Managing anthelmintic resistance in small ruminant livestock of resource-poor farmers in South Africa

A F Vatta[a,b*] and A L E Lindberg[c]

ABSTRACT

Gastrointestinal parasitism is one of the most important disease complexes of sheep and goats impacting on the resource-poor livestock farmer. Of the responsible nematodes, *Haemonchus contortus*, a blood-sucking worm of the abomasum, poses possibly the greatest threat. Over the past several decades, the worm has been controlled through the use of anthelmintics, but the emergence of anthelmintic resistance has threatened this chemotherapeutic approach. In Africa, the overall prevalence of anthelmintic resistance has not been extensively investigated, particularly within the resource-poor farming sector, but resistance has been reported from at least 14 countries with most of the reports emanating from Kenya and South Africa and the majority concerning *H. contortus*. While levels of resistance under commercial sheep farming systems in South Africa is considered to be amongst the worst in the world, resistance has also been reported from the resource-poor farming sector. Increases in productivity and reproduction of livestock and the development of markets for sale of animals are seen by international funding bodies as a way out of poverty for communities that keep livestock. This must lead to the greater need for parasite control. At such times, the risk of levels of anthelmintic resistance escalating is much greater and there is therefore a need to look at alternatives to their use. Proposed strategies include the appropriate, but judicious use of anthelmintics by application of the FAMACHA© system and the use of alternatives to anthelmintics such as strategic nutrient supplementation. It is also very clear that there is a strong demand for knowledge about animal diseases, including helminthosis, and their effective management in the resource-poor livestock farming communities. This is an important challenge to meet.

Key words: Africa, anthelmintic resistance, goats, *Haemonchus contortus*, sheep, small ruminants.

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INTRODUCTION

It is difficult to quantify the number of resource-poor livestock owners in South Africa. In the first instance, what is meant by resource-poor? A landless peasant who does not own animals would probably not consider a person that owns livestock to be resource-poor. On the other hand, comparing farmers within the South African community, one finds that there are very distinct differences in wealth between rural farming communities. These are most often distinguished along racial lines, but even within a particular community there are the resourced and less-resourced farmers.

It is sobering to note that there is a rural population in South Africa of about 17.5 million people that are living below the rural poverty threshold (Table 6b in ref. 51). It cannot be accurately ascertained what proportion of these people are resource-poor farmers. However, Thornton *et al.*[51] estimated that there were 10.6 million poor livestock keepers in South Africa. Of these, 3.5 million were living in mixed, rainfed, temperate production systems or tropical highlands; 3.1 million within mixed, rainfed, arid or semi-arid systems; 1.8 million within livestock only, rangeland-based arid or semi-arid systems (Table 7 in ref. 51); and a further 1.2 million were to be found in mixed, rainfed, humid or subhumid systems. The remaining 1.1 million were estimated to be found in livestock-only, rangeland-based, temperate or tropical highlands; mixed, irrigated, arid or semi-arid systems; mixed, irrigated, temperate or tropical highlands; livestock-only, rangeland-based, humid or subhumid systems, or other production systems.

A large number of resource-poor farmers in South Africa live in the previous 'homeland' areas[17,24]. An official survey of large and small-scale agriculture indicated that in the year 2000 there were 614 000 farming operations in the former homelands of South Africa in contrast to 84 000 farming operations in the former Republic of South Africa (*i.e.* South Africa excluding the former homelands)[47]. The farming operations of the homelands, designated for black Africans, were characterised by small-scale and subsistence farming while the farming operations of the former South Africa, designated for white ownership, were mostly large-scale commercial operations.

If one assumes that each farming operation supported at least one household, and given that the average size of a household for South Africa is 3.8 persons[2], one may estimate that there are 2.3 million people dependent on small-scale and subsistence farming. This is a somewhat lower figure than that estimated by Thornton *et al.*[51], but the figure nevertheless represents a sizeable number of people probably dependent on resource-poor farming.

In general terms, resource-poor livestock farmers will own only approximately 10 animals. They have no security of land tenure and the animals are grazed communally. The communities are characterised by skewed demographics (high proportions of women, the aged and children) – a legacy of a history of migrant labour systems in South Africa. The people have poor access to facilities, information, infrastructure and finance, and in the case of resource-poor farmers within these communities, poor access to agricultural support services. As can be expected from all these negative factors, production and reproduction of livestock in these situations are low.

Resource-poor people often rely on a variety of sources of income, food and support[12]. This spreads the risk in the case of a particular income-generating activity failing. Of these various activities, animal

[a]Onderstepoort Veterinary Institute, Private Bag X05, Onderstepoort, 0110, South Africa, and [b]University of KwaZulu-Natal, Private Bag X01, Scottsville, 3209.

[c]Department of Parasitology (SWEPAR), National Veterinary Institute, SE-750 07 Uppsala, Sweden. *Present address*: Swedish Dairy Association, Research and Development, PO Box 7019, SE-750 07 Uppsala, Sweden.

*Author for correspondence.
E-mail: vattaa@arc.agric.za

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production may be one of the most important, especially where lands for crop or vegetable production are marginal. Protein is an important component of the human diet and protein derived from animal sources fills a niche in the diet that is difficult to replace with vegetable products. In this regard, ruminants are especially important, being able to convert plant material that cannot be digested by humans into edible animal protein.

The most important helminth parasite of sheep and goats in the summer rainfall area of South Africa is *Haemonchus contortus*, both for the commercial and resource-poor farmer[10,52,71,72]. Haemonchosis was recently ranked amongst the top ten diseases or pathogens affecting the animals of poor livestock farmers in eastern, central and southern Africa, while gastrointestinal parasitism was given the highest global index as an animal health constraint impacting on the poor[45]. *H. contortus* is a blood-sucking nematode found in the abomasum of small ruminants, posing a threat from about November to April when ambient temperature and rainfall are suitable for it to complete its life cycle on pasture. However, *H. contortus* may also be a threat in the cooler months of the year and periodically causes problems in the semi-arid regions of the country in atypically wet years, as well as in the winter and non-seasonal rainfall areas.

AWARENESS OF GASTROINTESTINAL PARASITISM

Amongst resource-poor farmers, there appears to be a lack of understanding of the aetiology of disease, *e.g.* anaplasmosis is thought to be caused by 'excessive grazing of lush green grass, which is thought to bring about an accumulation of bile in the body'[34]. In this example this may lead to treatment being ill directed at attempting to remove excessive bile from the animal's body rather than correctly aimed at destroying the microorganisms concerned. Resource-poor farmers may use numerous ethnoveterinary medicines to prevent mortality and improve the health of their livestock. In many cases, these medications do have apparent rational and beneficial effects[18,34,54]. Resource-poor farmers also purchase commercial remedies when they are able to do so[18,34,35]. However, the extent of their use of stock remedies is poorly documented in South Africa. Sales of anthelmintics for sheep and cattle and endectocides (all animal species) amounted to more than 117 million rand in 2003/2004 (South African Animal Health Association market statistics, A du Plessis, pers. comm., 2004), but most of these sales were probably to the commercial farming sector.

It was the experience of Van Wyk *et al.*[68] that resource-poor farmers in the former Lebowa (in Mpumalanga and Limpopo Provinces) did not consider internal parasites important possibly because of their location inside the hosts and their generally small size. Many farmers also appeared not to be aware of the existence of internal parasites and their treatment was therefore given a low priority. This is contrasted with certain farmers in the Bulwer area of KwaZulu-Natal who purchase commercial deworm- ing remedies (B A Letty, KwaZulu-Natal Department of Agriculture and Environmental Affairs, pers. comm., 2002).

There appears to be a greater awareness of tapeworms than of the more dangerous roundworms[18]. This is probably because the tapeworm proglottids are visible with the naked eye on the dung of the animal. The women, who are traditionally tasked with the preparation of food, may be more likely to notice nematodes in the gastrointestinal contents but may not appreciate their importance (A F Vatta, pers. obs., 2002). Even then many of the nematodes may be missed because of their small size – several species are only visible under a microscope. The perceived lack of understanding of the importance of gastrointestinal roundworms is also demonstrated by an apparent lack of common names for the various nematodes in the indigenous languages of South Africa. Contrast this, for example, with common names for *Haemonchus contortus* and *Trichostrongylus* spp. which are respectively called wireworm and bankruptworm in English and *haarwurm* and *bankrotwurm* in Afrikaans.

PREVALENCE OF ANTHELMINTIC RESISTANCE

In farming systems where helminth control relies exclusively on the use of anthelmintics, the emergence of resistance to such compounds poses a severe threat to livestock production. This is of particular concern where a strain is resistant to drugs in more than one or all anthelmintic groups available on the market. In Africa, anthelmintic resistance has been reported in sheep and/or goats from at least 14 countries (Fig. 1). By far the most reports have emanated from Kenya and South Africa and the majority of these concern *Haemonchus* spp. There is a lack of detailed background information for some of the reports listed in Fig. 1, but it appears that the vast majority of the papers (52 out of the 63 cited) are from large-scale commercial or institutional farms. Six of the reports concern small-scale or resource-poor farms while five deal with both large and small farming enterprises. In South Africa, anthelmintic resistance in the commercial sheep farming sector has been described as being the worst in the world[68]. In resource-poor systems in South Africa, resistance has been reported in sheep in one study[68] and in goats in another two studies[5,72].

The overall prevalence of resistance in Africa has, however, not been extensively investigated and this is particularly so in the resource-poor context. Survey work for anthelmintic resistance is hampered, among other things, by the lack of readily available assays. The faecal egg count reduction test, which is the most commonly used test, requires the use of a relatively large number of animals, something which is rarely available in smallholder systems. It is also time-consuming and hence costly. The *in vitro* larval development assay has been adapted to the smallholder setting[1], but it requires specific training, kits and equipment that are not in place in South Africa at present.

DEVELOPMENT AND SPREAD OF ANTHELMINTIC RESISTANCE

The highly effective chemotherapeutic control of pest organisms (in this case nematodes) and preservation of drug efficacy are unfortunately mutually exclusive objectives. The gene or genes conferring anthelmintic resistance are thought to be present in a small portion of individuals in the population even before the worms are exposed to a drug for the first time[21]. Treatment with anthelmintics then selects for those individuals within a population that are resistant to the drug.

Van Wyk[59] has drawn attention to the importance of the role *refugia* plays in the development of anthelmintic resistance. *Refugia* refers to the proportion of a parasite population that is not exposed to anthelmintics during any one treatment *e.g.* nematode larval stages on pasture, thus escaping selection for resistance[37] and potentially able to propagate its genes to the next generation. Treatments carried out when there are few worms *in refugia* are likely to select strongly for resistance.

As stated above, most of the reports of anthelmintic resistance are from large-scale commercial or institutional farms. Under these conditions, the selection pressure for anthelmintic resistance is often intense with, for example, frequent anthelmintic treatment of the whole herd. This in itself exposes a greater proportion of the nematode population to anthelmintics and leaves fewer worms *in refugia* than would be the case, for example, if only those individual animals

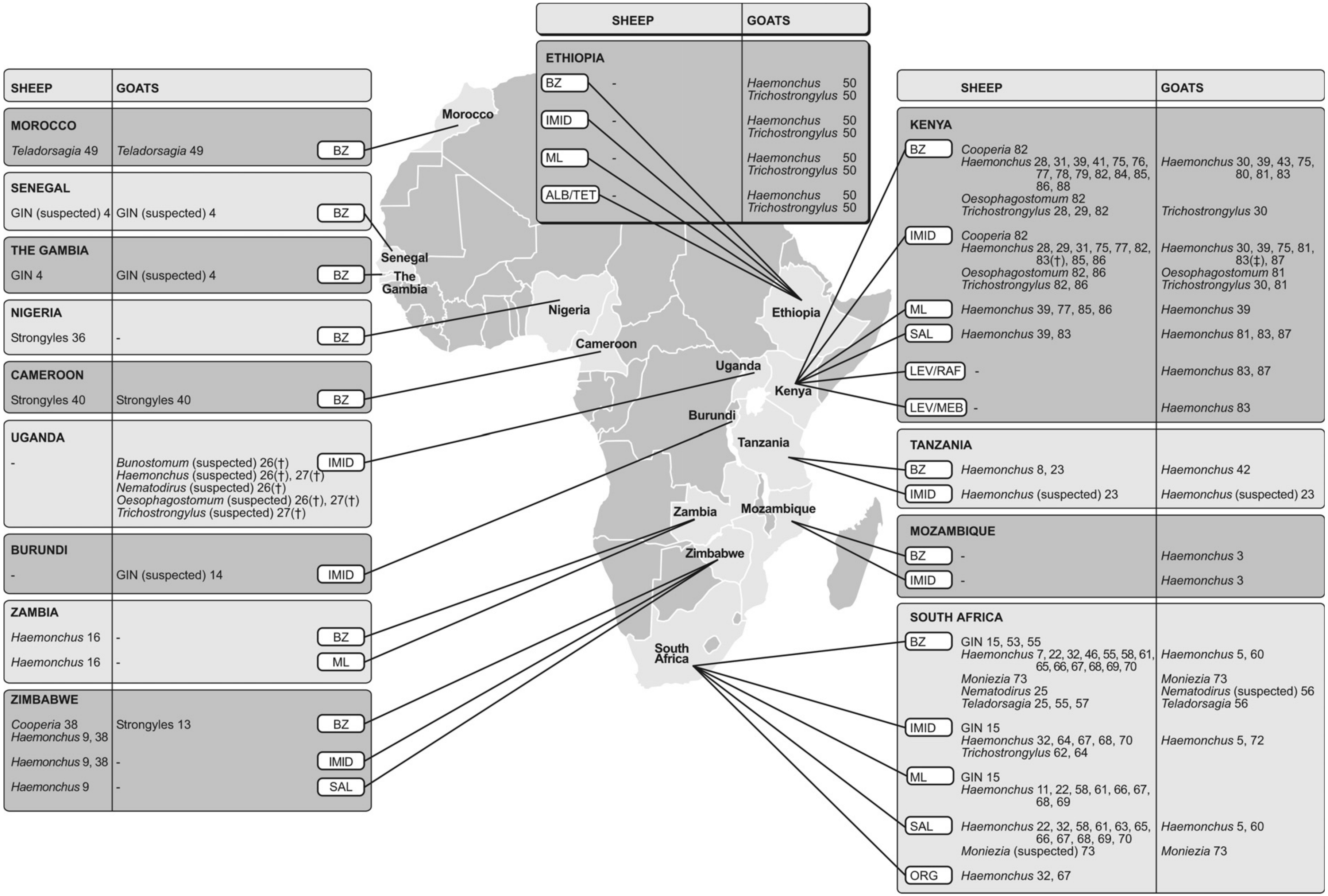

Fig. 1: **Reports of anthelmintic resistance in helminths of sheep and goats in Africa. Some studies are laboratory confirmations or repeat investigations of previously published reports. Where the original reports referred to *Ostertagia*, these are reflected as *Teladorsagia* in the figure above.**

Key: GIN: **gastrointestinal nematodes;** BZ: **benzimidazoles and pro-benzimidazoles;** IMID: **imidazoles;** ML: **macrocyclic lactones;** SAL: **halogenated salicylanilides and nitrophenols;** ORG: **organophosphates;** ALB/TET: **albendazole-tetramisole combination;** LEV/RAF: **levamisole-rafoxanide combination;** LEV/MEB: **levamisole-mebendazole combination; † products considered possibly substandard, adulterated or fake; ‡ one levamisole product considered substandard; true resistance found to a second product.**

showing signs of helminthosis were drenched. The frequent use of anthelmintics increases the frequency with which individual nematodes and their offspring are exposed to anthelmintics as well as the probability that a nematode will be exposed to an anthelmintic within a certain period of time. Large herd size has been reported as a risk factor for the presence of resistance[75]. Farmers with large flocks are more likely to be able to buy anthelmintics.

Conversely, farmers with smaller flocks often cannot afford to buy anthelmintics and this may serve to slow down the onset of resistance[75]. In South Africa, access to anthelmintics may also be difficult even for those who want to treat because of sparsely distributed agricultural cooperatives*[17] and size of packaging (McCrindle, 1996, cited by Gehring *et al.*[17]) which is generally too large for the number of animals that need to be treated[17]. This should also be seen in the context of other more important priorities such as access to water, hospital care and schools[18].

Nevertheless, anthelmintic resistance has been reported from the small-scale and resource-poor sector. Although anthelmintics may be used more sparingly by smallholder and resource-poor farmers than large-scale commercial farmers, the emergence of resistance in this sector has also been attributed to the prolonged use of drugs from the same class of anthelmintic[3,5,27,31] and frequent treatment of flocks[5,27,75].

Various authors speculate that the occurrence of anthelmintic resistance in a flock/herd resulted from the introduction of resistant worms from other flocks/herds. This may have been through the sale or distribution of stock (together with their resistant worms) from larger commercial or government-owned farms to smaller farms[5,68,72,75]; through the introduction of stock from other farms (where no mention of size of farm is made)[3,31]; through the appropriation of farms from commercial farmers and addition to existing communal pastures[68]; and through communal grazing[26,49]. Sissay *et al.*[50], on the other hand, exploited the apparent lack of anthelmintic resistance in communally grazed smallholder flocks to reverse to susceptibility the resistant status of a university goat flock.

Whether resistance develops on resource-poor smallholdings would depend on the numbers of imported worms in relation to the existing worm population and on the resulting frequency of worms with resistant genes. The further development will also depend on the way anthelmintics are used by the smallholder farmers. If, for example, the introduction of animals with resistant worms to a flock occurs and the whole flock is drenched with the same active to which there is resistance in the flock from which the animals were introduced and the drenching is carried out at frequent intervals and/or at times when there are few worms *in refugia,* the chances of resistance developing are higher than in cases where drenching of the herd occurs very infrequently (as was reportedly the case in the investigation by Sissay *et al.*[50]).

Other reasons given for the development of resistance under these farming conditions include underdosing by incorrect estimation of weights[26,31]; 'underdosing as a result of limited financial resources'[5]; and the use of sheep dosages in goats[26,75]. Van Wyk[59] argues that it is not underdosing *per se* that is necessarily responsible for the development of the resistance but that development of resistance is probably related to the elimination through drenching of 'all but the most resistant individuals combined with low numbers of worms *in refugia*'[59].

The use of expired products[3] and the use of substandard products[26,27] make it difficult to determine whether anthelmintic failure is as a result of resistance or inactivity of the product[75].

ALTERNATIVES TO ANTHELMINTICS IN THE CONTROL OF GASTROINTESTINAL PARASITISM

If management and productivity of small ruminants are improved in line with the global visions of internationally funded research bodies[45], helminths will need to be managed. Unless other methods of parasite control are available, this will call for an increased use of anthelmintics, which, in turn, is the driving force for the development of anthelmintic resistance. If resistance is already present, this potential pathway out of poverty will be severely hampered. The farmer therefore needs to be making the best use of the drugs now so that their efficacy is maintained for as long as possible, and also to find alternative and complementary ways of controlling gastrointestinal parasites.

Other options that have been considered as alternatives to the sole reliance on anthelmintics for parasite control include the better use of existing drugs, for example by combining the use of drugs with grazing strategies, vaccines, copper oxide wire particles, biological control through, for example, nematophagous fungi, nutrient supplementation[74], breeding of host animals for worm resistance[19], ethnoveterinary medicine[20] and tanniferous plants and extracts[44]. Many of these approaches are still being researched and evaluated and most of them are at present not suitable for the communal grazing systems of many resource-poor farmers. For example, the adoption of a common grazing strategy would require a community effort, which would currently be difficult to achieve in a communal grazing system. There are two possible interactions that would be of assistance to the resource-poor farmer and go some way towards achieving sustainable parasite control. These are the use of the FAMACHA© system and nutritional supplementation.

The FAMACHA© system

This is a method of targeted treatment and is a strategy for conserving the efficacy of existing drugs[33]. The system is based on the fact that sheep and goats suffering from haemonchosis show varying degrees of anaemia, which can be evaluated clinically by examination of the ocular mucous membranes. With the help of a colour chart, animals are scored in one of five colour categories (from red, non-anaemic, to very pale, severely anaemic). Only those animals in need of treatment are treated.

The advantages of such a system are that savings can be made in terms of anthelmintic use, the development of drug resistance should be slowed down and animals that repeatedly require treatment can be identified and culled from the flock or herd. The system should also complement the fact that resource-poor people often already have animals that have been naturally selected for hardiness over many years because of a lack of drug intervention. A great advantage of the system is that it can be easily understood and learnt by poorly literate people. This has been demonstrated on commercial farms[6], where the system has found great acceptance, and in resource-poor farming systems[71,72].

Nutritional supplementation

Nutritional or micronutrient deficiencies in livestock have also been ranked highly in terms of their importance to the resource-poor farmer[45]. In resource-poor areas of South Africa, dry-season hunger, as elsewhere in southern Africa, is a very important constraint to animal production. Relatively cheap supplements such as non-protein nitrogen, in liquid form for mixing with poor quality roughages or formulated into blocks or granules, are alternatives, but accessibility may similarly be hampered as for anthelmintics. To

*In the South African context, this refers to stores which sell stock remedies such as dewormers and dips, seed, agricultural implements, protective clothing and fertilisers.

overcome this limitation, local forages are being examined as dry-season supplements. In Zimbabwe, supplementation of does with seed pods of local browse trees produced an increase in milk yield and kid survival[48], but it was not investigated whether there was an effect on worm burdens.

EDUCATION

Perhaps education is the principal requirement for assisting resource-poor farmers to improve the health, productivity and welfare of their animals. Without knowledge, the resource-poor farmer cannot improve herd management and prophylaxis of disease by means of vaccination. Knowledge is required to be able to recognise the importance of specific disease conditions and circumstances favouring their development, for instance a greater awareness of the presence and pathogenic effects of nematodes, the epidemiological conditions that are optimal for their survival, and how to manage the infections for the long term.

CONCLUSION

Anthelmintics will remain an important part of the management of worm infections, but they need to be used in a sustainable manner. Particularly in the resource-poor sector of South Africa, where the level of anthelmintic resistance appears to be at a lower level than that on large-scale farms[68], the opportunity exists to slow the development of resistance. The best way forward must be education, and the opportunity now exists to build the control of gastrointestinal parasites on measures other than only anthelmintic treatment.

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