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Epizootiology of gastrointestinal parasites in equines of Kashmir valley, India

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ABSTRACT

Equine faecal samples from major tourist destinations of Kashmir valley were examined over a period of one year both qualitatively and quantitatively, and were finally subjected to coproculture, to map out the parasitic fauna of equines for the development of effective control strategies. The overall prevalence rate of parasites was found to be 85.11% with 96.77% prevalence rate in donkeys followed by 86.30%, 81.52% and 75.63% in ponies, mules, and horses, respectively. Prevalence of nematode infection was very high followed by very low prevalence rate of trematodes, cestodes and protozoa. Highest infection rate was recorded in spring, followed by summer, autumn and winter. Prevalence was found to be higher in young equines as compared to adult equines and in males than females. The overall mean EPG was found to be 755.20±33.47 with the highest mean EPG recorded in summer followed by spring, autumn and lowest in winter. Higher intensity of infection was recorded in young equines compared to adults and in females in comparison to males. The different strongylid larvae identified on coprocultures were *Cyathostomum* spp., followed by *Triodontophorus* spp., *Oesophagodontus* spp., *Trichostrongylus axei*, *Gyalocephalus* spp., *Strongylus edentatus*, *Poteriostomum* spp., *Strongylus vulgaris*, *S. equinus* and other larvae. Based on the prevalence pattern, it was concluded that deworming of equines in Kashmir valley should be carried out at least two times a year, i.e. mid-spring (April) and mid-autumn (October) to keep the parasitic load under control.

Keywords: Equines, Faecal samples, Kashmir, Parasites, Prevalence

India contributes around 2% to the world's and 5% to the Asian equine populations (Chauhan 2005) however, the number of equines has shown significant decrease over the previous census (Anonymous 2020). Unlike several states of the country, equines continue to have a significant impact on the economy of Jammu and Kashmir. There is a huge dependence of human population on the traditional means of transport, especially using equines, in the rural and border terrains of Jammu and Kashmir (Fazili and Kirmani 2011). As saddle-horses, ponies of the valley are providing entertainment to numerous tourists, since many decades, in world famous places like Pahalgam, Sonamarg, Gulmarg, etc. The Amar Nath (Baltal, Kashmir) and Vaishno Devi (Katra, Jammu) pilgrimage by millions of Hindus every year would not have been possible without this quadruped (Fazili and Kirmani 2011).The equines are greatly impacted by a number of diseases among which endoparasitic infection is responsible for a wide range of clinical syndromes varying from impaired performance, anaemia, unthriftiness and diarrhea to colic and occasional deaths in heavy infections (Proudman 2006). In broodmares, efficiency of reproduction is also adversely affected, with reports of increased early embryonic losses and decreased conception rates. Even light infections are known to hamper the development and performance of horses (Ogbourne 1978). Among these endoparasitic infections, the most common and pathogenic nematode parasites originate from the family Strongylidae and the subfamilies Cyathostominae and Strongylinae (Jürgenschellert *et al.* 2022). Breed, sex and geographic location are risk factors associated with susceptibility to infection (Romero *et al.* 2020) and in order to develop the suitable control strategies for the parasitic infections in equines, there is a need to map out the parasitic fauna of equines from every geographical area of the world. In Jammu and Kashmir, the incidence of parasitic infections in equines has been reported by very few workers (Katoch *et al.* 2006a, Pandit *et al.* 2008, Maria *et al.* 2012, Singh *et al.* 2012) from different regions, but no work has been carried out on the equines of major tourist destinations (Pahalgam, Sonmarg and Gulmarg) of Kashmir valley, where adequate number of equines are present. Therefore, the present study was conducted to work out the prevalence of endoparasitic infections in equines at major tourist destinations of the Kashmir valley to evolve a package of practices for their control.

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MATERIALS AND METHODS

Study area and animals: This study was conducted on locally reared equines of Kashmir valley over a period of one year. Since, the sizable number of equines is concentrated in and around the areas of world-famous tourist places like Pahalgam, Sonamarg and Gulmarg, therefore, maximum number of samples were collected from equines of these areas. Pahalgam, in south Kashmir, is nearly 95 km from Srinagar, located on the banks of Lidder river at an average elevation of 2,740 m (8,990 ft) at 34.01°N 75.19°E. The climate is temperate with long and cold winter and short and mild summer. Sonamarg "Meadow of Gold", in central Kashmir, is about 80 km north-east of Srinagar located at an altitude of 2,800 m (9,186 ft) at 34.40°N74.71°E. Even in the driest month, there is a lot of rain at this hilly station. Gulmarg is a popular skiing destination in north Kashmir and is nearly 56 km from Srinagar located at 34°15'N74°25'E at an altitude of 2,650 m (8,694 ft).

Parasitological examination: A total of 2008 faecal samples were collected from equines (ponies, horses, mules and donkeys) of both the sexes as well as from both the age groups, viz. young equines (<3 years) and adult equines (>3 years). The fresh samples were collected on the monthly basis, to work out the seasonal prevalence, with at least 500 samples in each season (spring, summer, autumn and winter), and were then brought to the Helminthology Laboratory of the Division in mini zip-locked polythene bags after properly labelling them. Samples were preserved at refrigeration temperature (4°C) till examination and were examined within 2-3 days of collection. Before examining the faecal samples microscopically, the gross examination was done by looking for colour, consistency, presence of blood, mucus, tapeworm segments and dead worms, if any. The samples were then examined qualitatively using sedimentation and floatation techniques for evaluating the incidence of various parasitic species (Soulsby 1982). A total of 500 faecal samples (randomly selected 25% of the samples) were also examined by quantitative technique (Modified McMaster's technique) to determine the parasitic load, i.e. egg per gram (EPG) of faeces. A total of 400 faecal samples (randomly selected 20% of the strongylid positive samples) were pooled and subjected to coproculture using petridish method as per standard protocol (Sahai, 1960). The harvested larvae were then identified under light microscope as per the standard keys (Soulsby 1965, Anonymous 1971, Georgi 1985).

Statistical analysis: The results were subjected to standard statistical analysis (Snedecor and Cochran 1994). The data on the prevalence between different groups was analyzed using 'z' test of proportions. Student's 't' test was employed for analysis of two means of EPG and more than two means of EPG were compared through ANOVA.

RESULTS AND DISCUSSION

Overall prevalence: In the present study, the overall prevalence of gastrointestinal (GI) helminths in equines was found to be 85.11% (Table 1). This overall prevalence rate is 8-10% less than the observations of earlier workers like Pandit *et al.* (2008) and Maria *et al.* (2012) who recorded an overall prevalence rate of 93.26 and 95.09%, respectively in equines of Kashmir valley, but 8-11% more than the observations of Khajuria *et al.* (2004) and Singh *et al.* (2012) who recorded an overall prevalence rate of 77.75 and 74.06%, respectively in equines of Jammu region. The overall prevalence rate of GI parasites was higher in donkeys followed by ponies, mules and horses with significant statistical variation ($P<0.05$) between horses and donkeys but non-significant statistical variation between ponies and donkeys and between mules and horses (Table 1).The present observations are almost in agreement with the findings of Maria *et al.* (2012), Khajuria *et al.* (2004) and Singh *et al.* (2012) who recorded an overall prevalence rate of 100% in donkeys, 82.71% in mules and 75.73% in horses, respectively. In other states of India, incidence ranging from as low as 15.59% (Sengupta and Yadav 2001) to as high as 84.00% (Adeppa *et al.* 2016) in unorganized sector and from as low as 3.74% (Sengupta and Yadav 2001) to as high as 14.18% (Sengupta and Yadav 1998) in organized sector has been reported. The overall prevalence of mixed infection in the present study was found to be 83.62%. Higher prevalence of mixed infection was found in donkeys followed by ponies, mules and horses (Table 1). Results of present study are in agreement with the findings of Maria *et al.* (2012) who recorded 91.45% prevalence of mixed infection in equines of central Kashmir but differ from those of Khajuria *et al.* (2004) who recorded only 20.84% prevalence of mixed infection in equines of Jammu region. In other states of India, mixed infection ranging from 25% in horses of Shimoga, Karnataka (Adeppa *et al.* 2016) to 47.50% in horses of Jabalpur, Madya Pradesh (Yadav *et al.* 2014) has been reported. The high prevalence of mixed infection could be attributed to high stocking density per unit area. In the present study, the prevalence rate was recorded highest for nematodes (85.11%) followed by very low prevalence rate of platyhelminths (1.10%) and *Eimeria leuckarti* (0.15%) (Table 1).

In nematodes, strongyles were found to be highly prevalent (85.11%) (Table 1). The highest prevalence of strongyles has also been reported by Maria *et al.* (2012) with prevalence rate of 94.72% in equines of Kashmir valley. Other than strongylid nematodes, the other gastrointestinal nematodes (GIN) recorded in the present study were *Strongyloides westeri*, *Parascaris equorum* and *Oxyuris equi* (Table 1). The incidence of *Strongyloides westeri* (5.73%) found in this study is almost similar to the incidence (6.19% and 6.90%) reported by Pandit *et al.* (2008) and Maria *et al.* (2012), respectively from equines of Kashmir valley but lower than the incidence (16.39% and 13.95%) reported from Jammu region by Khajuria *et al.* (2004) and Singh *et al.* (2012), respectively. In other states of India, incidence ranging from as low as 1.19% in equines of Tarai region of Uttaranchal (Sengupta and Yadav 1997) to as high as 76.92% in horses of Patiala, Punjab (Kaur

Table 1. Overall and seasonal prevalence of equine parasites in Kashmir valley

Season	Host	Total samples	Trematode	Cestode	Total platyhelminths	Total strongyles	Other nematodes				Total other nematodes	Total nematodes	Total helminths	Mixed infection	*E. leuckarti*
			A	B			C	D	E	F					
Spring	Pony	402	4 (1.00)	3 (0.75)	5 (1.24)	386 (96.02)	23 (5.72)	66 (16.42)^{b}	32 (7.96)	11 (2.74)	69 (17.16)	386 (96.02)	386 (96.02)	380 (94.53)	1 (0.25)
	Mule	69	0 (0.00)	0 (0.00)	0 (0.00)	68 (98.55)	3 (4.35)	1 (1.45)^{a}	7 (10.14)	2 (2.9)0	7 (10.14)	68 (98.55)	68 (98.55)	64 (92.75)	0 (0.00)
	Horse	21	0 (0.00)	0 (0.00)	0 (0.00)	21 (100.00)	1 (4.76)	2 (9.52)^{ab}	0 (0.00)	1 (4.76)	2 (9.52)	21 (100.00)	21 (100.00)	21 (100.00)	1 (4.76)
	Donkey	8	0 (0.00)	0 (0.00)	0 (0.00)	8 (100.00)	0 (0.00)	0 (0.00)^{a}	0 (0.00)	0 (0.00)	0 (0.00)	8 (100.00)	8 (100.00)	8 (100.00)	0 (0.00)
	Total	500	4 (0.80)	3 (0.60)^{AB}	5 (1.00)^{A}	483 (96.60)^{D}	27 (5.40)^{B}	69 (13.80)^{C}	39 (7.80)^{B}	14 (2.80)^{A}	78 (15.60)^{B}	483 (96.60)^{D}	483 (96.60)^{D}	473 (94.60)^{D}	2 (0.40)
Summer	Pony	395	0 (0.00)	0 (0.00)	0 (0.00)	358 (90.63)^{ab}	0 (0.00)	15 (3.80)^{ab}	18 (4.56)	0 (0.00)	24 (6.08)	358 (90.63)^{ab}	358 (90.63)^{ab}	358 (90.63)	0 (0.00)
	Mule	62	0 (0.00)	0 (0.00)	0 (0.00)	52 (83.87)^{a}	1 (1.61)	2 (3.23)^{ab}	1 (1.61)	3 (4.84)	5 (8.06)	52 (83.87)^{a}	52 (83.87)^{a}	50 (80.65)	1 (1.61)
	Horse	43	0 (0.00)	1 (2.33)	1 (2.33)	42 (97.67)^{b}	0 (0.00)	0 (0.00)^{a}	0 (0.00)	4 (9.30)	4 (9.30)	42 (97.67)^{b}	42 (97.67)^{b}	39 (90.70)	0 (0.00)
	Donkey	8	0 (0.00)	0 (0.00)	0 (0.00)	7 (87.50)^{ab}	0 (0.00)	1 (12.50)^{b}	0 (0.00)	0 (0.00)	1 (12.50)	7 (87.50)^{ab}	7 (87.50)^{ab}	6 (75.00)	0 (0.00)
	Total	508	0 (0.00)	1 (0.20)^{A}	1 (0.20)^{A}	459 (90.35)^{C}	1 (0.20)^{A}	18 (3.54)^{B}	19 (3.74)^{A}	7 (1.37)^{A}	34 (6.69)^{A}	459 (90.35)^{C}	459 (90.35)^{C}	453 (89.17)^{C}	1 (0.20)
Autumn	Pony	405	0 (0.00)	0 (0.00)	0 (0.00)	352 (86.91)^{b}	16 (3.95)	17 (4.20)^{a}	15 (3.70)	29 (7.16)	43 (10.62)^{b}	352 (86.91)^{b}	352 (86.91)^{b}	352 (86.91)^{b}	0 (0.00)
	Mule	42	0 (0.00)	0 (0.00)	0 (0.00)	29 (69.05)^{a}	0 (0.00)	3 (7.14)^{a}	3 (7.14)	0 (0.00)	4 (9.52)^{b}	29 (69.05)^{a}	29 (69.05)^{a}	27 (64.29)^{a}	0 (0.00)
	Horse	50	0 (0.00)	1 (2.00)	1 (2.00)	33 (66.00)^{a}	0 (0.00)	0 (0.00)^{a}	0 (0.00)	0 (0.00)	0 (0.00)^{a}	33 (66.00)^{a}	33 (66.00)^{a}	29 (58.00)^{a}	0 (0.00)
	Donkey	3	0 (0.00)	0 (0.00)	0 (0.00)	3 (100.00)^{b}	0 (0.00)	2 (66.67)^{b}	0 (0.00)	0 (0.00)	2 (66.67)^{c}	3 (100.00)^{b}	3 (100.00)^{b}	3 (100.00)^{b}	0 (0/00)
	Total	500	0 (0.00)	1 (0.20)^{A}	1 (0.20)^{A}	417 (83.40)^{B}	16 (3.20)^{B}	22 (4.40)^{B}	18 (3.60)^{A}	29 (5.80)^{B}	49 (9.80)^{A}	417 (83.40)^{B}	417 (83.40)^{B}	411 (82.20)^{B}	0 (0.00)
Winter	Pony	404	3 (0.74)^{a}	0 (0.00)	3 (0.74)^{a}	290 (71.78)^{b}	0 (0.00)	1 (0.25)^{a}	39 (9.65)	7 (1.73)	40 (9.90)	290 (71.78)^{b}	290 (71.78)^{b}	287 (71.04)^{b}	0 (0.00)
	Mule	38	0 (0.00)^{a}	0 (0.00)	0 (0.00)^{a}	23 (60.53)^{ab}	4 (10.53)	3 (7.89)^{b}	0 (0.00)	0 (0.00)	4 (10.53)	23 (60.53)^{ab}	23 (60.53)^{ab}	20 (52.63)^{a}	0 (0.00)
	Horse	46	5 (10.87)^{b}	7 (15.22)	12 (26.09)^{b}	25 (54.35)^{a}	0 (0.00)	2 (4.35)^{b}	0 (0.00)	0 (0.00)	2 (4.35)	25 (54.35)^{a}	25 (54.35)^{a}	23 (50.00)^{a}	0 (0.00)
	Donkey	12	0 (0.00)^{a}	0 (0.00)	0 (0.00)^{a}	12 (100.00)^{c}	0 (0.00)	0 (0.00)^{a}	0 (0.00)	0 (0.00)	0 (0.00)	12 (10.000)^{c}	12 (100.00)^{c}	12 (100.00^{c}	0 (0.00)
	Total	500	8 (1.60)	7 (1.40)^{B}	15 (3.00)^{B}	350 (70.00)^{A}	4 (0.80)^{A}	6 (1.20)^{A}	39 (7.80)^{B}	7 (1.40)^{A}	46 (9.20)^{A}	350 (70.00)^{A}	350 (70.00)^{A}	342 (68.40)^{A}	0 (0.00)

(Table 1 Continued)...

Table 1. *(Concluded)*

Season	Host	Total samples	Trematode A	Cestode B	Total platyhelminths	Total strongyles	Other nematodes C	D	E	F	Total other nematodes	Total nematodes	Total helminths	Mixed infection	*E. leuckarti*
Total	Pony	1606	7 (0.44)^{A}	3 (0.19)	8 (0.50)^{A}	1386 (86.30)^{BC}	39 (2.43)^{B}	99 (6.16)	104 (6.48)	47 (2.93)	176 (10.96)^{B}	1386 (86.30)^{BC}	1386 (86.30)^{BC}	1377 (85.74)^{A}	1 (0.06)^{A}
	Mule	211	0 (0.00)^{A}	0 (0.00)	0 (0.00)	172 (81.52)^{AB}	8 (3.79)^{B}	9 (4.27)	11 (5.21)	5 (2.37)	20 (9.48)^{AB}	172 (81.52)^{AB}	172 (81.52)^{AB}	161 (76.30)^{B}	1 (0.47)^{AB}
	Horse	160	5 (3.13)^{B}	9 (5.63)	14 (8.75)^{B}	121 (75.63)^{A}	1 (0.63)^{A}	4 (2.50)	0 (0.00)	5 (3.13)	8 (5.00)^{A}	121 (75.63)^{A}	121 (75.63)^{A}	112 (70.00)^{B}	1 (0.63)^{B}
	Donkey	31	0 (0.00)^{A}	0 (0.00)	0 (0.00)^{A}	30 (96.77)^{C}	0 (0.00)^{A}	3 (9.68)	0 (0.00)	0 (0.00)	3 (9.68)^{AB}	30 (96.77)^{C}	30 (96.77)^{C}	29 (93.55)^{A}	0 (0.00)^{A}
Grand total		2008	12 (0.60)	12 (0.60)	22 (1.10)	1709 (85.11)	48 (2.40)	115 (5.73)	115 (5.73)	57 (2.84)	207 (10.31)	1709 (85.11)	1709 (85.11)	1679 (83.62)	3 (0.15)

Note: Per cent values (in parenthesis) of prevalence across different hosts in a particular season that bear different small case superscript differ significantly ($P<0.05$). Per cent values (in parenthesis) of overall prevalence in different seasons for a particular parasite/group of parasites that bear different upper-case superscript differ significantly ($P<0.05$). Legend: A, Amphistomes; B, Anoplocephalids; C, *Dictyocaulus arnfieldi*; D, *Strongyloides westeri*; E, *Parascaris equorum*; F, *Oxyuris equi*.

and Kaur 2008) has been reported. Incidence of *Parascaris equorum* was found to be almost similar to the incidence reported by Pandit *et al.* (2008) (4.01%) and Maria *et al.* (2012) (4.36%) from Kashmir and that of Khajuria *et al.* (2004) (4.68%) and Singh *et al.* (2012) (4.82%) from Jammu. In other states of India, incidence ranging from as low as 1.84% in equines of Haryana (Sengupta and Yadav 1998) to as high as 84.61% in horses of Patiala, Punjab (Kaur and Kaur 2008) has been reported. The prevalence of *Oxyuris equi* recorded in the current study was lower than the prevalence rate of 9.40% and 8.18% reported by Pandit *et al.* (2008) and Maria *et al.* (2012), respectively from equines of Kashmir and is also lower than the incidence rate of 7.10% reported by Singh *et al*. (2012) from Jammu. In other states of India, incidence ranging from as low as 0.13% in horses of Rajasthan (Pilania *et al.* 2013) to as high as 6.65% in equines of Kangra valley, Himachal Pradesh (Singh 2003) has been reported. The chances of finding the eggs of *O. equi* in equine faecal samples are comparatively low because the gravid females of these worms travel to the opening of the anus to deposit their eggs in the perineal region. Therefore, for finding the exact incidence of this parasite, the perineal swabs should be examined, which is time consuming.

Since the eggs of lungworms are passed in faeces because of sputum being swallowed by animals, therefore, for the sake of convenience, they are considered together with other GI parasites. The prevalence rate of *Dictyocaulus arnfieldi* (2.40%) recorded in current study is lower than 14.10% and 13.09% reported earlier from the equines of Kashmir valley by Pandit *et al.* (2008) and Maria *et al.* (2012), respectively. The incidence of this nematode has been reported as 0.59% in equines of Tarai region of Uttaranchal (Sengupta and Yadav 1997), 18.37% in horses of Himachal Pradesh (Katoch *et al.,* 2006b), 0.38% in equines of Mumbai and Pune regions of Maharashtra (Matto *et al.* 2013) and 14.28% in mules of Western Himalayas (Sengupta and Yadav 2003).

The eggs of only trematode parasite encountered in present study were those of paramphistomes with a very low prevalence rate (0.60%) (Table 1), which is almost similar to the prevalence rate of 0.91% reported earlier from equines of Kashmir by Pandit *et al.* (2008) but lower than the incidence of 4.06% reported from equines of Jammu by Singh *et al.* (2012). From other states of India, incidence ranging from as low as 1.80% in organised sector (Sengupta and Yadav 2001) to as high as 10.11% in equines of unorganised sector, (Sengupta and Yadav 1997) has been reported. Amongst the paramphistomes, two species, i.e. *Pseudodiscus collinsi* (Varma 1957) and *Gastrodiscus aegyptiacus* (Shreekumaran and Chaubal 1974) have been reported in equines from India. The equids harbour only three species of tapeworms, viz. *Anoplocephala perfoliata* (most pathogenic), *A. magna* (largest) and *A. mamillana* (formerly *Paranoplocephala mamillana*). Since the eggs of these three species cannot be exactly differentiated from each other, therefore, it is not possible to identify

Table 2. Host, age and sex-wise prevalence of equine parasites in Kashmir valley

Type of equine	Age	Total samples	Trematode	Cestode	Total platyhelminths	Total strongyles	Other nematodes				Total other nematodes	Total nematodes	Total helminths	*E. leuckarti*
			A	B			C	D	E	F				
Pony	Adult	1213	4 (0.33)	3 (0.25)	5 (0.41)	1042 (85.90)	34 (2.80)	83 (6.84)^{b}	85 (7.01)	34 (2.80)	144 (11.87)^{b}	1042 (85.90)	1042 (85.90)	0 (0.00)
	Young	393	3 (0.76)	0 (0.00)	3 (0.76)	344 (87.53)	5 (1.27)	16 (4.07)^{a}	19 (4.83)	13 (3.31)	32 (8.14)^{a}	344 (87.53)	344 (87.53)	1 (0.25)
	Total	1606	7 (0.44)^{A}	3 (0.19)	8 (0.50)^{A}	1386 (86.30)^{BC}	39 (2.43)^{B}	99 (6.16)	104 (6.48)	47 (2.93)	176 (10.96)^{B}	1386 (86.30)^{BC}	1386 (86.30)^{BC}	1 (0.06)^{A}
	Male	1044	3 (0.29)	2 (0.19)	3 (0.29)	889 (85.15)	25 (2.39)	59 (5.65)	61 (5.84)	22 (2.11)^{a}	97 (9.29)^{a}	889 (85.15)	889 (85.15)	1 (0.10)
	Female	562	4 (0.71)	1 (0.18)	5 (0.89)	497 (88.43)	14 (2.49)	40 (7.12)	43 (7.65)	25 (4.45)^{b}	79 (14.06)^{b}	497 (88.43)	497 (88.43)	0 (0.00)
Mule	Adult	168	0 (0.00)	0 (0.00)	0 (0.00)	143 (85.12)^{b}	6 (3.57)	6 (3.57)	10 (5.95)	2 (1.19)^{a}	15 (8.93)	143 (85.12)^{b}	143 (85.12)^{b}	0 (0.00)^{a}
	Young	43	0 (0.00)	0 (0.00)	0 (0.00)	29 (67.44)^{a}	2 (4.65)	3 (6.98)	1 (2.33)	3 (6.98)^{b}	5 (11.63)	29 (67.44)^{a}	29 (67.44)a	1 (2.33)^{b}
	Total	211	0 (0.00)^{A}	0 (0.00)	0 (0.00)	172 (81.52)^{AB}	8 (3.79)^{B}	9 (4.27)	11 (5.21)	5 (2.37)	20 (9.48)^{AB}	172 (81.52)^{AB}	172 (81.52)^{AB}	1 (0.47)^{AB}
	Male	123	0 (0.00)	0 (0.00)	0 (0.00)	99 (80.49)	6 (4.88)	0 (0.00)^{a}	4 (3.25)	1 (0.81)	6 (4.88)^{a}	99 (80.49)	99 (80.49)	0 (0.00)
	Female	88	0 (0.00)	0 (0.00)	0 (0.00)	73 (82.95)	2 (2.27)	9 (10.23)^{b}	7 (7.95)	4 (4.54)	14 (15.91)^{b}	73 (82.95)	73 (82.95)	1 (1.14)
Horse	Adult	128	0 (0.00)^{a}	6 (4.69)	6 (4.69)^{a}	95 (74.22)	1 (0.78)	1 (0.78)^{a}	0 (0.00)	5 (3.91)	5 (3.91)	95 (74.22)	95 (74.22)	0 (0.00)^{a}
	Young	32	5 (15.63)^{b}	3 (9.38)	8 (25.00)^{b}	26 (81.25)	0 (0.00)	3 (9.38)^{b}	0 (0.00)	0 (0.00)	3 (9.38)	26 (81.25)	26 (81.25)	1 (3.13)^{b}
	Total	160	5 (3.13)^{B}	9 (5.63)	14 (8.75)^{B}	121 (75.63)^{A}	1 (0.63)^{A}	4 (2.50)	0 (0.00)	5 (3.13)	8 (5.00)^{A}	121 (75.63)^{A}	121 (75.63)^{A}	1 (0.63)^{B}
	Male	98	0 (0.00)^{a}	6 (6.12)	6 (6.12)	95 (96.94)^{b}	1 (1.02)	2 (2.04)	0 (0.00)	5 (5.10)	6 (6.12)	95 (96.94)^{b}	95 (96.94)^{b}	0 (0.00)
	Female	62	5 (8.06)^{b}	3 (4.84)	8 (12.9)	26 (41.94)^{a}	0 (0.00)	2 (3.23)	0 (0.00)	0 (0.00)	2 (3.23)	26 (41.94)^{a}	26 (41.94)^{a}	1 (1.61)
Donkey	Adult	31	0 (0.00)	0 (0.00)	0 (0.00)	30 (96.77)	0 (0.00)	3 (9.68)	0 (0.00)	0 (0.00)	3 (9.68)	30 (96.77)	30 (96.77)	0 (0.00)
	Young	0	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Total	31	0 (0.00)^{A}	0 (0.00)	0 (0.00)^{A}	30 (96.77)^{C}	0 (0.00)^{A}	3 (9.68)	0 (0.00)	0 (0.00)	3 (9.68)^{AB}	30 (96.77)^{C}	30 (96.77)^{C}	0 (0.00)^{A}

(Table 2 Continued)...

Table 2. *(Concluded)*

Type of equine	Age	Total samples	Trematode A	Cestode B	Total platyhelminths	Total strongyles	Other nematodes C	D	E	F	Total other nematodes	Total nematodes	Total helminths	*E. leuckarti*
	Male	23	0 (0.00)	0 (0.00)	0 (0.00)	22 (95.65)	0 (0.00)	2 (8.70)	0 (0.00)	0 (0.00)	2 (8.70)	22 (95.65)	22 (95.65)	0 (0.00)
	Female	8	0 (0.00)	0 (0.00)	0 (0.00)	8 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	1 (12.50)	8 (100.00)	8 (100.00)	0 (0.00)
Total	Adult equines	1540	4 (0.26)^{a}	9 (0.58)	11 (0.71)^{a}	1310 (85.06)	41 (2.66)	93 (6.04)	95 (6.17)	41 (2.66)	167 (10.84)	1310 (85.06)	1310 (85.06)	0 (0.00)^{a}
	Young equines	468	8 (1.71)^{b}	3 (0.64)	11 (2.35)^{b}	399 (85.26)	7 (1.50)	22 (4.70)	20 (4.27)	16 (3.42)	40 (8.55)	399 (85.26)	399 (85.26)	3 (0.64)^{b}
	Male equines	1288	3 (0.23)^{a}	8 (0.62)	9 (0.70)^{a}	1105 (85.79)	32 (2.48)	63 (4.89)^{a}	65 (5.05)	28 (2.17)^{a}	111 (8.62)^{a}	1105 (85.79)	1105 (85.79)	1 (0.08)
	Female equines	720	9 (1.25)^{b}	4 (0.56)	13 (1.81)^{b}	604 (83.89)	16 (2.22)	52 (7.22)^{b}	50 (6.94)	29 (4.03)^{b}	96 (13.33)^{b}	604 (83.89)	604 (83.89)	2 (0.28)
Grand total		2008	12 (0.60)	12 (0.60)	22 (1.10)	1709 (85.11)	48 (2.40)	115 (5.73)	115 (5.73)	57 (2.84)	207 (10.31)	1709 (85.11)	1709 (85.11)	3 (0.15)

Note: Per cent values (in parenthesis) of host wise and total prevalence between adult and young equines bearing different small case superscript differ significantly ($P<0.05$). Overall prevalence values for different hosts bearing different upper-case superscripts differ significantly ($P<0.05$). Legend:A, Amphistomes; B, Anoplocephalids; C, *Dictyocaulus arnfieldi*; D, *Strongyloides westeri*; E, *Parascaris equorum*; F, *Oxyuris equi*.

the infection with particular species by faecal sample examination. Accordingly in the present study, incidence of anoplocephalids (0.60%) was recorded (Table 1), and is lower than the incidence of 8.14 and 1.45% reported earlier from equines of Kashmir by Pandit *et al.* (2008) and Maria *et al.* (2012), respectively. In other states of India, incidence ranging from as low as 0.07% in equines of Mumbai and Pune regions of Maharashtra (Matto *et al.* 2013) to as high as 9.09% in horses of Rajasthan (Kachhawa *et al.* 2015) have been reported.

In the present study, the GI protozoa recorded was *E. leuckarti* (Table 1). This protozoan parasite has also been reported earlier from equines of Kashmir valley by Pandit *et al.* (2008) with prevalence rate of 0.91%. In India, *Eimeria leuckarti* was first reported from a horse by Hiregaudar (1956) and since then its occurrence in equines has been sporadically documented (Sengupta and Yadav 1998, Sharma *et al.* 1998, Pandit *et al.* 2008, Sudan *et al.* 2013, Valibasha *et al.* 2019).

Seasonal prevalence: The seasonal occurrence of overall GI helminths revealed highest infection rate in spring followed by summer, autumn and winter, varying significantly ($P<0.05$) with respect to all the seasons (Table 1). The present findings are almost in full agreement with those of Maria *et al.* (2012) who reported highest rate of infection in spring (100.00%) followed by summer (99.00%), autumn (94.66%) and winter (88.00%) but differ slightly from Pandit *et al.* (2008) who reported highest but similar rate of infection (100.00%) in spring and autumn followed by summer (91.03%) and winter (80.26%) in equines of Kashmir, having temperate climate. From tropical Jammu region, Singh *et al.* (2012) reported highest rate of infection in monsoon and post monsoon seasons (79.35 and 74.28%, respectively) followed by summer (69.23%) and winter (59.70%).

The total strongyle infection followed the same seasonal pattern, i.e. highest infection rate was recorded in spring, followed by summer, autumn and winter, varying significantly ($P<0.05$) with respect to all the seasons (Table 1). The lowest rate of infection in winter might be due to arrested development of cyathostomes in mucosa during unfavourable environmental conditions for free living stages. The resumption of development of these arrested stages results in maturation of these worms and egg production in spring. *Parascaris equorum* infection was found to be 7.80% in spring and winter seasons, followed by 3.74% in summer and 3.60% in autumn. *Oxyuris equi* was found to be most prevalent in autumn season followed by spring, winter and summer. Prevalence of *Strongyloides westeri* as found in present study was highest in spring season followed by autumn, summer and winter. Highest prevalence of *Dictyocaulus arnfieldi* was found in spring season followed by autumn, winter and summer season.

The paramphistome infection was recorded only in winter and spring seasons (Table 1). In the earlier studies, Pandit *et al.* (2008) has recorded the occurrence of paramphistomes in equines of Kashmir valley only in

Table 3. Season-wise intensity (EPG) of nematodes in equines of Kashmir valley

Season	Species	Total EPG	*Oxyuris* spp.	*Parascaris* spp.
Spring	Pony	857.96±63.35	1.43^{AB}±0.86	0.71±0.50
	Horse	562.86±141.83	0.00±0.00	0.00±0.00
	Mule	765.47±92.70	0.00±0.00	0.00±0.00
	Donkey	579.17±203.86	0.00±0.00	0.00±0.00
	Total	774.65^{B}±48.73	0.80±0.49	0.40^{AB}±0.28
Summer	Pony	1373.00^{B}±159.04	0.00^{A}±0.00	0.00±0.00
	Horse	1015.25^{AB}±140.44	0.00±0.00	0.00±0.00
	Mule	1210.00^{B}±109.08	0.00±0.00	0.00±0.00
	Donkey	625.00^{A}±259.33	0.00±0.00	0.00±0.00
	Total	1165.04^{C}±77.24	0.00±0.00	0.00^{A}±0.00
Autumn	Pony	782.93±141.85	5.49^{B}±3.76	0.00±0.00
	Horse	739.53±109.54	0.00±0.00	0.00±0.00
	Mule	823.21±114.58	0.00±0.00	0.00±0.00
	Donkey	225.00±218.80	0.00±0.00	0.00±0.00
	Total	760.30^{B}±68.48	1.80±1.24	0.00^{A}±0.00
Winter	Pony	349.47^{AB}±97.74	0.00^{A}±0.00	4.00±2.79
	Horse	410.37^{B}±71.03	1.88±1.88	1.88±1.88
	Mule	199.17^{AB}±62.57	0.00±0.00	0.00±0.00
	Donkey	34.38^{A}±27.52	0.00±0.00	0.00±0.00
	Total	313.49^{A}±46.35	0.60±0.60	2.20^{B}±1.27

Note: Mean EPG values for a particular parasite (in a column) across rows bearing different uppercase superscripts differ significantly (P<0.05).

spring season (1.37%) while as Sengupta and Yadav (1997) recorded the occurrence of paramphistomes in equines of Tarai region of Uttar Pradesh only in summer (30.90%). Data on seasonal prevalence of paramphistomes in equines from various other states of India is lacking. In the present study, the light infection of anoplocephalids was recorded in all the seasons (Table 1). The present findings are similar to that of Maria *et al.* (2012) who recorded highest infection rate in winter season (4.00%) but contrary to the findings of Pandit *et al.* (2008) who recorded highest infection rate of anoplocephalids in spring season (16.51%). Data on seasonal prevalence of these equine cestodes from other states of India is lacking. The GI protozoa, *E. leuckarti* was recorded only in spring and summer seasons (Table 1).

Age-wise prevalence: In the present study, overall prevalence of GI helminths was found to be non-significantly higher in young equines compared to adult equines (Table 2), which is similar to that reported by Maria *et al.* (2012), as regards higher infection in young equines (96.8%) as compared to adult equines (94.11%) in central Kashmir. The prevalence of Strongyles, *Oxyuris equi*, paramphistomes and anoplocephalids was found non-significantly higher in young equines as compared to adult equines but prevalence of *D. arnfieldi*, *Strongyloides westeri* and *Parascaris equorum* was found to be non-significantly higher in adult equines as compared to young equines (Table 2). The non- significantly higher prevalence of *D. arnfieldi*, *Strongyloides westeri* and *Parascaris equorum* in adult equines as compared to young ones might be due to very less number of faecal samples examined from young animals as compared to adult animals. *E. leuckarti* was recorded only in young ones (Table 2).

Sex-wise prevalence: Platyhelminth infection was found to be significantly (P<0.05) higher in females compared to males (Table 2), which is similar to that reported by Maria *et al.* (2012), as regards higher infection in females (98.93%) compared to males (92.83%) in central Kashmir but nematode infection was found non-significantly higher in males than in females (Table 2). These non-significant differences might again be due to less number of samples

Table 4. Host, age and sex-wise intensity (EPG) of nematodes of equines in Kashmir valley

Host	EPG				
	Adult	Young	Total	Male	Female
Pony*	664.73±57.97	$1281.63±136.07^{b}$	$825.93±58.71^{b}$	575.00±58.19	$1198.00±105.08^{b}$
Horse*	617.56±58.27	$1100.65±206.59^{b}$	$694.72±60.51^{b}$	454.52±52.65	$1132.75±119.69^{b}$
Mule	771.49±68.05	$853.53±116.02^{b}$	$790.72±58.65^{b}$	648.52±69.28	$1030.37±98.27^{b}$
Donkey	519.74±135.51	$0.00±0.00^{a}$	$365.74±105.42^{a}$	431.94±137.06	$233.33±158.82^{a}$
Overall*	673.24±34.32	1034.02±85.30	755.20±33.47	553.21±33.94	1089.43±61.93

Note:Age and Sex-wise mean EPG of different hosts bearing different small case superscript differ significantly (P<0.05). Astrik mark (*) indicates significant difference in mean EPG across adjacent columns.

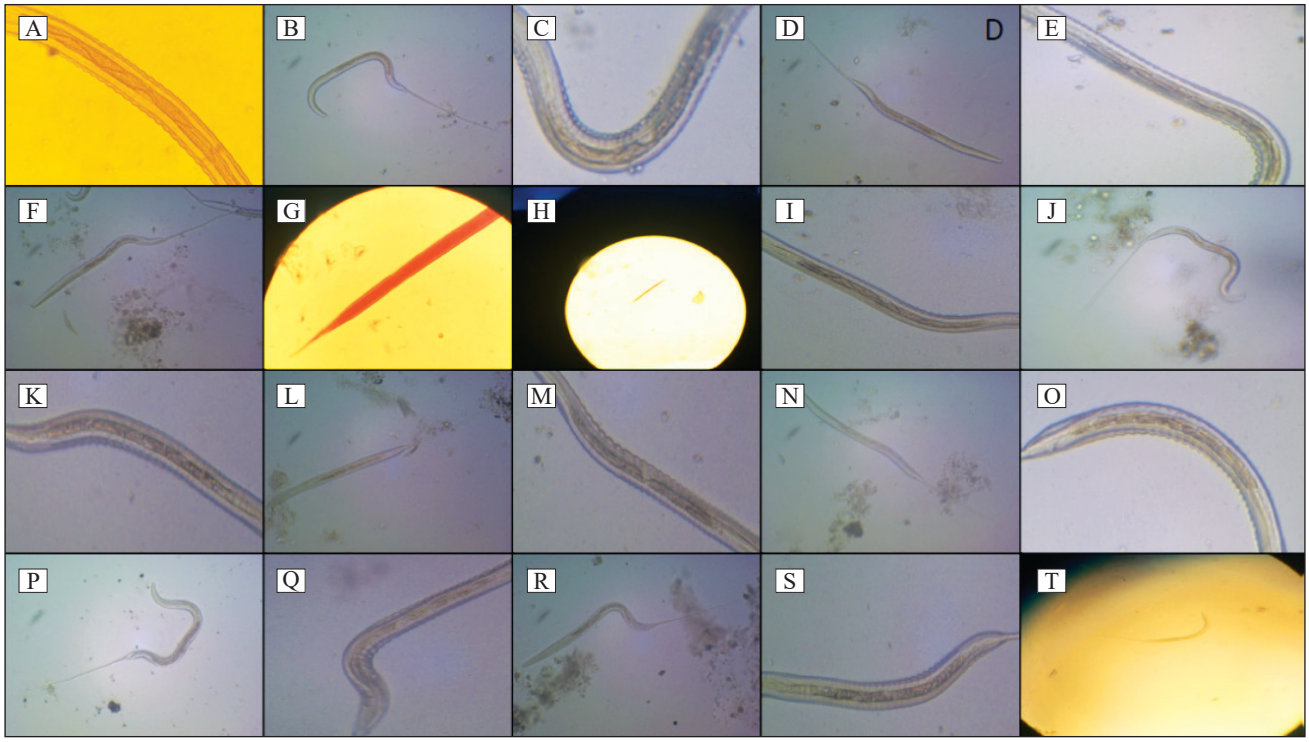

Fig. 1. Coproculture showing L_3 larvae of various strongyle worms A & B: *Cyathostomum* spp. (Well defined 8 triangular intestinal cells); C & D: *Triodontophorus* spp. (Broad larva with 18-20 triangular intestinal cells); E & F: *Oesophagodontus* spp. (Well defined 16 triangular intestinal cells); G & H: *Trichostrongylus* spp. (Tail of sheath short and conical); I & J: *Gyalocephalus* spp. (12 clear intestinal cells); K & L: *S. edentatus* (Thin and elongated larva having 18-20 indistinct cells); M & N: *Poteriostomum* spp. (Clearly defined 16 roughly rectangular intestinal cells); O & P: *S. vulgaris* (Large broad larva with 28-32 distinct rectangular intestinal cells); Q & R: S. *equines* (Thin larva with 16 indistinct intestinal cells); S & T: Other larva (dark indistinct intestinal cells). A, C, E, G, I, K, M, O, Q, S, (400X) and B, D, F, H, J, L, N, T (100X).

examined from females as compared to males. *E. leuckarti* was recorded non-significantly higher in females than in males (Table 2).

Intensity of infection: The overall mean EPG in equines was found to be 755.20±33.47. Higher intensity of infection (EPG) was found in ponies followed by mules, horses and donkeys with non-significant statistical variation (Table 4). Our observations varied from those of Maria *et al.* (2012) who reported the mean EPG of 1546.45±345.47 in equines of central Kashmir. Possible reason for lower EPG in present study as compared to previous one might be attributed to increased awareness amongst equine owners regarding deworming of animals. Highest mean EPG was found to be in summer followed by spring, autumn and winter. The variation in the intensity of infection with respect to seasons was statistically significant ($P<0.05$) except between autumn and spring where it was non-significant (Table 3). Our observations are in line with those of Devender (2002) and Maria *et al.* (2012) who reported highest EPG in summer and lowest in winter in equines of Uttaranchal and central Kashmir, respectively. The reason for highest EPG in summer is favourable environmental conditions in summer for development of free-living stages and unfavourable environmental conditions for development of free-living stages in winter because of which larvae undergo arrested development within the mucosa of intestine leading to lowest EPG. Significantly higher EPG was recorded in young equines compared to adult equines (Table 4) which is possibly due to development of age immunity by adults compared to young ones. Similarly, significantly higher EPG was recorded in females compared to males (Table 4), which can be attributed to stress factors like pregnancy and lactation in which there is relaxation of immunity. Our results are in agreement with those of Maria *et al.* (2012) as regards higher intensity of infection in young and female equines in central Kashmir.

Coproculture: The per cent prevalence of different strongylid worms harvested from equine coprocultures were *Cyathostomum* spp. (63.67%), followed by *Triodontophorus* spp. (18.17%), *Oesophagodontus* spp. (5.00%), *Trichostrongylus* spp. (4.50%), *Gyalocephalus* spp. (2.92%), *Strongylus edentatus* (1.83%), *Poteriostomum* spp. (1.5%), *S. vulgaris* (1.33%), *S. equinus* (1.00%) and other larvae (0.08%) (Fig.1). The predominance of *Cyathostomum* spp. in equine coprocultures over other strongylid worms has also been reported by Singh *et al.* (2002) from Uttaranchal and Uttar Pradesh and Maria *et al.* (2012) from central Kashmir. However, predominance of *Strongylus* spp. in coprocultures over other strongylid worms has been reported in equines of Tarai region of Uttar Pradesh (Sengupta and Yadav 1997), Haryana (Sengupta and Yadav 1998), Rajasthan (Sengupta and

Yadav 2001) and Western Himalayas (Sengupta and Yadav 2003).

In conclusion, the present study records the prevalence of *Cyathostomum* spp., *Triodontophorus* spp., *Oesophagodontus* spp., *Trichostrongylus* spp., *Dictyocaulus arnfieldi*, *Strongyloides westeri*, *Parascaris equorum, Gyalocephalus* spp., *Strongylus edentatus*, *Poteriostomum* spp., *S. vulgaris*, *S. equinus,* paramphistomes*,* anoplocephalids and *Eimeria leuckarti* GI parasites in equines of Kashmir valley. Prevalence of parasites was found highest in donkeys followed by ponies, mules, and horses. Significantly, the highest prevalence rate was recorded in spring followed by summer, autumn and least in winter. The highest intensity of infection was found in summer season followed by spring, autumn and lowest in winter. Significantly, higher EPG was recorded in young ones compared to adult equines and in females than males. It is concluded that deworming of equines in Kashmir valley should be carried out at least two times a year, i.e. mid-spring (April) and mid-autumn (October) to keep the parasitic load under control, with due consideration to anthelmintic resistance.

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