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Influence of annual rainfall on epidemiology of gastrointestinal parasites in sheep flocks of Rajasthan

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

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

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ABSTRACT

The translation of exogenous stages of gastrointestinal (GI) parasites varies according to climatic variables like temperature, rainfall and humidity. The present paper describes the influence of quantum of annual rainfall on the prevalence and intensity of GI parasites in field flocks of sheep in Rajasthan. The period of 9 years (2004–13) was divided in 3 categories as years with above normal, normal and below normal annual total rainfall (TRF). Faecal samples (59,398) were subjected to qualitative and quantitative evaluation and data on monthly incidence and intensity were analyzed according to categories of years. The effect of annual TRF was significant on incidence of strongyle worms for all the months except during June in semi-arid and April in arid region. During August to December (favourable season), it was higher in the years with below normal TRF in semi-arid and in the years with normal annual TRF in arid region. The incidence of *Trichuris* spp, *Strongyloides papillosus*, *Fasciola gigantica* and *Schistosoma indicum* was very low. Incidence of *S. papillosus* was higher in the years of normal annual TRF in semi-arid region only. The incidence of *Amphistomes* remained lowest in the years of normal annual TRF. Higher annual TRF resulted in lower monthly incidence of *Moneizia* infection. The intensity of strongyle infection for all the months was significantly lower in years with above normal annual TRF in semi-arid region however similar influence was noticed only for July and August in arid region. It was inferred that moderate flexibility in single drench schedule according to magnitude of annual rainfall effectively managed the GI nematodes in field flocks of Rajasthan. However, a different strategy is required to formulate for management of flukes depending on quantum of rainfall, availability of water reservoirs and water resources for flocks.

Key words: Epidemiology, Field flocks, Gastrointestinal parasites, Rainfall, Sheep, Rajasthan

Sheep rearing is a major constituent in Rajasthan as it ensures sustenance of resource-poor families where frequent droughts and crop failure are common phenomenon. Livestock production is mainly pastoral or agro-pastoral with major dependence for grazing on community grazing land. Gastrointestinal (GI) parasitism in livestock, recognised as a world-wide problem, has a severe detrimental effect on the sheep industry (Singh *et al.* 2011).The magnitude and spectra of GI parasites varies considerably depending on the regional / local environmental conditions, grazing resources / pattern and management practices (Swarnkar *et al*. 2008). The translation of exogenous stages of nematodes parasites and pasture infectivity varies from season to season based on rainfall, relative humidity and temperature pattern. Bioclimatographs revealed that the favourable period for translation of predominant GI nematode (*Haemonchus contortus*) was from June to mid-September in semi-arid and from late June to mid-August in arid Rajasthan (Swarnkar and Singh 2011). Like-wise the prevalence of other helminths and intermediate hosts is also influenced by climatic variables. For effective management it becomes essential to know the regional distribution and prevalence of GI parasites as well as their correlation with environmental conditions. Such information can be used to describe the dynamics of transmission and to design effective worm management programme at farmer level (Sissay *et al.* 2007, Torres-Acosta and Hoste 2008). Thus, the objectives of this study were to determine the influence of annual rainfall on the prevalence, seasonal dynamics and intensity of gastrointestinal parasites in sheep flocks managed by farmers in Rajasthan.

Present address: [1]Scientist (swarnkarcp@yahoo.com), [2]Principal Scientist (dherindra.singh56@gmail.com), Division of Animal Health, Central Sheep and Wool Research Institute, Avikanagar, Rajasthan

MATERIALS AND METHODS

Climate: Broadly, Rajasthan was categorized into semi-arid (east Rajasthan) and arid (west Rajasthan) agroclimatic regions. The major variation among 2 zones was in amount of rainfall from June to November, where semi-arid zone received almost double amount of precipitation compared to arid zone. Another variation was in maximum temperature during June to August where it remained about

4°C higher in arid zone compared to semi-arid zone (Swarnkar and Singh 2011). The sub-divisional normal total annual rainfall (TRF) was taken from the records from Hydromet Division, India Meteorological Department. Based on long term averages (1941–90), the annual normal TRF ranged from 297.00 mm in arid Rajasthan to 678.20 mm in semi-arid Rajasthan. To observe the effect of rainfall on epidemiology of GI helminths, the data collected from April 2004 to March 2013 were utilized. The study period of 9 years was categorized into 3 groups depending on amount of annual TRF as (i) above normal TRF, (ii) normal TRF, and (iii) below normal TRF. The per cent variation in annual rainfall was calculated in comparison to long term normal TRF (Table 1).

Animals: The number of flocks covered during the study period varied from 25 to 64 / annum with a sheep population ranging from 1,800 to 4,700 / annum. The flocks were managed under semi-intensive system and animals were drenched once per annum with tetramisole or closantel (annual rotation) in mid monsoon (late July-August) as per modified worm management programme (Swarnkar *et al.* 2008).

Parasitological observations: Faecal samples (59,398: 33,053 from semi-arid and 26,345 from arid region) were collected per rectum from April 2004 to March 2013 at monthly interval. Floatation and sedimentation techniques (Urquhart 1994) were employed to determine the incidence of different GI helminths. Identification of eggs was made on the basis of morphology (Soulsby 1965). The intensity of strongyle infection (faecal egg count - FEC /g of faeces) was determined by modified Mc Master technique (MAFF 1984). The monthly data for incidence and intensity were grouped based on categories of years according to annual TRF (Table 1).

Data analysis: The incidence data for different GI helminths were analyzed using cross-tab analysis and tested for significance by chi-square test. The FEC data were tested for significance by analysis of variance and means were compared by least square differences (LSD) using SPSS ver 16.

RESULTS AND DISCUSSION

Incidence of strongyle worms: In semi-arid region, the monthly incidence of strongyle worms in sheep flocks ranged significantly (P<0.001) from 11.4 (March) to 59.2% (July) in the years with above normal annual TRF, from

Table 1. Categorization of years according to annual total rainfall (TRF) in Rajasthan

Above normal TRF			Normal TRF			Below normal TRF		
Year	TRF (mm)	% variation	Year	TRF (mm)	% variation	Year	TRF (mm)	% variation
Semi-arid (Long term normal TRF – 678.20 mm)								
10–11	812.89	+ 19.86	04–05	668.95	- 1.36	05–06	580.71	- 14.37
11–12	758.83	+ 11.89	06–07	700.87	+ 3.34	07–08	555.61	- 18.08
12–13	823.09	+ 21.36	08–09	625.73	- 7.74	09–10	477.26	- 29.63
Arid (Long term normal TRF – 297.00 mm)								
06–07	366.95	+ 23.55	05–06	263.40	- 11.31	04–05	245.70	- 17.27
08–09	400.05	+ 34.70				07–08	258.38	- 13.00
10–11	469.14	+ 57.96				09–10	210.54	- 29.11
11–12	428.98	+ 44.44						
12–13	420.97	+41.74						

Table 2. Comparative incidence (%) of strongyle infection in sheep during different levels of annual TRF

Month	Semi-arid Rajasthan				Arid Rajasthan			
	AN	N	BN	p	AN	N	BN	p
Jan	20.1	42.8	42.3	**	30.4	45.9	18.9	**
Feb	15.5	39.2	27.2	**	27.9	39.4	22.1	**
Mar	11.4	31.9	15.7	**	32.2	26.1	19.1	**
Apr	26.1	41.9	39.7	**	31.7	32.8	-	NS
May	35.7	59.6	52.9	**	51.1	-	60.6	**
Jun	54.4	59.8	56.8	NS	69.2	-	76.2	*
Jul	59.2	73.9	53.8	**	78.2	51.5	63.8	**
Aug	44.7	50.9	79.3	**	68.8	78.8	70.5	*
Sep	46.9	51.5	70.4	**	60.3	84.1	68.7	**
Oct	40.4	54.7	70.1	**	51.5	82.6	48.6	**
Nov	16.3	53.3	60.0	**	35.4	63.7	15.8	**
Dec	16.6	43.9	46.4	**	37.2	57.2	20.0	**

AN, Above normal annul TRF; N, normal TRF; BN, below normal TRF; *, significant at P<0.05; **, significant at P<0.001; NS, nonsignificant at P>0.05.

Table 3. Comparative incidence (%) of non-bursate worms in sheep during different levels of annual TRF

Month	*Trichuris* spp								*Strongyloides papillosus*							
	Semi-arid				Arid				Semi-arid				Arid			
	AN	N	BN	p	AN	N	BN	p	AN	N	BN	p	AN	N	BN	p
Jan	0.4	0.2	0.8	NS	0.0	0.8	0.6	NS	0.1	0.7	3.0	**	0.1	0.7	0.0	NS
Feb	0.3	0.9	0.7	NS	1.3	0.7	0.0	**	1.4	0.0	0.7	NS	0.7	0.4	0.1	NS
Mar	0.1	1.2	0.8	*	0.1	1.4	0.2	**	0.1	0.3	2.8	**	0.2	0.0	1.0	*
Apr	0.0	0.4	6.0	**	0.0	3.4	1.9	*	1.2	0.7	-	NS	0.2	0.7		NS
May	0.4	0.6	1.4	NS	0.1	1.3	2.2	**	2.2		1.7	NS	0.0		0.5	*
Jun	0.7	1.8	3.0	*	0.1	0.7	0.2	NS	0.4		2.0	*	0.0		3.8	**
Jul	0.3	0.8	1.9	**	0.5	1.9	2.9	**	1.2	0.8	3.4	**	0.7	0.8	3.2	**
Aug	0.0	1.5	0.7	**	0.9	1.9	0.4	*	1.0	0.0	1.0	NS	2.7	0.0	0.7	**
Sep	0.2	0.0	0.0	NS	0.9	7.8	0.8	**	1.6	0.0	1.0	NS	1.2	1.3	0.6	NS
Oct	2.2	0.4	0.8	**	2.7	5.2	0.5	**	0.7	0.0	0.5	NS	0.6	0.0	0.6	NS
Nov	1.3	0.0	0.2	**	1.3	8.0	0.1	**	0.0	0.0	0.6	*	0.4	0.0	0.0	NS
Dec	0.2	0.0	2.7	**	1.2	3.2	0.0	**	0.0	0.7	0.0	**	0.2	0.7	0.0	NS

AN, Above normal annul TRF; N, normal TRF; BN, below normal TRF; *, significant at P<0.05; **, significant at P<0.001; NS, nonsignificant at P>0.05.

Table 4. Comparative incidence (%) of flukes in sheep during different levels of annual TRF

Month	*Amphistomes* spp								*Schistosoma indicum*							
	Semi-arid				Arid				Semi-arid				Arid			
	AN	N	BN	p	AN	N	BN	p	AN	N	BN	p	AN	N	BN	p
Jan	3.7	1.7	0.1	**	0.4	0.0	0.2	NS	0.0	0.0	0.0	-	0.1	0.0	0.0	NS
Feb	5.2	1.4	0.2	**	1.3	0.0	0.2	*	0.0	0.1	0.0	NS	0.1	0.0	0.0	NS
Mar	10.4	2.4	0.1	**	1.3	0.0	0.3	*	0.0	0.0	0.0	-	0.0	0.0	0.1	NS
Apr	2.5	3.4	0.5	*	0.0	0.0		-	0.0	1.1	0.0	*	0.2	0.0		NS
May	6.1	7.7	11.1	**	1.3		1.4	NS	0.0	0.6	0.0	*	0.2		0.5	NS
Jun	7.4	8.0	2.0	**	1.6		4.1	*	0.0	0.0	0.0	-	0.4		0.0	NS
Jul	17.3	15.9	21.4	**	4.9	0.8	6.9	*	0.0	0.5	1.1	*	0.2	0.0	1.0	*
Aug	20.7	14.1	25.7	**	3.9	8.9	3.1	**	0.1	0.8	0.5	*	0.1	1.2	0.5	*
Sep	10.0	5.2	4.5	**	2.1	0.4	1.8	NS	0.0	0.6	0.1	*	0.1	0.4	0.1	NS
Oct	1.8	0.3	2.3	**	0.1	0.0	0.0	NS	0.0	0.1	0.2	NS	0.0	0.0	0.2	NS
Nov	0.1	0.1	0.0	NS	0.0	0.0	0.1	NS	0.0	0.1	0.1	NS	0.0	0.0	0.1	NS
Dec	0.9	0.4	0.0	*	0.0	0.0	0.1	NS	0.0	0.0	0.0	-	0.0	0.0	0.0	-

AN, Above normal annul TRF; N, normal TRF; BN, below normal TRF; *, significant at P<0.05; **, significant at P<0.001; NS, nonsignificant at P>0.05.

31.9 (March) to 73.9% (July) in the years with normal annual TRF and from 15.7 (March) to 79.3% (August) in the years with below normal annual TRF. Like-wise in sheep flocks of arid region, it varied from 27.9 (February) to 78.2% (July) in the years with above normal annual TRF, from 26.1 (March) to 84.1% (September) in the years with normal annual TRF and from 15.8 (November) to 76.2% (June) in the years with below normal annual TRF (Table 2). The effect of annual TRF on incidence remained significant (P<0.05 / 0.001) for all the months except during June in semi-arid and April in arid region. In semi-arid region, monthly incidence from January to July was at minimum in the years of above normal annual TRF followed by in the years of below normal annual TRF and at maximum in the years of normal annual TRF however for the period from August to December, it remained at maximum in years with below normal annual TRF. On the other hand, in arid region higher incidence was observed in the years with normal annual TRF on majority of occasions.

Incidence of non-bursate worms: The monthly incidence of *Trichuris* spp remained usually unaffected with level of annual TRF and it remained <5.0% for all the months. On the other hand monthly incidence of *S. papillosus* was relatively higher during occurrence of normal annual TRF in semi-arid region and this could be attributed the fact that being parthogenetic nature of life cycle, exogenous stages of *S. papillosus* failed to resist both adverse conditions of rainfall (Table 3). In arid region, no major variation was observed in incidence of *S. papillosus.*

Incidence of flukes: In both the agroclimatic conditions of Rajasthan, the occurrence of *Fasciola gigantica* infection was sporadic and at the level of <0.5%. In general, incidence of liverfluke was relatively higher during the years with below normal annual TRF. In semi-arid region, the incidence

Table 5. Comparative incidence (%) of *Moneizia* and *Eimeria* spp in sheep during different levels of annual TRF

Month	*Moneizia* spp								*Eimeria* spp							
	Semi-arid				Arid				Semi-arid				Arid			
	AN	N	BN	p	AN	N	BN	p	AN	N	BN	p	AN	N	BN	p
Jan	3.0	8.0	4.0	**	2.1	3.5	1.4	NS	17.4	29.1	23.5	**	18.5	19.1	32.7	**
Feb	3.2	7.1	5.6	**	1.7	3.5	1.8	NS	22.3	37.6	25.5	**	21.4	23.8	21.8	NS
Mar	2.8	5.0	3.9	*	2.6	2.8	1.1	*	22.2	32.5	19.0	**	18.9	36.1	25.4	**
Apr	3.4	7.9	6.8	*	4.0	4.9		NS	15.8	30.9	46.3	**	21.7	47.0		**
May	4.2	3.2	5.8	NS	2.1		0.7	NS	20.2	31.7	21.8	**	35.4		26.4	**
Jun	2.3	4.7	6.5	**	2.1		3.2	NS	28.6	35.4	42.7	**	31.4		43.0	**
Jul	1.9	4.5	3.8	**	1.9	0.8	0.1	**	34.9	31.7	53.7	**	33.5	51.5	56.9	**
Aug	1.6	6.6	3.9	**	2.0	0.4	0.0	**	30.3	27.1	29.1	NS	42.3	17.4	37.3	**
Sep	3.2	2.9	4.0	NS	2.5	5.3	0.4	**	26.2	36.1	29.5	**	36.8	20.3	40.9	**
Oct	5.0	5.3	5.6	NS	3.6	3.0	1.8	*	28.9	31.1	37.9	**	28.4	38.8	34.8	**
Nov	4.8	7.8	6.4	*	4.3	7.0	2.5	**	24.1	41.5	34.3	**	24.5	39.8	34.2	**

of *Amphistomes* spp for all the months except November observed to be significantly (P<0.05/0.001) affected by level of annual TRF. In general, it remained lowest in the years of normal annual TRF. Further, was higher from January to March and September in the years with annual TRF above normal and in May, July and August in the year with annual TRF below normal (Table 4). Similar influence of quantum of annual TRF on monthly incidence of *Amphistomes* spp was observed in arid region but evidently at lower level. The incidence of *Schistosoma indicum* infection remained quit low with higher magnitude during the years with annual TRF below normal.

Incidence of Moneizia: The magnitude of monthly incidence of *Moneizia* spp remained relatively higher during the years of normal or below annual TRF (Table 5). Higher rainfall seems to causes destruction of oribatid mites (intermediate host for cestodes) and their sites of predilection resulting in lower incidence of *Moneizia* spp infection in flocks.

Incidence of Eimeria*:* On majority of occasions the monthly incidence of *Eimeria* spp was significantly (P<0.05/0.001) affected by level of annual TRF in both the agroclimatic regions of Rajasthan. In general higher incidence was noticed in the years with normal annual TRF in semi-arid region and with below normal annual TRF in arid region (Table 5).

Intensity of strongyle infection: In both the agroclimatic regions of Rajasthan, the monthly intensity of strongyle infection (predominantly *Haemonchus contortus*) was found to be affected significantly (P<0.001) by the level of annual TRF throughout the year except in April and September in arid and semi-arid region, respectively. In semi-arid region, the mean intensity of strongyle infection remained significantly lower in all the months with years above normal annual TRF compared to other 2 categories of annual TRF. However, the variation in mean monthly faecal egg counts between years with normal and below normal annual TRF were nonsignificant on majority of occasions. On the other hand in arid region the intensity of strongyle infection was significantly higher during July-August in the year with above normal annual TRF. Following anthelmintic intervention, the intensity after reinfection was higher in the years with normal annual TRF (Fig. 1). The lower intensity in the years with above normal annual TRF could be due to lower quantum of challenge infection from herbage as pasture infectivity influenced by herbage height.

Climate influences infective larval availability and therefore, rates of infection, through direct effects on the

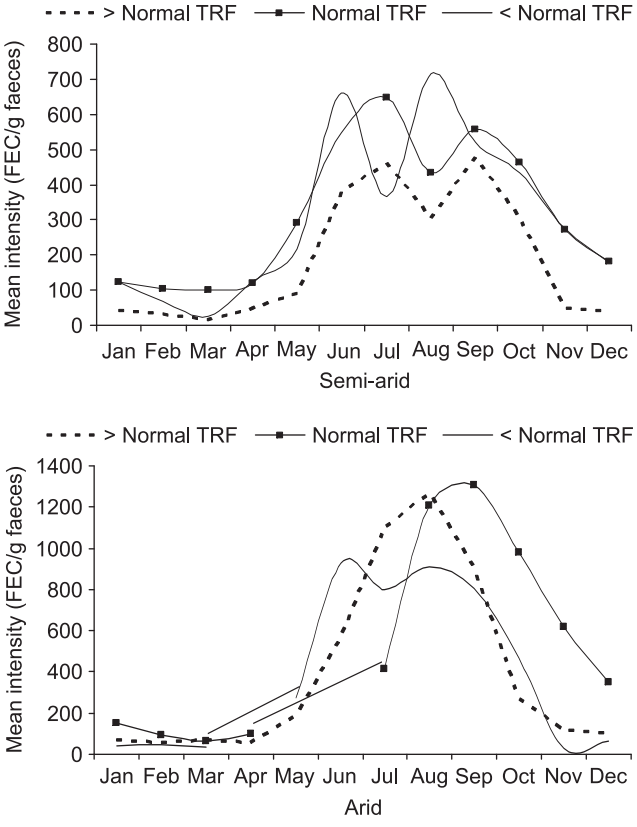

Fig. 1. Comparative monthly mean intensity of strongyle infection in sheep during different levels of annual total rainfall.

development and survival of the free-living stages and translation of larvae onto pasture (O'Connor *et al.* 2006). The free-living stages of gastrointestinal nematode parasites of sheep are strongly affected by climate. Extreme heat and cold are detrimental to development and survival, while, within tolerable limits, increasing temperatures generally accelerate development but also increase mortality. Moisture is needed for development and translation of larvae from faeces to pasture and so rainfall is a limiting factor for transmission (Morgan and Dijk 2012). Prevailing agro climatic conditions and management practices provided ideal conditions for transmission and build up of strongyle infection in sheep flocks only during July to September (Swarnkar and Singh 2011). The persistence of nematode infection could be attributed to either successful survival of the exogenous stages on the pasture or of the adult or hypobiotic larvae in the host (Gupta *et al.* 1987). Insufficient nutrition and increased stress due to grazing over long distance and drought conditions found to affect the intensity of infection (Okaiyeto *et al.* 2008). The observed variation in incidence was attributed to dilution or concentration of infectivity on pasture because of resultant herbage height according to amount of rainfall. Excessive rainfall resulted in increase in biomass production on community grazing area with herbage height unfavourable for strongyle larvae to disseminate as well as to better nutrient availability to sheep flocks. Further, excessive rainfall also resulted in runoff of faecal pellets and infective stages available on pasture. On the other hand during the years of low rainfall, there was poor growth of grasses on pasture with simultaneous under-nourishment of flocks along with concentration of source of infection in limited area. In addition occurrence of low rainfall forced animals to spend more of their energy in search of fodder and water. Thus all these conditions yielded to decrease in resistance status with concurrent increase in incidence rate during monsoon and post monsoon season. The present results could not support the hypothesis that lower density of herbage in grazing area allowed greater exposure of exogenous stages of strongyle larvae to direct sunlight with resultant lowered pasture infectivity due to higher killing of eggs or larvae (Tripathi 1977). The different patterns in arid region could be attributed to higher practice of feeding on top feeds.

Unfavourable climatic conditions, possible onset of hypobiosis, failure of larval translation on pasture, denudation of grass cover / mat in grazing area, practices of grazing in harvested field or on top feeds resulted in significant decline in FEC from November onwards without any anthelmintic intervention in both the regions. Irrespective of quantum of annual TRF, an increase in intensity of infection in May could be attributed to the fact that the resumption of hypobiosis in strongyle worms seems to be triggered by nutritional stress during extreme summer rather than climatic factors (Armour 1980). The statement is further supported by observation like relatively higher increase in arid region in May and June.

The regional variation in incidence of flukes in sheep flocks is mainly attributed to availability of water reservoirs and snail habitats (extensive in semi-arid region) and watering practices (use of tubewell water in arid region) adopted for flocks by farmers. The higher incidence in semi-arid region was due to higher prevalence during lower annual rainfall could be attributed to higher concentration of snail intermediate host and grazing of flocks on metacercariae infested grasses around water reservoirs. The possible reasons behind higher incidence during the years of above normal TRF were wide spread of snails due to massive runoff of rain water and availability of sufficient water in reservoirs for prolonged time. Our results reflected success of single drench schedule (during mid to late monsoon) in management of GI nematodes in field flocks under varying levels of annual rainfall. However, a different strategy is required to formulate for management of flukes depending on quantum of rainfall, availability of water reservoirs and water resources for flocks.

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