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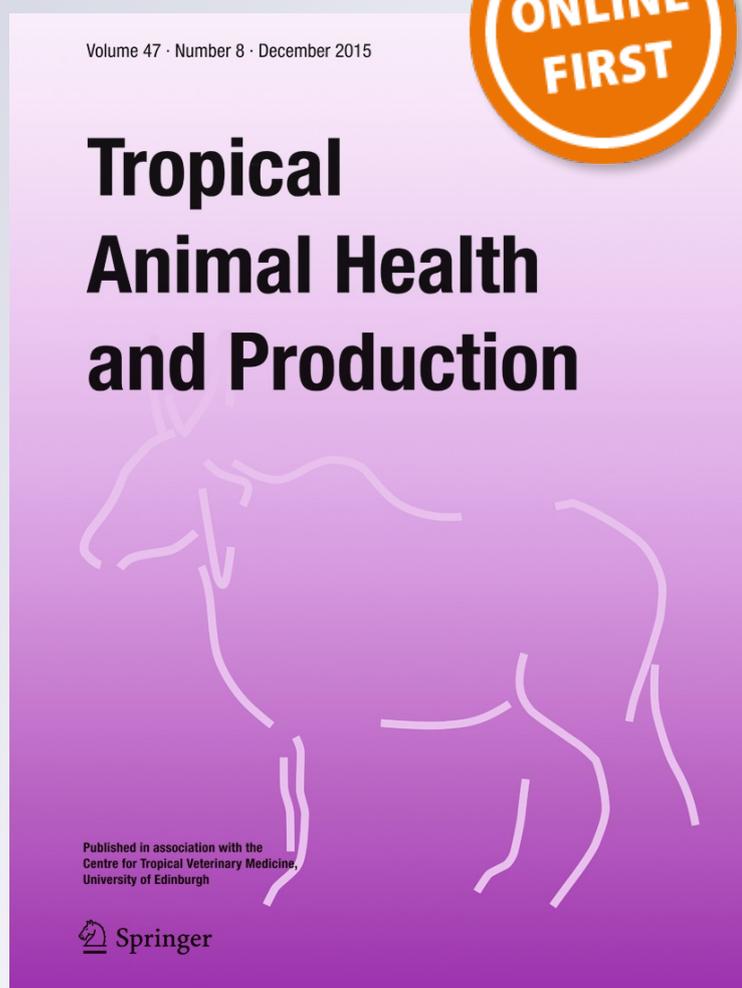ONLINE FIRST

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Anthelmintic administration to small ruminants in emergency drought responses: assessing the impact in two locations of northern Kenya

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Abstract Internal parasites are a significant determinant of the productivity of ruminant species in the tropics. Provision of anthelmintics has become a predominant part of animal health interventions in emergency drought responses, aiming to maintain the food conversion efficiency of livestock when pasture is scarce. This study aimed to assess the owner-perceived impact of anthelmintic provision on the health and productivity of small ruminants in the drought-prone counties of Isiolo and Marsabit, northern Kenya. Participatory approaches were used to retrospectively measure differences in key indicators of livestock output before and after anthelmintic administration. Results showed that there was no perceived impact of anthelmintic administration during droughts on small ruminant health and productivity, but some benefit of anthelmintic administration during rainy season was perceived. The study also provided some evidence of potential differences in the epidemiology of internal parasites between the counties. These findings may be utilised to inform future livestock intervention programmes in drought-prone areas.

Introduction

In the last two decades, northern Kenya has been affected by four major drought periods (Aklilu and Wekesa 2002; Zwaagstra et al. 2010) resulting in a loss of up to 43 % of sheep and goats, 35 % of cattle and 18 % of camels with a total economic loss of US$77 million (Aklilu and Wekesa 2002). There are estimated to be over one million small ruminants within the drought-affected counties of Isiolo and Marsabit in northern Kenya that are kept in pastoral husbandry systems (Behnke and Muthami 2011). Over 90 % of the human population within these counties are engaged in pastoralism and dependent on livestock to meet their basic needs (Frakin 1998; Doss and McPeak 2006). Small ruminant livestock species are a source of daily nutritional intake through milk and meat

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(Sadler et al. 2009, 2012). They also maintain the economic viability of households through sales of animals and their produce (Doss and McPeak 2005, 2006) and serve a number of cultural and social purposes (Kristjanson et al. 2004). Loss of livestock during drought periods results in food insecurity, increased vulnerability and decreased resilience to future shocks (Chinogwenya and Hobson 2009).

Drought relief programmes have aimed to support the livelihoods of pastoralists to mitigate the effects of drought on human health and wellbeing (Lautze et al. 2006). Livestock-based interventions are integral to these programmes. Five key technical areas are identified: provision of feed, provision of water, provision of animal health packages, destocking and restocking (Young et al. 2001; Aklilu and Wekesa 2002; Longley and Wekesa 2006; Catley et al. 2009). Animal health activities predominantly consist of the administration of anthelmintics and vaccinations (Aklilu and Wekesa 2002; Zwaagstra et al. 2010; Longley and Wekesa 2006).

Internal parasites are ubiquitous to livestock in Africa (Hansen and Perry 1990; Craig 1999) and are considered to contribute to poor feed conversion efficiency of affected animals. Infection results in a decline in the overall productivity of the animal (Odoi et al. 2008) resulting in a nutritional and economic loss for the households (Maichomo et al. 2004). Strategic control can therefore have significant cost benefits in terms of improving both animal health and human wellbeing (Zinstag et al. 1997). However, environmental conditions in droughts are not favourable to parasite proliferation. The change in the morphology of infective larvae can be stalled by high temperatures and low moisture levels (Craig 1999). Questioning the epidemiological rationale behind anthelmintic use is necessary for effective animal health care.

To the authors' knowledge, no studies to date have assessed the impact of anthelmintic distribution in emergency drought responses. Ethical and practical considerations in an emergency setting often mean that the use of a comparative control group—that did not receive anthelmintic—is not possible (Catley and Admassu 2003). Baseline data collection, to enable assessment of the difference in the respective indicator before and after an intervention, is also not usually carried out. It follows that a retrospective assessment of the measurement of an indicator before and after an intervention is often the only possible means of measuring change. This study assesses the perceived impact of anthelmintic administration in emergency drought responses using modified participatory techniques (Catley and Admassu 2003). The study focused on the activities of two implementing partners (IPs) involved in the administration of anthelmintics in the counties of Isiolo and Marsabit through government veterinary services.

Aims and objectives

The primary aim of the study was to assess how livestock owners perceived the effect of the emergency anthelmintic provision in Marsabit and Isiolo districts during the drought response on the health needs of small ruminants they owned. The specific objectives of the project were to measure the following:

1. The relative importance of internal parasites as a cause of loss of livestock productivity in drought periods according to pastoralists
2. The difference in livestock production before and after emergency anthelmintic administration during the drought period

Methods

Ethical considerations

The study was approved by the Kenyan Scientific and Technical Research Council (NCST/RCD/12A/012/38) and the Ethics and Welfare Committee of the Royal Veterinary College, University of London (URN 2012 1143). The study was based on pastoral perceptions and all respondents provided verbal consent to participate in the study. No animals were examined or sampled.

Study areas, study population and sampling

The study took place in the Merti, Central and Garba Tula districts of Isiolo and the Dukana and North Horr districts of Marsabit. The administrative structure of Kenya is such that each district is sub-divided into sub-locations. A two-stage sampling technique was used where the primary unit was the sub-location and individuals eligible for participatory rural appraisals (PRAs) and household interviews (HHI) were the secondary unit.

Sampling of primary units

Sub-locations of areas where emergency anthelmintic administration had taken place were identified from records at the regional office of the veterinary services. The following inclusion criteria were used to generate a sampling frame of sub-locations: (i) accessibility, including distance from where the research team stayed, and (ii) adequate security that would not inhibit movement to and from the sub-location.

A random sample of sub-locations within the sampling frame was then selected from each county. Convenience sampling was then used to select one location (within each sub-

location) for the assessment, based on likelihood of residence of livestock owners at the time of study and the presence of geographical features—e.g. watering point, petty trade—that meant a representative sample of inhabitants of the sub-location was likely to be available on the day of data collection.

Sampling of secondary units

The sampling frame in all sub-locations included all households and household members that had owned livestock at the time of the anthelmintic administration in the 2012 drought response. A meeting was held with the chief of each sub-location. The purpose of the impact assessment and methods to be used were discussed. Participants to take part in the PRA were then identified by the chief. The study population of household interviewees was selected by the research team according to the availability and consent of the head of the households identified.

Data collection

In each sub-location, one PRA and up to six HHIs were carried out. In addition, semi-structured interviews (SSIs) were carried out with key informants (KIs) involved in operational activities and members of PRAs that were providing unique information that informed the study.

A team comprising of a primary researcher, two local facilitators and two translators carried out the assessment in each location. One facilitator, a veterinarian trained in participatory methods and fluent in both Borana and Gabra, led all PRAs to ensure standardisation of methods used. The primary researcher was responsible for recording results. A second facilitator (who spoke the community language, had experience in semi-structured interview techniques and was familiar with animal health) was employed separately in each county and responsible for carrying out the HHIs.

An orientation day was organised to familiarise each facilitator with both the PRA and HHI. The two primary facilitators were responsible for guiding the participatory work and interviews through the translators.

Participatory rural appraisals

A pilot study was carried out to guide the structure and questions of the PRAs and HHIs.

Participants defined the meaning of household wellbeing, contributing factors and the importance of livestock in this respect; listed the livestock species that were owned within the location; and discussed the products from each livestock species that contributed to their household wellbeing. They ranked the outputs according to their importance to household wellbeing. Due to the high level of ownership, the subsequent exercises focussed on small ruminants.

A seasonality calendar was created to assess the change in each of the three most important outputs of small ruminants throughout the drought in the preceding years. Starting with present time, participants identified the last substantial period of rainfall that had ended the drought—October 2011. From this point, they were able to identify the time of the rain before the drought period began. Using these two points, participants created a transect line. Five photos of different grass qualities were provided. The facilitator ensured that the groups were in agreement about the interpretation of each photo and the association of each with the temporality of. Participants then placed the photos along the transect line in an order that represented increasing time without rain. This method was used to divide the transect timeline into six stages: (1) April–June, 2008: long rains; (2) June–October, 2008: dry season; (3) 2008–2009: extended dry season; (4) 2009–2011: drought period; (5) October 2011: short rains and (6) April 2012: data collection.

Taking each output defined by the PRA participants (milk, weight and sale of animals), proportion piling was used to show the change in output at each of the stages on the timeline. Ten counters were provided as the maximum possible output possible at any one time. The number of counters placed at each stage therefore showed the output relative to the maximum possible output.

Participants discussed the reasons for the change in outputs of small ruminants in an open discussion. The facilitator then used guiding questions to focus discussion on diseases that affected the outputs. Local names for diseases and conditions were cross-checked with the clinical signs that were seen and the facilitator used his clinical knowledge to confirm the disease or condition that was being discussed.

The conditions that affected small ruminants were then ranked according to the perceived effect they had on the outputs of individual animals. Factors affecting the decision-making process determining the rank included the number of animals affected by the condition, mortality rate and the severity of production loss.

An open discussion then followed, to generate information on the prevention and treatments used by livestock owners for each disease. In PRAs where internal parasites had not been perceived to have an effect on output, participants were asked to list all animal health treatments their livestock received. The mention of anthelmintic provision initiated discussion about reasons for its use and the perceived effect of internal parasites.

Finally, before and after scoring was used to assess the perceived difference in small ruminant outputs after receiving anthelmintics. The exercise mirrored the proportion piling exercise used earlier in the appraisal. Two sets of ten counters were provided to participants and divided onto two different coloured cards. The lead facilitator explained that each pile represented the maximum amount of each output. Pile A was the output (relative to the maximum possible) before anthelmintic administration and pile B was the relative output after anthelmintic

administration. The exercise was conducted for the outputs of weight of animals and milk production, respectively.

Household interviews

Semi-structured HHIs contained questions overlapping with those in the PRA to triangulate the data collected. Basic demographic information of interviewees, livestock ownership and household income were gathered using closed questions.

Livestock owners were asked directly if they perceived their animals to be affected by internal parasites, the species and demographics of animals that were affected. Further closed questions were used to ascertain clinical signs that livestock owners attributed to internal parasites and if there were particular times when more animals displayed these clinical signs.

Data recording

PRAs were audio-recorded with a digital dictaphone. The primary researcher was responsible for recording the quantitative data generated throughout the appraisal. General discussion around the key topics was monitored and chaired by the facilitator. Whilst PRA participants reached consensus, the facilitator relayed to the primary researcher individual differences of opinion that were transcribed at the time. Key informant interviews were carried out when new pieces of information were generated to capture the differences in perceptions within participating groups. The interviewer transcribed the SSIs with key informants at the time of the interview.

Data analysis

The mean proportion (score/10) of each output across all groups at each stage of the drought and the corresponding standard deviations were calculated using Microsoft Excel and used to assess the change in livestock species output throughout the drought cycle.

Use of ranked data

The ranking of each disease in each PRA group was converted into a score using the following formula:

$$Sc_{ij} = N_{ij} - r_{ij} + 1$$

Sc_{ij} Score for the jth disease in the ith group
N_{ij} The number of diseases identified by group i
r_{ij} The rank given to disease j by the group i

Where the disease had not been voluntarily mentioned by the group, it was assumed that it was not perceived to have an effect on output and therefore denoted the score 0.

The individual scores for each disease were standardised to be comparable using the following formula:

$$STSc_{ij} = Sc_{ij}/N_{ij} \times 10$$

$STSc_{ij}$ Standardised score for the jth disease in the ith group
Sc_{ij} Score for the jth disease in the ith group
N_{ij} The number of diseases identified by group i

Statistical analysis

The median and interquartile range (IQR) of the standardised scores of diseases perceived as affecting outputs by different groups were determined. Friedman's test was used to test the null hypothesis that there was no difference in the standardised scores of all the diseases. A Wilcoxon rank sum test was used to test the null hypothesis that there was no difference between the score of each disease and that of internal parasites when individually compared. An independent Welch t test was used to ascertain if there was statistical evidence of a perceived difference in outputs after anthelmintic administration, both in dry periods and following the rains, using data gathered from the PRAs.

Results

Study population

The study took place in 23 locations in Marsabit and Isiolo counties between March and April 2012. Twenty-three PRAs, including 265 participants, and 122 HHIs were conducted. Each study site comprised between 4 and 14 central and satellite settlements. Government food aid was distributed to 100 % of the study population at the time of the study.

The median number of small ruminants kept per household at the time of data collection in Isiolo was 20 (IQR 10–40) and in Marsabit 35 (IQR 20–60). The median number of cattle owned (2, IQR 0–5) was greatest in Isiolo but the number of camels owned per household (5, IQR 0–100) was greatest in Marsabit. The average number of household members was 7.9 (95 % confidence interval (CI) 6.9–8.8) and 30 % of the households were female-headed.

All PRA participants were small ruminant owners and females accounted for 30 % of the study population.

PRA and HHI findings

Almost all (22/23) participatory groups identified livestock ownership as the principal contributor to household

wellbeing, and all groups identified milk as the most important output of all livestock species as it provided a constant source of nutritional intake for all household members. Sale of livestock to generate cash to meet basic needs such as purchase of clothes, food when necessary and pay school fees of children was regarded as the second most important output from livestock species. Meat for consumption and occasionally sales was the third most important output. When using the condition score or weight of animals as a proxy measure for the amount of meat on an animal slaughtered, these criteria all corresponded with the factors affected by internal parasites.

All groups identified a period of 3 years where no rainfall was seen between April 2008 and October 2011. A period of drought was recognised as the period from where the second long rains should have occurred until the next rainfall. All appraisal groups attributed the lack of rain and subsequent lack of pasture and water as the primary contributing factor to the decline in milk and weight of small ruminants throughout the drought period. These trends were inversely correlated with the number of live sales made by households (Table 1). An increased incidence of disease was considered the second most important factor.

The diseases perceived to contribute to the loss in production in all species and the number of appraisal groups that voluntarily mentioned the disease in question are shown in Table 2. Diseases perceived to cause highest mortality in animals were given the highest rank.

There was good evidence to support the assumption that there was a difference in the scores between diseases in all species ($P<0.001$) and that participants perceived internal parasites to affect output less than contagious caprine pleuropneumonia (CCPP) ($P=0.008$) or "gid" cyst ($P=0.015$) (Table 2).

Whilst 74 % of all groups identified internal parasites as a cause for production loss in small ruminants, this proportion differed between the two counties; 86 % of PRA groups in Isiolo considered internal parasites as a cause of weight loss and reduced milk output in open discussion and 100 % were affirmative that it affected the output of their livestock on direct questioning. However, only 44 % of appraisal groups in Marsabit considered internal parasites as a cause of reduced output in open discussion and 90 % on direct questioning. The

reasons for not considering internal parasites in open discussion differed between the two counties.

In Marsabit, the reasons for not considering it as a cause of reduced output were as follows:

- "No signs are seen…. told that they cause emaciation but not observed."
- "Some may see in intestines on slaughter but no signs when alive."

These results were corroborated in the HHIs; 40 % of interviewees in Marsabit considered internal parasites a cause of declining output of all livestock species unprompted and 86 % on direct questioning. Half (50 %) reported signs of parasites in slaughtered animals but did not attribute them to any sign in living animals and 50 % reported no clinical or pathological signs.

The mean proportions and corresponding confidence intervals of milk output and condition score in all livestock species before and after anthelmintic administration in the drought itself show considerable overlap (Table 3). There was no evidence of a difference in the perceived change of either output after administration of anthelmintics during a drought response ($P=0.34$ for milk output and $P=0.31$ for condition score). However, there was good evidence of a difference in the mean milk output ($P=0.001$) and body condition score ($P<0.001$) when anthelmintic administration was carried out after the rains. However, other factors also contributed to the changes seen after the rains, including increased grass and water availability that occurred concurrently to anthelmintic administration after rainfall.

Discussion

Whilst the study sought to include a representative sample population for each sub-location, the study design is likely to have resulted in a bias towards a sedentary household study population. Whilst geographical features within these sites meant that members of peripheral locations and more mobile members of society were present, daily duties and travel time are likely to mean that participation in PRAs was lower than

Table 1 Average proportion pile appointed by participatory groups (standard deviation) demonstrating the relative productivity of small ruminant parameters throughout the 2008–2011 drought period (maximum = 10)

Production parameter	Stage of drought period					
	Long rains	Normal dry season	Extended dry season	Drought period	End of drought—short rains	Data collection
Milk	9.56 (1.00)	6.04 (1.59)	3.06 (1.61)	0.84 (0.61)	7.84 (3.3)	3.8 (1.66)
Body condition score	8.5 (1.95)	7.87 (2.03)	4.87 (2.05)	1.39 (0.94)	7.21 (3.14)	5.87 (2.40)
Number of animals sold	2.13 (1.67)	3.13 (1.86)	4.56 (1.71)	7.69 (1.66)	1.69 (1.41)	3.56 (2.03)

Table 2 Diseases identified and median score (interquartile range) appointed by participatory groups in Isiolo and Marsabit with *P* value of evidence of difference in score to internal parasites

Condition (local name)	Number of participatory groups identifying disease unprompted, *n* (%)	Median standardised score	Wilcoxon signed rank test *P* value
CCPP (sombese)	21 (91)	8.4 (5.31–10)	0.008
"Gid" cyst (sirgo)	14 (61)	6.67 (0–8)	0.015
Pox (Kurtabale)	15 (65)	5.78 (0–7.88)	0.14
Internal parasites (minyoo)	17 (74)	2.91 (0.4–4.3)	na
Ectoparasites (Shilmi)	11 (48)	1 (0–5.75)	0.87
"Quando"	11 (48)	0.83 (0–5)	0.87
PPR (Dhadi ree)	7 (30)	0 (0–7.78)	0.45
Footrot (Oryale)	11 (48)	0 (0–3.95)	0.27
Enterotoxaemia (Albati)	7 (30)	0 (0–3)	0.005
Mange	9 (39)	0 (0–2)	0.15
Jaagsiekte	2 (9)	0 (0–0)	0.007

static contemporaries. Pastoralists that are more mobile are likely to experience different risks of disease that may have affected the results. Responses regarding the effects of internal parasites or anthelmintics will be influenced by the expectations of future work as a result of the appraisal (Mosse 1994). Whilst the research team tried to mitigate this by providing a full explanation of their purpose, it cannot be excluded as an influencing factor in participants' responses.

This study asked participants their perceptions of disease on each species that they owned and assumed that all livestock species were kept homogenously in a household. Participants of PRAs and HHIs consistently mentioned that small ruminants are not kept homogenously in a drought period. The majority of the animals owned are moved increasing distances away from the homesteads to access available pasture during the dry periods and drought. A number of small ruminants were left at the locations for the female and child members of the household to use as a food source. These differences suggest a difference in the risk of parasitic burden between the two livestock populations. Livestock kept close to the homestead will have a limited distance they can move for pasture. A more rapid decline in pasture levels and nutritional status are factors known to increase the risk of parasite infection in wild ruminants (Ezenwa 2003). These findings suggest sedentary livestock populations have a different risk of internal parasite

infection to the mobile herds that may move to better pasture. Whilst the study provides evidence that the relative effect of internal parasites to animal health is small when compared to other diseases, a more detailed study of the risks of disease in different demographic groups of the livestock population is needed. The intra-household division of livestock species may result in differences in the risks of infection, differences in the accessibility to animal health services to meet health needs and ultimately a difference in the value of the emergency response in maintaining the health of each population.

The effect of internal parasites on the condition score and milk production of livestock species is well documented (Maichomo et al. 2004; Perry and Dijkman 2010) justifying the indicators used to assess the importance of internal parasites and impact of anthelmintics on animal health. These impacts must be considered relative to the loss of production attributed to the decline in pasture and water during a drought period. However, these conditions exacerbate concurrent infection as acknowledged by the study population.

The difference in responses by participants of PRAs and HHIs on issues surrounding internal parasites raises important points for discussion and likely reflects inter-district differences in the epidemiology of internal parasites. In Isiolo, responses were consistent with internal parasites being perceived as a condition that was always present. Whilst causing

Table 3 Average proportion pile appointed by participatory groups (95 % CI) comparing the relative output of small ruminant products before and after deworming during dry and rainy seasons (maximum = 10)

	Before	After	Welch *t* test *P* value
Dry			
Milk	1.93 (1.38–2.47)	2.32 (1.68–2.97)	0.34
Weight	2.08 (1.51–2.65)	2.5 (1.85–3.1)	0.31
Rains			
Milk	5.56 (4.50–6.68)	8.41 (7.62–9.21)	0.001
Condition score	5.13 (4.24–6.01)	8.19 (7.33–9.04)	<0.001

some clinical signs, these were not comparable to the mortality and morbidity seen with other diseases that were of greater concern. The sudden onset of more severe clinical signs of other diseases resulted in the perception of the impact of such diseases on livestock health being far greater. The inability of livestock owners to compensate or control for these alternative conditions also influenced response. This suggests there was a perception that internal parasites are an endemic but controllable condition. Where it is necessary, pastoralists can meet their own needs and purchase anthelmintics. Internal parasites were therefore considered of lower importance than diseases that could not be managed.

In Marsabit, participants did not perceive internal parasites to be present or that they existed with such a low burden that they did not cause clinical signs. Previous studies have shown that small ruminants within the sub-tropics are usually affected by mixed infection of internal parasite species (Biffa et al. 2007). *Trichostrongyloidea* are the most prevalent species in the tropics and responsible for clinical signs that are consistent with those listed by recipients at the time of data collection. The predominant species of gastrointestinal parasites in small ruminants is *Haemonchus contortus* (Fagbeni and Dipleolu 1982; Githiori et al. 2005). These parasites have a direct life cycle involving a period of larval development on the ground before an infective third larval (L3) stage is ingested by the animal during grazing. This maturation period requires optimal conditions of temperature and humidity (Sheurele 2009). However, the high temperatures featured in a drought will inhibit any movement of surviving L3 larvae onto surrounding herbage where they may be consumed. Faecal pats will therefore be the most important reservoir of infective L3 (Chiejina et al. 1989).

In extensive grazing systems—such as those practiced by all pastoralists—livestock should have a low parasitic burden as they have less contact with reservoir faecal pats. It is therefore highly likely that information collected from Marsabit (suggesting there was little to no infection with internal parasites) is justified. This study provides plausible evidence that there may be a limited burden of internal parasites in small ruminants kept in extensive systems within arid lands. Further work is needed to provide epidemiological evidence to support and explain these findings.

The neutral effect of anthelmintic administration in the drought period is consistent with the findings of a low parasitic burden. However, participants were also cautious that the high levels of livestock loss in the drought negated any effects to the herd health status and that because of the lack of pasture there could be no improvement in food conversion efficiency. The apparent improvement in rainy times is confounded by several factors other than anthelmintic use that could have contributed to this improvement including improvements in feed and water availability. Therefore, it cannot be concluded that the increase in livestock outputs in the rainy season can be attributed solely to anthelmintic use although it is possible that there is a partial effect.

Findings from this study suggest anthelmintic use is not timely during a drought and that the lack of water and pasture will negate any potential effects. However, there is a need for better epidemiological evidence on internal parasite burdens in livestock in these regions, which could then be used to inform evidence-based decision-making on strategic animal health programmes within these areas.

Compliance with ethical standards

Statement of animal rights   No animals were sampled in this study.

Conflict of interest   The authors declare that they have no competing interests.

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