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Helminths and Coccidia of Markhor (*Capra falconeri*) in Kazinag National Park, Jammu and Kashmir, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A coprological analysis was carried out from October 2016 to September 2019 to determine the prevalence and associated determinants of gastrointestinal tract (GIT) parasites in Markhor *Capra falconeri* of Kazinag National Park, India. Fecal floatation and sedimentation technique revealed 150 pellet samples out of 248 pellet samples were positive for one or more parasites. Out of 248 pellet samples 147 (9.27%) were found positive for helminth and three (1.20%) were positive for protozoan. In this study six helminth species were detected, including five nematodes, one cestode and a protozoan: *Haemonchus* spp. (27.30%), *Ostertagia* spp. (11.15%), *Trichuris* spp. (5%), *Chabertia* spp.(4.23%), *Cooperia* spp. (3.07%), *Moniezia spp.* (1.15%), and *Eimeria* spp. (1.15%).

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The egg per gram (epg) of pellets was recorded highest for *Haemonchus* spp. (1500-2000 ± 210) followed by *Ostertagia* spp. (820-930 ± 55), *Trichuris* spp. (660-850 ± 80) *Chabertia* spp. (600-750 ± 86), *Cooperia* spp. (800-1200 ± 158) and *Moniezia* spp. (320-450 ± 42). Mixed infections were recorded in15samples. The cyst per gram for *Eimeria* spp. was found to be (320-562 ± 97). Highest prevalence of parasite egg/cystin pellets was recorded during summer season (70.42%) followed by autumn (58.73%) and least prevalence was recorded in winter (51.47%), with significant variation in prevalence. It is the pioneering study on this wild goat in the study area and the findings can assist to devise the appropriate control measures and prophylactic strategies against the GIT parasites of Markhor (*Capra falconeri*).

Keywords: GIT helminths; prevalence; season; markhor; kazinag national park.

1. INTRODUCTION

Markhor (*Capra falconeri*), a wild goat is found north India, in north-east Afghanistan, northern and central Pakistan, southern Tajikistan, south-western Turkmenistan and southern Uzbekistan [1]. According to Schaller and Binyuan [2], Markhor are exclusively found in Jammu and Kashmir, India. In Jammu and Kashmir Markhor occurs only in Kazinag National Park, Hirpura Wildlife Sanctuary and Poonch. Schaller and Khan [3] believed that there were around 5000 Markhor, of which roughly 1800 were from Kashmir and 250–300 from Jammu [4]. The estimated current population of Kashmir markhor is between 2000 and 2200, with Jammu and Kashmir housing only the second-largest population after Pakistan [5]. A variety of threats to Markhor are identified, common among which are competition with livestock due to sharing of grazing grounds and militancy related disturbances in the area, trophy and meat poaching, increased population dispersion, and a lack of understanding among villagers and government officials [6].

Other threat to markhor decline is diseases, as Morgan *et al*. [7] suggested parasites are responsible factor for population decline of some ungulates in the natural habitat. Parasitic infections are widespread, and low grade infections frequently go unnoticed [8]. Clinical manifestations in host vary on the parasite species, their number, and the occurrence of several concurrent infections, the age, the immunological status of the individual animals [9]. Wild animals never, or very infrequently, receive anthelmintic medications or veterinary care. These parasites drain host of essential nutrients thus making them weak and prone to predators and other diseases [10]. By dispersing pellets carrying eggs and cysts from many parasites, wild animals increase the chance of transmission by contaminating the environment. The spread of infection could occur as a result of parasite positive pellets contamination of food sources and water, which can be ingested by other animals including livestock [11, 12].

In Kashmir valley, the expansion of upland horticultural areas extensive livestock grazing is observed. As a result, a potential risk of infection for livestock in close proximity to wild habitats is not ruled out. Despite the fact that markhor are host to many parasites, little is known about the kind, frequency, and severity of their parasitic infections. The creation of databases for these parasites can be essential for the control and transmission programmes. In contrast to other regions, the Kashmir valley has not been the subject of any comprehensive study on markhor parasites. Climate, and geography have an impact on the species and severity of the parasites [13]. Thus, examining each areas status is necessary. Markhor parasites from the Kazinag National Park have not been reported. The aim of the present study was to investigate the incidence of intestinal helminth infections and seasonal variation in markhor populations in the Kazinag National Park, India.

Alteration in anthropogenic activities may change the stability associated with transmission rates, host range, and virulence [14]. In this context, baseline data on patterns of infection in wild goat populations is important in order to provide an index of population health and to assess and manage pathological risks. Wildlife is highly vulnerable to gastrointestinal helminths of livestock due to overlapping of habitats and grazing grounds with the domestic animals.

Prevalence of GI helminthes, in domestic animals, has been found to range from 0.72 to 84.1% in different parts of the world [15, 16]. There are many risk factors that influence the prevalence of GI helminthes in domestic ungulates, including age, sex, weather condition

and management practices [17, 18, 19, 20]. A good number of studies have documented the prevalence of gastrointestinal parasites of ruminants of Kashmir [21, 22, 23, 24], however, the gastrointestinal parasites of Kashmir wild ungulates remain poorly explored.

2. MATERIALS AND METHODS

2.1 Study Area

The Kazinag National Park (Fig. 1)is situated between 34°10'0"N latitude and 74°2'0"E longitude in western Himalaya of India. It is about 70 km west of Srinagar, with a total area of 157 km^2. It is located on the north bank of river Jhelum close to Actual Line of Control (LOC) under Kathai Forests within the Baramulla block of the Jhelum Forest Division. The study area is mainly forest range with some meadows and grass lands that are used as grazing territory for domestic ruminants and wild ungulates. Temperatures dip to as low as -9 ºC in winter and goes up to 38 ºC in summer, with an average rainfall of 84cm [25]. The humidity varies from 50 - 80% throughout the year and drops to about 55% at night during the winter and 64% during the summer. The whole national park remains snow covered during winter. The Kashmir Himalaya region has a temperate climate with four distinct seasons throughout the year: spring (March to May), summer (June to August), autumn (September to November), and winter (December to February) [26].

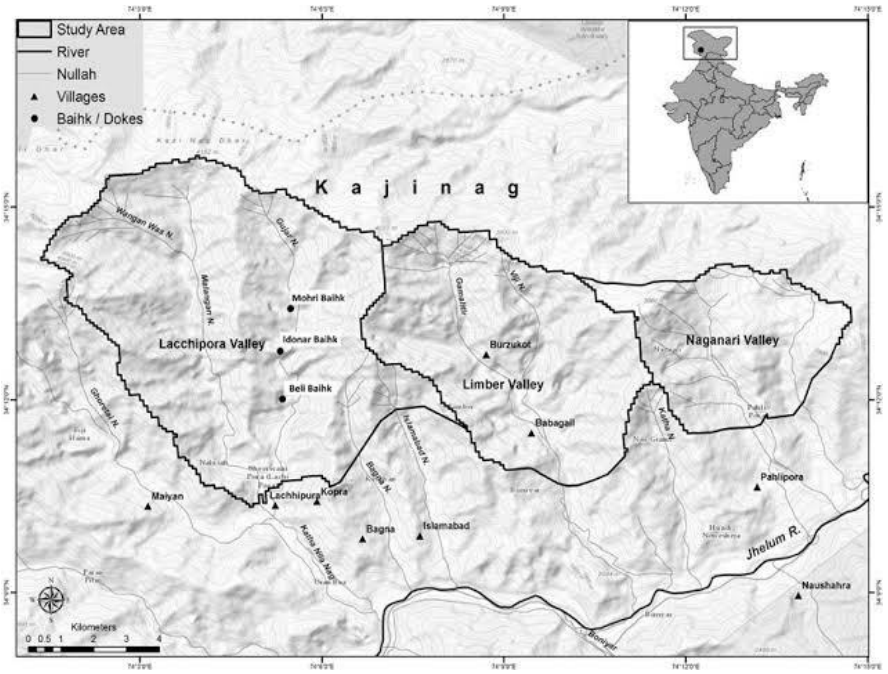

Fig. 1. Kazinag National Park (Source: QGIS)

(a) (b) (c)

Fig. 2. Fecal pellets of (a) Goral, (b) Markhor, (c) Domestic goat

2.2 Sample Collection and Processing

During the study period (October 2016 to September 2019) regular visits were made to study area. Fresh markhor pellets were collected from feeding sites of markhor after directly observing the animal defecating. We followed the method of Ashraf [27] to age pellet as fresh (moist or oily texture), old (dry, slightly crusted) or aged (decaying). Shape and size of pellets was species specific and error of identification was very unlikely [28]. The markhor pellets were differentiated from the pellets of goral, domestic sheep and goat; with whom it shares the habitat, on the morphological characters *viz*. dimension, shape and structure (Fig. 2) [28]. Pellet samples were collected in sterile vials marked with date. To prevent hatching of eggs or development of cyst, pellets were kept in 5% formalin. We used approved techniques of concentration by Zinc Sulphate flotation, fecal sedimentation and Modified McMaster technique [29, 30] to isolate parasite egg from pellet.

Parasites were identified on the basis of egg coloration, egg shape and size [31]. Worm infection grades were extrapolated from, infection severity index, defined by [31]. Animals have been said to have mild, moderate, heavy and severe helminth infestation, if their fecal egg counts are less than 500, 800-1000, 1100-1500 and more than 1500, respectively.

For samples, with total mean egg counts of greater than 1000, fecal culture was done. Copro-culture method is widely used to match parasite eggs to larvae for identification of nematodes [32]. The ability to identify most of the parasite species, by examination of the host fecal samples, even with cultured larvae, is limited. Consequently, majority of our findings are presented at the genus level.

2.3 Data Analysis

The frequency of parasite eggs contained in pellets were determined by statistical analysis. The formula FOi (%) = (ni/N) x 100 was used to calculate the frequency, where N represented the total number of pellet samples and ni represented the number of positive pellets. The 95% confidence interval was used to calculate the confidence boundaries. To determine the effect of seasons on frequency variance, the data was analyzed using the Chi-Square test; the significance level was defined as $p< 0.05$.

3. RESULTS

The helminth species found in the markhor of the study area were *Haemonchus* spp*., Cooperia* spp*., Chabertia* spp*., Trichuris* spp*., Ostertagia* spp*.* and *Moniezia* spp*.* Only one protozoan parasite, isolated from pellets during the present study was *Eimeria* spp.(Table1).The highest EPG was that of *Haemonchus* spp. (1500-2000 ± 210), followed by *Ostertagia* spp. (820-930± 55), and least was that of *Moniezia* spp. (320-450 ± 42) (Table 1) Mixed infections were detected in 15 of the studied samples (Table 3).

Table 1. Prevalence and Egg per gram (EPG)/Oocyst per gram of different parasite species in Markhor during 2017-18

Parasites	Positive (Prevalence) n=248	Average Eggs/cysts per gram of fecal sample ± SD	*p* value
Haemonchus spp*.*	71 (27.30%)	1500-2000 ± 210	0.003
Cooperia spp*.*	8 (3.07%)	800-1200 ± 158	
Chabertia spp*.*	11 (4.23%)	600-750 ± 86	
Trichuris spp*.*	13 (5%)	660-850 ± 80	
Ostertagia spp*.*	29 (11.15%)	820-930 ± 55	
Moniezia spp*.*	3 (1.15%)	320-450 ± 42	
Eimeria spp*.*	3 (1.15%)	320-562 ± 97	

Table 2. Prevalence of helminth infection in Markhor from Kazinag National Park

Season	Year 2017		Year 2018		Overall prevalence (N=248)	P Value
	Fecal samples Examined	Infected (Prevalence)	Fecal samples Examined	Infected (Prevalence)		
Winter	34	17 (50.0%)	34	18 (52.94%)	51.47%	0.05
Spring	21	11 (52.38%)	25	14 (56.%)	54.34%	
Summer	38	26 (68.42%)	33	24 (72.72%)	70.42%	
Autumn	27	15 (55.55%)	36	22 (61.11%)	58.73%	

Table 3 Co-Infection with parasites

Co-Infection	Positive samples
Haemonchus spp. and *Trichuris* spp.	4
Haemonchus spp. and *Chabertia* spp.	3
Haemonchus spp. and *Ostertagia* spp.	3
Trichuris spp. and *Ostertagia* spp.	2
Chabertia spp. and *Trichuris* spp.	2
Haemonchus spp. and *Cooperia* spp.	1

Out of 248 pellet samples of markhor examined from Kazinag National Park 147 (59.27%) were positive for helminth infections and three samples, (1.20%)were positive for protozoan infections. Out of the total examined samples highest prevalence was for *Haemonchus* spp*.* (27.30%) followed by *Ostertagia* spp*.* (11.15%), *Trichuris* spp. (5%),*Chabertia* spp. (4.23%), and least was *Cooperia* spp*.* (3.07%) (Table 1).Mixed infections were recorded in 15 samples (Table 3). Besides three samples were positive for *Eimeria* spp*.*

Highest prevalence of helminth infection was in summer season (n=50, 70.42%). Protozoan infection was also recorded during this season (n=3, 1.20%). It was followed by autumn (n=37, 58.73%), and spring (n=25, 54.34%).Least prevalence was recorded in winter (n=35, 51.47%) (Table 2).

4. DISCUSSION

Parasite infection in wild ungulates is a concern for wild life conservation.. The epidemiology of many parasite illnesses in wild animals has not received much attention [33]. Wild animals are a vital component of our natural ecosystem, and their poor living conditions or extinction could have a negative impact on the environment and food chain [34].

One hundred and forty-seven of the two hundred and forty-eight markhor fecal samples studied tested positive for GIT helminth infection, with an overall prevalence of 59.27%. In this study, parasite prevalence was found to be higher than that reported in Hangul deer (53.59%) from Dachigam National Park by Lone[35] but lower than that reported in Kashmir previously (81.17%) by Pandit *et al.* and (61.64%) by Tariq *et al*.[36, 23] in domestic ungulates. The parasite infection reduces the mass of body, decrees fecundity and increase chances of mortality in wild ungulates[37]. *Haemonchus* spp. is well known for anemia by causing ulcerations in intestines, besides it makes host weak and prone to other anomalies [38]. Summer had the highest prevalence (70.83%), while winter had the lowest (50%). Spring (53.06%) and fall (59.70%) saw a moderate level of infection. Lone et al. [35] revealed that there were distinct seasonal patterns of infection in Hangul deer (*Cervus elaphus hanglu*), with the highest infection in summer and the lowest in winter.According to Lone *et al.* [22], domestic sheep and goats in Kashmir exhibit the same pattern of helminth infection. The observations made by different workers [24, 39, 40, 41] are consistent with this seasonal trend. As a result, the season significantly influences the prevalence of helminth infections in Markhor. The reason for the greater prevalence during the summer is that the high temperatures create a suitable environment for the growth of helminths. In the pastures, the eggs are at the ideal temperature and sufficient moisture to hatch. A warm, wet summer is ideal for the growth and survival of nematode free-living stages. An increased parasitic burden among deer populations is as a result of the rainy season's higher warmth and humidity, which are conducive for the growth of endo-parasites [42, 34]. High spring rainfall also aids in ensuring an appropriate salt molarity in the soil, which is crucial for ecdysis [31].

The domestic cattle of Bakkarwals and locals occupied some significant feeding sites for Markhor throughout the summer, which is a significant source of helminth infection and may result in the spread of illnesses and helminth infestation to Markhor during this season. This protected areas alpine and subalpine grazing areas are so polluted with helminth eggs and larvae that domestic animals excrete with their feces during the summer, leading to a higher prevalence of infection during these months. According to Woodford [43], there is a potential that cattle, particularly those owned by nomads, will transmit disease to wild caprines. According to Frisina *et al.* [44], helminth infections are frequent in domestic sheep and goats and are probably also present in wild sheep and wild goats. There is a chance that livestock could transmit a disease to Markhor [43]. The

altitudinal migration of Markhor in response to climate circumstances and livestock disturbance may also be contributing factors to the high prevalence of helminth infection throughout the summer. They interact with animals and share grazing areas with them, making them vulnerable to illnesses. Animals that roam are more prone to unintentionally contract parasites, according to Horak's[45] research. A combination of climatic conditions and the migratory patterns of the wild animals in the Park, some parasites of wild animals from the Krugar National Park exhibit seasonal patterns [46, 47]. Because they share pastures with domestic livestock in many game ranches, Impalas and livestock in South Africa are discovered to have helminth fauna in common, according to a study by Horak [48]. These diseases are lethal and can significantly reduce the population of Markhor [45]. These findings imply that grazing ruminants are susceptible to GIT helminth infections, particularly during and after the rainy season. This could be due to poor nutrition throughout the harsh winters and these diseases have a deleterious effect on the health of the hosts. The helminth infestations in Markhor is significantly influenced by the climate, therefore, additional research on this subject is crucial.

5. CONCLUSION

The study contributes baseline data on the patterns of parasitic infection in Markhor. This is one of the initial studies on helminth disease risk assessment for health and management plans of threatened Markhor populations. The Markhor harbours the same helminths that are found in other domestic ruminants. Therefore, the access of domestic ruminants to the markhor habitats should be barred to avert any habitat contamination. Gastrointestinal parasite identification by fecal analysis is definitely poor method; however, it is the only authentic method to study the parasitic infestation in threatened faunal species. Further studies using molecular analysis is needed to improve on identification and classification of the gastrointestinal helminthes of markhor, as well understanding of the risks of epizootic transmission.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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