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Coprological survey of gastrointestinal parasitism in captive wildlife of three zoological parks located in southern India

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ABSTRACT

Gastrointestinal parasitism (GIP) is one of the important causes of diarrhoea in captive wildlife. Due to lack of systematic data on GIP in captive wildlife of southern parts of India, a study was conducted. Faecal samples (793) were collected from wildlife of three zoological parks, viz. Sri Venkateswara Zoological Park (SVZP), Tirupati (n=244); Indira Gandhi Zoological Park (IGZP), Visakhapatnam (n=221) and Nehru Zoological Park (NZP), Hyderabad (n=328). The collected samples were screened by faecal sedimentation and faecal flotation methods for detection of parasite ova, cysts or oocysts. An overall prevalence of GIP at 19.92% (158/793) with 16.39% (130/793) of helminths, 2.27% (18/793) of intestinal protozoa and 1.26% (15/793) of mixed infections were recorded. The highest prevalence of GIP was recorded in NZP (22.26%) followed by SVZP (20.90%) and IGZP (15.38%). The prevalence of GIP was observed highest in reptiles (42.31%) followed by herbivores (26.32%), carnivores (23.59%), birds (9.09%), rodents (9.09%) and primates (8.89%). Monitoring of captive wildlife at regular intervals is needed to assess the GIP to alert the zoo authorities to take up proper preventive measures.

Keywords: Captive wildlife, Gastrointestinal parasitism, South India, Zoological parks

Zoological gardens exhibit wild animals for aesthetic, recreational, educational and conservation purposes (Rao and Acharjyo 1984). The captive wildlife is more prone to parasitic infections due to their maintenance in confined areas which increases the density of population in a smaller area like zoological park and subsequently they succumb frequently to parasitic infections (Goossens *et al*. 2005). Among these, gastrointestinal parasitism constitutes one of the major drawbacks which threaten the existence of wild animals in captivity causing diarrhoea and even mortality (Cordon *et al*. 2008). A serious threat to endangered wild species may lead to sudden and unexpected declines in their population (Muoria *et al*. 2005). A set of circumstances that may make it possible to transfer the parasitic diseases from wildlife to man and domestic animals, and *vice-versa* (Gortazar *et al*. 2007).

Moreover anthelmintic resistance limits the control of parasites in captive wild animals. Hence, they need utmost care in terms of health and strategic deworming programme. Non-invasive coprological surveys of captive wildlife provide a valuable insight on the status of the epidemiological aspects of gastrointestinal parasitic fauna (Moudgil *et al*. 2015). Due to the meager information on the status of parasitic fauna of captive wildlife from the southern parts of India, an attempt was made with an objective to establish the occurrence of gastrointestinal parasites of confined wildlife of three zoological parks in southern parts of India, viz. Sri Venkateswara Zoological Park (SVZP), Tirupati; Indira Gandhi Zoological Park (IGZP), Visakhapatnam and Nehru Zoological Park (NZP), Hyderabad.

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MATERIALS AND METHODS

Sampled area: Faecal samples were collected from wildlife located at SVZP, Tirupati; IGZP, Visakhapatnam and NZP, Hyderabad of south India.

Sample collection: Faecal samples (793) were collected from herbivores (n=16 species), carnivores (n=21 species), primates (n=17 species), birds (n=59 species), reptiles (n=13 species) and rodents (n=2 species) belonging to three Zoological parks, viz. SVZP (n=244), IGZP (n=221) and NZP (n=328) during 2013 and 2014. The labeled samples were transported on ice to the laboratory and stored at 4–8°C till further processing.

Sample screening: Faecal samples were screened macroscopically for the presence of parasites and/or parasitic segments and later microscopically by simple faecal sedimentation and Willi's flotation methods (Soulsby 1982). Based on morphological features, identified helminth ova, protozoan cyst/oocysts (Soulsby 1982, Sloss *et al*. 1994, Zajac and Conboy 2013).

RESULTS AND DISCUSSION

The present study was conducted in a wide range of captive wild species of three zoological parks located in south India. In contrast, previous reports were restricted to certain

species of wildlife (Acharjyo 2004, Singh *et al*. 2009, Jeyathilakan *et al*. 2015, Mir *et al*. 2016). Further, the majority of earlier reports were based on the wild animals of only one zoological park (Varadharajan and Pythal 1999, Patel *et al.* 2000, Thawait *et al.* 2014).

Macroscopic examination of faecal samples revealed no adult/immature parasites. Of 793 samples, 158 were found to be infected with GIP by coproscopy. Between the zoological parks, NZP had the highest parasitic infection followed by SVZP and IGZP (Table 1).

The highest prevalence rates compared to the present findings were recorded by several workers (Varadharajan and Pythal 1999, Cordon *et al*. 2008, Lim *et al*. 2008, Opara *et al.* 2010, Khatun *et al.* 2014, Thawait *et al*. 2014, Sprenger *et al*. 2018). The lower rate of infection was noticed by Lalosevic *et al*. (2007). The variations might be due to the difference in sample size, hygiene, frequency of deworming, nutritional factors, geographical conditions, overcrowding, management practices and screening methods. The highest prevalence of GIP in NZP could be due to its location, i.e. heart of densely populated and polluted part of the city.

The prevalence of GIP was recorded highest in reptiles, followed by herbivores, carnivores, birds, rodents and primates. The present results indicated that, helminth infections were more common than intestinal protozoan infections. Helminth infections were noticed highest in reptiles, followed by herbivores and carnivores. The lowest helminth infections were observed in rodents, followed by primates and birds (Table 2). Similar results were observed in other studies (Varadharajan and Kandasamy 2000, Lim *et al*. 2008, Opara *et al.* 2010, Thawait *et al*. 2014, Mir *et al*. 2016, Sprenger *et al*. 2018). Among the helminths, nematode infections were observed at a higher prevalence and this could be due to their direct life cycles and are transmitted easily by faeco-oral routes. Moreover, nematode infections potentially accumulate in the captive environment and withstand for adverse conditions (Atanaskova *et al*. 2011). Mixed infection was observed comparatively low in wildlife under the study (Table 2) and a differed finding was recorded by Mir *et al*. (2016).

In the current study, the majority of black bucks in SVZP were mostly infected with strongyle infection and *Schistosoma* spp. was noticed in an elephant. Mixed infection with *Eimeria* spp. and strongyle spp. was recorded in Guar. The lions and wolves were infected with *T. leonina* and *Ancylostoma* spp. respectively. Strongyle larvae were observed in a primate sample. In peacocks, mixed infections were noticed by *A. galli*, *Capillaria* spp., *Eimeria* spp., *H. gallinarum* and *Hymenolepis* spp. In faecal samples of Indian star tortoise, strongyle type eggs were observed (Table 3; Fig. 1).

Faecal samples of herbivores located in IGZP showed *Eimeria* spp. and *B. coli*. In a wild boar, mixed infection with *A. suum* and *Eimeria* spp. was detected. In carnivores, *T. cati*, *Ancylostoma* spp. and *T. leonina* were observed. In a rusty spotted cat, mixed infection with *Ascaris* spp., strongyle larva and *Trichuris* spp. were noticed. In primates, *Ascaris* spp. and *B. coli* infections were recorded. Strongyle eggs were observed in an Indian porcupine. In green iguana, *Nyctotherus* spp. and pinworm eggs were detected. In star tortoise, *B. coli*, *Camallamus trispinosus*, coccidian oocysts,

Table 1. Overall prevalence of gastrointestinal parasitism in captive wildlife

Wildlife	Zoological Park			Total
	SVZP, Tirupati	IGZP, Visakhapatnam	NZP, Hyderabad	
Herbivores	27/74 (36.49)	6/88 (6.82)	42/123 (34.15)	75/285 (26.32)
Carnivores	7/72 (9.72)	21/70 (30.0)	18/53 (33.96)	46/195 (23.59)
Primates	1/14 (7.14)	1/11 (9.09)	2/20 (10.0)	4/45 (8.89)
Birds	11/72 (15.23)	0/44 (0.0)	10/115 (8.70)	21/231 (9.09)
Rodents	0/6 (0.0)	1/3 (33.33)	0/2 (0.0)	1/11 (9.09)
Reptiles	5/6 (83.33)	5/5 (100.0)	1/15 (6.67)	11/26 (42.31)
Total	51/244 (20.90)	34/221 (15.38)	73/328 (22.26)	158/793 (19.92)

Figures shown as number positive/number screened (percent positive).

Table 2. Type of gastrointestinal parasitism recorded in captive wildlife

Wildlife	Type of infection			Total
	Helminths	Intestinal Protozoa	Mixed Infection	
Herbivores	67/285 (23.51)	5/285 (1.75)	3/285 (1.05)	75/285 (26.32)
Carnivores	44/195 (22.56)	2/195 (1.03)	0/195 (0.0)	46/195 (23.59)
Primates	3/45 (6.67)	0/45 (0.0)	1/45 (2.22)	4/45 (8.89)
Birds	7/231 (3.03)	11/231 (4.76)	3/231 (1.30)	21/231 (9.09)
Rodents	1/11 (9.09)	0/11 (0.0)	0/11 (0.0)	1/11 (9.09)
Reptiles	8/26 (30.77)	0/26 (0.0)	3/26 (11.54)	11/26 (42.31)
Total	130/793 (16.39)	18/793 (2.27)	10/793 (1.26)	158/793 (19.92)

Figures shown as number positive/number screened (percent positive).

pinworm eggs and *Tachygonetria* spp. were observed (Table 4; Fig. 1).

In NZP, deer were infected with paramphistomosis infection. In a bison faecal sample, *Eimeria* spp. and strongyle eggs were noticed. Bengal tigers were infected with *T. cati*, and lions with *T. leonina.* The white tigers were infected with *Isospora* spp. oocysts and olive baboons with *Trichuris* spp. In birds, *Eimeria* spp. was detected and in Russels viper, mixed infection with strongyle eggs and tapeworm ova (unidentified) was noticed (Table 5; Fig. 1).

Black bucks of SVZP were infected with GIP, but none of them were identified at other two zoological parks. Bisons in all zoological parks were infected with GI parasites. Most of the deer species at NZP were detected with GIP, but none of the Nilgai and swamp deer were noticed with parasite stages at other zoological parks. Faecal samples of lions from NZP showed a higher prevalence of parasitic infection followed by IGZP and SVZP (Table 6).

In the current study, paramphistomosis was observed in deer species located at NZP and *Schistosoma* spp. eggs were noticed in one of the elephants in SVZP. *Hymenolepis* spp. was recorded in a peacock at SVZP. Tapeworm eggs (unidentified) were noticed in Russels viper at NZP. These findings were comparable with earlier reports (Varadharajan and Pythal 1999, Thawait *et al*. 2014, Mir *et al*. 2016). The low prevalence of platyhelminth infections in the current study might be due to the complex life cycles and also due to captivity of wild animals. In carnivore faecal samples, ascarid infection was the major infection, particularly in lions and followed by Bengal tigers. Ancylostomosis was identified in wolves and jungle cats. The intestinal protozoa identified in carnivore was *Isospora* spp. and that also restricted to two white tigers. The present study findings are consistent with the earlier reports (Lim *et al*. 2008, Opara *et al*. 2010, Pawar *et al*. 2012, Stuart *et al*. 2013, Khatun *et al*. 2014, Thawait *et al*. 2014, Peng *et al*. 2016, Kobbekaduwa *et al*. 2017, Sprenger *et al*. 2018). The high

Table 3. Prevalence of gastrointestinal parasitism in captive wildlife at SVZP, Tirupati

Wildlife	Parasite egg/ oocyst identified	Number positive/ number screened (%)
Herbivores		
Black buck (*Antilope cervicapra*)	Strongyle type	14/16 (87.5)
Elephant (*Elephas maximus*)	*Schistosoma* spp.	1/5 (20)
Guar/Bison (*Bos gaurus*)	*Eimeria* spp.	3/3 (100)
	Strongyle type	1/3 (33.33)
Hog deer (*Hyelaphus porcinus*)	Strongyle type	2/5 (40)
Spotted deer (*Axis axis*)	Strongyle type	7/13 (53.85)
Carnivores		
Lion (*Panthera leo*)	*Toxascaris leonina*	5/31 (16.13)
Wolf (*Canis lupus*)	*Ancylostoma* spp.	2/2 (100.0)
Primates		
Stump tail macaque (*Macaca arctoides*)	Strongyle larvae	1/1 (100.0)
Birds		
Common peacock (*Pavo cristatus*)	*Ascaridia galli*	4/24 (16.67)
	Capillaria spp.	2/24 (8.33)
	Eimeria spp.	4/24 (16.67)
	Heterakis gallinarum	3/24 (12.5)
	Hymenolepis spp.	1/24 (4.67)
White peacock (*Pavo cristtus*)	*Ascaridia galli*	2/5 (40)
	Capillaria spp.	1/5 (20)
	Heterakis gallinarum	1/5 (20)
Reptiles		
Star tortoise (*Geochelone elegans*)	Strongyle type	5/5 (100)

Table 4. Prevalence of gastrointestinal parasitism in captive wildlife at IGZP, Visakhapatnam

Wildlife	Parasite egg/ oocyst identified	Number positive/ number screened (%)
Herbivores		
Guar/Bison (*Bos gaurus*)	*Eimeria* spp.	1/8 (12.5)
Hog deer (*Hyelaphus porcinus*)	*B. coli*	1/10 (10)
Sambar deer (*Cervus unicolor*)	*Eimeria* spp.	1/17 (5.88)
Wild boar	*Ascaris suum*	3/3 (100)
	Eimeria spp.	1/3 (33.33)
Carnivores		
Bengal Tiger (*Panthera tigris tigris*)	*Toxocara cati*	2/12 (16.67)
Jungle cat (*Felis chaus*)	*Ancylostoma* spp.	1/2 (50)
Lion (*Panthera leo*)	*Toxascaris leonina*	17/22 (77.27)
Rusty spotted cat (*Prionailurusrubiginosus*)	*Ascaris* spp.	1/1 (100)
	Strongyle larva	1/1 (100)
	Trichuris spp.	1/1 (100)
Primates		
Rhesus monkey (*Macaca mulatta*)	*Ascaris* spp.	1/2 (50)
	B. coli	1/2 (50)
Rodents		
Indian Porcupine (*Hystrix indica*)	Strongyle type	1/3 (33.33)
Reptiles		
Green iguana (*Iguana iguana*)	*Nyctotherus* spp.	1/1 (100)
	Pinworm ova	1/1 (100)
Star tortoise (*Geochelone elegans*)	*B. coli*	1/4 (25)
	Camallanus trispinosus	1/4 (25)
	Coccidia oocyst	3/4 (75)
	Pinworm	4/4 (100)
	Tachygonetria spp.	1/4 (25)

Figures shown as number positive/number screened (per cent positive); Data shown for wildlife which were positive for GIP in at least one zoological park. Wild boar showed in herbivores.

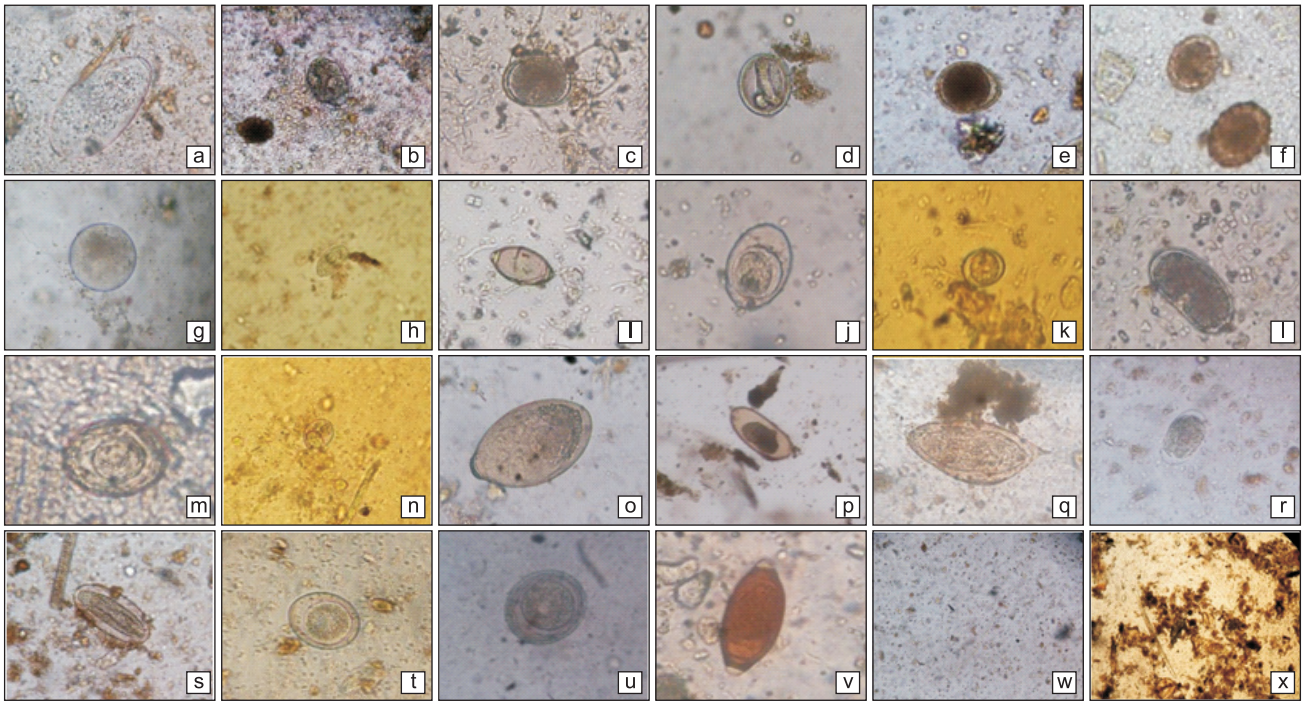

Fig. 1. Pictomicrograph showing the gastrointestinal parasite egg/cyst/oocyst in captive wildlife of zoological parks in south India. (a) Amphistome egg, (b) *Ancylostoma* spp. egg, (c) *Ascaridia galli* egg, (d) Ascarid egg in Rusty spotted cat, (e) Ascarid egg in Rhesus monkey, (f) *Ascaris suum* egg, (g) *B. coli* cyst, (h) *Camallanus trispinosus* egg, (i) *Capillaria* spp. egg, (j) Cestode egg, (k) *Eimeria* spp. oocyst, (l) *Heterakis gallinarum* egg, (m) *Hymenolepis* spp. egg, (n) *Isospora* spp. oocyst, (o) *Nyctotherus* spp. egg, (p) Pinworm egg, (q) *Schistosoma* spp. egg, (r) Strongyle egg, (s) *Tachygonetria* spp. egg, (t) *Toxascaris leonina* egg, (u) *Toxocara cati* egg, (v) *Trichuris* spp. egg, (w) Strongyle larva in Rusty spotted cat, (x) Strongyle larva in Stump tail macaque.

Table 5. Prevalence of gastrointestinal parasitism in captive wildlife at NZP, Hyderabad

Wildlife	Parasite egg/ oocyst identified	Number positive/ number screened (%)
Herbivores		
Guar/Bison (*Bos gaurus*)	*Eimeria* spp.	1/6 (16.67)
	Strongyle type	1/6 (16.67)
Nilgai (*Boselaphus tragocamelus*)	Amphistome	4/7 (57.14)
Sambar deer (*Cervus unicolor*)	Amphistome	4/4 (100)
Spotted deer (*Axis axis*)	Amphistome	27/34 (79.41)
Swamp deer (*Cervus duvaucelii*)	Amphistome	6/6 (100)
Carnivores		
Bengal tiger (*Panthera tigris tigris*)	*T. cati*	4/6 (66.67)
Lion (*Panthera leo*)	*T. leonina*	12/12 (100)
White tiger (*Panthera tigris tigris*)	*Isospora* spp.	2/2 (100)
Primates		
Olive baboon (*Papio anubis*)	*Trichuris* spp.	2/2 (100)
Birds		
Common peacock (*Pavo cristatus*)	*Eimeria* spp.	8/8 (100)
White peacock (*Pavo cristatus*)	*Eimeria* spp.	2/6 (33.33)
Reptiles		
Russels viper (*Vipera ruselli*)	Strongyle type	1/1 (100)
	Tapeworm ova	1/1 (100)

intensities of ascarid infection in the current study could be due to the ability of the worms to infect young animals in utero and transmammarily (Peng *et al*. 2016) and infects all age groups. Contrary to the present findings, in a report, none of the wild lions were found with toxocariosis and this might be due to the fact that *Toxascaris* was not usually found in wild lions, but appears frequently in zoo lions (Muller-Graf 1995). In the present study, mixed infection

Table 6. Wildlife with gastrointestinal parasitism in three zoological parks

Wildlife	SVZP, Tirupati	IGZP, Visakhapatnam	NZP, Hyderabad	Total
Herbivores				
Black buck (*Antilope cervicapra*)	14/16 (87.5)	0/12 (0)	0/22 (0)	14/50 (28)
Elephant (*Elephas maximus*)	1/5 (20)	0/1 (0)	0/5 (0)	1/11 (9.09)
Guar /Bison (*Bos gaurus*)	3/3 (100)	1/8 (12.5)	1/6 (16.67)	5/17 (29.41)
Hog deer (*Hyelaphus porcinus*)	2/5 (40)	1/10 (10)	0/2 (0)	3/17 (17.65)
Nilgai (*Boselaphus tragocamelus*)	0/6 (0)	0/3 (0)	4/7 (57.14)	4/16 (25)
Sambar deer (*Cervus unicolor*)	0/14 (0)	1/17 (5.88)	4/4 (100)	5/35 (14.29)
Spotted deer (*Axis axis*)	7/13 (53.85)	0/11 (0)	27/34 (79.41)	34/58 (58.62)
Swamp deer (*Cervus duvaucelii*)	0/3 (0)	0/3 (0)	6/6 (100)	6/12 (50)
Wild boar (*Sus scrofa*)	0/2 (0)	3/3 (100)	0/0 (0)	3/5 (60)
Carnivores				
Bengal tiger (*Panthera tigris tigris*)	0/3 (0)	2/12 (16.67)	4/6 (66.67)	6/21 (28.57)
Jungle cat (*Felis chaus*)	0/0 (0)	1/2 (50)	0/3 (0)	1/5 (20)
Lion (*Panthera leo*)	5/31 (16.13)	17/22 (77.27)	12/12 (100)	34/47 (72.34)
Rusty spotted cat (*Prionailurusru biginosus*)	0/0 (0)	1/1 (100)	0/0 (0)	1/1 (100)
White tiger (*Panthera tigris tigris*)	0/8 (0)	0/3 (0)	2/2 (100)	2/13 (15.38)
Wolf (*Canis lupus*)	2/2 (100)	0/0 (0)	0/1 (0)	2/3 (66.67)
Primates				
Olive baboon (*Papio anubis*)	0/1 (0)	0/0 (0)	2/2 (100)	2/3 (66.67)
Rhesus macaque (*Macaca mulatta*)	0/3 (0)	1/2 (50)	0/0 (0)	1/5 (20)
Stump tail macaque	1/1 (100)	0/0 (0)	0/0 (0)	1/1 (100)
Birds				
Common peacock (*Pavo cristatus*)	9/24 (34.62)	0/6 (0)	8/8 (100)	17/40 (42.50)
White peacock (*Pavo cristtus*)	2/5 (40)	0/1 (0)	2/6 (33.33)	4/12 (33.33)
Rodents				
Indian Porcupine (*Hystrix indica*)	0/6 (0)	1/3 (33.33)	0/2 (0)	1/11 (9.09)
Reptiles				
Green iguana (*Iguana iguana*)	0/0 (0)	1/1 (100)	0/2 (0)	1/3 (33.33)
Russels viper (*Vipera ruselli*)	0/0 (0)	0/0 (0)	1/1 (100)	1/1 (100)
Star tortoise (*Geochelone elegans*)	5/5 (100)	4/4 (100)	0/0 (0)	9/9 (100)

with *Ascaris* spp., strongyle larvae and *Trichuris* spp. was noted in a rusty spotted cat at IGZP. On the contrary, no GIP was observed in rusty spotted cats in Sri Lanka (Kobbekaduwa *et al*. 2017).

The GIP observed in primates in the present study included, *Ascaris* spp., strongyle type eggs, *Trichuris* spp. and *B. coli*. Similar findings were recorded in earlier studies (Lim *et al.* 2008, Opara *et al*. 2010, Khatun *et al*. 2014, Thawait *et al.* 2014). The current findings did not conform to previous observations (Gotoh 2000, Chakraborty and Goswami 2001). The variations in parasite species could be attributed due to the geographical, climatic conditions, animal habitat, hygiene, season and sampling differences. In the present study, the prevalence of GIP in wild birds was recorded at 9.09%. On the contrary, numerous studies reported a higher prevalence of infection (Patel *et al.* 2000, Cordon *et al*. 2009, Parasani and Momin 2009, Sprenger *et al*. 2018). The parasites identified in the present study were in conformity to previous reports (Chauhan *et al*. 1973, Cordon *et al*. 2009, Sprenger *et al*. 2018), but contrary to the findings of Patel *et al*. (2000) and Parasani and Momin (2009). The reasons for low prevalence of infection in wild birds of the present study could be due to no overcrowding conditions, less contact with other species, low level of stress, better hygiene, frequent removal of litter and regular deworming.

Among two species of rodent samples, strongyle infection was identified in a porcupine and similar findings were noted by Varadharajan and Kandasamy (2000). Among the reptiles, 30.77% were positive for helminths and 11.54% for mixed infections. *Nyctotherus* spp. and pin worm eggs were identified in a green iguana. Tapeworm ova and strongyle ova were identified in Russels viper. Multiple infections were identified in star tortoise. The present findings were in agreement with earlier reports (Opara *et al.* 2010, Jeyathilakan *et al*. 2015).

In conclusion, the outcome of present data demonstrates that, gastrointestinal parasitic infections were prevalent in captive wildlife of three zoological parks in south India. Nematode infections were more common than intestinal protozoans. Further studies with sensitive diagnostic procedures involving necropsy findings for species level identity of parasites are warranted to arrive accurate prevalence data as well as to improve the health status of

endangered captive wildlife.

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