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Prevalence of intestinal parasites among captive Asian Elephants *Elephas maximus*: effect of season, host demography, and management systems in Tamil Nadu, India

V. Vanitha[1], K. Thiyagesan[2] & N. Baskaran[3]

[1,2] Postgraduate and Research Department of Zoology and Wildlife Biology, A.V.C. College, Mannampandal, Mayiladuthurai, Tamil Nadu 609305, India.
[3] Asian Nature Conservation Foundation, Innovation Centre, Indian Institute of Science, Bengaluru, Karnataka 560012 India.
Present address: [1] D.G. Government Arts College (Women), Mayiladuthurai, Tamil Nadu 609001, India.
Email: [1] vanithabaskar@rediffmail.com (corresponding author), [2] kthiyagesan1@rediffmail.com, [3] baskar@ces.iisc.ernet.in

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Abstract: Maintenance of wild animals in captivity is fraught with numerous challenges, including the control of disease. This study evaluates the effect of season, host demography (age-sex), and differing management systems on the prevalence of intestinal parasites among elephants managed in three captive systems: temple, private, and forest department, in Tamil Nadu. In addition, the study also assessed the availability of veterinary care for elephants in these systems. The parasitic prevalence was evaluated by direct microscopic identification of helminth eggs in faecal samples (n = 115) collected from different age/sex classes of elephants. Of the 115 elephants examined, 37% showed positive results, being infected only with *Strongyles* sp. The prevalence rate varied significantly across seasons, with the highest rate during summer (49%) followed by monsoon (41%) and the lowest rate during winter (15%). While males had a significantly lower parasite prevalence compared to females (29% vs. 40%), age classes showed no significant difference. Despite the fact that the proportion of animals receiving veterinary care was higher under the forest department system (100%) compared to the private system (26%), parasite prevalence was significantly higher under the former (48%) than the latter (31%) system. The difference in the proportion of animals with parasitic prevalence among the three systems could be due to differing management practices (i.e. in solitary versus groups) and the details are discussed.

Keywords: Captive Asian Elephants, forest department, intestinal parasite, management prevalence, private, Temple.

INTRODUCTION

Most free-living organisms harbour parasites of several species (Begon & Bowers 1995), which can adversely affect host health, fecundity and foraging, and may also modify host behaviour to facilitate parasite transmission (Wesenberg-Lund 1931; Holmes & Bethel 1972; Moore 1984). Parasitism has been shown to directly affect both the evolution and ecology of hosts through processes such as sexual selection (Hamilton & Zuk 1982) or parasite-mediated competition, which can lead to a reduction in population size, or the extinction of one host (Price et al. 1986). Asian Elephants *Elephas maximus* are susceptible to gastrointestinal parasitic infection in the wild (Watve 1995; Dharmarajan 2000; Vidya & Sukumar 2002) and in captivity are often confined to small enclosures and/or maintained in isolation (Vanitha 2007) in damp unhygienic conditions that may result in enhanced susceptibility to parasitic disease (Dhungel et al. 1990; Chandrasekaran et al. 1995; Suresh et al. 2001).

Tamil Nadu, a southern state of India, manages approximately 150

captive elephants under three different management systems: private, temple and forest department (Vanitha 2007; Vanitha et al. 2010). The captive elephants in the temple system are managed with very limited mobility and are used mainly for religious and cultural ceremonies in Hindu temples, while private elephants are used for commercial purposes such as in films and in VIP programmes with extensive travel, in addition to cultural and religious ceremonies in Hindu temples that do not own an elephant. In contrast, captive elephants in the Tamil Nadu forest department are managed mostly in semi-wild conditions at forest camps located in Mudumalai and Anamalai wildlife sanctuaries (presently tiger reserves). While originally used for timber logging, captive elephants under the forest department management are presently used predominantly for ecotourism. Additionally, on a rotational basis, a few elephants from the timber camps are placed by the forest department at the Arignar Anna Zoological Park, Chennai, for education and entertainment (Vanitha et al. 2010).

Given the widely differing husbandry conditions in which elephants are managed under the three systems (Vanitha 2007; Vanitha et al. 2008, 2009), it is meaningful to ask whether there is variability in the prevalence of parasites in the different management systems. There have been studies on the prevalence of parasitic infection in captive elephants managed in nature reserves (Arunachalam et al. 2007), zoological gardens (Suresh et al. 2001) and Hindu temples (Saseedran et al. 2003). This paper presents data comparing the occurrence of intestinal parasites among captive elephants in three management systems during various seasons and among various age–sex classes in Tamil Nadu.

MATERIALS AND METHODS

Study animals and sampling procedures: Between 2003 and 2005, faecal samples (one/individual) were collected from 115 captive elephants managed by: (i) the Tamil Nadu Forest Department at the elephant camps in Mudumalai and Anamalai wildlife sanctuaries, and Arignar Anna Zoological Park, Vandalur (n = 42), (ii) temples (n = 38: Appendix 1), and (iii) private owners (n = 35: Appendix 2). Dung samples were collected within a few hours of defecation and stored in 10% formalin. From each dung pile, a representative sample was collected from the outer and inner parts of different boli; parts in contact with soil were avoided. Details of the age and sex of the study animals were recorded by interviewing the mahouts (keepers) as well as by verifying the studbook or register of records. Where proper age records were not available, as in the case of animals caught/rescued from the wild by the forest department or those bought from other states by private and temple authorities, age was estimated by employing the shoulder height method of Sukumar et al. (1988). Considering the diverse climatic conditions that prevail across the study area: the Western Ghats, where the forest department manages most of its captive elephants, and the plains, where the private and temple systems manage their elephants, the year was divided into three seasons - summer, monsoon, and winter and designated according to similarities in climate. For the timber camps of the forest department, the period from February to April was treated as summer, May to November as monsoon, and December to January as winter. In the case of private, temple and Arignar Anna Zoological Park elephants, March to July was classified as summer, August to November as monsoon, and December to February as winter.

Parasite prevalence appraisal: The prevalence of intestinal parasites among captive elephants was assessed through coprological analysis using direct microscopic examination, and the sedimentation floatation methods following Watve (1992, 1995), Vidya & Sukumar (2002), and the sedimentation technique standardized by Monson-Bhar & Bell (1982). In the sedimentation floatation method, a known weight of dung sample (in 10% formalin) was strained to remove the coarse debris and the filtrate was centrifuged. The dung that sedimented was dissolved in 10ml of saturated zinc sulphate solution (specific gravity 1.8%) and centrifuged again. In the first centrifugation, nematode eggs sink with the faecal matter. Nevertheless, in the second round they float to the surface due to the high specific gravity of zinc sulphate. Six loopfuls of the solution were removed from the surface using a wire-loop of 5mm diameter and the solution was examined to record presence or absence of eggs. If no eggs were found in a sample, 12 more loopfuls of the solution (six at a time) were scanned for eggs to confirm the absence of parasite infection. In the sedimentation technique (Monson-

Bhar & Bell 1982), a small amount of faecal sample was emulsified with 10ml of water in a centrifuge tube and was centrifuged for two minutes at 3000rpm. The supernatant was poured off carefully and a drop of the sediment was placed on a slide and examined under the microscope.

Veterinary care: The availability of professional veterinary care for the elephants in the three management systems was evaluated through a questionnaire survey with the concerned authorities, and also by scrutinizing the register (medical) records of the elephants. Information such as presence or absence of periodic medical check-ups by veterinarians, and the number of medical check-ups per year were obtained for each elephant.

Analysis: The prevalence of parasitic infection among captive elephants in three management systems, three seasons, and different sex and age-classes was determined by the presence or absence of data on parasitic infection of individual elephants. Statistical significance for the proportion of elephants infected with parasites out of the total number of individuals examined was tested using the proportion test. A logistic regression analysis using presence or absence of parasites (coded as 1 or 0) at the individual level as the independent variable, and the management system (private, temple, forest department), season (monsoon, summer, winter), age class (calf & juvenile (0-5 yr), sub-adult (5-15 yr), adult (15 yr and above)) and sex (male, female), as dependent variables were coded as 1 to 2 or 3 according to number of categories. Data on the proportion of elephants with periodic medical check-ups in the three management systems was tested using the proportions test.

RESULTS

Intestinal parasite prevalence

Overall and among seasons: Out of 115 individuals examined for intestinal parasite prevalence, 43 (37%) individuals were found positive (Table 1). All the positive cases were infected only with helminthic parasites (*Strongyles* sp.). Both eggs and worms of *Strongyles* sp. were identified from the infected individuals. The eggs were found in all infected cases and worms were found only in one case. The proportion of elephants (43 out of 115) infected with intestinal parasites was significantly lower than uninfected individuals ($\chi^2 = 6.817$, df = 1, p = 0.009). Parasite prevalence was significantly different in three seasons (Wald = 9.681, p <0.01) (Table 2), with the highest infection rate found during summer (19 out of 39 or 49%), followed by monsoon (23 out of 61 or 38%), and the lowest infection rate during winter (1 out of 15 or 7%). The rate of infection between monsoon and winter did not vary significantly (B ± SE = 2.089 ± 1.147, Wald = 3.315, p > 0.05), while the infection rate between summer and winter varied statistically (B ± SE = 3.238 ± 1.169, Wald = 7.670, p < 0.01), indicating parasite prevalence was more common during summer.

Table 1. Number of elephants examined for prevalence of intestinal parasites and the details of individuals infected in different systems and sexes

Details	Forest Department	Temple	Private	Overall
Number of individuals examined	42	38	35	115
Number of individuals infected	20	12	11	43
Number of females examined	16	37	31	84
Number of males examined	26	1	4	31
Number of females infected	12	12	10	34
Number of males infected	8	0	1	9

Prevalence among three management systems: The occurrence of intestinal parasites varied significantly among the three management systems (Wald = 8.753, p = 0.01) with the prevalence of parasite infection being higher among captive elephants in the forest department (20 out of 42 or 48%) system than in temple (12 out of 38 or 32%) and private (11 out of 35 or 31%) systems (Table 1). The proportion of infected individuals between the private and forest department systems was not significantly different (B ± SE = -1.300 ± 0.697, Wald = 3.483, p > 0.05) (Table 2), while the infection rate observed between the temple and forest department systems showed a significant difference (B ± SE = - 2.239 ± 0.757, Wald = 8.750, p < 0.01) indicating a higher susceptibility to parasitic diseases for elephants in the forest department system.

Table 2. Results of logistic regression analyses carried out to test the significance of intestinal parasite prevalence among systems, seasons, age–classes and between sexes

Variables	Coefficient ± SE	Wald	P level
Among systems: private (n = 35), temple (n = 38) and forest department (n = 42)	-	8.753	0.013
Between systems: Private / Forest Department	-1.300 ± 0.697	3.483	0.062
Between systems: Temple / Forest Department	-2.239 ± 0.757	8.750	0.003
Among seasons: monsoon (n = 61), summer (n = 39) and winter (n = 15)	-	9.681	0.008
Between seasons: monsoon / winter	2.089 ± 1.147	3.315	0.069
Between seasons: summer / winter	3.238 ± 1.169	7.670	0.006
Among age–classes: calf and juvenile (n = 8), sub-adult (n = 21) and adult (n = 86)	-	1.221	0.543
Between age–classes: calf and juvenile / adult	-0.836 ± 0.922	0.821	0.365
Between age–classes: sub-adult / adult	-0.419 ± 0.590	0.503	0.478
Between sex: female and male	-1.693 ± 0.649	6.811	0.009

Prevalence between sex and among age–classes: Among the 31 males and 84 females sampled, the prevalence of helminthic infection was significantly higher in females (34 out of 84 or 40%) than in males (9 out of 31 or 29%), (B ± SE = - 1.693 ± 0.649, Wald = 6.811, $p < 0.01$) (Table 2) suggesting that females are more prone to helminthic infection under captive conditions than males. Among the three major age classes of elephants tested, the prevalence of intestinal parasites was not significantly different (Wald = 1.221, $p > 0.05$) with 41% individuals in adult class, 29% of individuals in sub–adult class, and 25% of juvenile and calves being infected.

Periodic medical care: The data on the veterinary care in the three captive management systems reveal that only one-fourth (26%) of the elephants in the private system, and three-fourths (75%) in the temple system had periodic medical examinations. All the elephants (100%) in the forest department system were checked periodically by veterinarians. A proportions test on the percentage of elephants with periodical medical check-ups in the three systems reveal that the observed difference was statistically significant ($Z = -2.54$; $p < 0.01$) indicating that in Tamil Nadu elephants managed in the private system had significantly less access to veterinary care than elephants in the other two systems.

DISCUSSION AND CONCLUSIONS

In general, macroparasites (i.e. parasitic species where reproduction usually occurs via transmission of free-living infective stages that passes from one host to the next) aggregate across their host population with most individuals harbouring low number of parasites, but a few individuals play host to higher parasitic burdens (Shaw & Dobson 1995). Such heterogeneity is generated due to variation between individuals in their exposure to infective stages and differences in their susceptibility (Wilson et al. 2002). The intestinal parasite *Strongyle* sp. was prevalent among 37% of the captive elephants monitored across three management systems in Tamil Nadu during 2003-2005. This parasite infection rate is similar to the prevalence rate of 36% reported for Mudumalai timber camp elephants (Arunachalam et al. 2007), and lower than that reported (majority of the 245 cases) among the captive elephants in Kerala (Chandrasekharan et al. 1995). However, the present estimate was considerably higher than the 10% parasite infection reported for the Guruvayoor Temple elephants (Saseedaran et al. 2004). Such differences among different elephant populations could be attributed to variable treatment levels, husbandry practices, sampling season, and age-sex classes.

Among the three management systems studied, the parasite prevalence was higher in the captive elephants of the forest department system compared to temple and private systems, while the elephants in the former facility had a higher level of medical attention than

those in the latter two systems. In the forest department system, over 90% of the captive elephants are managed at the timber camps in social groups, sharing the natural habitat of wild elephants which are known to have a high parasite prevalence (Watve 1995; Dharmarajan 2000; Vidya & Sukumar 2002). The social life style, along with the semi-natural environment shared by wild elephants is likely to enhance susceptibility to parasitism from conspecifics both within the system as well as from the wild. In support of this, at the Anamalai timber camp, 14 of the 16 forest department elephants examined for parasites showed positive results. Most of the private and temple elephants are managed in solitary conditions or in small groups, and provided with Astasooranam, a traditional herbal medicine prepared by mahouts, at periodic intervals for digestive ailments (Vanitha 2007). In addition, regular vaccinations and de-worming activities organised by the Tamil Nadu government during the special rejuvenation camps for the temple and private elephants coinciding with this study (2003-2005) may have contributed to the lower prevalence of intestinal parasites among the private and temple elephants. The higher prevalence of helminthic parasite infection during summer and early monsoon could be due to the prevalence of ideal climatic conditions (temperature & humidity) for faster rates of egg hatching and rapid development to the infective stage as reported elsewhere (English 1979), and due to poor hygienic conditions of the resources such as shelter, food and water. Further, the nutritional state of the host is known to affect immuno-competence (Rolston 1992; Lyles & Dobson 1993), and as the rainy season progresses, the increased vegetation growth could reduce nutritional stress and thus improve overall resistance to helminth infection (Dharmarajan et al. 2005).

The present study and that from the Nehru Zoological Park, Hyderabad (Suresh et al. 2001) show the prevalence of intestinal parasites was higher in females than males, contradicting the general trend reported for mammals (Poulin 1996; Schalk & Forbes 1997). Such trends among captive elephants could be related to the more social nature of females with frequent physical contacts to various age-sex classes compared to males, and hence more susceptibility to parasitic infection. Besides the above reason, the lesser mobility of female elephants compared to males, observed during the course of grazing in natural habitats at the timber camps in the forest department system (Vanitha 2007), resulted in the same space being more frequently used by females than males. In comparison to free ranging elephants, such a constraint imposed by captivity could also contribute to the higher prevalence of parasitic infection among females. The observed higher (80%) proportion of females with parasitic prevalence at timber camps is in line with the above statement.

In general, wildlife medicine has received less interest in India when compared to the western world, and the situation is the same with regard to captive elephant health care (Krishnamurthy & Wemmer 1995; Bist 2002; Vanitha 2007). Lack of clinical facilities with appropriate equipment and financial constraints contribute to inadequate veterinary care in all the captive elephant management systems. The situation is more prominent in private and temple systems, as shown by data on the proportion of elephants receiving veterinary care in the three systems in this study, and elsewhere (Krishnamurthy 1998; Bist et al. 2002; Vanitha 2007). Therefore, due to a lack of exercise, quality and quantity of food, and other appropriate husbandry practices along with inadequately trained veterinary support, elephants in the temple and private systems experience more major health problems (like arthritis, foot rot, skin diseases, overweight and underweight) than the elephants in the forest department system (Vanitha 2007), and this needs immediate redressal. Overall, the study shows that the prevalence of intestinal parasites is higher (i) in cases of captive elephants managed by the forest department in social groups within natural habitats shared with wild conspecifics than those solitarily managed in private and temple facilities, (ii) during summer and monsoon when compared to the winter season, and (iii) among females than males. Therefore, the study suggests more frequent diagnosis and deworming for the forest department captive elephants, especially those managed at the timber camps of Mudumalai and Anamalai wildlife sanctuaries, during summer and monsoon seasons.

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Appendix 1. List of temple elephants from different places of Tamil Nadu examined for intestinal parasites

	Elephant name	Place and District
1	Abaiyambal	Mayiladuthurai, Nagapattinam
2	Abirami+	Thirukkadaiyur, Nagapattinam
4	Andal	Azhagar Koil, Madurai
5	Andal	Srirangam, Tiruchirapplli
6	Ankaiyarkanni+	Madurai
3	Athinayagi	Alwarthirunagari, Tuticorin
7	Avai+	Thiruperunkundram, Madurai
8	Bavani	Rameswaram
9	Boomadevi	Uppiliappan Koil, Thanjavur
10	Chooligambal	Thirupugalur, Thiruvarur
11	Dharmambal	Thiruvaiyaru, Thanjavur
12	Durga	Swamimalai, Thanjavur
13	Gomathi	Thiruvidaimaruthur, Thanjavur
14	Kalyani	Perur, Coimbatore
15	Kasturi	Palani, Dindugul
16	Kothai	Sriperumpathur, Kanchipuram
17	Kumuthavalli	Thirukkolur, Tuticorin
18	Kurunkudinachiyar	Thirukurunkudi, Tirunelveli
19	Lakshmi	Rettai Thirupathi, Tuticorin
20	Lakshmi+	Malaikottai, Tiruchirappalli
21	Maduravalli	Madurai
22	Mangalam	Kumbakaonam, Thanjavore
23	Mariyappam	Samayapuram, Tiruchirapplli
24	Masiniyamma+	Thiruverkadu, Thiruvallur
25	Muthulakshmi	Perungulam, Tuticorin
26	Parvathy+	Madurai
27	Rajeswari+	Salem
28	Rowthilakshmi	Peraiyur, Madurai
29	Rukku	Thiruvannamalai
30	Sengamma	Mannargudi, Thiruvarur
31	Shanthi	Thiruchendur, Tuticorin
32	Sivakami+	Tiruppattur, Sivaganga
33	Sornavalli+	Kalaiyar Koil, Sivaganga
34	Subbulakshmi+	Kundrakudi, Sivaganga
35	Sumathi+	Palani, Dindugul
36	Valli	Thiruthani, Thiruvallur
37	Vedanayagi	Bhavani, Erode
38	Vellaiyammal+	Thanjavur

+ indicates infected individual

Appendix 2. List of private elephants from different places of Tamil Nadu examined for intestinal parasites

	Elephant name	Place/District
1	Ambika+	Swamimalai, Thanjavur
2	Ammukutti	Srirangam, Tiruchirapplli
3	Beham+	Madurai
4	Eswari	Srirangam, Tiruchirapplli
5	Faseela	Srirangam, Tiruchirapplli
6	Fathima	Nagur, Nagapattinam
7	Geethavalli	Peraiyur, Madurai
8	Gulabhi	Kumbakonam, Thanjavur
9	Gulebahawali	Venkatachalapuram, Madurai
10	Indra	Palani, Dindugul
11	Jaini	Kadayanallur, Madurai
12	Jothi	Tuticorin
13	Kamala+	Samayapuram, Tiruchirapplli
14	Kushma	Madurai
15	Lakini+	Padavedu, Tiruvannamalai
16	Lakshmi	Coimbatore
17	Lakshmi+	Palani, Dindugul
18	Lakshmi+	Salem
19	Lakshmi+	Madurai
20	Lakshmi Priya	Madurai
21	Malolan	Tambaram, Kanchipuram
22	Meenakchi	Kodumudi, Erode
23	Mohan Prasad+	Thirvidaimaruthur, Thanjavur
24	Nalan	Dharmapuram, Nagapattinam
25	Periyanayagi	Vaitheswaran Koil, Nagapattinam
26	Prasanna+	Chennai
27	Seetha	Thallakulam, Madurai
28	Shiyamala+	Swamimalai, Kumbakonam
29	Sita	Srirangam, Tiruchirappalli
30	Sulochana+	Viruthunagar
31	Suma	Srirangam, Tiruchirappalli
32	Sumathi	Venkatachalapuram, Madurai
33	Sumithra	Samayapuram, Tiruchirapplli
34	Thulari	Madurai
35	Vijayan	Samayapuram, Tiruchirapplli

+ indicates infected individual

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Author detail: Dr. V. Vanitha is presently an assistant professor in zoology. She obtained her PhD in 2008 for the study on 'Status and management of captive Asian Elephants in Tamil Nadu, India from Bharathidasan University, Tiruchirapalli. Dr. K. Thiyagesan is an associate professor, working on ornithology and is the research adviser to number of PhD students. Dr. N. Baskaran is a scientist at the Asian Elephant Research and Conservation Centre, working on wild Asian Elephants across Eastern, and Western Ghats and Eastern Himalaya for more than two decades. His research interest includes behavioural ecology of various mammalian fauna, and assessment of population, habitats, biodiversity and impact of development activities.

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