Gastrointestinal Helminth Parasites of Wild Ungulates In Hirpora Wildlife Sanctuary, Kashmir, India

Rouf Ahmad Bhat

University of Kashmir

Hidayatullah Tak

University of Kashmir

Bilal A. Bhat

University of Kashmir

Riyaz Ahmad

Wildlife Trust of India

Jahangir Ahmad Dar (✉ jahangirwildlife10@gmail.com)

University of Kashmir <https://orcid.org/0000-0001-5686-2476>

Research Article

Keywords: Wild ungulates, helminth parasites, prevalence, EPG, mixed infection, Hirpora Wildlife Sanctuary

Posted Date: January 6th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1216666/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Parasitic infection represents an emerging threat to wild ungulates and a challenge to their management. Although a lot of work has been carried out on helminth parasitic infestation of domestic ungulates of Kashmir but the data pertaining to this aspect of wild ungulates has being ignored. The study on gastrointestinal helminth parasitic infestation of wild ungulates was carried out during post livestock grazing period (November to May) of 2018/2019 in Hirpora Wildlife sanctuary (HWLS) to fill the gap in the existing literature. During the study fresh faecal samples of musk deer *Moschus* sp.(n=44) and markhor *Capra falconeri* (n=41) were collected and examined qualitatively and quantitatively for gastrointestinal helminth parasites. A total of seven helminth parasites were recorded which are arranged in the descending order of their overall prevalence as *Haemonchus* spp. (44.70%), *Nematodirus* spp. (40%), *Trichuris* spp. (37.64%), *Strongyloides* spp. (34.11%) *Trichostrongylus* spp. (28.23%), *Moniezia* spp. (23.52%) and *Fasciola* spp. (20%). The mean EPG (eggs per gram) of different parasites showed a considerable variation in both the wild ungulates. The highest mean EPG was that of *Haemonchus* spp. and the lowest mean EPG was that of *Fasciola* spp. in both hosts. A statistically significant difference was observed in the mean EPG of different parasites among two wild hosts ($t=3.606$, $p=0.01$).

Introduction

Understanding gastrointestinal parasitic (GIT) diversity is of crucial importance for management of wild animals as these parasites pose a threat to the populations of different wild ungulates (Daszak et al., 2000) and play a vital role in survival of some major mammalian taxa (Lafferty and Gerber, 2002). Different parasites effect the growth and survival of various wild ungulates (Coop and Kyriazakis 1999). Different parasites effect the growth and survival of various wild ungulates (Ahmad 2020). In case of some wild ungulates helminth parasitic load is considered as one of the crucial factor, responsible for their extreme decline (Morgan et al. 2006). Helminth parasitic infection is responsible for mortality of hosts in protected areas on a major scale (Borghare et al. 2009). The effects of parasitism have become a serious concern for the conservation of various categories of ungulate species as it causes considerable population decline by causing mortality which may lead to extinction of some species (Ahmad 2020).

Gastrointestinal parasites are preferably present in duodenum, ileum, cecum and large intestines (Solusby 1982). These parasites have adapted themselves according to the feeding habits of the host, besides the continuous physiological changes related to feeding (Leonard 1987). These parasites drain the essential nutrients from the host rendering them weak and making them prone to other diseases (Loukopoulos et al. 2007). The parasites of the gastrointestinal system pass the infectious propagules with the faecal matter which require the maturation period outside the body of host resulting in accumulation of the infectious agents in the habitat and increase their chances of transmission (Soulsby 1982).

The preliminary data on gastrointestinal parasitic infestation of hangul deer (*Cervus hanglu hanglu*) is available from Kashmir (Lone et al. 2016; Khurshid et al. 2021), but the baseline information on other wild ungulates is lacking. Keeping in view the global status of markhor *Capra falconeri* (Near Threatened, IUCN 2021) and musk deer *Moschus* spp. (Endangered, IUCN 2021), the present study was undertaken to examine the status of gastrointestinal helminth parasites of these two threatened mountain ungulates in the Hirpora

Wildlife Sanctuary (HWLS) of Kashmir Himalaya for designing a future road map in parasitic disease monitoring and control in wildlife habitats.

Materials And Methods

Study area

The study was conducted in HWLS (33°39'55" N and 73°39'40" E) located at a distance of 70 km from Srinagar in Shopian district of Kashmir at an altitude of 2546mts (Ahmad et al. 2014) (Fig. 1). HWLS is surrounded by Lake Gumsar on north, Hirpora village on northeast, Rupri on east, Saransar on south and Pir Panjal pass on west. The steepness of mountain cliffs of HWLS varies, some of the peaks are very steep while as the others are moderately steep. The HWLS consists of different vegetation types like mixed coniferous forest, deciduous sub-alpine scrub forest and sub-alpine pastures. The sanctuary is known for Himalayan musk deer and Pir Panjal markhor (Ahmad et al. 2014). The sanctuary remains under the heavy grazing pressure of domestic live-stock belonging to local shepherds, migratory Gujars and Bukerwals from June to October (Bhat et al. 2019).

Climate

The climate of Kashmir valley is a typical warm temperate. The average temperature ranges from 30°C (maximum) and 20°C (minimum) in June - July to 4°C (maximum) and -9°C (minimum) in December - January. The absolute humidity ranges from 50 - 80% throughout the year and drops to about 55% at night during the winter and 64% during the summer. The whole valley remains covered with snow in winter. On the basis of temperature and precipitation, four seasons are recognized in a year in Kashmir valley: winter (December to February), spring (March to May), summer (June to August) and autumn (September to November) (Dar et al. 2002).

Sample collection

During the period of investigation systematic surveys were carried in HWLS for the collection of samples. Fresh faecal pellets of markhor and musk deer were randomly collected on weekly basis from November to May of 2018/2019. In order to avoid contamination of samples, only that portion of the faecal sample was collected which was not in contact with the soil. Faecal pellets were placed in collection vials and zip lock bags which were carefully labelled with animal identification, species, date, and place of collection along with GPS coordinates. In-order to preserve the parasitic eggs/oocysts 4% formalin was added to collected samples. Preserved samples were transported to the Parasitology Research Laboratory, Department of Zoology, University of Kashmir where faecal samples were microscopically examined for helminth eggs and larvae using concentration methods by Zinc sulphate flotation, fecal sedimentation and Modified McMaster techniques (Soulsby 1982). Morphological characters like shape, size and color were used for identification (Soulsby 1982).

Data analysis

Percentages with their respective means $\pm$ SD (standard deviation) and 95% confidence intervals were employed to calculate the prevalence of helminth parasites. Eggs were estimated as number of eggs per gram of faeces with their respective median and percentile. Chi-square test was used to evaluate the significance in the EPG among different helminth species of two hosts. The data was analyzed using Statistical packages MINITAB software version 13.2 (Minitab 2002) and SPSS-17 for windows. Confidence level was held at 95% and $P < 0.05$ for significance.

Results

The results revealed multiple combinations of various helminth parasites in markhor and musk deer. Out of 44 samples of musk deer and 41 samples of markhor examined, 21 (47.72%) samples of musk deer and 19 (46.34%) samples of markhor were positive for one or more than one species of GIT helminth parasites with an overall prevalence of 47.05%. Nematodes were most prevalent in both the species of wild ruminants (Table.1). In musk deer the different helminth parasites recorded are arranged in the descending order of their prevalence as *Haemonchus* spp. (45.45%), followed by *Nematodirus* spp. (40.90%), *Trichuris* spp. (38.63%), *Strongyloides* spp. (34.09%), *Trichostrongylus* spp. 29.54%), *Moniezia* spp. (25%) and *Fasciola* spp. (20.45%). The most prevalent parasite in markhor was *Haemonchus* spp. (43.90%), followed by *Nematodirus* spp. (39.02%), *Trichuris* spp. (36.58%), *Strongyloides* spp. (34.14%), *Trichostrongylus* spp. (26.82%), *Moniezia* spp. (21.95%) and *Fasciola* spp. (19.51%) (Table.2). *Haemonchus* was the most prevalent and *Moniezia* the least prevalent parasite in both hosts. A considerable variation was observed in the mean EPG among different parasites and between two hosts. (Table. 2). In case of musk deer the highest mean EPG (1605.14 ± 416.50) was that of *Haemonchus* spp. followed by *Nematodirus* spp. (1370.48 ± 267.27), *Trichuris* spp. (1337.57 ± 190.68), *Strongyloides* spp. (1225.14 ± 221.29) *Trichostrongylus* spp. (1196.64 ± 234.03), *Moniezia* spp. (1145.60 ± 87.17) and *Fasciola* spp. (732.61 ± 111.86). Similarly in case of markhor the highest mean EPG recorded was that of *Haemonchus* spp. (1390.86 ± 131.76) followed by *Nematodirus* spp. (1338 ± 119.25), *Trichuris* spp. (1266.66 ± 102.34), *Strongyloides* spp. (997.21 ± 284.34), *Trichostrongylus* spp. (899.41 ± 195.45), *Moniezia* spp. (590.47 ± 123.03) and *Fasciola* spp. (225.39 ± 131.76). A statistically significant difference was observed in the mean EPG of different parasites among two wild hosts ($t = 3.606$, $p = 0.01$). Most of the positive samples of both the hosts were infected with the mixed infection of two or more than two species of parasites. Among 21 positive samples of musk deer, 19 samples (90%) (Table.4) were infected with mixed parasites and two with single parasite (one with *Haemonchus* spp. and one with *Strongyloides* spp. Similarly among 19 positive samples of markhor, mixed infection was reported in 16 samples (84.21%) (Table.3) and single infection in three samples (two samples with *Haemonchus* spp. and one with *Trichuris* spp.)

Discussion

The literature on parasitic infestation of domestic ungulates is available from Kashmir (Bhat et al. 2019). The data pertaining to such aspect of wild ungulates is lacking from this region except some preliminary reports on hangul deer (Lone et al. 2016; Khurshid et al. 2021). Almost all the parasitic species reported in the two wild ungulate species are present in the domestic livestock which remain in the sanctuary from June to October (Bhat et al. 2019). The changing environmental conditions and utilization of natural habitats for live-

stock grazing increases the risk of cross-transmission of parasites (Gottdenker et al. 2014). These parasites are reported by different workers in the captive wild animals from different areas (Fagiolini et al. 2010; Thawait et al. 2014). The prevalence reported in the study is in close agreement with other workers (Adeniyi et al. 2015; Lone et al. 2016; Khurshid et al. 2021). The prevalence of nematodes was more than cestodes and trematodes. The high prevalence of nematodes is because most of the nematodes reported in the study have direct life cycle and do not involve intermediate hosts for transmission which may account for their high transmission rate and prevalence (Soulsby, 1982). This is in close agreement with several studies (Mckenzie and Davidson, 1989; Pacon, 1994; Shibashi et al., 2003) who have also reported high prevalence of nematodes than trematodes and cestodes. The high prevalence of nematodes than trematodes and cestodes is in concordance with Santin et al., 2004 who has worked on several species of deer in Spain. Among the nematodes the most prevalent parasites recorded in these wild hosts was *Haemonchus* spp. which is in close approximation with the studies of several researchers of the world (Cook et al., 1979; Mason, 1994; Naseimento et al., 2000). The low prevalence of cestodes and trematodes is because of limited availability of intermediate hosts which are important for their propagation (Soulsby, 1982). The low prevalence of cestodes in wild ungulates is in agreement with the studies of several workers (Vengust, 2003; Chroust and Chroustova, 2004).

The presence of *Haemonchus* spp., *Moniezia* spp. and *Trichostrongylus* spp. in two wild ungulates of the study area is in concordance with Suzy et al. 1987 from the Davis Mountains of Texas. *Haemonchus* spp. and *Trichostrongylus* spp. recorded in the study have already been reported in some wild hosts (Rana et al. 2015; Bajwa et al. 2019). The high prevalence of *Haemonchus* spp. and *Nematodirus* spp. revealed in the study is because the infectious agents of these species have the tendency to withstand the harsh (dry and cold) environment for a long time (Poole 1956). *Moniezia* spp. reported in the study had already been reported in cervids of Pakistan (Rana et al. 2015), and wild sheep of Iran (Eslami et al. 1981).

The EPG in the present study is low as compared to the EPG recorded by Lone et al. 2016 in hangul deer (*Cervus elaphus hanglu*) in Dachigam National Park Kashmir, India. This may be due to low group size, scattered population and less congregation of wild ungulates in HWLS. The EPG of different parasites showed considerable variation in two hosts and between different parasites. The highest egg count was that of *Haemonchus* spp. and lowest of *Fasciola* spp. This is because of the fact that production of eggs by the parasite depends on several factors which includes variation in the number of eggs produced by different parasites, individual host immunity and the severity of infection (Hudson et al., 1992; Zajac and Conboy, 2012). Some of the parasites like *Haemonchus* spp. are prolific and are capable of producing 5000 eggs per day while as others like *Trichostrongylus* produces only few hundreds (Stein et al., 2002). The mixed infection in most of the infected samples and the spectrum of helminths identified in the current study in which *Haemonchus* spp. was most prevalent is in agreement with previous studies conducted in different parts of the world (Ezenwa 2003; Waruira et al. 2005; Obanda et al. 2019).

The parasitic infestation decreases the response of the hosts towards secondary infection by causing immune suppression (Abee et al. 2012). The gastro-intestinal helminth fauna drains the essential nutrients rendering the animals weak which affects the reproductive potential and survival rate of hosts (Toft 1982; Panayotova- Pencheva 2013). The helminth parasites lower the body mass, reduce fecundity, and increase mortality among wild ungulates (Stein et al. 2002). The nematodes may significantly affect the general

health of endangered animals by causing various morbidities and mortalities and play a vital role in population regulation of wild ungulates (Roche, 1988). *Strongyloides* spp. cause several ill effects like diarrhoea, anorexia, weight loss, anemia and dyspnea (Gupta et al. 2011). *Haemonchus* spp. is known to cause intestinal ulceration leading to loss of blood, which makes the host weak and susceptible to other diseases besides causing significant morbidity and mortality (Davidson et al. 1980). The parasitic load can cause the death of hosts in severe cases which results in their population decline (Zhang et al. 2008). Intestinal parasitosis is known to cause disease and death in some wild hosts as reported by several workers (Solórzano-García and Pérez-Ponce de León 2017), The present study needs further elaboration for understanding the impact of GIT helminth parasites on the diseases dynamics of threatened mountain ungulates in Kashmir.

Conclusion

The presence of gastrointestinal helminth parasites in markhor and musk deer with known ill impacts may threaten the survival of these two threatened mountain ungulates. This study has opened a vision for monitoring and managing of wildlife parasitic disease in livestock dominated protected areas, detailed investigation of the intensity of infection and evaluation of mode of transmission at length in future.

Declarations

Acknowledgement

Thanks are due to SERB-DST Govt. of India for providing financial assistance under the project number CRG/2019/002369. The financial assistance by the University of Kashmir under component 10 of RUSA 2.0 is duly acknowledged. Authors are thankful to the Head, Department of Zoology, University of Kashmir for providing laboratory and other facilities. Our sincere thanks goes to the Department of Wildlife Protection, Jammu and Kashmir for providing necessary permission. Our sincere thanks also go to Ifshan Deevan, Wildlife Warden Shopian, the team members of Wildlife Trust of India working in Jammu and Kashmir for their support and cooperation.

Funding

Study was financially supported by DST-SERB, Govt. of India New Delhi, India under the grant number CRG/2019/002369 and university of Kashmir under component 10 of RUSA 2.0.

Conflict of interest statement

The authors declare no competing interests. Equipment brands, chemicals, and other trade names are mentioned here solely for the convenience of the reader and imply no endorsement by the authors.

Author contribution

Rouf Ahmad Bhat: methodology, formal analysis, experimental work.

Hidayatullah Tak: investigation, formal analysis, visualization, writing-review, and editing.

Bilal A. Bhat: conceptualization, methodology, writing-original draft preparation, and funding acquisition.

Riyaz Ahmad: sampling, methodology and analysis.

Ethics approval All procedures and methods used in this study regarding the use and care of animals were carried out in accordance with accepted international animal use and care guidelines.

Statement of Animal Rights

All animal sampling were carried out in open fields and followed international animal Ethical guidelines.

References

1. Abee C, Mansfield K, Tardif S, Morris T (2012) Nonhuman Primates in Biomedical Research: Diseases(. American College of Laboratory Animal Medicine Series, USA
2. Adeniyi IC, Morenikeji OA, Emikpe BO (2015) The prevalence of gastro-intestinal parasites of carnivores in university zoological gardens in South West Nigeria. J Vet Med Anim Health 7(4):135–139
3. Ahmad R, Dar SA, Suhail I, Zargar R, Charoo SA, Sofi MN, Mir FA, Bodhankar S, Bhattacharya T, Kaul R (2014) Recovering Markhor in Jammu and Kashmir, status, distribution, and habitat use. Wildlife Trust of India, Noida
4. Ahmad S (2020) Parasites of markhor, urial and chiltan wildgoat in Pakistan. Ann. Parasitol. 66(1):3-12.DOI: 101720/ap6601.232
5. Bajwa AA, Cuff JP, Imran M, Islam S, Mansha R, Ashraf K, Khan A, Rashid MI, Zahoor MY, Khan WA, Habib-ur-Rehman NA, Wenge O, Shehzad W (2019) Assessment of nematodes in Punjab urial (*Ovis vignei punjabiensis*) population in Kalabagh Game Reserve: development of a DNA barcode approach. Eur J Wildlife Res .65,63.<https://doi.org/10.1007/s10344-019-1298-y>
6. Bhat RA, Tak H, Bhat BA, Wani HM, Haq IUL, Ahmad R (2019) Livestock Helminth Infestation as A potential threat to wild Ungulates in Hirpora Wildlife sanctuary. J.Himalayan Ecol.Sustain.Dev.14,71-78
7. Borghare AT, Bagde VP, Jaulkar AD, Katre DD, Jamde PD, Maske DK, Bhangale GN (2009) Incidence of gastrointestinal helminthiasis of captive deers at Nagpur. Vet World 2(9):337–338
8. Cook TW, Ridgeway BT, Androeid R, Hodge J (1979) Gastrointestinal helminths in White tailed deer of luinois. J Wildl Dis 15(3):405–407
9. Coop RL .and Kyriazakis.Nutrition –parasite interaction.Vet.Parasitol. 84:187–204
10. Davidson WR, Crow CB (1980) Parasites, diseases and health status of sympatric populatons of white tailed deer and sika deer in Maryland and virgina. J wildl Dis 19:345–348
11. Daszak P, Cunningham AA, Hyatt AD (2000) Emerging infectious diseases of wildlife 328 – threats to biodiversity and human health. Science 287:443–449
12. Eslami A, Rahbari S, Meydani M (1981) Cestodesand trematodes of wild sheep, *Ovis ammon orientalis*,and goitered gazelle, *Gazella subgutturosa*, in Iran. Vet Parasitol 8:99–101
13. Ezenwa VO (2003) Habitat overlap and gastrointestinal parasitism in sympatric African bovids. J Parasitol 126(4):379–388

14. Fagiolini M, Riccardo PL, Piero L, Paolo C, Riccardo M, Stefania P (2010) Gastrointestinal parasites in mammals of two Italian zoological gardens. *J ZooWild Med* 41(4):662–670
15. Gottdenker NL, Streicker DG, Faust CL, Carroll, C.R. (2014) **Anthropogenic land use change and infectious diseases: a review of the evidence.** *Ecohealth*, 11 pp. 619-632, 10.1007/s10393-014-0941-z
16. Gupta A, Dixit AK, Dixit P, Mahajan C, Shrivastava AB (2011) Incidence of gastrointestinal parasites in wild ruminants around Jabalpur. India *J Threat Taxa* 3(11):2226–2228
17. Hudson JP, Dobson PA, Newborn D (1992) Do parasite make prey vulnerable to predation? Red grouse and parasites. *J. Anim Ecol* 61(3):681–692
18. Islam S (2006) Parasites and parasitic diseases of wildlife. Proceedings of XVII National Congress of Veterinary Parasitology and National Symposium on “Strengths, Challenges and Opportunities”. *Vet. Parasitol.* 43-52
19. Khurshid N, Tak H, Nazir R, Bhat KA, Manzoor M (2021) On the epidemiology of helminth parasites in Hangul Deer *Cervus hanglu hanglu* (Mammalia: Artiodactyla: Cervidae) of Dachigam National Park, India. *J Threat Taxa* 13(1):17517–17520
20. Leonard RJ (1987) : Physiology of gastrointestinal tract. 2nd ed. Raven press. 1780 p
21. Lone BA, Chishti MZ, Ahmad F, Tak H (2012) A survey of gastrointestinal helminth parasites of slaughtered sheep and goats in ganderbal. *Kashmir Glob Vet* 8:338–341
22. Lone BA, Chishti MZ, Ahmad F, Tak H, Bandh AS, Khan A (2016) A field survey on the status of gastrointestinal helminth parasites in hangul (*Cervus elaphus hanglu*) in Dachigam national park Kashmir. *J Parasit Dis* 40(30):750–755
23. Lafferty K, Gerber L (2002) Good medicine for conservation biology: the intersection of 399 epidemiology and conservation theory. *Conserv Biol* 16:593–604
24. Loukopoulos P, Komnenou A, Papadopoulos E, Psychas V (2007) Lethal *Strongylus* megatyphlon infection in a green iguana (*Iguana iguana rhinolopa*). *J Zoo Wildl Med* 38:131–134
25. Mason P (1994) Parasites of deer in New Zealand. *N Z J Zool* 21(1):39–47
26. Mckenzie ME, Davidson WR (1989) Helminth parasites of intermingling axis deer, wild swine and domestic cattle from this land of Molokai. *Hawaii J Wildl Dis* 25(2):252–257
27. IUCN (2021) *The IUCN Red list of Threatened Species. Version 2021-2.* <https://www.iucnredlist.org>
28. Morgan ER, Shaw SE, Brennan SF, De Waal TD, Jones BR, Mulcahy G (2006) *Angiostrongylus vasorum*: A real heart breakers. *Trends Parasitol* 21:49–51
29. Naseimento AAD, Bonuti MR, Mapell EB, Tebaldi JH, Arantes IG, Zettermann CD (2000) Nematodes Trichostrongylidae Cram, infections in deer (Mammals: Cervidae) from the States of Mato Grosso do Sul and São Paulo. *Braz. J Vet Res Anim Sci* 37(1/6):153–155
30. Obanda V, Maingi N, Muchemi G, Ng’ang’a CJ, Angelone S, Archie EA (2019) Infection dynamics of gastrointestinal helminths in sympatric non-human primates, livestock and wild ruminants in Kenya. *PLoS ONE* 14(6). DOI: 10.1371/journal.pone.0217929. e0217929
31. Pacon J (1994) Parasites of mouflons, stags and roe-deer from the Lower Silesia region. “*Wiad Parazytologiczne*” 40(3):279–292

32. Panayotova-Pencheva MS (2013) **Parasites in Captive animals: a review of studies in some European Zoos**Zool. Gart 82:6071. 10.1016/j.zoolgart.2013.04.005ArticlePDF(260KB)
33. Poole JB (1956) Reaction to temperature by infective larvae of *Nematodirus filicollis*, Trichostrongylidae (Nematoda). Can J Comp Med 20:169–172
34. Rana MA, Jabeen F, Shabnam M, Ahmad I, Hassan MM (2015) Comparative study of endo-parasites in captive hog deer (*Axis porcinus*). Int J Biosci 6(1):162–170
35. Roche M, Layrisse M (1988) The nature and causes of hookworm anemia. Am J Trop Med 15(6):1031–1102
36. Santin DM, Alunda JM, Hoberg EP, Fuente CDL (2004) Abomasal parasites in wild sympatric cervids, red deer, *Cervus elaphus* and fallow deer, *Dama dama*, from three localities across central and western Spain: relationship to host density and park management. J Parasitol 90:1378–1386
37. Shibashi T, Shimamura A, Izumo A, Nogami S (2003) A survey of parasites in the feces of Sika deer, *Cervus nippon*, from Kanagawa, Saitama and Chiba prefectures, Japan. Jpn J Zoo Wildl Med 8(2):95–99
38. Stein A, Irvine RJ, Ropstad E, Halvorsen O, Langvatan R, Albon SD (2002b) The population dynamics of *Ostertagia Gruheneri* in reindeer: a model for the seasonal and intensity dependent variation in nematode fecundity. Int J Parasitol 32(5):991–996
39. Suzy S, Stubblefield DB, Pence and Robert J. W (1987) Visceral helminth communities of sympatric mule and white-tailed deer from the Davis Mountains of Texas. J. wildl. Dis 23(1):113–120
40. Smith KF, Acevedo-Whitehouse K, Pedersen AB (2009) The role of infectious diseases in biological conservation. Anim Conserv 12:1–12
41. Soulsby EJJ (1982) Textbook of veterinary clinical parasitology, vol I. Helminth Oxford Blackwell Scientific, London
42. Solórzano-García B, de Pérez-Ponce G (2017) Helminth parasites of howler and spider monkeys in Mexico: insights into molecular diagnostic methods and their importance for zoonotic diseases and host conservation. Int J Parasitol Parasites Wildl 6:76–84
43. Stein A, Irvine RJ, Ropstad E, Halvorsen O, Langvatn R, Albon SD (2002) The impact of gastrointestinal nematodes on wild reindeer: experimental and cross-sectional studies. J Anim Ecol 71:937–945
44. Thawait VK, Maiti SK, Dixit AA (2014) Prevalence of gastro-intestinal parasites in captive wild animals of Nandan Van Zoo, Raipur, Chhattisgarh. Vet. World. 7(7): 448-445.10
45. Toft JD (1982) The pathoparasitology of the alimentary tract and pancreas of nonhuman primates: a review. Vet Pathol 7:44–92. 10.1177/030098588201907s06
46. Vengust G (2003) Comparison of the parasitic fauna of fallow deer (*Dama dama*) from two enclosures in Slovenia. Slov Vet Zb 40(1):27–31
47. Waruiru RM, Otieno RO, Mutune MN (2005) Gastro-intestinal parasitic infections of sheep and goats in semi-arid areas of Machakos district. Kenya B A H PA 53(5):25–34
48. Zajac AM, Conboy GA (2012) “*Veterinary Clinical Parasitology*”. Jhon Wiley and Sons
49. Zhang JS, Daszak P, Huang HL, Yang GY, Kilpatrick AM, Zhang S (2008) Parasite threat to panda conservation. EcoHealth 5:6–9

Tables

Table 1.Prevalence of nematodes, cestodes and trematodes in Markhor and Musk deer

Host	Number examined(n)	No.of positive samples	Nematodes(Prevalence)	Cestodes (Prevalence)	Trematodes (Prevalence)
Musk deer	44	21	21(47.72%)	11(25%)	9(20.45%)
Markhor	41	19	18(43.90%)	9(21.95%)	8(19.51%)
Overall	85	40	39(63.42%)	20(33.43%)	17(30.29%)

Table 2. Prevalence and mean EPG of different parasites in Markhor and Musk deer

Parasite	Markhor (n = 41)		Musk deer (n = 44)		
	Positive samples (Prevalence %)	Mean EPG ± S.D	Positive samples (Prevalence %)	Mean EPG ± S.D	Overall prevalence
<i>Haemonchus</i> spp.	18(43.90%)	1390.86±131.76	20(45.45%)	1605.14±416.50	44.70%
<i>Nematodirus</i> spp.	16(39.02%)	1338±119.25	18 (40.90%)	1370.48±267.27	40%
<i>Trichuris</i> spp.	15(36.58%)	1266.66±102.34	17 (38.63%)	1337.57±190.68	37.64%
<i>Strongyloides</i> spp.	14(34.14%)	997.21±284.34	15(34.09)	1225.14±221.29	34.11%
<i>Trichostrongylus</i> spp.	11(26.82%)	899.41±195.45	13(29.54%)	1196.64±234.03	28.23%
<i>Moneizia</i> spp.	09(21.95)	590.47±123.03	11(25%)	1145.60±87.17	23.52%
<i>Fasciola</i> spp.	08(19.51%)	225.39±131.76	09(20.45%)	732.61±111.86	20%

t=3.606, p=0.01

Table 3. Mixed infection of parasites in Markhor

Host	Markhor
Multiple parasites	+ ve samples (%)
<i>Haemonchus</i> spp., <i>Trichuris</i> spp., <i>Nematodirus</i> spp., <i>Fasciola</i> spp., <i>Trichostrongylus</i> spp., <i>Strongyloides</i> spp., <i>Moniezia</i> spp.,	5(26.31%)
<i>Trichuris</i> spp., <i>Fasciola</i> spp., <i>Haemonchus</i> spp., <i>Nematodirus</i> spp., <i>Trichostrongylus</i> spp., <i>Strongyloides</i> spp	3(15.75%)
<i>Trichuris</i> spp., <i>Moniezia</i> spp., <i>Haemonchus</i> spp., <i>Strongyloides</i> spp., <i>Nematodirus</i> spp.	3(15.75%)
<i>Trichostrongylus</i> spp., <i>Haemonchus</i> spp., <i>Trichuris</i> spp., <i>Nematodirus</i> spp., <i>Strongyloides</i> spp.	2(10.52%)
<i>Trichostrongylus</i> spp., <i>Haemonchus</i> spp., <i>Nematodirus</i> spp., <i>Moniezia</i> spp.	1(5.26%)
<i>Nematodirus</i> spp., <i>Haemonchus</i> spp., <i>Trichuris</i> spp., <i>Strongyloides</i> spp.	1(5.26%)
<i>Nematodirus</i> spp. <i>Haemonchus</i> spp.	1(5.26%)
Total	16 (84.21%)

Table 4: Mixed infection of parasites in musk deer

Host	Musk deer
Multiple parasites	+ve samples (%)
<i>Haemonchus</i> spp., <i>Trichuris</i> spp., <i>Nematodirus</i> spp., <i>Strongyloides</i> spp., <i>Moniezia</i> spp.,	6(28.57%)
<i>Trichuris</i> spp., <i>Fasciola</i> spp., <i>Haemonchus</i> spp., <i>Nematodirus</i> spp., <i>Trichostrongylus</i> spp.	5(23.5)
<i>Trichuris</i> spp., <i>Moniezia</i> spp., <i>Haemonchus</i> spp., <i>Strongyloides</i> spp., <i>Nematodirus</i> spp., <i>Trichostrongylus</i> spp.	4(19.04%)
<i>Trichostrongylus</i> spp., <i>Haemonchus</i> spp., <i>Nematodirus</i> spp., <i>Strongyloides</i> spp., <i>Fasciola</i> spp.	2(9.52%)
<i>Fasciola</i> spp., <i>Trichuris</i> spp., <i>Haemonchus</i> spp., <i>Strongyloides</i> spp., <i>Nematodirus</i> spp., <i>Trichostrongylus</i> spp.	1(4.76%)
<i>Haemonchus</i> spp., <i>Trichuris</i> spp., <i>Strongyloides</i> spp., <i>Trichostrongylus</i> spp., <i>Fasciola</i> spp., <i>Moniezia</i> spp	1(4.76%)
Total	19 (90%)

Figures

Figure 1

Map showing the study area and the distribution of sampling points of two hosts.