



Comparative impact of conventional and strategic worm management schemes in sheep flocks of arid Rajasthan

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ABSTRACT

A study on comparative impact (in terms of worm profile and flock performance) of two schemes of worm management in naturally infected sheep flocks was made in arid Rajasthan. During the period from May 2004 to March 2012, sheep (8415) were monitored for gastrointestinal strongyles by examining 24,310 faecal samples as well as for production performance of flock. The monthly incidence and intensity of strongyle nematodes remained almost similar among flocks given either strategic (one drench / annum) or conventional (3 drenches / annum) anthelmintic treatment. The epidemiological profile exhibited higher magnitude of infection only during monsoon (June-October). The data on flock performance exhibited 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 arid Rajasthan which is based on systematically gathered epidemiological information.

Key words: Arid, Gastrointestinal nematodes, Rajasthan, Sheep, Worm management schemes

The small ruminant production is very important source of livelihood to the rural people of India especially when agriculture fails (Gupta and Suresh 2010). An exhaustive review commissioned by WHO, OIE, FAO, concluded that gastrointestinal parasitism (GIP), an important production limiting diseases of livestock, had the highest global index as an animal health constraint to the poor. Based on sheep population (Census 2003), Singh *et al.* (2011) estimated an annual loss of ₹ 1,191.708 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%). It is an accepted fact that 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 the 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.

Despite the progress made to manage GI parasites, farmers continue to incur substantial losses due to insufficient availability of information on the epidemiology of these parasites. For effective management it becomes essential to know the regional distribution and prevalence of GI parasites and their correlation with environmental conditions and management practices. The knowledge of epidemiology of GI helminths at regional or even local level is a pre-requisite for the design of an integrated control approach (Torres-Acosta and Hoste 2008).

In Rajasthan sheep breeders treat their flocks for GI helminths at an average frequency of 2.59 ± 0.03 /sheep/year. Mostly flocks were drenched thrice a year during April/June, September/ November and February indicating that anthelmintic intervention was coupled with shearing of sheep (Swarnkar and Singh 2010a). Epidemiological studies in Rajasthan showed that translation and availability of strongyle larvae on pasture was mainly restricted to the wet season (Swarnkar and Singh 2011). Llyod *et al.* (2000) 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. Present communiqué describes the result on comparative impact of conventional and strategic worm

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management schemes in sheep flocks of arid Rajasthan.

MATERIALS AND METHODS

The study was conducted from May 2004 to March 2012 by adopting all flocks of 2–3 villages/year in 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 $7.9 \pm 0.3^{\circ}\text{C}$ (January) to $28.1 \pm 0.2^{\circ}\text{C}$ (June) and from $23.0 \pm 0.3^{\circ}\text{C}$ (January) to $42.1 \pm 0.2^{\circ}\text{C}$ (May). The average monthly total rainfall ranged from 2.8 ± 0.7 mm (January) to 103.3 ± 15.9 mm (August). The average relative humidity in atmosphere at 8.30 AM IST varied from $40.6 \pm 1.2\%$ (April) to $76.9 \pm 0.9\%$ (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 scanty 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 scanty rainfall) during September to November (Swarnkar and Singh 2011).

Flock management: Flocks (122) comprising 8,415 sheep 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. Use of vaccination against enterotoxaemia and sheep pox was sporadic in arid region.

Treatment groups: Based on bench-mark study during the period from 2000–2004, a region based modified worm management programme was formulated (Swarnkar *et al.* 2008) which included strategic anthelmintic intervention in flocks during mid-late monsoon. In the present study, to test the effectiveness and impact 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 (7,426) in strategic group (SG) were administered tetramisole or closantel on annual rotational basis by the institute while sheep (989) 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 May 2004 to March 2012, a total of 24,310 faecal samples (22,858 from SG and 1,452 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 McMaster 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 returns from different schemes all figures were 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 arid Rajasthan, over the years evaluation of faecal samples revealed that the average monthly incidence of strongyle nematodes in sheep flocks ranged significantly ($P < 0.01$) from $23.93 \pm 3.93\%$ (March) to $70.00 \pm 4.52\%$ (June) in strategic treatment group and from $26.90 \pm 7.83\%$ (January) to $73.84 \pm 10.64\%$ (August) in conventional treatment group (Fig. 1). The incidence rate remained statistically almost similar for all the months among 2 treatment groups. In both the groups incidence of strongyle nematodes started rising with the occurrence of pre-monsoon rains in June and remained higher during monsoon and declined thereafter. The initial rise during May could be attributed to resumption of development in hypobiotic larvae in host. This could be triggered by nutritional and walking stress in animals as both macro- and micro-climates were unsuitable for larval translation with least chance of infection from pasture. On the other hand, the persistence of infection even after anthelmintic intervention during monsoon indicate availability of climatic conditions suitable for translation of exogenous stages of nematodes. The occurrence of delay in

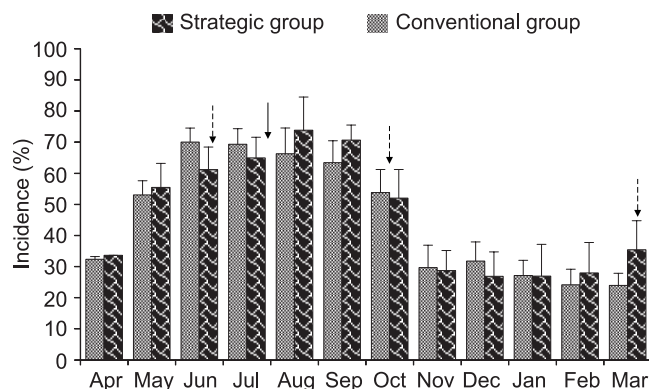


Fig. 1. Monthly incidence (mean $\pm$ SE) of strongyle nematodes in sheep flocks under 2 anthelmintic treatment schemes (time of anthelmintic intervention is indicated by solid arrow in SG and by dotted arrows in CG flocks).

peak of incidence in CG flocks could be due to use of additional anthelmintic intervention during March and June. The year to year variation in monthly incidence of strongyle worms in sheep flocks was attributed to type and efficacy of anthelmintics used. Further nonsignificant variation in incidence of strongyle nematodes among both the group reflected that higher anthelmintic frequency in arid conditions of Rajasthan had no impact on reducing the incidence of infection.

Intensity of strongyle nematodes: The overall monthly FECs varied significantly ($P < 0.001$) from 48.99 ± 10.55 (March) to 927.64 ± 214.29 epg (August) in SG flocks and from 58.76 ± 29.42 (February) to 1644.04 ± 454.38 (August) in CG flocks (Fig. 2). Within a month, variation in intensity of strongyle infection among both the groups was non-significant. Persistency of strongyle infection was either due to the successful survival of the exogenous stages on the pasture or of the adults or hypobiotic larvae in the host. The intensity of strongyle infection in sheep flocks of arid Rajasthan exhibited that with few exceptions, higher number of strongyle eggs were shed in the faeces from July to September 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 occurred 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 possessed 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. 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

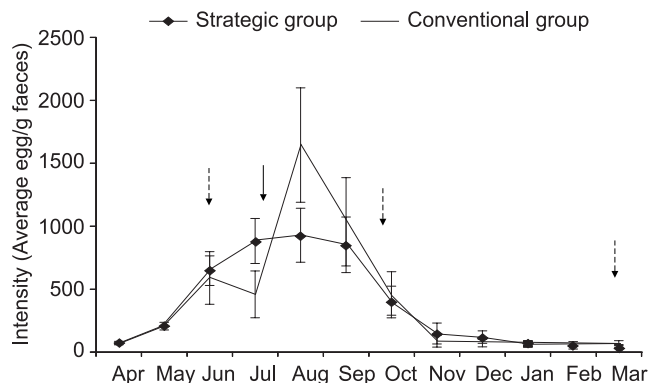


Fig. 2. Monthly intensity (mean $\pm$ SE) of strongyle infection in sheep flocks under 2 anthelmintic treatment schemes (time of anthelmintic intervention is indicated by solid arrow in SG and by dotted arrows in CG flocks).

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 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

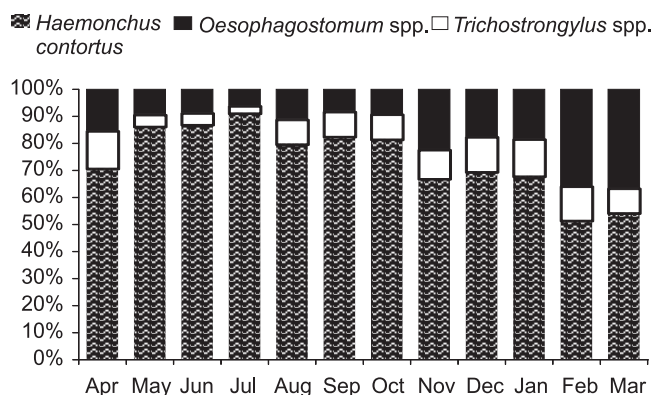


Fig. 3. Average monthly composition of strongyle larvae on coproculture.

was economically and scientifically unsound because GIN and climatic conditions prevailed or confined to very short period of monsoon (Swarnkar and Singh 2011, Swarnkar *et al.* 2008). Our results demonstrated the value of a strategic scheme for the management of GIN, which is based on relevant epidemiological information. Further strategic intervention during mid to late monsoon not only helped in maintaining the quantum of *refugia* (Singh and Swarnkar 2008) but also supposed to increase drug efficacy due to ingestion of more dry fodder (Sanyal *et al.* 2003).

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 *H. contortus* ranged from $51.88 \pm 10.31\%$ (February) to $91.35 \pm 2.41\%$ (July). The monthly proportion of *Trichostrongylus* and *Oesophagostomum* spp. varied from $2.77 \pm 1.50\%$ (July) to $13.58 \pm 8.78\%$ (January) and from $5.85 \pm 1.75\%$ (July) to $36.29 \pm 10.12\%$ (March), respectively (Fig. 3). The proportion of non-haematophagous species remained higher in arid region compared to semi-arid region (Swarnkar *et al.* 2008; Singh and Swarnkar 2011) and this could be attributed to prevailing more humid climate during winter in arid region compared to semi-arid region. The 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 groups 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 CG flocks was higher (92.52%) compared to SG flocks (79.87%). The other factors, which affected the flock dynamics (i.e. purchase and sale of animals) remained almost similar in both the groups. The average annual morbidity

varied from 37.05% (SG flocks) to 45.46% (CG flocks) and major entities were lameness, foot wound / abscess, facial mange, enteritis and pneumonia. The average annual mortality remained slightly higher (8.92%) in CG flocks compared to SG flocks (6.08%). Similarly no effect of anthelmintic treatment schemes on lambing and mortality was observed by Morris *et al.* (1977) in breedable ewe in Victoria, Australia, and in sheep flocks of semi-arid Rajasthan (Swarnkar and Singh 2012). The overall annual expenditure/100 sheep was ₹ 68,119.2 and ₹ 62,921.4 in SG and CG flocks, respectively. The major component of expenditure in both the groups was feed and fodder (49.6 to 77.3%) followed by purchase of animals (16.2 to 40.3%) and health input (6.5 to 10.1%). The overall net annual income/100 sheep was higher (₹ 12,2828.7) in SG flocks compared to CG flocks (₹ 98,617.9). Based on dynamics and economics of flocks, it was clearly perceived that reduction in anthelmintic frequency in modified worm management practices as against conventional practices had no adverse effect of flock performance. The benefit 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. Similarly, Kelly *et al.* (2010) demonstrated that sheep with integrated parasite management scheme had lower FEC, require fewer anthelmintic treatment and less production losses, low mortality compared to sheep with traditional worm practices.

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). 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. Conventional approach achieved almost similar control of parasite and gave 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

Table 1. Comparative production performance of sheep flocks under 2 schemes of worm management in arid Rajasthan

	2004-05		2005-06		2006-07		2007-08		2008-09		2009-10		2010-11		2011-12		Overall	
	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG	SG	CG
a Strength	516	209	1078	1325	70	615	205	636	145	745	1514	997	360	7426	989			
b Lambing																		
No.	412	175	920	1109	66	582	193	604	167	601	957	746	314	5931	915			
%	79.84	83.73	85.34	83.7	94.29	94.97	94.15	94.97	115.17	80.67	63.21	74.48	87.22	79.87	92.52			
(b1/a) × 100																		
c Purchase																		
No.	3	11	51	82	6	130	-	-	52	35	20	-	-	321	69			
%	0.58	5.26	4.73	6.19	8.57	21.14			35.86	4.7	1.32			4.31	6.98			
(c1/a) × 100																		
d Sale																		
No.	179	59	305	438	38	230	123	399	85	395	502	418	86	2866	391			
%	19.23	14.49	14.89	17.41	26.76	17.33	30.9	32.18	25.35	28.6	20.15	23.98	12.76	20.95	19.82			
(d1/a+b1+c1)×100																		
e Mortality																		
No.	73	27	155	169	24	69	26	62	12	85	138	81	87	832	176			
%	7.84	6.84	7.56	6.72	16.9	5.2	6.53	5	3.3	6.15	5.54	4.65	12.91	6.08	8.92			
(e1/a+b1+c1)×100																		
f Morbidity																		
No.	230	106	783	1077	85	552	205	500	143	529	745	652	358	50.68	897			
%	24.7	26.84	38.21	42.81	59.86	41.6	51.51	40.32	39.29	38.21	29.91	37.41	53.12	37.05	45.46			
(f1/a+b1+c1)×100																		
g Addition																		
Number	163	100	51	584	10	413	44	143	122	156	337	247	141	2554	417			
%	31.59	47.85	47.4	44.08	14.29	67.15	21.46	22.48	84.14	20.94	22.26	24.77	39.17	34.39	42.16			
(b1+c1-d1-e1)/a ×100																		
h Exp (Rs)/	34871.1	24695.5	47564.9	31607.1	47891.4	57952.7	32580.5	28506.4	111294.5	47599.9	34580.2	27735.9	8705.8	68119.2	62921.4			
100 sheep																		
Feed	32131.8	14928.2	38537.1	21720.8	27857.1	27723.6	30341.5	24481.1	38413.8	33503.4	28150.6	23159.5	3333.3	52623.6	31218.5			
Medicine	1266.4	2111.8	1631.1	1166.7	2034.3	1222.1	1190.2	1750.9	2660	2182.4	2507.2	2766	4358.6	4441.3	6357.7			
Other	1472.9	7655.5	7396.7	8719.6	18000	29007	1048.8	2274.4	70620.7	11914.1	3922.4	1810.4	1013.9	11054.3	25345.2			
i Inc (Rs)/	55134.7	34130.8	49699.3	43454.3	58614.3	42912.6	46211.2	72501.6	79957.3	73775.2	59507.3	96200.5	55055.5	152912.6	114783.9			
100 sheep																		
Animal	43759.7	25322	38824	31184.9	49000	32175.4	55902.4	65676.1	65448.3	60389.3	48421.4	77472.4	47777.8	123248.2	96697.2			
Wool	4064.1	4976.1	3417.2	3797.7	4042.9	2846.3	3512.2	2278.3	2440	2298.7	2852.7	3482.4	2833.3	6561.7	6576.1			
Manure	7310.9	3827.7	7458.1	8471.7	5571.4	7890.9	6796.6	4547.2	12069	11087.2	8233.2	15245.7	4444.4	23102.7	11510.6			
j Inc. (Rs) by	14820	16104	45310	41435.2	12861	57749	19957.8	23604	93816.1	23871.6	32499.6	45825	78340	38035.3	46755.4			
addition																		
Based on g																		
and price																		
fetched																		
l Net inc Rs /	(600/-)	(600/-)	(950/-)	(940/-)	(900/-)	(860/-)	(930/-)	(1050/-)	(1115/-)	(1140/-)	(1460/-)	(1850/-)	(2000/-)	(1106/-)	(1109/-)			
100 sheep	35083.6	25539.3	47449.4	53282.4	23583.9	42708.9	33588.5	67599.2	62478.9	50046.9	57426.7	114290.6	124689.7	122828.7	98617.9			
(i+j-h)																		

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 arid Rajasthan. 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 more financially rewarding one in all the years and also provided 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 reduced the unwanted expenditure incurred by farmer on anthelmintic use.

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