



Evaluation of conventional and strategic worm management schemes in sheep flocks of semi-arid Rajasthan

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ABSTRACT

A comparison of parasitological status and economic benefit derived from 2 schemes of worm management in naturally infected sheep flocks was made in semi-arid Rajasthan. During the period from June 2004 to March 2011, sheep (8061) were monitored for productive performance and evaluated for gastrointestinal strongyles by examining 25172 faecal samples. The monthly incidence and intensity of strongyle nematodes remained almost similar among flocks given either strategic (1 drench/annum) or conventional (3 drenches/annum) anthelmintic treatment. The epidemiological profile exhibited higher magnitude of infection only during monsoon (July–October). The comparative economic evaluation showed that reduction in anthelmintic frequency in strategic scheme as against conventional scheme had no adverse effect on flock performance and yields better financial return to farmers. The result reflected the value and success of single drench schedule (strategic scheme) for the effective management of predominant gastrointestinal nematodes in field flocks of semi-arid Rajasthan which is based on relevant epidemiological information.

Key words: Gastrointestinal nematodes, Rajasthan, Semi-arid, Sheep, Worm management schemes

In developing countries like India, the productive potential of small ruminants is adversely affected by factors such as poor nutrition, diseases, parasitism and poor management. Parasitism particularly gastrointestinal (GI) nematodosis alone constitutes a major source of economic loss in flock. Based on sheep population (Census 2003), Singh *et al.* (2011) estimated an annual loss of Rs 1191.708 million due to gastrointestinal nematodes in sheep of Rajasthan and the components of losses were – decreased mutton production (59.56%), predisposition to mortality (16.57%), increased premature disposal (11.25%), reduced fertility (7.97%) and decreased wool production (4.65%). The approaches advocated for worm management in today's context comprised both chemotherapeutic (suppressive, strategic, tactical, targeted selective) and non-chemotherapeutic (grazing/pasture management, nutritional management, use of phyto-chemicals, genetic control, immunological control, biological control) measures (Singh and Swarnkar 2007). It is an accepted fact that the eradication of GI nematodes of small ruminants is impractical. Further in the present scenario concerns about increasing food production and economic activity through the use of available technologies with a

particular reliance on the use of synthetic chemicals are increasing (Molento 2009). Taking in view of increasing reports of anthelmintic resistance in strongyle nematodes and frequent drug failure (Singh and Swarnkar 2008) as well as rising demand for residue free animal products, the main objective of control/management programme should therefore, be to minimize associated economic losses by containing worm population at levels that do not significantly affect the flock productivity.

In Rajasthan sheep breeders treat their flocks for GI helminths at an average frequency of 2.59 ± 0.03 /sheep/year. Majority of flocks were drenched thrice a year during April/June, September/November and February indicating that usual practice of anthelmintic intervention was coupled with shearing of sheep (Swarnkar and Singh 2010a). Epidemiological studies in semi-arid region indicated a distinct seasonality in translation and availability of strongyle larvae on pasture and it was mainly restricted to the wet season (Swarnkar *et al.* 2008, Swarnkar and Singh 2011). The only means to carry the infection from one rainy season to another is through animals harbouring adult worms and/or arrested (hypobiotic) larvae (Tembely *et al.* 1997). Strategic worm control programme for sheep based on the epidemiology of their gastrointestinal nematodes was successfully evaluated in UK (Taylor *et al.* 1991) and Australia (Das and Waller 1987). Several studies have

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confirmed that strategic drenching can be highly effective and superior for worm control than most schedules of suppressive drenching that are applied at a time when pasture infectivity is high (Llyod *et al.* 2000). On perusing the literatures, it was evident that uncertainty surrounds the value of measures used to manage GI nematodosis in sheep. Thus an economic analysis was attempted in a study to compare the flock performance under 2 different treatment strategies for whole of life production as well as epidemiological aspect of strongyle nematodes in sheep flocks at farmer's field.

MATERIALS AND METHODS

The study conducted from June 2004 to March 2011 by adopting total flocks of 2–3 villages/year in semi-arid Rajasthan. The same flocks were monitored for worm profile and performance on monthly basis for at least 3 years.

Climate: The average monthly minimum and maximum temperature ranged from 9.9 ± 0.3 °C (January) to 28.6 ± 0.3 °C (May) and from 23.6 ± 0.3 °C (January) to 41.1 ± 0.3 °C (May). The average monthly total rainfall ranged from 0.1 ± 0.1 mm (November) to 200.3 ± 34.5 mm (July). The average relative humidity in atmosphere at 8.30 AM IST varied from $28.3 \pm 1.0\%$ (April) to $78.6 \pm 1.2\%$ (August). The prevailing climate was characterized as cold-humid (low temperature, high humidity and scanty rainfall) during December to February, hot-dry (high temperature, low humidity and low rainfall during March to May, hot-humid (high temperature, high humidity and moderate rainfall) during June to August and hot-humid (high temperature, moderate humidity and low rainfall) during September to November (Swarnkar *et al.* 2008).

Flock management: Flocks (106) comprising 8061 sheep distributed in 12 villages were used for study. All the flocks were managed by semi-intensive system through 8–10 h/day grazing on community grazing area/post-harvested fields/top feed. Though, lambing in flocks occurred throughout the year but majority of ewes lambed during September to December. The majority of flocks were vaccinated against enterotoxaemia and sheep pox.

Treatment groups: Based on bench-mark study during the period from 2000–2004, a region based worm management programme was formulated (Swarnkar *et al.* 2008), which includes strategic anthelmintic intervention in flocks during mid-late monsoon. In present study, to test the effectiveness of strategic approach, the flocks were grouped in 2 categories as flocks received strategic anthelmintic treatment (once a year during mid-late monsoon) and flocks received conventional anthelmintic treatment (3 treatments/year during spring, summer and winter). The sheep (6390) in strategic group (SG) were administered tetramisole or closantel on annual rotational basis by the institute while sheep (1671) in conventional group (CG) were administered the anthelmintics by farmers themselves in addition to by the institute.

Parasitological study: From each flock around 30% of animals were sampled each month and thus from July 2004 to March 2011, a total of 25172 faecal samples (22 982 from SG and 2 190 from CG) were collected per rectum. The samples were evaluated qualitatively to determine the incidence of strongyle nematodes using saturate salt solution by floatation technique (Urquhart 1994). The intensity of strongyle infection (faecal egg count - FEC/g of faeces) was determined by modified Mc master technique (MAFF 1984). On each occasion faecal culture was made (at 27 °C for 5 days) from pooled faeces to ascertain the generic composition of strongyle worms (Soulsby 1965).

Flock performance study: To visualise and demonstrate the effect of modified worm management programme on productivity of flocks, on each occasion at the time of faecal sampling, observations on activities undertaken by farmers between 2 subsequent visits were recorded through verbal interaction with flock owner on structured set of questionnaire (Swarnkar *et al.* 2008). The information collected comprised flock dynamics (flock strength at the start of month, number of lambs born, number of sheep purchased/sold, number of sheep died), flock management (grazing resources, health measures undertaken, number of animals treated) and economic aspects (expenditure made on feed and fodder, medicine, purchase of animals, shearing and income received from sale of animals, wool and manure). The method of economic evaluation of schemes used was partial farm budgeting (Morris 1969). Only the component of gross income and cost of sheep production which were affected by the use of anthelmintic treatments were considered. Care was taken to construct the partial budget so that the twin errors of double counting and erroneous omission of benefits or costs were avoided. In the calculation of net return from different schemes all figures have been adjusted to a standard flock of 100 sheep to facilitate the comparison of schemes.

Statistical analysis: The prevalence data were analyzed by using cross-tab analysis. The FEC data were tested for significance by analysis of variance and means were compared by Duncan's multiple range test (DMRT) using SPSS ver 16.

RESULTS AND DISCUSSION

Incidence of strongyle nematodes: In semi-arid conditions of Rajasthan, over the years evaluation of faecal samples exhibited that the average monthly incidence of strongyle nematodes in sheep flocks ranged significantly ($P < 0.01$) from $26.7 \pm 9.3\%$ (March) to $61.3 \pm 5.1\%$ (July) in strategic treatment group. Similarly, in flocks administered anthelmintics as per conventional pattern, the average monthly incidence varied significantly ($P < 0.001$) from $20.8 \pm 4.8\%$ in March to $67.5 \pm 9.7\%$ in August (Fig. 1). The incidence rate remained statistically almost similar for all the months among 2 treatment groups. It was observed that in both the groups

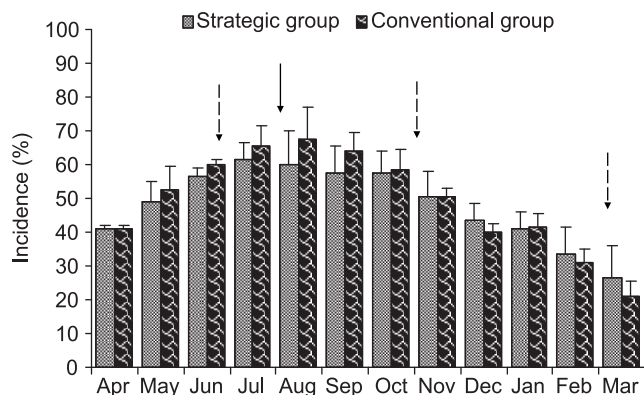


Fig. 1. Monthly incidence (mean $\pm$ SE) of strongyle nematodes in sheep flocks under 2 anthelmintic treatment schemes. (Time of anthelmintic intervention is indicated by solid arrow in SG and by dotted arrows in CG flocks.)

incidence of strongyle nematodes started rising with the onset of rains in June and remained higher during monsoon and declined thereafter. The initial rise could be attributed to resumption of development in hypobiotic larvae in host. The persistence of infection even after anthelmintic intervention during monsoon indicates availability of climatic conditions suitable for translation of exogenous stages of nematodes. Further nonsignificant variation in incidence of strongyle nematodes among both the group reflects that higher anthelmintic frequency in semi-arid conditions of Rajasthan had no impact on reducing the incidence of infection. On the other hand, climatic conditions and host environment found to play significant role in variation in infection rate.

Intensity of strongyle nematodes: The overall monthly FECs varied significantly ($P < 0.001$) from 86.9 ± 55.9 (March) to 528.4 ± 141.6 epg (August) in SG flocks and from 38.0 ± 9.9 (March) to 648.2 ± 161.1 (August) in CG flocks (Fig. 2). Within a month, variation in intensity of strongyle infection among both the groups was nonsignificant. Persistency of strongyle infection is either due to the successful survival of the exogenous stages on the pasture or of the adults or hypobiotic larvae in the host. The epidemiological profile of strongyle infection in sheep flocks of semi-arid Rajasthan exhibited that with few exceptions, higher number of strongyle eggs were shed in the faeces from July to October each year. Similar observations were made by Gupta *et al.* (1987) from Haryana, Singh *et al.* (1997) and Swarnkar *et al.* (2010) from Rajasthan. Higher FEC that occur in sheep of this area shortly after the onset of rains is therefore presumed to be associated with the maturation of large numbers of hypobiotic larvae into adult worms. Similar hypothesis was proposed by Gatongi *et al.* (1997) in Kenya. However, it was observed that sheep of CG flocks possess relatively higher FECs during monsoon compared to sheep in SG flocks and this could be attributed to the fact that untimely anthelmintic intervention (before monsoon) in CG flocks failed to contain the level of infection in host.

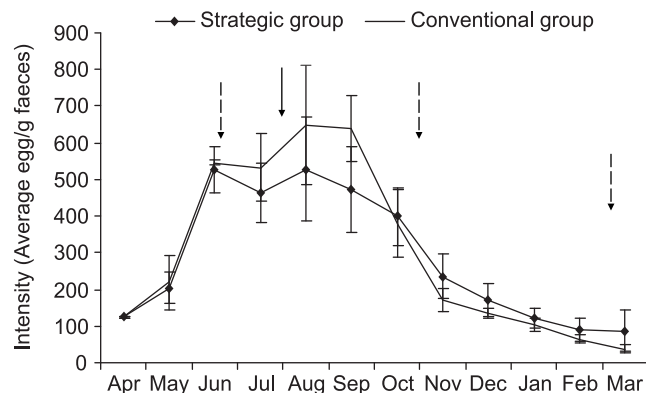


Fig. 2. Monthly intensity (mean $\pm$ SE) of strongyle infection in sheep flocks under 2 anthelmintic treatment schemes. (Time of anthelmintic intervention is indicated by solid arrow in SG and by dotted arrows in CG flocks.)

Similarly, another drench during winter had no evident impact on intensity of infection in CG flocks as phenomenon of hypobiosis occurred in both the groups. In addition, unfavourable climatic conditions, 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 SG flocks exhibited that a single anthelmintic intervention during mid-monsoon is equally effective as conventional practices (3 drench/year) adopted by farmers. The rising trend in FECs were started from June in both the groups and this 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).

Further, as per flock rearing practices (Swarnkar and Singh 2010b) in Rajasthan, most of the lambing occurred during October to December, the epidemiology of strongyle nematodes in present study suggested absence of typical peri-parturient rise in faecal egg counts. This could be attributed to environmental factors (which limit the translation of exogenous stages of worms on pasture, Swarnkar *et al.* 1997) as well to practices of grazing the animals on crop-stubbles in post-harvested field (Swarnkar *et al.* 2008) with resultant non-acquisition of infection by hosts. Similarly absence of peri-parturient rise in faecal egg count was reported by Singh *et al.* (1997) and Swarnkar *et al.* (1998) in farm flocks of semi-arid Rajasthan.

Conventional control of worms depends heavily on anthelmintic intervention (suppressive, strategic and tactical) within the host. High frequency of suppressive treatment is likely to hasten the development of anthelmintic resistance. Strategic control programme use epidemiological information to develop fixed time treatments aimed at minimizing larval contamination of pasture. Such programmes also become ineffective because of increased anthelmintic resistance secondary to reduction in unselected refugia (Basier and Love

2003, Kelly *et al.* 2010). The earlier studies on epidemiology and management of GIN in sheep flocks of Rajasthan exhibited that conventional way of using anthelmintic treatment without epidemiological support for flocks in state was economically and scientifically unsound because GIN and climatic conditions prevails or confined to very short period of monsoon (July to September) (Swarnkar and Singh 2011, Swarnkar *et al.* 2008). The results of present study demonstrated the value of a strategic scheme for the management of GIN, which is based on relevant epidemiological information.

Generic composition of strongyle nematodes: On coproculture, only 3 species of strongyle worms namely *Haemonchus contortus*, *Trichostrongylus* spp. (both *T. axei* and *T. colubriformis*) and *Oesophagostomum* spp. were recovered. In the present study, the average monthly proportion of predominant strongyle nematode - *H. contortus* ranged nonsignificantly from $90.00 \pm 4.35\%$ (September) to $98.13 \pm 0.69\%$ (May). The monthly proportion of *Trichostrongylus* and *Oesophagostomum* spp. varied from $0.05 \pm 0.03\%$ (April – June) to $4.22 \pm 2.63\%$ (September) and from $1.00 \pm 0.64\%$ (November) to $6.84 \pm 1.70\%$ (February), respectively (Fig. 3). Over the years, pattern in generic composition of strongyle nematodes in sheep of semi-arid revealed minor variation among treatment schemes. From similar agroclimatic conditions, Gupta *et al.* (1987), Singh *et al.* (1997), Swarnkar *et al.* (2008) and Singh and Swarnkar (2011) reported that infective larvae of *H. contortus*, *Trichostrongylus* and *Oesophagostomum* spp. were available throughout the year with predominance of *H. contortus*. Thus it appears that succession of strongyle nematodes is due to the persistence of mature worms in the host all year round. However, minor variation in proportion of haematophagous and non-haematophagous strongyle larvae occurred depending upon type of anthelmintics used with relative rise in proportion of non-haematophagous strongyle worms following treatment with closantel (Swarnkar *et al.* 2000)

Economic appraisal of flock performance: The year-wise comparative production performance of sheep flocks in both

the treatment group is presented in Table 1. During the study period, though there was year to year variation in lambing rate among both the groups but the average annual lambing rate in SG flocks was marginally higher (79.95%) compared to CG flocks (71.51%). The other factors which affected the flock dynamics i.e. purchase and sale of animals remained higher in SG flocks compared to CG flocks. The average annual morbidity varied from 42.51% (CG flocks) to 46.67% (SG flocks) and major entities were lameness, foot abscess, facial mange, contagious ecthyma, enteritis, bronchitis, pneumonia, pasteurellosis, pica, anorexia and nasal ulceration. The occurrence of sheep pox was also observed in one flock of SG group during 2005–06. The average annual mortality remained slightly higher (11.99%) in CG flocks compared to SG flocks (10.40%). Similarly no effect of anthelmintic treatment schemes on lambing and mortality was observed by Morris *et al.* (1977) in breedable ewe in Victoria, Australia. The overall annual expenditure/100 sheep were ₹ 15785.60 and ₹ 27941.00 in SG and CG flocks, respectively. The major component of expenditure in both the groups was purchase of animals followed by feed and fodder and health input. The overall net annual income/100 sheep was found higher (₹ 66189.70) in SG flocks compared to CG flocks (₹ 52526.50). Based on dynamics and economics of flocks, it was clearly observed that reduction in anthelmintic frequency as against conventional practices had no adverse effect of flock performance. The benefits of scheme was not materially changed by variation in components of animal productivity and over the years the net return on expenditure was high in SG flocks in comparison to CG flocks. While making an economic evaluation of different worm control schemes in breedable ewes, Morris *et al.* (1977) also observed that net financial return remained substantially low in traditional treatment scheme compared to critical treatment scheme.

Drug use in livestock production system, particularly intensive ones, has created a build up of chemicals in the food chain and the environment. Leathwick *et al.* (2006) stated that non-strategic administration of anthelmintics result not only in direct economic losses (cost of anthelmintics), but also in a subsequent increase of the parasite burden, as expected after the disturbance of the host-parasite immunity balance. Green (1963) stated that our challenge is to advise programme which enable us to obtain the greatest economic yield for the farmer under his particular conditions. Even after 5 decades, this concept is still the main focus of many research groups (Jackson and Miller 2006, Torres-Acosta and Hoste 2008). The real index of economic benefit is an estimate of the net return from different schemes in comparison with a control group based on a properly conducted trial (Banks *et al.* 1966, Anderson *et al.* 1976). Information on the economic benefit of helminths control in sheep is meagre and comparison of results is difficult. Higher return was obtained from the flocks kept in strategic scheme.

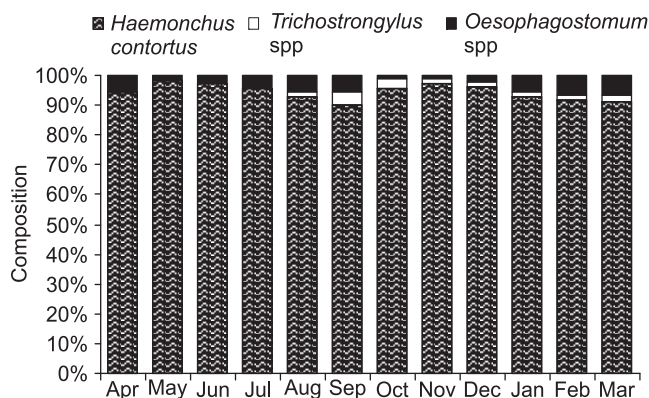


Fig. 3. Average monthly composition of strongyle larvae on coproculture.

Table 1. Comparative production performance of sheep flocks under two schemes of worm management in semi-arid Rajasthan

		2004-05		2005-06		2006-07		2007-08		2008-09		2009-10		2010-11		Overall	
		SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG
a	Strength	602	560	1105	674	970	122	1031	95	618	220	1092	972	6390	1671		
b	Lambing																
1	No	385	356	1043	465	770	94	754	79	539	201	899	717	5107	1195		
2	%	(b1/a) × 100	69.95	63.57	94.39	68.99	79.38	73.13	83.16	87.22	91.36	81.5	73.77	79.95	71.51		
c	Purchase																
1	No	2	3	140	8	93	30	179	31	2	15	20	51	487	86		
2	%	(c1/a) × 100	0.33	0.36	12.67	1.19	9.59	24.54	17.36	0.32	6.82	1.83	5.25	7.62	5.15		
d	Sale																
1	No	59	105	341	150	447	13	340	66	295	126	526	440	2448	460		
2	%	(d1/a+b1+c1)×100	5.97	11.44	14.9	13.05	24.39	5.28	17.31	32.2	28.9	26.16	25.29	20.42	15.58		
e	Mortality																
1	No	72	104	313	147	123	25	194	23	89	55	260	195	1246	354		
2	%	(e1/a+b1+c1)×100	7.28	11.33	13.68	6.91	10.16	9.88	11.22	7.68	12.61	12.93	11.21	10.4	11.99		
f	Morbidity																
1	No	410	279	1247	558	838	105	1149	91	597	222	119	1207	5567	1255		
2	%	(f1/a+b1+c1)×100	41.46	30.39	54.5	45.72	42.68	58.5	44.39	51.51	50.92	55.64	69.37	46.67	42.51		
g	Addition in flock																
1	Number	(b1+c1-d1-e1)/a × 100	256	149	529	293	86	399	21	157	35	133	133	1900	467		
2	%		42.52	26.6	47.87	36.21	70.49	38.7	22.11	25.4	15.94	12.18	13.68	29.73	27.95		
h	Annual expenditure (₹)/100 sheep	5457.2	6127.9	28639.5	12423.1	21429.3	36195.1	11823.9	60114.7	7279	24844.1	16150.7	20719.2	15785.6	2794		
	Feed	2215.2	2213.3	2598.6	4390.5	1793.8	0	1493.7	4210.5	4126.2	2454.6	7229.8	4892	3464.2	2653.8		
	Medicine	2400.7	1692.4	4242.4	4115.5	1519.5	1563.9	1788.5	2162.1	2029.8	3499.1	3957.1	4329.8	2895.4	2595.6		
	Other	941.3	2222.2	21798.5	3917.1	18116	34631.2	7541.7	53742.1	1123	18945.5	4963.8	11497.4	9426	22691.6		
i	Annual receipt (₹)/100 sheep	19598.9	26954.8	54729.4	53530.2	51401.7	14614.7	62687.6	114949.5	52863.3	74997.8	71968.9	63285.1	53791.3	56989.5		
	Animal	11428.6	17982	42296.6	36740	42914.6	7459	55168.6	107228.4	45275.1	67077.3	57038	49501	43374.7	47277.5		
	Wool	4780.3	5147.8	6844.9	9555.1	4487.1	3155.7	4535	4221.1	3251.6	3829.6	3589.3	4374.5	4551.8	5181.8		
	Manure	3390	3825	5587.9	7235.1	4000	4000	2984	3500	4336.6	4090.9	11341.6	9413.6	5864.8	4530.2		
j	Income (₹) by addition and price fetched	25512	15960	42125.6	19060.3	28095.3	49343	38700	22110	24130	18649.8	14372.4	14975.6	28184	23478		
k	Total receipt (₹) /100 sheep	(₹600)	(₹600)	(₹880)	(₹730)	(₹930)	(₹700)	(₹1000)	(₹1000)	(₹950)	(₹1170)	(₹1180)	(₹1095)	(₹948)	(₹840)		
	(I+i)	45170.9	42914.8	96855	72590.5	79497	63957.7	101387.6	137059.5	76993.3	93647.6	86341.3	78264.7	81975.3	80467.5		
1	Net income (₹) /100 sheep/year	39713.7	36786.9	68215.5	60167.4	58067.7	27762.6	89563.7	76944.8	69714.3	68803.5	70190.6	57545.5	66189.7	52526.5		
	(k-h)																

Conventional approach achieves almost similar control of parasite and yields a low financial return to farmer.

The present study revealed that with adequate information to delineate critical times of the year when parasites will be most vulnerable to anthelmintic treatment, a rational and effective worm management scheme can be devised and the financial benefit of the strategic treatment scheme was therefore high. The magnitude of FECs in present study reflected success of single drench schedule (during mid to late monsoon) in management of GI nematodes in field flocks of semi-arid region. The conventional practice of 2–3 drench/year seems to be unwarranted as there is continuous decline in FEC after monsoon. Thus, it was concluded that there is no merit for the farmers in adopting the conventional worm management scheme in preference to the strategic worm management scheme, since the latter was not only more financially rewarding one in all the years but also provide better opportunities for gainful interaction between epidemiology, weather and management of flocks, reduction in anthelmintic drench frequency, better rotational use of anthelmintic types, reduction of selection pressure in parasite population and reduces the unwanted expenditure incurred by farmer on anthelmintic use.

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