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Gastrointestinal Strongyle Infections in Captive and Wild Elephants in Sri Lanka

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Abstract. We assessed gastrointestinal strongyle prevalence and abundance in 141 captive Asian elephants under two management regimes and compared them to 50 wild elephants. Gastrointestinal nematode prevalence was found to be 38% in Pinnawela Elephant Orphanage, 90% in privately owned and 100% in wild elephants. Mean number of larvae was 1.9 in Pinnawela, 108 in privately owned and 372 in wild elephants. Elephants being dewormed every 3 months had significantly less parasites than the ones on a 6-monthly regime. Variance in parasite prevalence and load is likely to be primarily related to differences in anthelmintic treatment, and secondarily to husbandry practices.

Introduction

The Asian elephant (*Elephas maximus*) is classified as 'endangered' (IUCN 2017). Asian elephants are unique among endangered megafauna in that a significant number are in captivity and managed by a variety of institutions and individuals. Currently about 15,000 Asian elephants are in captivity, comprising one-third of the global population (Fernando 2012). In many range countries captive elephants play a prominent role in tourism, logging, religious and cultural festivals.

Sri Lankans have a close association with captive elephants that extends back millennia (Fernando *et al*. 2011). Historically elephants were used in wars, hauling heavy items, cultural and religious parades and kept as a hallmark of nobility. Currently, temples, private owners, the National Zoological Gardens, the Pinnawela Elephant Orphanage and the Elephant Transit Home keep elephants in Sri Lanka (Fernando *et al*. 2011).

Gastrointestinal helminths are common in all animals (e.g. Fagiolini *et al*. 2010). Nematode worms and particularly strongyles are prevalent among mammals and their control is an important aspect of animal husbandry. While internal parasites of domesticated species are well documented, studies on gastrointestinal helminths in species such as elephants, both in captivity and in the wild, are limited (Woodroffe 1999).

Nutritional and physiological status, stress and captive conditions of animals can influence their resistance to parasites (Geraghty *et al*. 1982). It has been found that the severity of parasite infections is higher in weaker animals than in healthy animals (Lively & Dybdahl 2000; Smith *et al*. 2009). Occurrence of parasites in captive elephants is thought to vary according to husbandry practices, disease prophylaxis and treatment (Fowler 2006; Vanitha *et al*. 2011).

In Sri Lanka, both western and traditional veterinary care is used for captive elephants, targeting active control of gastrointestinal parasites. Here we determine the occurrence and intensity of nematode infections in captive elephants under two different management systems and compare them to that of wild elephants.

Materials and methods

Origin of samples

A total of 191 samples were collected from 47 captive elephants at the Pinnawela Elephant Orphanage (PEO), 94 privately owned elephants, and 50 wild elephants.

Samples from wild elephants were collected in Galgamuwa in Northwest Sri Lanka. This region is characterized by high habitat heterogeneity with interspersed crop fields, irrigation reservoirs, settlements and forest patches. Wild elephants occur over much of the landscape, leading to high human-elephant conflict. We collected 50 samples from dung piles of wild elephants, found around water bodies.

The PEO is a captive elephant breeding centre managed by the state and currently holds 88 Elephants (37 males and 51 females) representing three generations (Fernando et al. 2011). Western veterinary care was provided in-house for elephants at the PEO and anthelmintic treatment administered every 3 months. Elephants at the PEO are managed as a herd during daytime and allowed free range over a few acres, but individually stalled at night. The 47 PEO samples were collected in 2012 and 2013.

At the time of the study 112 elephants were kept by temples and private owners in Sri Lanka (Fernando *et al*. 2011). Most such elephants were managed individually. In May and June 2012 samples were collected from 11 elephants kept in Colombo and 3 in Kegalle. In July 2012 samples were collected from 46 elephants at the perahera (an annual religious festival and parade) in Kandy. In August 2013 we collected a further 18 samples at the Kandy perahera and 16 at the Kataragama perahera in the South. Information on anthelmintic treatment of individual elephants was obtained from the elephant keepers. Their veterinary treatment varied for logistic reasons and irregular access to treatment. For 63 elephants (67.7%) treatment was administered every three months while 26 elephants (28.0%) were on a 6-monthly deworming schedule. Four owners administered treatment only when 'necessary'. Of the privately owned elephants six received traditional and 59 western veterinary care. The remaining 28 received both western and traditional care. Treatment information was not available for one elephant.

Elephants at the PEO and privately held elephants were provided with similar food, consisting mainly of jackfruit tree (*Artocarpus heterophyllus*) leaves, kitul palm (*Caryota urens*) stems and coconut palm (*Cocos nucifera*) fronds. Wild elephants are known to consume a wide range of graze and browse, consisting of over a hundred species (Samansiri & Weerakoon 2007).

Sample collection

An elephant dung pile consists of a number of discrete boli. Samples were collected from freshly deposited dung piles of captive elephants. Samples from wild elephants were obtained from dung piles estimated to be less than 12 hours post-defection. Scrapings from a number of boli of a dung pile were mixed together to obtain a 12 g composite sample, which was placed in a small plastic container and capped.

Lab techniques

The sample was incubated in the dark at room temperature for 7 days, checked periodically and moistened if dry. Samples were processed and analyzed according to Abeysinghe *et al*. (2012) using faecal culture and harvesting through Baermann technique. Strongyle nematode L3 larva were identified and quantified based on morphology and morphometry (Condy 1973; Fowler 2006). Sample processing and analysis was done at the Animal Physiology Laboratory, University of Peradeniya, the Department of Zoology, University of Colombo and at the field station of the Centre for Conservation and Research in Galgamuwa.

Statistical analysis

Data was analyzed using the computer program JMP 11.0.0. Chi-squared tests were used to evaluate significance of differences in nematode prevalence. For comparisons, the number of parasites was logarithmized to increase normality. If there were zero parasites, the logarithm was taken from 0.5, giving a slightly negative value (-0.693). A one-way ANOVA with Tukey-Kramer HSD post-hoc tests was used to compare the number of parasites between the three populations and to assess the effects of health regime and deworming frequency on parasite numbers. For all other comparisons unpaired t-tests were used.

Results

Prevalence of nematodes

Gastrointestinal strongyle prevalence was 38.3% in the dung of PEO elephants, 90.4% in privately owned elephants and 100% in the wild. Prevalence was significantly different between the three groups (Chi-square, $P < 0.0001$).

Parasite load

The mean number of strongyle larvae detected per 12 g sample was 1.9 ± 3.6 (range 0–18) in PEO elephants, 108.4 ± 253.4 (range 0–2158) in privately owned elephants and. 371.6 ± 388.9 (range 20–1473) in wild elephants. Parasite numbers were significantly different across the 3 populations (One-way ANOVA, $P < 0.0001$). All pair-wise comparisons revealed significantly different parasite loads between wild, privately owned and PEO Elephants (Tukey-Kramer HSD, all $P < 0.0001$, Fig. 1).

In samples from privately owned elephants, there was no significant difference in parasite numbers (t-test, $P = 0.723$) between males ($N = 71$) and females ($N = 23$) or between samples (t-test, $P = 0.309$) from 2012 ($N = 60$) and 2013 ($N = 34$).

Regardless of the type of health care, privately owned elephants had significantly higher parasite numbers than PEO elephants ($P < 0.0001$) (Fig. 2). Private elephants on Western veterinary care had the same number of parasites as the ones on traditional ($P = 0.999$) or mixed care ($P = 0.893$).

Privately owned elephants which were dewormed every 3 months had significantly less parasites than the ones on a 6-monthly regime ($P = 0.0001$), or on a 'if necessary' schedule ($P = 0.0042$) (Fig. 3). Elephants receiving anthelmentic drugs 'if necessary' had a similar parasite load as the ones on a 6-monthly schedule ($P = 0.5833$) or wild elephants ($P = 0.999$).

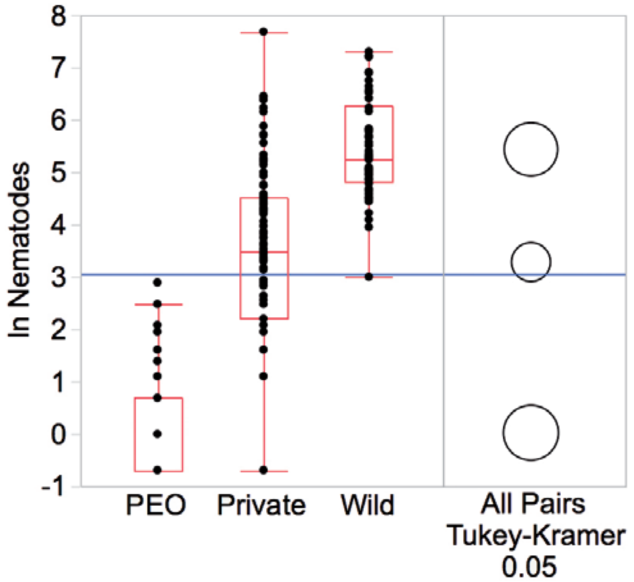

Figure 1. Logarithmic parasite loads of PEO, privately owned and wild elephants. The blue horizontal line represents the grand mean. The comparison circles on the right visualize whether or not the mean values for the three categories are significantly different (no overlap).

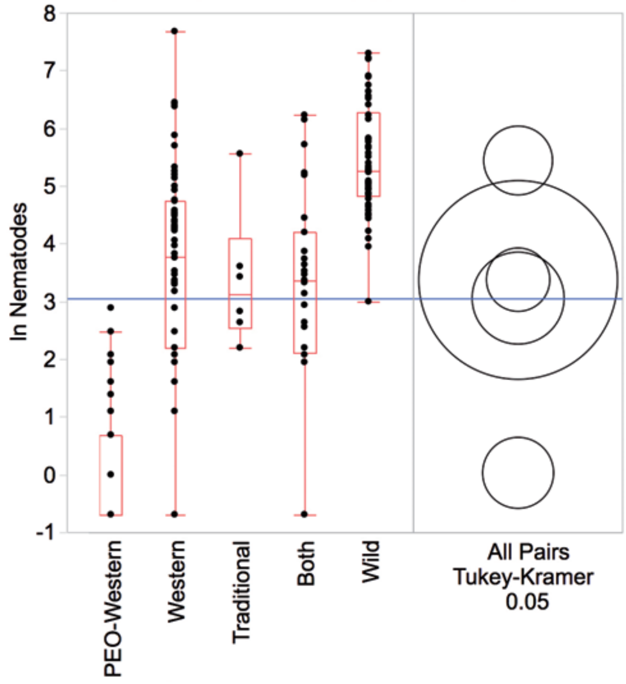

Figure 2. Logarithmic parasite loads of elephants based on their health care regime.

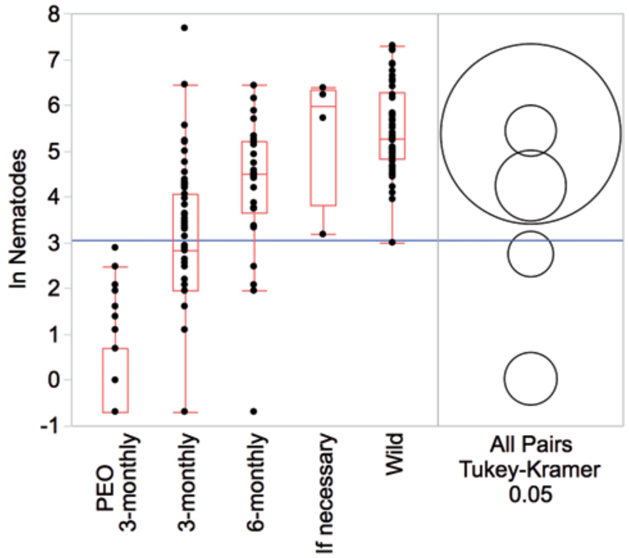

Figure 3. Logarithmic parasite loads of elephants based on the deworming frequency.

Discussion

Prevalence of nematodes

We found all samples from wild elephants to be positive for strongyles but high variation in parasite load among samples. A nematode prevalence of 83% was found in wild elephants in Udawalwe National Park (Heinrich 2016). A study of wild elephants in Nilgiris, South India found parasite presence in 86.8% of samples (Vidya & Sukumar 2002). Strongyles were observed in 40%, 16% and 8% of samples from Mudumalai, Anamalai and Sathyamangalam forests respectively in South India (Nishant *et al*. 2012). A study of wild Borneo elephants found a strongyle prevalence of 82.7% and 50% in fragmented and intact habitat respectively and concluded that habitat fragmentation was associated with increased disease incidence (Hing 2012). Therefore, intestinal parasites in general and strongyles in particular appear to be widespread in wild elephants but the incidence seems to vary widely between sites.

Gastrointestinal parasite infections in wild elephants have been assumed to be determined by intrinsic and extrinsic factors including host demographic aspects such as age, sex and group composition (Vidya & Sukumar 2002). However, Vidya and Sukumar (2002) failed to find any correlation with these factors and parasite load in wild elephants in Southern India. Research on primates has found that within social groups, individuals might vary in their susceptibility to parasitic infection according to their major histocompatability complex genotype, physiological status, general health and immune status (Lilly *et al*. 2002; Schad *et al*. 2005). Given the wide range of possible determinants, intensive, long-term and large-scale studies would be needed to identify the factors responsible for the observed variance in incidence and parasite load in wild elephants.

We found gastrointestinal strongyle prevalence in wild elephants to be significantly higher than in captive elephants (Fig. 1). Similarly, another study in Sri Lanka found a nematode prevalence of 83% in wild elephants in Udawalawe and 53% in captive elephants at the National Zoo and Elephant Transit Home (Heinrich 2016). A study of gastro-intestinal helminths in India found an incidence of 38.1% in wild elephants in Kanha National Park, and incidences of 25%, 41.4% and zero in captive elephants in Kanha, a circus and a zoo respectively (Kashid *et al*. 2002). In Tamil Nadu, India, lower parasite prevalence was observed among private and temple elephants compared to elephants kept by the Forest Department (Vanitha 2007). The difference was attributed to solitary management and traditional medicine of private and temple elephants, and sharing habitats of wild elephants and management as groups of Forest Department elephants (Vanitha 2007). Thus Vanitha (2007) implies cross infection from presumed higher parasite prevalence in wild elephants in the case of Forest Department elephants. None of the captive elephants in Sri Lanka have any opportunities to socialize with wild elephants (Fernando *et al*. 2011), therefore cross infection from the wild cannot explain the variation observed in our study.

The majority of Sri Lankan privately owned elephants were managed under solitary conditions, but they had a higher strongyle nematode prevalence than elephants managed in groups at the PEO. Group living provides more opportunities of parasite transmission and elephants managed in groups can be expected to have higher prevalence (Vanitha 2007). However, our results suggest that managing elephants in groups or solitarily is not a major determinant of parasite prevalence in Sri Lanka.

The major difference between our three groups was the presence/absence and level of anthelmintic treatment. The most intensive treatment was at the PEO where anthelmintics were given every 3 months. While some of the privately held elephants were said to be on a similar schedule, as a group, the privately held elephants received less and more variable treatment and the wild elephants none. Thus, the main determinant of the variation in prevalence we observed could be attributed to differences in treatment. Our findings are consistent with others that have attributed low gastrointestinal strongyle prevalence among captive elephants to regular deworming (Saseedran *et al*. 2003).

Parasite load

We found significantly higher parasite loads in wild elephants than in captive elephants, and higher levels in privately held elephants than in PEO elephants. Variation in parasite load followed the pattern observed for prevalence and could also be attributed to the differences in treatment.

Decrease in parasite load caused by treatment may depend on frequency of administration and compounds used, which are likely to vary greatly among individually owned elephants. However, we also found higher parasite loads in privately held elephants on the same treatment regime as the PEO elephants. Occurrence of internal nematodes in captivity may also vary according to the type of husbandry practices (Geraghty *et al*. 1982). Differences in quantity of fodder, cleanliness of stalls and healthcare is likely to be greater among privately held elephants than at the PEO, which may also partly explain the observed differences in parasite load. The observed lack of difference in parasite load between the sexes and inter-annually in privately held elephants, probably reflects the similarity in management of males and females and the overarching impact of husbandry practices over environmental factors. We also failed to detect any difference in the effectiveness of western medicine over traditional medicine with regard to parasite load.

Gastrointestinal parasite management in captive elephants

Gastrointestinal parasite control in animals has largely been developed targeting high-intensive livestock production and is based on regular anthelmintic drug treatment. Although productivity is usually not a factor, livestock parasite control practices are often directly applied to captive management of wild species. For example in captive elephants, completely eliminating internal parasites through intensive anthelmintic use is the norm and many studies have stated the effectiveness of albendazole against strongylosis in captive elephants (Chandrashekaran 1992; Suresh *et al*. 2001; Saseedran *et al*. 2003).

Farm animals typically have a short life span, which in most cases is less than 10 years. In contrast the life span of a captive elephant can exceed 70 years (Sukumar *et al*. 1997). Long-term effects of intensive anthelmintic treatment targeting parasite elimination in captive elephants may have negative consequences (Stringer & Linklater 2014). Intensive use of anthelmintics has led to widespread drug resistance in farm animals and this has become a global concern (Gasbarre *et al*. 2009). In contrast, chronic helminth infections may also have beneficial effects such as lowering the prevalence of allergic diseases (Maizels *et al*. 1993; van den Biggelaar *et al*. 2000). Using naturally acquired immunity to control gastrointestinal helminth infections in farm animals is gaining interest (Sutherland *et al*. 1999).

Host-parasite relationships may play an important role in evolution and speciation (Nunn *et al*. 2004; Stringer & Linklater 2014). Our study demonstrates the universal prevalence of gastrointestinal parasites in wild elephants. Parasites and elephants have co-existed and co-evolved for millions of years. Captive elephants have a recent wild origin rarely exceeding 2–3 generations at most (Fernando *et al*. 2011).

Therefore inherent parasite resistance is likely to be still effective in them.

Control of gastrointestinal helminths in captive elephants based on natural immunity would be preferable to possible negative consequences of intensive long-term drug use. Thus, enhancing the immunity of captive elephants through proper nutrition, sanitation and minimizing stress, together with regular faecal testing and treatment of individuals with above 'normal' parasite loads maybe a better management approach.

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