collect firewood and medicinal plants are available in plenty but not written down. At present pugmark and scat, identification requires a combination of limited reference resources and mammal experts' help. Therefore, a necessity of such a detailed field guidebook for Sri Lanka remains. Furthermore, the requirement of a reference collection of Plaster of Paris (POP) pugmarks casts also remains. Method of preparing POP cast is described by Rogers, 1991; Singh, 1999; Talwar & Usmani, 2005; Miththapala, 2018.

Finally, we report in this study a total of 17 mammals belonging to the following families: 8 Carnivora, 2 Artiodactyla, 1 Proboscidea, and 1 Lagomorpha by pugmark, scat, and/or skeletal evidence, and 2 Primates, 2 Rodentia and 1 Chiroptera by visual observation of which 4 are nationally endangered, 2 nationally vulnerable and 1 endemic species (Appendix 1).

Conclusion

In conclusion, we suggest the great need for a detailed field guide book on pugmark and scat identification of mammals of Sri Lanka along with a reference collection of POP pugmark casts. Both of which will be greatly beneficial for future researchers and we hope our preliminary study will increase an interest in this currently understudied field of research in Sri Lanka.

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Appendices

Appendix 1: NCS – National Conservation Status. LC – Least Concerned, VU – Vulnerable, EN – Endangered, '*' – Endemic species.

	Observation	Family	Scientific name	English name	NCS
1	Pugmarks	Carnivora	*Lutra lutra*	Eurasian otter	VU
2			*Hystrix indica*	Porcupine	LC
3			*Prionailurus viverrinus*	Fishing cat	EN
4			*Melursus ursinus*	Sloth bear	EN
5			*Canis aureus naria*	Sri Lanka Jackal	LC
6			*Herpestes sp.*	Mongoose	LC
7			*Viverricula indica*	Small Indian Civet	LC
8			*Prionailurus rubiginosus*	Rusty spotted cat	EN
9		Proboscidea	*Elephas maximus maximus*	Sri Lanka elephant	EN
	Scat	Carnivora	*Prionailurus viverrinus*	Fishing cat	EN
			Hystrix indica	Porcupine	LC
		Proboscidea	*Elephas maximus maximus*	Sri Lanka elephant	EN
10		Lagomorpha	*Lepus nigricollis*	Black napped hare	LC
11	Skeletal remains	Artiodactyla	*Sus scrofa*	Wild boar	LC
12			*Axis axis*	Spotted deer	LC
		Proboscidea	*Elephas maximus maximus*	Sri Lanka elephant	EN
13	Visual	Rodentia	*Funambulus palmarum*	Palm squirrel	LC
14			*Ratufa macroura*	Giant squirrel	LC
15		Primate	*Macaca sinica**	Toque macaque	LC
16			*Semnopithecus priam*	Grey langur	LC
17		Chiroptera	*Rhinolophus beddomei*	Lesser woolly horseshoe bat	VU