Gastrointestinal parasites of six large mammals in the Wasgomuwa National Park, Sri Lanka

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ABSTRACT

Gastrointestinal (GI) parasites may impose detrimental consequences on wildlife populations due to their capacity to cause mortality and reduce fitness. Additionally, wild animals play an important role in the transmission of zoonoses. Despite this importance, information on GI parasites of tropical wild mammals is critically lacking. The present study aimed to document GI parasites of six wild-dwelling large mammal taxa in Sri Lanka: Asian elephant (*Elephas maximus*), Sloth bear (*Melursus ursinus*), civet (*Paradoxurus* sp.), Leopard (*Panthera pardus*), Grey langur (*Semnopithecus priam*) and buffalo (*Bubalus* sp). Fresh faecal samples (n = 56) collected from the Wasgomuwa National Park, Sri Lanka were subjected to coprological examination using faecal smears, and the brine floatation technique followed by microscopic identification; quantitative data were accrued using the formol-ether method. The survey revealed a high prevalence of GI parasites, where 86% (48/56) of faecal samples screened positive for parasitic infections. Faecal samples of the civet, buffalo and Leopard recorded 100% prevalence, while the lowest (40%) was recorded for the Grey langur. Eight types of GI parasites were documented: protozoan cysts, platyhelminth ova (three types of digenean and a single cyclophillidean type), nematode ova (strongyle, strongyloid, ascarid, and trichuroid types) and rhabditiform larvae. The buffaloes and civets had a comparatively high number and diversity of GI parasites (buffalo: 7 types, H' = 1.02; civet: 6 types, H' = 1.52), whilst only a single type (digenean) was detected in the Grey langur. Likewise, parasite loads were also highly variable; highest in the bear (486 per g faeces) and lowest in the monkey (10 per g faeces). The outcome of this survey is important on two accounts; i) to fill the knowledge gap on GI parasites of tropical wild mammals, and ii) the revelation of many first-time parasite-host records for some of the threatened wild-dwelling large mammals in Sri Lanka.

1. Introduction

Parasites in wild animals presents an important field of investigation as they may have vital conservation and zoonotic implications (Liatis et al., 2017). Parasites or parasitic diseases may cause irreparable damage to wild animal populations directly by killing the host (Borgsteede 1996), or indirectly, through negative impacts on host fitness, thereby further endangering species that are already facing threats of extinction (Leroy et al., 2004). The reduction in fitness caused by high parasitic loads would also make animals more vulnerable to stochastic environmental events (Woodroffe 1999) and predation (Mech 1966). Investigating the disease burden of wildlife is therefore an important aspect of wildlife conservation and management (Peterson and Ferro 2016). Furthermore, since some wild mammals are reservoirs for parasites, they may serve as sources of infectious diseases that may affect feral or domestic animals and/or human beings (Peterson and Ferro 2016). Fragmentation and loss of forest habitats (Froeschke et al., 2013; Pérez-Rodríguez et al., 2018), and the expansion of agriculture and human settlements into natural landscapes (Brearley et al., 2013) have facilitated greater contact between domestic and wild populations increasing the potential to spread infectious agents and parasites to new hosts and environments (Mackenstedt et al. 2015). Thus, in relation to epidemiological factors, wild animals may have an extremely important role in the transmission of zoonoses (Kruse et al., 2004; Otranto and Deplazes 2019).

Sri Lanka is home to many charismatic large mammals; many of these species are listed as nationally and globally threatened species (Ministry of Environment MoE, 2012; Williams et al., 2020). Despite their importance, only a handful of studies have documented information on GI parasites of these and other wild mammals in Sri Lanka.

Available information on native mammals revealed the presence of helminth and protozoan infections in wild monkeys (Dewit et al., 1991; Ekanayake et al., 2004; Ekanayake et al., 2006; Huffman et al., 2013) and in captive Asian elephants (Abeysekara et al., 2018; Abeysinghe et al., 2017; Aviruppola et al. 2016; Dangampola 2011); trichurids in captive monkeys (Dangampola 2011), and information on the presence of several other GI parasites in other captive mammals (Aviruppola et al. 2016). However, there is a severe paucity of information on GI parasites of wild mammals. Hence, the present study aimed to document the richness, diversity, and prevalence of GI parasites in six selected native, wild dwelling, large mammal taxa in Sri Lanka; Asian elephant (*Elephas maximus*), Sloth bear (*Melursus ursinus*), civets (*Paradoxurus* sp.), Leopard (*Panthera pardus*), Grey langur (*Semnopithecus priam*) and buffalo (*Bubalus* sp.). These findings were compared with previously documented information on GI parasites in the selected species, in Sri Lanka and elsewhere.

2. Materials and methods

2.1. Study site

The Wasgomuwa National Park (7° 43′ 0″ N, 80° 56′ 0″ E) that spreads across two administrative districts, Matale and Polonnaruwa, covers an extent of 33,649 ha. This protected area falls within the dry zone of Sri Lanka, where the annual rainfall is between 1,250 and 1,900 mm, and which is marked by a protracted dry period of several months prior to the rainy season from October to January. The mean temperature is 32 °C throughout the year (DWC, 2007). The Park supports a high diversity of large mammals and was hence selected for collection of faecal samples. Permission was sought and granted by the Department of Wildlife, Sri Lanka to collect dung samples from the Wasgomuwa National Park.

2.2. Coprological analysis

Fresh faecal samples (n = 56) of large mammals (n = 6 species) from the roadside and grasslands in the Wasgomuwa National Park, were collected into 50 ml glass vials and preserved in 10% formalin. The faecal type was identified as belonging to a particular taxon, by the texture, size and shape of the faecal pellets, and its constituents – fruits, insects, herbage, bones, based on Chame (2003) and prior observations at the study site (Table 1). Freshness of the faecal samples was ensured by the presence of a mucous layer which covered the faecal pellets, the wetness of the dung, and the non-disturbance by insects (Cox et al., 2005). A sample was collected from the centre of the dung pile, placed in a glass vial with the name of the host animal, transported in ice to the laboratory and stored at 4 °C. In the laboratory, thin faecal smears as well as faecal flotation using saturated sodium chloride solution, were used for analysis (Fernando and Udagama-Randeniya 2009; WHO 1994). Parasite ova, cysts and larvae were identified using the atlas of medical helminthology and protozoology (Jeffrey and Leach, 1966), Soulsby (1982) and bench aids for the diagnosis of intestinal parasites (WHO, 1994).

Quantitative data was accrued using the formol-ether method (WHO 1994). A sample of 2g of stool was treated with 12 ml of a 10% formalin solution. Lumpy residues were removed by filtration. Filtrate of the faecal suspension was thoroughly mixed with 3 ml of ether. The centrifuge tube was then vigorously shaken and allowed to release the pressure inside, followed by centrifugation at 3000 rpm for 5 min. Following centrifugation, the fatty plug was loosened with a wooden applicator and the supernatant was poured away by quickly inverting the tube. The resultant sediment was thoroughly mixed with a known volume of saline. Three separate smears, each of 20 μl volume of the concentrated faecal suspension were observed under light microscopy (Nikon, Japan); the number of ova/cysts was counted by examining the slide in a zigzag fashion, starting from the top left corner of the slide, and

Table 1

Characteristics of faeces used for the identification of large mammal taxa in the Wasgomuwa National Park, Sri Lanka.

Species	Description
Asian elephant (*Elephas maximus*)	Large and cylindrical boluses distinguished mainly by size. These appear greenish brown owing to the high fiber and woody content.
Sloth bear (*Melursus ursinus*)	Cylindrical faeces deposited in small patches or in large accumulations. Although generally black in colour, locally, it may change owing to seasonal differences in the diet varying from those that comprise termite, ant, and larval remains, to those with seeds and fruits.
Civet (*Paradoxurus* sp.)	Little or large accumulations of pellets. Pellets are pointed shaped at both ends. Since these are omnivores a variety of remains can be observed in the contents ranging from grass leaves, seeds, hair, insects, crustaceans, to plant tissues. Mostly the blackish colour and large seeds found in the remains help identification. The type of seeds may differ depending on the season.
Leopard (*Panthera pardus*)	Cylindrical compact faeces (sausage-shaped), with subdivisions, tapered at one of the extremities. They contain hair and bone remains. The hair found in these are relatively longer indicating the ingestion of large prey species. The size and type of remains enables identification of the faeces as that of the Leopard and sets it apart from scat of other felids.
Grey langur (*Semnopithecus priam*)	Shape and size may vary, and therefore its identification is generally confirmed through the existence of their presence, which was the case in the present study.
Buffalo (*Bubalus* sp.)	Loose flat blob-like faeces that accumulates in circular piles, and which are generally very moist.

covering the entire area of spread of the 20 μl smear. The average value of the three counts was used to estimate the number of ova/cysts in the initial volume of saline used and there by the number of ova/cysts per gram of faecal matter (Ramalingam et al. 1983).

The calculated indices with respect to the GI parasites included prevalence (% of infected samples from the total number screened per taxa), richness (number of types recorded per taxa), diversity (Shannon-Wiener Diversity Index (H') = $-\sum(Pi \ln Pi)$ where Pi is the proportional abundance of parasites) and parasite load (number of parasites per sampling unit) (Gannong and Willing 1995).

3. Results

A total of 56 faecal samples surmised to belong to the Asian elephant (*Elephas maximus*) (n = 7), Sloth bear (*Melursus ursinus*) (n = 25), civet (*Paradoxurus* sp.) (n = 6), Leopard (*Panthera pardus*) (n = 5), Grey langur (*Semnopithecus priam*) (n = 5) and the buffalo (*Bubalus* sp.) (n = 8) were randomly collected from the roadsides and grasslands within the Wasgomuwa National Park. *In toto*, most of the faecal samples (86%) screened positive for one or more GI parasitic stages. Individual taxa varied with respect to prevalence of GI parasites; a high prevalence (100%) was recorded for the civet, buffalo, and Leopard, while the lowest was found in the Grey langur (40%) (Table 2). Overall, the faecal samples recorded eight types of GI parasites which included protozoan cysts, platyhelminth ova i.e., three types of digenean and a single cyclophillidean type, four types of nematode ova i.e., strongyle, strongyloid, ascarid and trichuroid, and rhabditiform larvae (Fig. 1; Table 2). Table 2 indicated either a single type or two/three types in combination of digenean ova, as the three ovum types were not counted separately in faecal samples, due to a vital oversight.

Considering the distribution of GI parasite types among the six mammal taxa in the wild, two GI parasite types were recorded exclusively in two host species (e.g., rhabditiform larvae in the Asian elephant and buffalo, and cyclophyllidean ova in the Leopard and buffalo), whilst some were recorded from as many as five host species (e.g., digenean ova recorded in Asian elephant, bear, buffalo, civet and Grey langur). It was apparent that the buffalo had the highest number of GI parasite

Table 2
Summary of the gastrointestinal parasites in six large mammal taxa in the Wasgomuwa National Park, Sri Lanka.

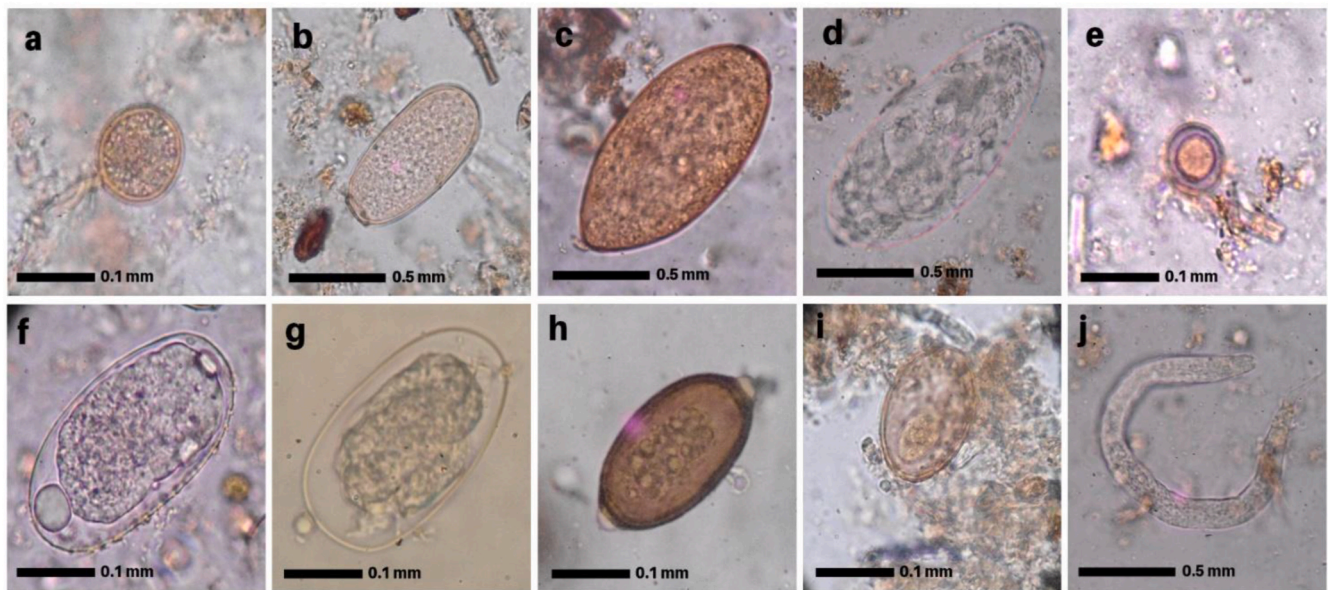|	Asian Elephant (*Elephas maximus*)	Bear (*Melursus ursinus*)	Civet (*Paradoxurus* sp.)	Leopard (*Panthera pardus*)	Grey Langur (*Semnopithecus priam*)	Buffalo (*Bubalus* sp.)
Prevalence (%) (# positive/# total samples)	71 (5/7)	88 (22/25)	100 (6/6)	100 (5/5)	40 (2/5)	100 (8/8)
Number of GI parasite types	4	6	6	4	1	7
Shannon Weiner Diversity (H′)	1.32	0.75	1.52	0.91	0	1.02

Fig. 1. Photomicrographs of gastrointestinal parasites in faecal samples of six wild-dwelling large mammal taxa, from the Wasgomuwa National Park in Sri Lanka. (a) Protozoan Cyst (x 400); (b), (c) and (d) Digenean type ova (x 400) (e) Cestode (cyclophyllidean) type ova (x 400); Nematode ova types (f) strongyle type (x 400), (g)strongyloidtype (x 400), (h)trichuroid type (x 400), (i) ascaroid type (x 400); (j) Rhabditiform larva (x 100).

types (7 types), whilst only a single type was detected in the Grey langur.

Considering parasite loads of the different parasite types, it is noteworthy that the protozoan cysts were more abundant in the mammal taxa examined, except in the Grey langur, in comparison to the other types of GI parasites. Considering the mammal taxa, the highest mean parasite load was recorded in the Sloth bear (486 parasites/g) which also harboured the highest load of both strongyle type ova (90/g) and

protozoan cysts (370/g) (Table 3). The highest load of digenean ova (85/g) was recorded in the buffalo, while the highest load of rhabditiform larva was observed in the Asian elephant (24/g). Civet faeces harboured the highest diversity of GI parasites while the lowest was in the faeces of the Grey langur (H' = 1.52).

Table 3
Gastrointestinal parasite loads and prevalence of the different parasite types recorded in faecal samples of six large mammals from the Wasgomuwa National Park, Sri Lanka.

Parasite type/ stage	Asian Elephant (*Elephas maximus*)	Bear (*Melursus ursinus*)	Civet (*Paradoxurus* sp.)	Leopard (*Panthera pardus*)	Grey Langur (*Semnopithecus priam*)	Buffalo (*Bubalus* sp.)
Protozoan cysts	47 ± 14.1[a] (100%)[b]	370 ± 174 (68%)	29 ± 3.75 (100%)	176 ± 35.6 (100%)	–	262 ± 51.9 (100%)
Digenean ova	19 ± 7.89 (57%)	9 ± 4.3 (16%)	4 ± 2.71 (33%)	–	10 ± 6.0 (40%)	85 ± 51 (75%)
Cyclophillidean Ova	–	–	–	24.2 ± 14.9 (40%)	–	24 ± 9.0 (75%)
Nematode Ova Type						
Strongyle	–	90 ± 33.5 (36%)	11 ± 9.87 (33%)	15.6 ± 9.56 (40%)	–	14 ± 9.52 (25%)
Strongyloid	24 ± 6.86 (86%)	5 ± 2.39 (16%)	5 ± 3.42 (33%)	–	–	4 ± 2.9 (25%)
Trichuroid	–	3 ± 3.2 (4%)	16 ± 7.27 (50%)	–	–	4.0 ± 2.63 (25%)
Ascaroid	–	9 ± 4.02 (20%)	4 ± 2.71 (33%)	32 ± 8.15 (80%)	–	–
Rhabditiform larva	24 ± 12.2 (43%)	–	–	–	–	3.0 ± 2.5 (12.5%)

[a] parasite load: mean ± SD (ova/cysts per gram faeces).
[b] prevalence (%).

4. Discussion

Data are virtually non-existent in the context of GI parasites in wild-dwelling mammals of Sri Lanka, with the exception of a few restricted studies focusing on the Asian elephant and species of monkeys (Abeysinghe et al., 2017; Dewit et al., 1991; Ekanayake et al., 2004; Huffman et al., 2013). The present study thus assumes special significance as many of the considered large mammals are nationally and globally threatened. To the best of our knowledge this is the first study which has documented information for the wild-dwelling Sloth bear, Leopard, civets, and buffaloes in Sri Lanka; accordingly, many first-time host-parasite records were established.

This study revealed the presence of eight types of GI parasites which included protozoan cysts, nematode ova – strongyle, strongyloid, ascarid, trichuroid types, rhabditiform larvae and platyhelminth ova – digenean and cyclophillidean types. Differences were noted between the diversity and prevalence of GI parasites in this study for wild mammals and those reported for these mammals in captivity in Sri Lanka. Our findings show that, apart from the Grey langur, the other five mammals screened positive for at least two of the eight recorded GI parasite types, with the buffalo recording seven types. Whereas under captivity, of 70 native and exotic mammals examined, only 25% tested positive for one or more infections (Aviruppola et al. 2016). It was also interesting to note that the highest number of parasite types recorded in any one of these 70 mammals was three (Aviruppola et al. 2016) as compared to seven that were recorded in the buffalo under wild conditions in the present study. Further differences between GI parasites in wild mammals and their captive counterparts (according to Aviruppola et al., 2016) were observed; under captivity the Grey langur did not harbour any GI parasites while only one parasitic stage each was recorded in the Asian elephant (protozoan cysts), Sloth bear (hook worms), Leopard (*Toxocara*) and native civets (*Entamoeba*) which differed considerably from observations of the same mammals living in a wild setting in the current study. The only exception was protozoan cysts recorded in Asian elephants, both under wild (present study) and captive (Aviruppola et al. 2016) conditions; the cyst loads recorded were much higher in those under captivity (1000 cysts per g faeces) than in the wild (~47 per g faeces). Also, Dangampola (2011) has reported the presence of trichuroid ova in faeces of Patas monkeys under captivity (*Erythrocebus patas*), but the wild Grey langurs in the present study did not harbour this parasite type. Similarly, it is interesting that some of the GI parasites recorded in our study (strongyle, strongyloid and trichuroid) and others (e.g., *Giardia* and *Entamoeba*) have been recorded from dung of native mammals in captivity (e.g., Fishing cat, Jungle cat, Eurasian otter, and Wild boar) not considered in the present study. The overall comparisons revealed that the wild mammals carried a greater diversity of GI parasites in comparison to captive mammals, although loads of selected parasites may be higher in captive mammals.

Many factors have been cited as contributing to disparities between parasitic indices in captive and wild mammals (Martin-Solano et al., 2017; Stuart et al., 1990; Wren et al., 2015). For instance, conditions in the environment may increase or decrease chances of exposure influencing the occurrence and intensity of parasitic infections (Fakae 1990). Thus, one of the plausible explanations for the greater diversity of parasites in wild mammals would be that, in comparison to the sheltered captive animals, wild animals will have a greater probability of being exposed to a variety of parasitic infections in the natural environment. Also, various types of life cycles are inherent among parasitic nematodes where completion may or may not require an intermediate host (Soulsby 1982). For parasites that require the presence of an intermediate host, being in a natural environment would better facilitate its transmission. It is reported that variations in diet between the wild and captive animals may also result in disparities in GI parasites between them (Soulsby 1982). Also, the occurrence of ingestion through the faeco-oral route and direct penetration through skin is more likely in the wild than under captive conditions (Soulsby 1982). Furthermore, high moisture, shade and relatively cool temperatures are conducive to the survival of GI parasites that inhabit the soil (Soulsby 1982). Based on this premise, mammals within enclosures would be less prone to infections as opposed to those living in forested environments, as those screened during the present survey. Also, captive animals generally undergo rigorous GI parasite treatment which will, to a large extent, curtail the occurrence and spread. It has been noted that individuals may also vary considerably in their infection loads and diversity of coinfecting parasite taxa (Heitlinger et al., 2017; Irvine et al., 2000; MacIntosh et al. 2010). All these factors operating collectively may cause differences in the diversity, prevalence and loads of GI parasites between captive and wild mammals. We recognize the limitations imposed by the low number of samples examined in our study owing to pragmatic difficulties in obtaining fresh dung from wild mammals. Examining a greater number of faecal samples from the considered wild mammals may plausibly have resulted in more parasites being detected.

Comparing the findings of the present study with previously reported information for wild mammals in Sri Lanka, with respect to the Asian elephant, strongyle type infections were not recorded by us in those from the Wasgomuwa National Park. However, two former studies have reported a high prevalence of strongyle type infections in Asian elephants from other areas of the island; 100% in the Udawalawe National Park (NP), 100% Minneriya NP, 87.5% Yala NP, 80% Maduru Oya NP (Abeysekara et al., 2018) and 100% in the Galgamuwa area (Abeysinghe et al., 2017). Trichuroid ova were not recorded in Grey langurs in the present study, but Huffman et al. (2013) and Dewit et al. (1991) recorded these from faeces of individuals in wild habitats. No previous information is available for the Sloth bear, Leopard, civets, and buffaloes from wild habitats in Sri Lanka.

Comparing the findings of the present study with those reported elsewhere (both in the wild and in captivity) for the same taxa, in the Sloth bear, we recorded a low prevalence of trichurids (4%) which is consistent with that reported from Bengaluru for this species under captive conditions (Manjunatha et al., 2019), but contrasts with findings of Veeraselvam and coworkers (2013) who reported a moderate prevalence of 32% for captive individuals. With respect to the civets, although similar parasites (e.g. strongyloides) have been recorded in those from the Western Ghats, India (Chakraborty et al., 2016), neither data on parasite loads nor prevalence is available for comparison. For wild Leopards, as in the present study, strongyloid eggs were recorded in faecal matter in those from Thailand (Patton and Rabinowitz 1994). In the Asian elephant, no strongyle stages were recorded in the present study; conversely, Nishanth et al. (2012) had recorded a low prevalence (8%) in those from the Sathyamangalam forests in South India.

Many factors influence the occurrence and spread of parasites in wildlife. These include environmental conditions that affect the viability and behavior of parasites (Rogers and Sommerville 1968), and the feeding, movement and defecation patterns of the hosts (Lozano 1991; Price et al. 1988). Compatibility is also responsible for shaping host–parasite associations (Combes 2001). Four possible combinations have been proposed to explain the existence or non-existence of a parasite within animals (Kołodziej-Sobocińska, 2019); non-existence maybe explained by (i) the absence of an encounter and non-compatibility, (ii) presence of an encounter but non-compatible, (iii) absence of an encounter, although compatible, whereas occurrence is possible when (iv) there is both encounter and compatibility. Thus, one of the reasons for the higher diversity of parasites in wild mammals may be the greater variety of mammals in the shared habitats which offer greater chances of encountering parasites. The host population size and density also influence the speed and efficiency of disease transmission and spread (Tompkins et al. 2003). Parasites are able to persist only if the density of hosts are above critical thresholds (Anderson and May 1978). This may prove to be a limiting factor for threatened mammals whose population sizes are generally low. Host migration affects parasite dynamics in many wildlife species (Peacock et al., 2018). This factor may not have influenced the presence (or

absence of GI parasites) in the presence study since significant seasonal spatiotemporal changes in terrestrial mammals have not been recorded in Sri Lanka. Neither have any drastic changes in the rates of competition and predation between hosts and vectors (Raffel et al., 2010) been recorded in the survey region. Host–parasite dynamics can be strongly affected by both climate and season (Brooks et al., 2014). The prolonged drought season experienced in the study region may limit the development and survival of parasites as shown by Holmes et al. (2018) and Kutz et al. (2014) as would the fluctuation of food resources which are sometimes the sources of parasites (Duscher et al., 2017).

Animals are generally not free of parasites either on the body surface or in the intestinal tract, but the parasite loads are generally managed through behavioural strategies (Hart and Hart 2018; Herrera and Nunn 2019) and immunological responses (Ferreira et al. 2021). Most often parasites are in equilibrium with the host organism, causing limited harm and with little or no clinical impact (Thompson 2013). Nonetheless, parasitic diseases are among the most prevalent and important infectious diseases in wildlife (Liatis et al., 2017), warranting the need for frequent parasitological screening to be carried out. Parasitic surveys are indeed fundamental to understanding the life cycle of parasites and the potential transmissions to other animals, and to humans (Macpherson 2005). It is known that wild mammals serve as intermediate hosts of diseases that may affect domestic animals or humans (Karunaweera et al., 2001; Recht et al. 2020; Sumangali et al. 2012) and that transition of parasites may occur between an infected prey or predator (Moore 1983). Baseline data is therefore essential to trace-back systems during disease outbreaks and when translocating animals from one ecosystem to another. This would be particularly relevant for species that are currently threatened in the wild.

While there are many limitations attached to basic parasitic surveys such as the non-identification of species (Gassó et al., 2015; Kołodziej-Sobocińska 2019), documenting preliminary information on parasite loads particularly in the developing tropics where such information is lacking, is vital (Hing 2012; Vidya and Sukumar 2002). The precise identification of ova, cysts, and larvae in coprological examination by microscopy at times may be unfeasible, requiring the use of sophisticated molecular detection methods. In as much as an unknown organism thus detected in faecal matter may merely be a commensal of the host species, conversely it maybe a potentially pathogenic organism for that host or for other host species.

Wildlife disease control begins with surveillance while monitoring is an important element of recovery plans for rare species (Gortázar et al., 2007). In the light of this, the present study documented important baseline information on the prevalence of parasitic infections in several mammal species with conservation importance that inhabits one of the largest national parks in Sri Lanka. Detection of parasitic infections in wild animals will reduce threats of extinction and support conservation efforts (Pedersen et al., 2007), particularly in the case of the threatened large mammals such as the Asian elephant, Sloth bear and the Leopard. Such information would also assist in identifying potential dangers to domestic animals and humans living in areas adjacent to natural habitats further contributing to assist the process of preventing zoonotic outbreaks (Otranto and Deplazes 2019).

5. Conclusion

The present survey on gastrointestinal parasites of a few selected native, large wild mammals is a pioneering study conducted in Sri Lanka as it has generated many novel host-parasite records, particularly for the threatened Asian elephant, Sloth bear and Leopard. Many disparities were revealed between wild and captive mammals with respect to GI parasite diversity, abundance, and prevalence. The finding that wild mammals harbour a greater diversity of parasites in comparison to their counterparts in captivity suggests that regular monitoring of parasites in wild animals is of great importance in the perspectives of zoonoses, and where appropriate, conservation management actions to mitigate

threats of extinction are necessary.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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