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Influence of sheep breeds on the susceptibility to strongyle infection in Rajasthan

D SINGH[1] and C P SWARNKAR[2]

Central Sheep and Wool Research Institute, Avikanagar, Rajasthan 304 501 India

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ABSTRACT

A study was conducted to observe the influence of sheep breeds on the susceptibility to natural strongyle infection in Rajasthan. Faecal samples (39,896) from native, crossbred and exotic sheep managed under farm condition in both arid and semi-arid agro-climate of Rajasthan were evaluated for incidence and intensity of strongyle infection (predominated by *Haemonchus contortus*). In semi-arid region, parasitological profile showed relatively the lowest susceptibility of Garole and its crosses followed by Malpura, Chokla, Kheri and the highest susceptibility in crossbreds. Like-wise in arid region, the lowest susceptibility was expressed by Nali sheep followed by Marwari, Chokla, crossbreds and the highest susceptibility by exotic sheep. During wormy season, at Arid Region Campus, Bikaner, Marwari sheep possessed greater resistance compared to Magra sheep. It was also observed that similar genotype of sheep vary in susceptibility according to agroclimatic conditions and resultant pasture infectivity. The over-dispersion phenomenon in faecal egg counts suggested that inter-individual variation in susceptibility to natural infection was of more importance than inter-breed differences. Further the study suggested that for selection for resistance to GIN infection in Indian sheep under natural condition might be possible.

Key words: Breeds, Gastrointestinal nematodes, Rajasthan, Sheep, Susceptibility

Infection with gastrointestinal nematodes (GINs), negatively affecting health and overall productivity of infected animals, can be a major cause of economic losses in small ruminant production (Singh *et al*. 2011b). Studies reported a moderate to high prevalence of infection in sheep with *Haemonchus, Trichostrongylus* and *Oesophagotomum* spp as the most common nematode genera of economic importance (Singh and Swarnkar 2011). Today, the control of GIN in sheep has become less effective due to the development of anthelmintic resistance (Swarnkar and Singh 2012). Furthermore, the climate change will probably lead to changes in epidemiology and intensity of parasite infections (van Dijk *et al*. 2010). Determination of the resistance of breed types to GI nematode infections is imperative because of the crisis of the sheep husbandry threatened by strains of GINs that are resistant to available anthelmintics. Important breeds identified as resistant to endoparasites are Florida native (Zajac *et al*. 1990) and St. Croix (Gamble and Zajac 1992) from USA; Red Massai (Baker *et al*. 1993) from East Africa and Djallonke (Baker 1995) from West Africa and many other breeds from various parts of the world. In addition, some other breeds, which are not fully characterized but appear to be resistant includes Sabi in Zimbabwe (McKenzie 1986) and Garole in India (Ghalsasi *et al*. 1994, Singh *et al*. 2011a). It is believed that the breed differences in FEC and worm burden are under genetic control, and these are also heritable (Good *et al*. 2006).

In India Malpura sheep had low susceptibility for haemonchosis compared to high susceptibility of Sonadi (Pachlag and Kumar 1974) in Rajasthan; Coimbatore breed excreted fewer worm eggs in faeces compared to purebred Merino, Rambouillet and their crosses (Sanyal 1988); Munjal (Nali × Lohi) lambs had low susceptibility for *H. contortus* than Hisardale (Nali × Corriedale) (Yadav *et al*. 1993); Malpura lambs showed minimum susceptibility to GINs followed by Avikalin (50% exotic inheritance); and maximum in Bharat Merino (75% exotic inheritance) in semi-arid region of Rajasthan (Swarnkar *et al*. 1997). Since, most of the studies were based on smaller number of observations over limited period of time, the present study was conducted on extensive set of data to determine the relative susceptibility to GINs in different breeds managed in organised farms in different agroclimatic conditions of Rajasthan.

MATERIALS AND METHODS

Animals and study areas: The sheep breeds used in present study were native (Malpura, Chokla, Marwari, Magra, Nali and Kheri), indigenous (Garole and its crosses with Malpura),

Present address: [1]Principle Scientist (dherindra.singh56 @gmail.com), [2]Scientist (Selection Grade, swarnkarcp @yahoo.com), Division of Animal Health.

crossbred (Avikalin, Rambouillet crosses) and exotic (Rambouillet). Malpura, Chokla, Kheri, Garole and its crosses and Avikalin sheep were maintained at Central Sheep and Wool Research Institute (CSWRI), Avikanagar (semi-arid Rajasthan). Chokla, Marwari, Nali, Rambouillet crosses, and Rambouillet sheep were maintained at Sheep Breeding Farm (SBF), Fatehpur (arid Rajasthan) while Marwari and Magra were maintained at Arid Region Campus (ARC), CSWRI, Bikaner (Arid Rajasthan). All the sheep were raised under semi-intensive management system. Prophylactic health measures against enterotoxaemia, *peste des petits ruminants* and sheep pox were practiced in the flocks. For management of GINs, strategic anthelmintic intervention (closantel or tetramisole on annual rotation) were given during monsoon (August or September) as per modified worm management programme (Swarnkar *et al*. 2008). Sporadically on few occasions additional tactical drench was given at SBF, Fatehpur. On the other hand in Marwari flocks at both the farms, GINs were managed through targeted selective treatment approach (Singh and Swarnkar 2012).

Parasitological measurements: Fresh faecal samples (around 10% of sheep in flock per occasion) were taken directly from the rectum of the individual sheep at monthly interval. Faecal samples (39,896) were examined from December 2001 to March 2013. The samples were evaluated for incidence (Soulsby 1965) and intensity (eggs per gram of faeces, FEC) of strongyle worms was determined by a modified McMaster method (MAFF 1984) using saturated sodium chloride as the flotation fluid.

Data analyses: The incidence data (arc-sin transformed) were analyzed by cross-tab analysis and tested for significance using chi-square test. The data on intensity of strongyle infection ($\log_{10}$ FEC + 10) were tested to observe the effect of breed within agroclimatic region as well variation in breed between agroclimatic regions by univariate analysis using general linear model. The monthly mean FECs were compared by LSD (least square differences) using SPSS ver 16.

RESULTS AND DISCUSSION

Breed-wise incidence of strongyle infection: In semi-arid region, breed of sheep had significant ($P<0.05/0.001$) effect on monthly incidence of strongyle infection throughout the year except during April, July and September (Table 1). In another sheep (Fatehpur) farm located in arid region, breed had significant ($P<0.05/0.001$) effect on monthly incidence throughout the year. The variation among monthly incidence pattern in 2 agroclimatic conditions could be reflection of level of herbage infectivity, type of anthelmintic used as well as amount and timing of precipitation. At SBF Fatehpur, among different breeds, Nali sheep showed relatively lower monthly incidence on majority of occasions suggesting that Nali sheep are relatively less susceptible to strongyle worms compared to other breeds. Compared to exotic and crossbred sheep, the higher incidence in native Marwari sheep during September – October was due to variation in anthelmintic intervention strategy as Marwari sheep were managed through targeted selective approach while other breeds were given whole flock treatment approach at strategic time (August-September). At ARC, Bikaner, Marwari sheep showed lower monthly incidence than Magra sheep during wormy season.

Comparison of monthly incidence of strongyle worms in crossbred and Chokla sheep reared in 2 different agro-climates exhibited that on majority of occasions the incidence was higher in semi-arid region compared to arid region

Table 1. Monthly incidence (%) of strongyle worms in different breeds of sheep in Rajasthan

Breed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CSWRI Avikanagar												
Malpura	60.4	56.7	70.3	65.2	83.6	91.7	77.3	86.9	87.8	78.7	78.9	71.0
Cross bred	59.0	55.6	63.8	66.4	83.0	91.7	77.3	81.9	89.0	76.8	77.5	67.6
Garole crooses	43.7	39.8	45.6	56.9	70.9	82.2	77.6	76.9	85.3	55.0	65.0	50.0
Chokla	62.5	40.0	50.0	66.7	80.0	88.9	100.0	93.3	100.0	50.0	66.7	90.9
Kheri	56.8	38.5	50.0	58.8	69.4	85.7	87.0	85.7	100.0	52.1	70.8	47.7
Significance	*	**	**	NS	*	*	NS	*	NS	**	*	**
SBF Fatehpur												
Exotic	48.5	59.6	54.3	81.9	45.0	71.4	84.6	80.1	78.0	75.5	66.7	47.4
Cross bred	44.7	48.1	54.8	71.9	49.7	54.0	77.2	72.7	72.2	78.1	61.5	43.8
Marwari	31.6	40.1	58.1	24.2	39.1	59.2	73.3	89.1	94.5	84.2	51.3	36.6
Chokla	55.4	57.7	56.8		62.5	71.2	94.7	90.2	92.0	86.0		47.1
Nali	29.8	32.2	36.8	59.6	77.7	81.1	58.0	72.8	75.0	64.6	62.0	26.9
Significance	**	**	**	**	**	**	**	**	**	**	*	**
ARC Bikaner												
Magra							41.1	50.0	53.1	76.3	68.9	
Marwari							40.3	45.5	42.5	54.6	37.2	
Significance							NS	NS	*	**	**	

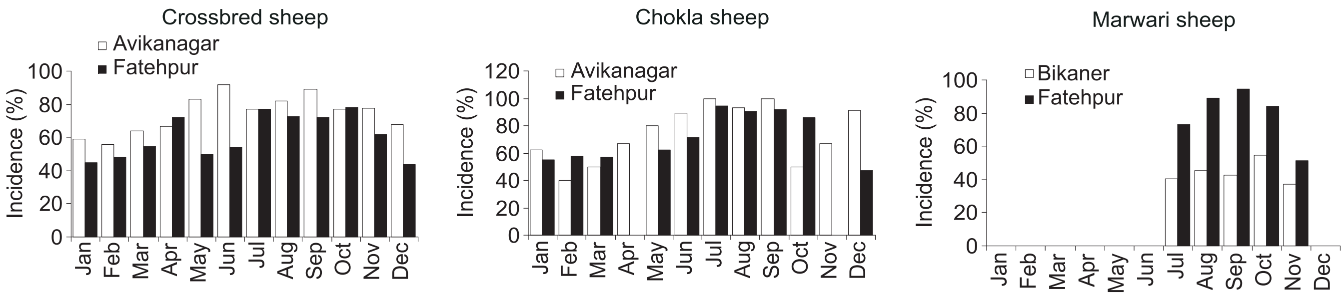

Fig. 1. Comparative incidence (%) of strongyle worms in different agro-climate of Rajasthan.

(Fig. 1). Like-wise comparative incidence in Marwari sheep at 2 locations in arid region showed lower incidence in more arid area (ARC, Bikaner). Though the observed variations were mainly attributed to climatic conditions and pasture infectivity but the data indicated that same breed of animal had varying level of response depending on exogenous factors.

Breed-wise variation in intensity of strongyle infection within zone: In semi-arid region, the magnitude of FECs remained <500 epg from January to April and attained a peak during the period from July to September in all the breeds (Fig. 2). The mean monthly intensity of strongyle infection ranged significantly (P<0.001) from 169.0±9.1 (February) to 1,743.0±99.5 epg (September) in Malpura, from 66.7±21.1 (April) to 1,446.7±420.3 epg (August) in Chokla, from 97.4±36.3 (February) to 2,641.3±472.8 epg (July) in Kheri, from 189.5±15.1 (February) to 1,205.6±143.9 epg (July) in Garole and its crosses and from 189.5±11.7 (February) to 2,204.7±157.3 epg (September) in crossbred sheep. The monthly FECs differed significantly (P<0.05/0.001) among breeds throughout the year except in August and October. In general, relatively lower intensity of strongyle infection was observed in Garole and its crosses followed by native breeds and maximum in crossbred sheep.

At SBF Fatehpur, the magnitude of FECs remained <500 epg from December to March in exotic and crossbred sheep and from November to May in native breeds. The peak of intensity was attained during monsoon (July to October) depending on timing of anthelmintic intervention (Fig. 3). The mean monthly intensity of strongyle infection ranged significantly (P<0.001) from 184.9±24.6 (January) to 2,238.2±195.3 epg (September) in Rambouillet, from 191.7±17.7 (January) to 1,820.6±110.7 epg (October) in Crossbred, from 68.2±20.3 (April) to 3,398.5±417.8 epg (September) in Marwari, from 118.5±19.7 (January) to 1,810.5±347.0 epg (July) in Chokla and from 49.1±7.5 (December) to 732.8±139.7 epg (September) in Nali breed. The monthly FECs differed significantly (P<0.05/0.001) among breeds throughout the year except in May. In general, relatively lower intensity of strongyle infection was observed in Nali followed by Marwari, Chokla, crossbred and higher in exotic sheep. The higher peak in Marwari sheep was due to application of targeted selective treatment and sampling from visually anaemic sheep.

At ARC, Bikaner the intensity of strongyle infection remained <500 epg during monsoon season in both the breeds. The breed differences in monthly FECs remained nonsignificant (P>0.05) from July to September, however FECs were significantly (P<0.001) higher in Magra breed during October-November compared to Marwari breed (Fig. 4).

Zonal variation in intensity of strongyle infection within

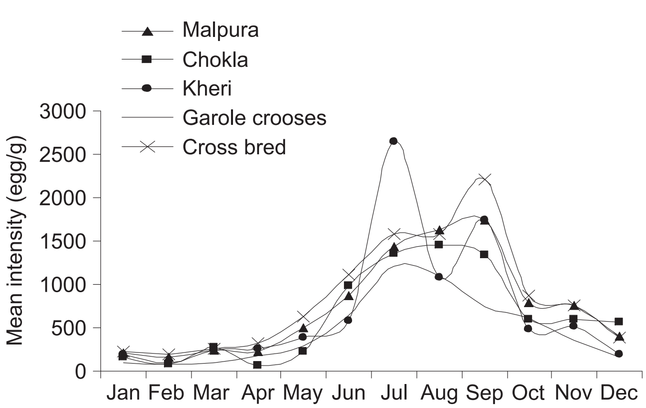

Fig. 2. Breed-wise monthly mean FECs in sheep at CSWRI, Avikanagar.

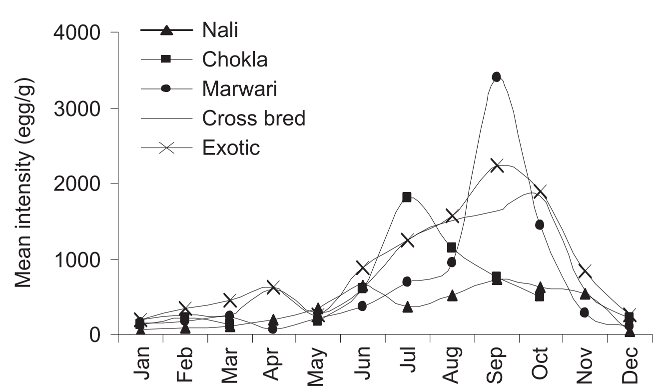

Fig. 3. Breed-wise monthly mean FECs in sheep at SBF, Fatehpur.

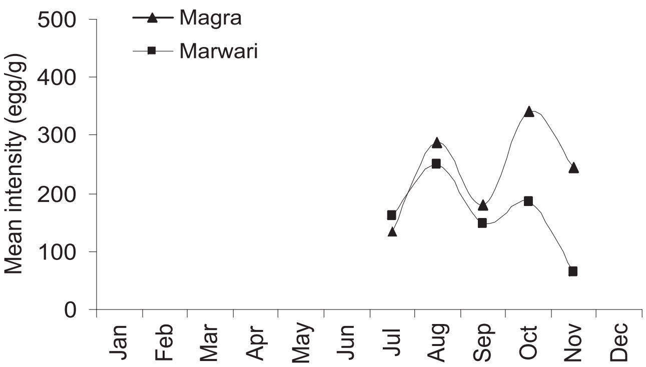

Fig. 4. Breed-wise monthly mean FECs in sheep at ARC, Bikaner.

breed: The intensity of strongyle infection within breed showed evident effect of agro-climate in crossbred sheep only. The monthly FECs remained statistically nonsignificant (P>0.05) for January, March and August between sheep maintained at semi-arid and arid region. The intensity of infection remained significantly (P<0.001) higher in semi-arid region during favourable period from May to September while in other periods (from October to April) it was significantly (P<0.05/0.001) higher in arid region (Fig. 5). In native Chokla sheep, the regional variation in monthly FECs remained nonsignificant throughout the year except in December. Within similar agro-climatic conditions (i.e. arid), Marwari sheep showed significant (P<0.001) influence of farm during wormy season with higher FECs at SBF, Fatehpur compared to at ARC, Bikaner.

Over-dispersion in faecal egg counts: In general, within breed the distribution of FEC data exhibited that around 40% of animals had intensity to the tune of >1,000 epg during July to September in all the breeds maintained in semi-arid region of Rajasthan (Table 2). Similarly, in SBF, Fatehpur >30% of the animals within breed possess faecal egg counts to the tune of >1,000 epg during July to October. Further, there was breed-wise variation in proportion of animals having different level of intensity of strongyle infection. However in ARC, farm majority of animals were found to possess moderate level of infection (<500 epg) in both the breeds.

Evaluation of genetically resistant livestock is a potentially alternative means of controlling GINs. Since mid-1930s, there have been many reports of substantial variations among sheep breeds in resistance, particularly to *H. contortus*, *Teladorsagia circumcincta* and *T. colubriformis*. For about 20 years after World War II, the genetic association between sheep breeds and *H. contortus* was studied in USA and Europe (Gregory *et al.* 1940, Whitlock 1955, Jilek and Bradley 1969). Since the early 1970s, a number of reports have demonstrated variation among different breeds of sheep and such differences were reported in different individuals of the same breed (Gamble and Zajac 1992, Bishop *et al.* 1996, Miller *et al.* 1998, Baker *et al.* 1999, Woolaston and Windon 2001). Between- and within-study variations in the infection rate of parasites under natural conditions are not unexpected. These may be due to an inequality of the contamination of pasture with infective larvae (Swarnkar *et al.* 2008), seasonal climatic fluctuations (Al-shaibani *et al.* 2008), nutritional level (Coop and Holmes 1996) and genetic backgrounds of animals (Reeg *et al.* 2005). In the present study, the nonsignificant variation among different breeds during April could be due to similar rate of resumption of development of hypobiotic larvae (Singh *et al.* 2011a) while in July and September could be attributed to the effects of self-cure phenomenon (Allonby and Urquhart 1973) and anthelmintic intervention, respectively. The monthly incidence was usually higher (>70%) during the period from May to November in all breeds except in Garole and its crosses where it was from May to September. The lower incidence in October was due to anthelmintic intervention in September. Garole and its crosses with Malpura found to posses relatively lower monthly incidence compared to other breeds suggesting relative resistance / resilience to strongyle infection in Garole sheep. Similarly, Singh *et al.* (2011a) also observed minimum incidence in Garole followed by Garole × Malpura and maximum in Malpura sheep throughout the year in the same agroclimatic region. A study in Maharashtra (India) comparing the resistance to *H. contortus* of F1 Garole crossbred lambs with that of Bannur, Deccani and Bannur × Deccani lambs, revealed that lambs with 50% Garole inheritance were significantly more resistant than the other breeds and crosses tested and lambs with 50% or more Bannur inheritance ranked second in resistance (Nimbkar *et al.* 2003).

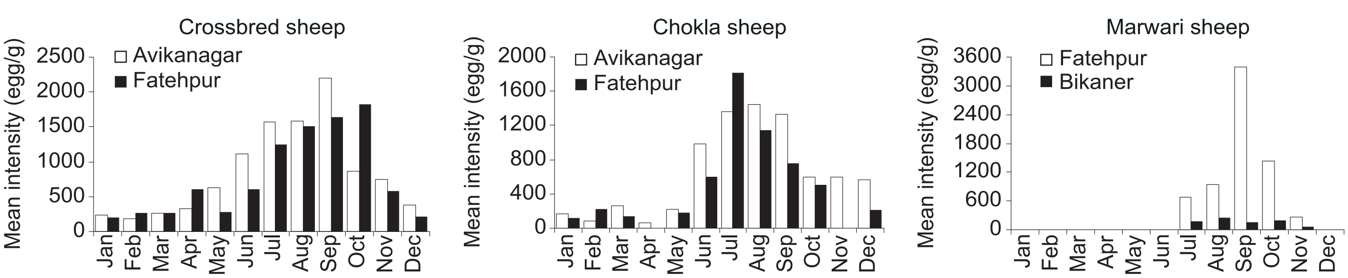

Fig. 5. Comparative intensity (egg/g) of strongyle worms in different agro-climates of Rajasthan.

Table 2. Monthly over-dispersion in intensity of strongyle infection in different breeds of sheep in Rajasthan

Breed	FEC level (epg)	Proportion (%)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							CSWRI, Avikanagar						
Malpura	Nil	39.6	43.3	29.7	34.8	16.4	8.3	22.7	13.1	12.2	21.3	21.1	29.0
	1-1000	56.9	54.9	67.6	62.3	69.9	64.5	37.5	41.9	44.1	54.9	58.6	60.5
	>1000	3.5	2.1	2.7	2.9	13.7	27.2	39.8	44.9	43.7	23.8	20.3	10.5
Crossbred	Nil	41.0	44.4	36.2	33.6	17.0	8.3	22.7	18.1	11.0	23.2	22.5	32.4
	1-1000	55.3	53.7	59.5	59.0	64.0	53.7	37.2	39.5	43.5	45.7	55.7	59.6
	>1000	3.7	1.9	4.3	7.4	19.0	38.1	40.1	42.4	45.5	26.2	21.8	8.0
Garole and its crosses	Nil	56.3	60.2	54.4	43.1	29.1	17.8	22.4	23.1	14.7	45.0	35.0	50.0
	1-1000	43.7	39.8	45.6	56.9	69.1	63.4	40.0	36.2	66.0	39.0	58.0	48.5
	>1000	0	0	0	0	1.8	18.8	37.6	30.8	19.2	16.0	7.0	1.6
Chokla	Nil	37.5	60.0	50.0	33.3	20.0	11.1	0	6.7	0	50.0	33.3	9.1
	1-1000	62.5	40.0	33.3	66.7	80.0	33.3	60.0	40.0	66.7	25.0	33.3	72.6
	>1000	0	0	16.7	0	0	55.6	40.0	53.3	33.3	25.0	33.3	18.2
Kheri	Nil	43.2	61.5	50.0	41.2	30.6	14.3	13.0	14.3	0	47.9	29.2	52.3
	1-1000	51.3	35.9	43.7	52.9	58.3	68.6	28.3	45.3	53.3	35.4	50.0	45.5
	>1000	5.4	2.6	6.2	5.9	11.1	17.2	58.7	40.4	46.7	16.7	20.8	2.3
							SBF, Fatehpur						
Exotic	Nil	51.5	40.4	45.7	18.1	55.0	28.6	15.4	19.9	22.0	24.5	33.3	52.6
	1-1000	46.1	51.2	43.8	59.8	38.5	48.9	50.1	44.5	34.6	44.4	45.2	40.1
	>1000	2.4	8.4	10.6	22.2	6.4	22.4	34.5	35.6	43.4	31.0	21.6	7.2
Crossbred	Nil	55.3	51.9	45.2	28.1	50.3	46.0	22.8	27.3	27.8	21.9	38.5	56.2
	1-1000	41.4	41.5	48.7	50.4	43.4	35.4	46.4	41.8	40.8	35.1	46.6	39.1
	>1000	3.3	6.6	6.1	21.6	6.3	18.6	30.7	31.0	31.4	33.1	14.9	4.7
Marwari	Nil	68.4	59.9	41.9	75.8	60.9	40.8	26.7	10.9	5.5	15.8	48.8	63.4
	1-1000	29.0	35.7	54.2	24.3	30.9	53.4	53.5	57.6	36.7	46.2	45.0	35.3
	>1000	2.6	4.3	3.9	0	8.2	5.8	19.9	31.5	57.8	38.0	6.3	1.3
Chokla	Nil	44.6	42.3	43.2		37.5	28.8	5.3	9.8	8.0	14.0		52.9
	1-1000	55.4	52.5	55.6		62.5	51.9	42.1	51.2	76.0	74.0		41.4
	>1000	0	5.1	1.4		0	19.2	52.6	39.0	16.0	12.0		5.7
Nali	Nil	70.2	67.8	63.2	40.4	22.3	18.9	42.0	27.2	25.0	35.4	38.0	73.1
	1-1000	29.8	31.3	35.1	59.7	69.3	71.4	47.9	56.3	51.7	47.7	43.5	26.9
	>1000	0	0.8	1.7	0	8.5	19.7	10.1	16.6	23.3	16.8	18.6	0
							ARC, Bikaner						
Magra	Nil							58.9	50.0	46.9	23.7	31.1	
	1-1000							40.5	44.5	51.4	70.4	66.2	
	>1000							0.6	5.6	1.7	5.9	2.7	
Marwari	Nil							59.7	54.5	57.5	45.4	62.8	
	1-1000							37.0	39.2	41.1	51.9	37.2	
	>1000							3.3	6.2	1.4	2.7	0	

In South Africa, Dorper breed was determined to be more resistant than the Hampshire sheep, but much less resistant than the Red Massai (Preston and Allonby 1979). In Ireland, Texel sheep are less susceptible to natural nematode challenge when compared with Suffolk sheep (Good *et al.* 2006). However, Idris *et al.* (2012) observed no significant differences between Meinoland, German Blackhead Mutton, Texel and Rhoen sheep and attributed it to natural selection and adaptation of Rhoen, Meinoland and German Blackhead Mutton breeds. Sabi ewes were more resistant to internal parasites than Dorper ewes in Zimbabwe (Matika *et al.* 2003). Golding and Small (2009) observed that Shetland and Manx Loaghtan sheep may have greater resistance to gastrointestinal parasites compared to Southdown sheep in UK.

Inter-individual variations in susceptibility to natural nematode infections were found to be more important than inter-breed differences. The high variation in FEC within breeds was earlier reported in different breeds and regions (Bisset *et al.* 1996, Bouix *et al.* 1998, Gauly and Erhardt 2001). Animals under natural conditions are unevenly exposed to nematode infection due to the differences in pasture contamination with infectious larvae. The animals in this study were kept in various farms with different feeding quality and husbandry systems. These factors could promote this variation in infection within breeds (Wassmuth *et al.* 2001). Even so, the obtained variation of FEC in this study might indicate partly the differences in host animal resistance against gastrointestinal nematode infections, which can be explained by the variety in the genetic basis of animals. Therefore, selection for resistance to nematode infections in Indian sheep under natural conditions might be possible. The use of breeds with resistance to nematode infection would not only reduce the parasitic burden of these animals but the reduced egg output would also lead to a less infective pasture, benefiting co-grazing animals.

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