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Control measures for some important and unusual goat diseases in southern Africa☆

G.F. Bath[a,*], J.A. van Wyk[b], K.P. Pettey[a]

[a] Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, Onderstepoort 0110, South Africa
[b] Department of Veterinary Tropical Diseases, Faculty of Veterinary Science, University of Pretoria, Onderstepoort 0110, South Africa

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Abstract

The paper comprises an overview of important or unusual goat diseases occurring in southern Africa, with the emphasis on current effective disease control measures and recent developments in this field. The diseases are dealt with under four headings: (1) Infections; (2) Parasites; (3) Plants and nutrition; (4) Genetic and other conditions. In each section, the following are given more prominence: (1) Heartwater, certain clostridial diseases, pasteurellosis, abscessation and orf; (2) Haemonchosis, coccidiosis and certain ectoparasites; (3) Redgut and phytobezoars; (4) Abortions, postnatal mortality, exposure, predation and swelling disease. The major diseases of helminthosis and heartwater are dealt with at greater length. Helminth control currently concentrates on individual treatment of badly affected goats, rather than mass treatment. This lowers the selection rate for worms resistant to anthelmintics. A break with the old policy of "treat-all-and-move" is advocated for the same reason. The use of the FAMACHA© system (clinical anaemia evaluation) for haemonchosis control in goats is explained and the potential of body condition scoring for identifying animals heavily infected with other pathogenic helminths is highlighted. Replacement of highly resistant worm populations by a dilution method is outlined and several practical measures for managing worms in goats are given. The control of heartwater is determined by epidemiological and risk factors, comprising those affecting the vector (climate, season, vegetation, wild reservoir hosts, tick control), the organism (strain virulence, infection rate of vectors), and the host (species, age, breed, genetic resistance and immune status). In circumstances of very low infection risk, surveillance and treatment is recommended. In higher risk situations, strict tick control or zero grazing may be the best option. In endemic areas, immunity is the preferred and most reliable approach. This is achieved by exposure to infected ticks, vaccination and animal selection. Details of these options and their practical implementation are given.

Keywords: Goat health; Goat disease control; Goat diseases of southern Africa

1. Introduction

Much of southern Africa is arid, and unsuited to all agriculture except extensive livestock farming. Many of these areas are characterized by bush rather than grass, and are thus especially suitable for goat

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* Corresponding author.
E-mail address: gareth.bath@up.ac.za (G.F. Bath).

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farming. The majority of goats in South Africa (6.6 million) are either Angoras or Boer goats, which are farmed commercially. The balance is mainly a variety of hardy Indigenous goats (Anonymous, 2004). Angoras are renowned for their mohair production, but unfortunately also for their susceptibility to a number of diseases. To a lesser extent, Boer goats may also be more susceptible than Indigenous goats to certain diseases.

Many diseases and problems are related to inappropriate farming decisions and systems, such as grazing on pure grass or legume pastures rather than mixed bushes, incorrect breeding objectives, poor rangeland management, malnutrition, inadequate facilities and poor disease control choices (Maree and Casey, 1993). For profitable and sustainable farming, the impact of these problems has to be minimised by measures that are cost-effective as well as appropriate for the circumstances.

2. Infectious diseases

2.1. Heartwater

2.1.1. Introduction

Cowdriosis or heartwater is a tickborne disease of sheep, goats, cattle and some wild ruminants, caused by the rickettsia, *Ehrlichia ruminantium*. Three-host ticks from the *Amblyomma* genus (bont ticks) act as vectors that can acquire the infection from any of the hosts infected with *E. ruminantium* and probably retain their infectivity for life (Neitz, 1968; Ilemobade, 1976). These ticks occur in frost-free, relatively dry bushveld that is particularly suited to goats, and heartwater may be a major factor affecting profitable goat farming. Sheep and goats are more susceptible to heartwater than cattle and there is a considerable variation between breeds (Uilenberg, 1983; Donkin et al., 1992). Angora goats are highly susceptible to heartwater and their immunity is of short duration (Du Plessis et al., 1983). Genetic resistance, which is due to a recessive sex-linked gene, has been demonstrated in Creole goats in Guadeloupe (Matheron et al., 1987). Wild ruminants, guinea fowl, tortoises and scrub hares are reservoirs of *E. ruminantium* and hence of epidemiological importance where stringent tick control in domestic animals is practised (Oberem and Bezuidenhout, 1987). Factors which are important in the epidemiology of heartwater include immunological strain differences of *E. ruminantium* with variable cross-protection between them (Jongejan et al., 1988; Du Plessis et al., 1989), the presence of wild reservoir hosts and vectors, infection rates in ticks, age and genetic resistance of domestic ruminant populations, seasonal fluctuations in tick abundance and activity, and the intensity of tick control (Uilenberg, 1983). Other factors, especially species, breed, age, degree of natural resistance and immune status play a role in determining whether an animal will develop heartwater or not.

2.1.2. Immunity

Protective immunity to *E. ruminantium* is apparently predominantly cell mediated (Totté et al., 1999), resulting in proliferation of T cells, which have also been shown to produce potent inhibitors to the growth of *E. ruminantium* in endothelial cells in vitro. Studies on cytokines suggest a highly complex multifactorial response that can result either in resistance or aggravated disease.

2.1.3. Clinical signs and diagnosis

Clinical signs vary from a peracute to subclinical form, with acute heartwater being most common in endemic areas. Susceptible animals progressively manifest symptoms such as listlessness, poor appetite, decreased milk yield and nervous symptoms ranging from mild incoordination to pronounced convulsions. Fever of 40 °C or higher usually persists for 3–6 days and is followed by a drop to subnormal levels shortly before death. Definitive diagnosis is possible by the demonstration of *Ehrlichia* organisms in Giemsa or CAM's Quick-stained brain smears made from the hippocampus (Coetzer et al., 1994).

2.1.4. Treatment

Tetracycline at a dose rate of at least 10 mg/kg during the early febrile stages usually results in recovery. In the advanced stages of the disease, however, additional supportive therapy must be considered, although this is not always successful. Supportive treatment includes drugs active in reducing oedema (Shakespeare et al., 1998), stabilization of membranes and blocking the effect of vasoactive compounds released with cellular death (Van Amstel and Oberem, 1987). Observations during the manufacture of the heartwater blood "vaccine" (J.L. du Plessis, personal communication, 1982) have indicated that partial exsanguination may help alleviate the symptoms, presumably by reducing oedema by pulling extra-vascular fluid back into the circulatory system.

2.1.5. Control measures

Current options for management are summarized in Table 1.

It is important to emphasize that a strategic decision has to be taken at the outset on which of three basic options should be followed to control the disease. The options are largely exclusive, i.e. they cannot be followed simultaneously.

(a) *Management*: In marginal (transitional or heartwater-unstable) areas where climatic conditions determine the bont tick's survival, control may be difficult. The immune status of individual animals is unpredictable, thus it is recommended that animals be observed twice a day for any abnormal signs or behaviour that could indicate the onset of heartwater.

(b) *Tick control*: Because of damage caused to the host, *Amblyomma* ticks need to be controlled, but sustained intensive tick control may lead to animals becoming susceptible to heartwater, even in endemic areas. Also, there is a risk of the ticks developing resistance to the dips. Less intensive tick control is needed which will limit damage to the animals, while allowing a sufficient number of ticks to maintain the animals' immunity through regular re-infection at intervals not exceeding 3–6 months.

(c) *Immunity*:
- *Inherent*: As mentioned above, this is variable between breeds of goats, e.g. more resistant Creole goats in Guadeloupe and Indigenous goats, compared with highly susceptible Saanens and Angoras in South Africa.
- *Natural*: Young kids possess a non-specific resistance that is independent of the immune status of the dam and lasts for only the first week (Neitz and Alexander, 1941; Alexander et al., 1946; Uilenberg, 1981; Du Plessis et al., 1987). This refractive period can be utilised for vaccination.
- *Acquired by vaccination*: A blood "vaccine" produced in South Africa from sheep infected with live, virulent *E. ruminantium* organisms (BALL3-strain) (Bezuidenhout, 1989) is used to provide a degree of immunity to strains of heartwater present by administration to young kids in their first week after birth, or to older goats that are susceptible (which escaped natural infection, or had been kept tick free, or were imported into a heartwater area). Since the vaccine contains live, unattenuated heartwater organisms, it must be used with great care in susceptible goats after their first week of life, since such animals may develop heartwater and die if not treated. They must be observed twice daily, with temperatures being recorded daily (preferably at the same time each morning) for up to 1 month after vaccination, so that animals developing clinical signs can be treated. Note also that with the exception of kids, animals that do not develop a febrile reaction may remain susceptible. Susceptible pregnant does introduced into

Table 1
Management options for heartwater control

Options	Features	Consequences
(a) Management	Regular observations and treatment with available drugs when necessary	Intensive and unpredictable
		Important in unstable heartwater areas where the immune status fluctuates in the animals
(b) Tick control	Regular dipping	Animals susceptible, tick resistance
	Zero grazing on concrete or wooden slatted flooring	Animals very susceptible
(c) Immunity	Inherent (breed)	Selection and culling policy
	Natural (very young kids)	Utilise for acquiring immunity
	Acquired (exposure): two options	Vaccine-dangers
		Challenge-unpredictable

heartwater endemic areas or heartwater unstable areas should not be vaccinated because they may abort. They should be kept free from ticks until they have kidded and thereafter they should be immunized. If this is impossible, a somewhat risky alternative is to vaccinate them and then to block the heartwater reaction 9 days later with tetracycline treatment before a febrile reaction occurs. The vaccine is administered intravenously to goats at a dosage of 3 ml, irrespective of size or age (Combrink et al., 1997). Tetracyclines must be administered as soon as a temperature reaction is detected. Another option is to administer a subcutaneous doxycycline ear implant at the time of vaccination. The dosage has to be precise and the amount of implant must be determined on the basis of individual animal weights. Immunity to heartwater develops within approximately 4–6 weeks after immunization and immunized animals will be protected against serious disease caused by most (but not all) naturally occurring strains of heartwater. Revaccination is risky because of possible anaphylaxis due to sensitisation to foreign blood from the previous vaccination. Recent advances made towards inactivated and sub-unit/DNA vaccines are promising and can be expected to replace the above infection-and-treatment methods when they become commercially available (Mahan et al., 1995; Collins et al., 2003).

- *Acquired by challenge*: Regular exposure of newborn kids and immunised goats to infected bont ticks will ensure maintenance of immunity provided the challenge is high.
- *Blocking techniques*: Another form of challenge to protect goats against heartwater consists of a series of “blocking” tetracycline injections to protect susceptible goats when introduced into an endemic area. A short-acting tetracycline is administered at a dose rate of 3 mg/kg body weight on days 10, 20, 30, 45 and 60 after introduction, during which period the animals should not be dipped (Gruss, 1981).

2.2. *Enterotoxaemia*

It is a common disease of goats in the region. The post mortem picture in goats is not nearly as clear as in sheep, since one often sees sudden death only, and few (if any) lesions. It is therefore possibly often misdiagnosed (Coetzer et al., 1994; Bath and De Wet, 2000). Vaccination is regarded as essential in most circumstances (Van Tonder, 1975). The first vaccination should be with the oil-based Onderstepoort Biological Products (OBP) enterotoxaemia vaccine which is given at 2–4 months, followed by boosters with the alum-based vaccine at 6 months, 12 months, and then annually thereafter. This can be reduced in frequency depending on the circumstances. Other commercial vaccines are effective, but are expensive and multivalent, which may be inappropriate (Swan et al., 2004). Note that some forms of enterotoxaemia are caused by *Clostridium perfringens* types A and C, and are not covered by the usual vaccine, but in these cases vaccines effective for *Cl. perfringens* type B (lamb dysentery) are protective.

2.3. *Pasteurellosis*

Pneumonia can be a major problem, especially where goats are intensively housed due to a high occurrence of theft or predation. Mastitis can also become troublesome (Coetzer et al., 1994; Bath and De Wet, 2000). The most common pathogen is *Mannheimia* (formerly *Pasteurella*) *haemolytica*. However, in the region *P. multocida* may also be involved. The sheep and goat OBP vaccine is often used and the OBP cattle vaccine, though not registered for use in goats, may be useful. There are also good multivalent vaccines available but they may be expensive and inappropriate (Swan et al., 2004). Note that the off-label use of vaccines has certain legal implications and such usage may render any claims for losses null and void. Furthermore, in South Africa such advice is restricted to veterinarians. The identity of bacteria actually causing cases should be established, rather than making assumptions.

2.4. *Subcutaneous abscesses*

Arcanobacterium pyogenes (formerly *Corynebacterium pyogenes*) can cause abscesses, particularly on the udder and on the face. It is often more effective to have good tick control than to vaccinate. Areas most likely to attract ticks (especially the head and legs) should be treated with an appropriately registered spot treatment. When abscesses are drained, hygiene is very important. Pus should be drained onto newspaper in a sunny area, which will militate against survival of the organism. The lesion should then be irrigated and an antibiotic or antiseptic introduced (Smith and Sherman, 1994; Bath and De Wet, 2000). The exudate and pus should be burned or disposed of effectively.

2.5. Pituitary abscess

This is potentially a severe problem, particularly in Boer goats with very backswept horns. It is often mistakenly diagnosed as heartwater because the symptoms are similar. Ticks with long mouthparts attaching at the back of the horns initiate the infection, which is non-specific, i.e. different bacteria may be involved. The infection appears to be spread from the tick attachment site to the pituitary area by veins connecting subcutaneous to cranial venous systems. The effective solution is either to dehorn goats (which creates its own problems) or to use a spot treatment for ticks at the base of the horns. Another but longer-term approach is not to breed goats with excessively backswept horns. The option of breeding polled goats is not recommended due to the well-known association with hermaphroditism (Coetzer et al., 1994; Smith and Sherman, 1994; Bath and De Wet, 2000).

2.6. Foot abscess and foot rot

Foot abscess is a disease quite common in Africa, and is usually the result of infection caused by ticks with long mouthparts (especially *Hyalomma* spp. but also *Amblyomma* spp. and *Rhipicephalus glabroscutatum*), but also the sequel of wounds caused by thorns, or the effects of prolonged moisture. As *A. pyogenes* is the most common pathogen, the *A. pyogenes* vaccine is of some value. It is recommended to rather concentrate on tick control, if this is the primary cause (Bath and De Wet, 2000). In contrast, foot rot is relatively uncommon in the region. Control measures are similar to those used with sheep (Martin and Aitken, 2000), comprising appropriate management, hoof paring, zinc sulphate dips, isolation and culling.

2.7. Orf

A widespread and often severe problem, which tends to occur in outbreaks every few years, depending on the size of the susceptible population. A commercial vaccine is available in South Africa. Alternatively, an autogenous vaccine can easily be made when required (Van Tonder, 1975). Bits of the lesions should be removed (not more than a teaspoonful and which are easy to break off) and crushed with a little saline either in a pestle and mortar or simply between two spoons, then add a few drops of injectable antibiotic (e.g. penicillin/streptomycin) to keep bacteria in check. Strain through muslin and the vaccine is ready. It lasts for months under refrigeration, but especially if frozen or freeze dried. A drop of vaccine is applied to the skin (on the inner thigh or alternative suitable area, but not the face or legs), after excoriating (scratching) the skin until serum or a speck of blood is seen oozing out. This ensures that the vaccine will come into contact with the circulatory system and thus the reticulo-endothelial system, which mounts the immune response. In a few days there should be a little inflammation, or even a little swelling and scabbing, and after a week the animal will be immune for life. If already infected, the growths will start dropping off after a week. However, if there is secondary infection this will need other intervention, like antibiotics. If a herd is immunised, no new cases may be seen for a few years, but then as susceptible, unvaccinated animals become dominant, the disease will recur (Coetzer et al., 1994; Smith and Sherman, 1994; Bath and De Wet, 2000).

2.8. Other infectious diseases

Blue tongue is usually asymptomatic in goats and therefore vaccination is seldom recommended. Control measures used will depend on the serotype, severity and circumstances. Anthrax, botulism and tetanus are rarely encountered. The use of *Brucella Rev I* is not recommended at all because *B. ovis* is not a problem in goats and the vaccine can cause epididymitis. Unless it is proven that *B. melitensis* is present, vaccination should be avoided. Confirmed cases of *B. melitensis* must be reported to State Veterinary Authority, as it is a controlled disease in South Africa. Does which are kidding in kraals (pens) are susceptible to gangrenous metritis, caused by *Cl. septicum*, *Cl. novyi* (*oedematiens*) or even *Cl. chauvoei*, while kids could contract lamb dysentery (*Cl. perfringens* type B) under these conditions. Vaccination may be advisable in these circumstances. Rift Valley Fever and Wesselsbron disease are rarely a problem between epizootics, only two of which have been recorded (Coetzer et al., 1994). *Corynebacterium pseudotuberculosis* (formerly *C. ovis*) is not common in goats, but may become severe enough to warrant vaccination with the correct vaccine as part of the control measures. Other control measures are similar to those used against *A. pyogenes.* Although diseases like ringworm, *Escherichia coli* septicaemia, chlamydiosis, infectious keratoconjunctivitis and *Dermatophilus congolensis* infection are quite common, and can be economically important, the control measures used are very similar or identical to those in use elsewhere and are therefore not laid out here. Though it has so many goat diseases, South Africa is notable for the absence of both Caprine Arthritis Encephalitis Virus and Scrapie. The latter was inadvertently introduced via sheep in the 1960s but was very quickly eradicated by a vigorous policy of total destocking of all farms that had received imports (Coetzer et al., 1994).

3. Parasitic diseases

3.1. Helminths

3.1.1. Introduction

Haemonchus contortus is by far the biggest problem in the summer rainfall regions of South Africa, and *Trichostrongylus* spp. (principally *T. colubriformis*) occur commonly throughout much of the country (Horak, 1981; J.A. van Wyk, unpublished observations, 1990). However, in the southern coastal belt where most goats are found, *Ostertagia/Teladorsagia circumcincta* is the principal species, in addition to varying numbers of *T. colubriformis* and *H. contortus*. *Oesophagostomum columbianum* has been a special problem, and in the past was recognised as a major cause of poor production of small ruminants, but it has subsequently been virtually eradicated by frequent drenching on most commercial farms. More recently, it is again increasing in importance. *Nematodirus spathiger* causes losses in the more arid regions. Although *Strongyloides papillosus* infection is usually of little importance, in Namibia up to 50% mortality may occur in kids. The condition was given the name of Gobabis Boksiekte (Pienaar et al., 1999). Kids of 1–3 months left in open pens (kraals) by day when their dams went to graze were most affected (J.D. Bezuidenhout, personal communication, 1975).

Outbreaks were associated with heavy rains that diluted the levels of urine in the pens and allowed the survival of eggs and free-living larvae. In turn this led to rapid proliferation of the parasite. Signs include dehydration and abdominal pain and dry faeces, although diarrhoea may occur (Pienaar et al., 1999). Since *Strongyloides* worms are small and inconspicuous they may be overlooked at necropsy (Levine, 1980). Effective control requires the use of mobile pens to prevent the buildup of parasites (J.D. Bezuidenhout, personal communication, 1975).

Gaigeria pachyscelis (sandveld hookworm) is another parasite that is very common in Africa. It is a particularly avid blood sucker, often leading to acute death that may be incorrectly ascribed to *H. contortus* infection because the symptoms are very similar. It occurs in the more arid regions, where it is usually associated with leaking drinking troughs and perennial rivers. As with *Oes. columbianum*, it seems to have been suppressed by regular use of anthelmintics on most commercial farms (J.A. van Wyk, personal observations, 1990).

3.1.2. New approaches

The advent of highly effective and very safe anthelmintics during the 1960s to 1980s resulted in the extensive use of these chemicals to the virtual exclusion of other approaches. This caused the rapid development of anthelmintic resistance (AR) (Le Jambre, 1978; Van Wyk et al., 1997, 2001). Thus, it became clear that conventional chemical-based systems of worm management were unsustainable and that radical and innovative thinking was required for a thorough reassessment of worm management strategies (Michel, 1985; Barger, 1999; Van Wyk, 2001; Anonymous, 2002; Van Wyk et al., 2002).

The most important change that emerged from the reassessment has been the central role now assigned to the principle of refugia (the phenomenon describing non-exposure of a proportion of a parasite or pest population to a given control measure, e.g. free-living worm stages on pasture when the hosts are treated) when designing worm management systems. Except when animals have been newly introduced to new pasture, worm eggs and larvae on pasture (i.e. in refugia) will usually overwhelmingly outnumber the parasitic stages in the hosts, and are not exposed to anthelmintics when the animals are treated. These worm stages on pasture act as a buffer against selection for AR since, when voided on infected pasture, the offspring of the relatively few survivors of a highly effective treatment are highly diluted genetically by the unselected parasites, and there is thus negligible selection for AR in the total population (discussed by Martin, 1985; Van Wyk, 2001).

The phenomenon of refugia can be utilised in practice, since in a given population the parasites are grossly over-dispersed, i.e. the vast majority of the parasites are concentrated in a small minority of overly susceptible hosts (Barger, 1985). Also, of these susceptible hosts, some may die from serious worm challenge unless treated, while the rest may be resilient (better able to withstand the effect of worm infection despite high worm burdens). Thus, if the relatively lightly affected majority can be left untreated, they will significantly enlarge the non-treated buffer effect of refugia against selection for AR, by continuing to void a majority of unselected parasites onto pasture, compared to the progeny of the parasites surviving the treatment of the susceptible hosts. Until recently there was no practical method for identifying the badly affected animals. However, South African researchers have developed the FAMACHA© system of clinical comparison of the colour of the ocular mucous membranes with a custom-made colour chart, for indirect appraisal of haemonchosis though clinical assessment of anaemia (Bath et al., 1996, 2001; Van Wyk and Bath, 2002).

3.1.3. Anaemia estimation

The FAMACHA© system, more widely tested for field use in sheep than in goats, has been shown to be more difficult to apply in goats, since there appears to be a smaller spectrum of colour variation in these animals (Bath et al., 2001; Van Wyk and Bath, 2002; Vatta et al., 2001). Sheep farmers, farm workers and veterinarians have rated the system independently as either very good (category 4 on a 5-point scale) or excellent (category 5) in a structured questionnaire. It was reported by 13 farmers to have reduced anthelmintic treatment costs by an average of 58%, compared to their previous usage (Bath et al., 2001; Van Wyk and Bath, 2002). Genetic correlation (BLUP analysis) of clinical FAMACHA© estimates on the single farm for which results have been analysed, have been shown to be on a par with haematocrit determination and log faecal worm egg count (FEC) in animals heavily challenged by *Haemonchus* infection. In addition, there were very high genetic correlations between FAMACHA© scores, FECs and haematocrit evaluations (Bisset et al., 2001). The effects on animal production, and a reduction in labour requirements are in need of further investigation, to give the farmer a more informed indication of the full extent of the financial implications of application of the system, as well as to make it more practical for use under circumstances of scarce and expensive labour in developed countries.

3.1.4. Body condition score

As the FAMACHA© system is limited to use in haematophagous worm species, a similarly practical method of clinical evaluation is required for non-haematophagous worm species, such as *Trichostrongylus* spp., *Ostertagia* spp. and *Oes. columbianum*. Body condition scoring (BCS) appears to hold promise for this purpose, since in sheep it consists of the simple, easily learned clinical scoring of the tissue over the lumbar vertebrae and has shown high genetic correlation with FAMACHA© scores, haematocrit values and FECs on one sheep farm in South Africa. While this initial work is only indicative of its potential usefulness, it is enough to merit thorough testing both in sheep and goats.

3.1.5. AR reversion

One of the most pressing problems today is that once AR has developed in a worm population, natural reversion to susceptibility is so slow as to be of no practical use (Borgsteede and Duyn, 1989; Scott et al., 1995). Hence, since no unrelated new anthelmintic activity groups are reaching the market, there was until recently no practical action that the farmer could take to address the problem of severe, multiple AR, once it had developed. However, using a process of dilution of the existing population of highly resistant *H. contortus* with a contrasting, highly susceptible population of the same worm species, Van Wyk and Van Schalkwyk (1990) developed an artificial system in South Africa for obtaining a valuable degree of reversion of AR. This novel approach has given promising results under semi-laboratory conditions and also on some farms. The principle involved is the introduction of the susceptible population at a time when the resistant population is at a minimal level, and has been implemented as follows.

At a time when very low levels of free-living stages of an extremely resistant strain of *H. contortus* were expected to be in refugia on pasture, all the sheep on two properties were dewormed as thoroughly as possible with a battery of anthelmintics. After a delay, timed to coincide with the residual efficacy of the anthelmintics used, the sheep were artificially infected with larvae of a susceptible population of the same worm species, whereupon only salvage anthelmintic treatment was given to individual sheep that were in danger of being overwhelmed by worm challenge. With the exception of the result for one of the drugs, the efficacy of the three compounds (from different activity groups) that were used, improved from an initial 0–76% to 75–97% (Van Wyk et al., 2001). Similar encouraging results have been obtained in the USA (Bird et al., 2001) and Guadeloupe and France (J. Cabaret, personal communication, 2001).

3.1.6. Practical guidelines for Sustainable Integrated Worm Management

The following recommendations, incorporating the latest findings and research, are based on our current understanding of practical measures that can contribute most to sustainable worm management (Anonymous, 2002).

- *Higher dosage rates*: Goats generally metabolise drugs faster than sheep, therefore the efficacy of some compounds may be compromised in goats at the dosage recommended for sheep. Thus, higher dosage levels may be required in goats, but note that this may invalidate recourse to claims if the instructions for use do not include such variation.
- *Worm identification*: Differential larval counts and post mortem examinations should be used to estimate the relative importance of different worm genera and species in each region and even on individual farms.
- *Composite (bulk) FECs*: These can be used instead of individual counts to reduce costs. Cut off the nozzle end of a 3 or 5 ml plastic syringe and use the open end of the syringe to measure an equal volume (0.5 or 1 ml) of faeces from each of 10–15 goats and adjust the volume of flotation fluid used for the count accordingly (F.S. Malan, personal communication, 2000). Have FECs done at key times, particularly when heavy worm challenge is expected.
- *Tests for drug efficacy*: Faecal Egg Count Reduction tests should, as far as possible, be done annually to keep track of AR. Costs can likewise be reduced in this case by using composite FECs and testing one anthelmintic activity group at a time (i.e. whatever compound is being used at the time).
- "*Treat-&-stay*": This is a major shift from previously accepted practice. Do not treat all animals in a group and then move them soon thereafter to a "safe" pasture (with low levels of parasites in refugia). Either treat selectively only (as discussed above), or else leave the animals in the infected paddock for long enough to become re-infected with the unselected worms in refugia on pasture before moving them (Van Wyk, 2001).
- *Residual drug efficacy*: Different compounds and formulations of a given compound can differ significantly. High residual efficacy for conventional formulations of ivermectin is only about a week against *H. contortus*, but a slow-release formulation (a so-called bolus) may be active for up to 3 months. This residual efficacy determines how long animals should remain on infected pasture before being moved to "safe" pasture, to minimise severe selection for AR (Van Wyk, 2003).
- *Alternation of anthelmintic activity groups and the use of mixtures*: While there is no irrefutable evidence, whether experimental or from mathematical modelling, that alternation of anthelmintic activity groups will or will not lead to less selection for AR than when each is used sequentially until it fails, it is perhaps better not to alternate unless the efficacy of the compounds concerned can be evaluated very regularly. Without such testing AR could be masked by alternation, and therefore lead to multiple resistance before it is discovered (Van Wyk et al., 1997; Van Wyk, 2001). Very importantly, mixtures of compounds from different activity groups can have the same masking effect, hence their use for countering resistance cannot be condoned.
- *Adequate nutrition*: Malnourished goats are more susceptible to endoparasitism and suffer more severely from its effects. Provided that it is economically justifiable, the provision of supplementary feed, particularly protein, will be beneficial where the basic diet is inadequate.
- *Breed resistant/resilient animals*: The fact that heritability of both FAMACHA© values and the FEC

are relatively high, makes selection for host resistance and resilience to worm infection and culling of overly susceptible animals practical and valuable for improving the ability of a given flock or herd of animals to be able to withstand worm challenge. While the FEC can help to identify only resistant animals, the FAMACHA© system and haematocrit determination detect both resistant animals (those that can withstand worm infection) and those that are resilient (able to withstand the effect of worm infection) (Bisset et al., 2001).

- *General management measures*: Mend leaking drinking troughs, denude holding pens of foliage and fence off marshy areas that favour helminth infection.
- *All worms are prone to AR*: For example, there is probably no fasciolicide to which at least one population of *Fasciola hepatica* has not yet developed resistance (Fairweather and Boray, 1999). Therefore, do not depend too heavily on chemicals for managing any worm genus; sustainable integrated methods are essential.
- *Tapeworms*: Treat for tapeworms only if essential. In South Africa the frequent use of cestocidal drugs has resulted in widespread resistance of *Moniezia expansa* to the benzimidazoles and also niclosamide (Visser et al., 1987; J.A. van Wyk, unpublished observations, 1994).

3.2. Coccidiosis

Goats raised under intensive conditions are most prone to develop clinical disease (Van Tonder, 1975). The essential factor is naïve goats (usually weanlings) ingesting a massive dose of embryonated oocysts before they can develop immunity. Therefore, these susceptible animals should be housed separately, preferably on slatted floors if this is possible. The main source of infection is usually the water or feed trough. These troughs should be raised higher than tail height, with a low step or two to give goats access, while making faecal contamination unlikely. Ensure that goats have good nutrition (especially selenium) and if necessary, include coccidiostats (usually ionophores) in the feed (Swan et al., 2004). Diclazuril (Vecoxan®, Janssen) is the best for treatment as it is both coccidiostatic and coccidiocidal, but it is also unfortunately expensive (Swan et al., 2004). Electrolytes and water for dehydration should be given in severe cases. Antibiotics may have to be given for secondary infections. To re-establish normal gut flora subsequent to antibiotic treatment, probiotics (Swan et al., 2004) should be administered.

3.3. Ectoparasites

Lice are a problem in Angoras, mainly in the southern coastal areas, especially with goats in poor condition in winter. The species involved are *Damalinia limbata, D. caprae* (red or biting lice) and *Linognathus stenopsis* (blue louse) (Howell et al., 1978). Mites seldom cause problems. The Karoo Paralysis tick (*Ixodes rubicundus*) is found across a large part of the southern section of the central plateau. It is a three-host tick and only adults are found on goats from early autumn or midwinter, when it causes a reversible paralysis. Control is focused on acaricide treatment at this time, but also involves habitat change by periodic burning and avoidance of dangerous areas at the peak period of incidence (Bath and De Wet, 2000). Plunge dips are not routinely recommended for goats, mainly because local treatment (foot or belly bath, or spot treatment) is usually sufficient. *Rhipicephalus evertsi* and *R. simus* may also cause paralysis, particularly in spring, when prevention by dipping may be necessary.

The Sand Tampan (*Ornithodorus savignyi*) can be a specific problem in sandy areas like the Kalahari Desert. This soft-shelled tick can lie dormant for months and even years in the sand under thorn trees, but will emerge and actively seek a host when it detects higher carbon dioxide levels from the animals' breath. It is a prodigious bloodsucker and can cause severe anaemia, loss of production and death. Dipping has been the only practical solution to date, although conserving ground-feeding birds like guinea fowls does help to reduce numbers (Howell et al., 1978).

Nuisance insects like blackflies (*Simulium* spp.), sandflies (*Leptoconops* spp.) and stable flies (*Stomoxys* spp.) may become troublesome and require specific attention. This will usually entail measures to limit breeding of the insects (Bath and De Wet, 2000) and the treatment of goats in those body areas most prone to insect attack, like the head. The insecticide group best suited for this purpose are the synthetic pyrethroids which are contact poisons (Swan et al., 2004). *Gedoel-*

stia hassleri is a type of bot fly which normally infests certain antelope but can affect goats, where it causes nervous symptoms or bulging eyes because the life cycle is aberrant. Contact between the species has to be minimized, but this is difficult to achieve in practice (Howell et al., 1978).

4. Plants and nutrition

4.1. Redgut

The term has been borrowed from the sheep disease and should rather have been termed "gut twist", which is more descriptive. It describes a fatal disease caused by a twisting of a large part of the intestines, due to the intake of excessive quantities of protein, mainly lush legumes (Bath and De Wet, 2000; Martin and Aitken, 2000), which results in the enlargement and displacement of the caecum. The intestinal mass becomes unstable and susceptible to torsion. The torsion in goats may be initiated when kids play "King of the Castle", or otherwise when goats are turned over for hoof trimming or similar procedures. There is no cure, prevention being based on lowering the protein intake and the provision of hay.

4.2. Phytobezoars

Three types of abomasal phytobezoar have been described in South Africa. Louw and Steenkamp (1965) recorded bezoars in sheep formed by the seedheads of bushman grass (*Stipagrostis obtusa* and *S. ciliata*), while Schneider and Hugo (1980) recorded the disease in lambs grazing Seradella pastures. In some parts of the arid Karoo, important economic losses may arise from a third form of this condition. The most important type of plant fibre concrement found in the abomasum of goats rather than sheep is that caused by the ingestion of certain Karoo bushes, notably *Eriocephalus ericoides*, *Arthrosolen polycephalus* and *Chrysocoma ciliata* (Bath and Bergh, 1979; Bath et al., 1992). It appears that goats (particularly Boer goats) are prone to eating the flowers and mature seed heads, which become felted together to form bezoars that can be large enough to almost fill the abomasum and cause fatal obstruction. There is no prevention or cure known for the condition, but palpation of the abomasum just behind the xiphoid cartilage can at least allow farmers to identify and sell or slaughter affected goats before they lose much condition.

4.3. Poisonous plants

Goat farming in southern Africa can be severely challenged by the presence of a large number of poisonous plants (Van Tonder, 1975; Kellerman et al., 1988; Kellerman et al., 1996), most of which are not found elsewhere. Nearly all of them become an economic problem only when the natural grazing (veld) has been mismanaged, and usually only when this has happened over many years. This allows the poisonous plants, which are usually a minor component of veld, to become dominant when more palatable plants have been largely removed by selective grazing. Other factors can be the utilisation of a dangerous section of a farm at the wrong time, introducing too many animals simultaneously, or introducing naïve animals at times of danger (Danckwerts and Teague, 1989; Maree and Casey, 1993; Le Roux et al., 1994). The poisonous plants which can cause most economic losses in goats include *Tylocodon* and *Cotyledon* spp., which cause krimpsiekte or nenta, characterised by paralysis and weakness; *Chrysocoma ciliata* (bitterbush) which causes hair loss in kids; *Salsola* spp. (ganna) causing oedema, prolapse and prolonged gestation; *Galenia africana* (kraalbos) causing cirrhosis and dropsy; *Geigeria* spp., causing paralysis of the oesophagus; *Tribulus terrestris* (devil's thorn), causing severe photosensitisation; *Senecio* spp., causing severe liver damage; *Thesium* spp. (stormbush) causing sudden death. There are also many other toxic plants, including those causing problems elsewhere in the world, such as plants containing toxic levels of prussic acid and nitrate. Although some of these poisonings can be treated, it is always more advisable to prevent outbreaks as far as possible (Kellerman et al., 1988; Danckwerts and Teague, 1989). In virtually all cases this demands an effective and sustainable grazing system; establishing the risk profiles of plants, animals and climate; using appropriate stocking rates and not introducing hungry goats onto dangerous pasture; supplementary feeding, where necessary; not introducing naïve livestock when it is dangerous to do so; and careful monitoring of goats and pasture condition when necessary.

4.4. Nutrition

Since most of southern Africa receives low rainfall and is prone to droughts, absolute undernutrition is frequently encountered, especially in areas that are communally farmed (Danckwerts and Teague, 1989; Maree and Casey, 1993). Good rangeland management and fodder flow planning remain the keys to minimizing these problems, but supplementation of protein (using especially urea-based licks) or energy (using mainly maize-based fodder) may be necessary. A range of trace element deficiencies may be encountered, notably zinc, iodine, selenium, manganese, copper and cobalt (Bath and De Wet, 2000). In some cases supplementation may be practical using fertiliser additives, but more commonly injectable formulations (Swan et al., 2004). If castrates (known as kapaters in South Africa) are fed high concentrate rations such as those used in feedlots, obstructive urolithiasis (struvite calculi) may become a major problem. Prevention is based on lowering the phosphorus content or adding urinary acidifiers to the ration. The same problem may result from bucks being fed in preparation for shows.

5. Genetic and other conditions

5.1. Abortions

Losses due to abortion have been a significant problem especially in Angoras (Van der Westhuizen and Wentzel, 1971; Wentzel, 1974). Culling has significantly reduced the occurrence of habitual or genetic abortion. The major cause is however usually stress or nutrition. As the corpus luteum in goats produces all the progesterone needed to maintain pregnancy, abortions can result from luteolysis when prostaglandin production is triggered by stress or malnutrition. Prevention is exclusively managemental, including the provision of adequate nutrition, especially for young does. Abortions can however also be caused by *Coxiella burnetii* and a range of other factors as better described in sheep (Smith and Sherman, 1994; Bath and de Wet, 2000; Martin and Aitken, 2000). The control measures are therefore also similar.

5.2. Postnatal mortalities

The occurrence and causes tend to overlap to a large extent with the problems encountered in lambs (Bath and De Wet, 2000). However, in kids, and especially Angoras, abdominal rather than subcutaneous fat distribution makes them very susceptible to chilling, notably when Antarctic cold fronts sweep the country in winter, bringing the simultaneous chill factors of cold, rain and wind across the southern coast (Van der Westhuizen et al., 1981). Angora does are often reputed to be bad mothers due to poor selection policies in the past. If this is coupled with suboptimal nutrition and chilling, large-scale losses may be experienced. The control of this problem, which can be economically very significant, is largely managemental. Proper selection of does, coupled with the culling of those that fail to rear their offspring, should be instituted along with appropriate feeding and the provision of shelter (Van der Westhuizen et al., 1981; Bath and De Wet, 2000).

5.3. Exposure

Deaths due to cold are a particular problem in Angoras of all ages, which in addition to having intra-abdominal rather then subcutaneous fat, are shorn at potentially dangerous times and may produce excessive quantities of mohair relative to metabolic weight (Van der Westhuizen et al., 1981). Feeding of supplements and the provision of shelter offer some short-term relief, but the breeding of a more balanced goat is the better long-term solution.

5.4. Swelling disease (Swelsiekte)

This problem is unique to Angoras, especially highly bred stud animals aged between 4 and 18 months (Van Tonder, 1975). It is usually precipitated by some form of stress, and often associated with lush pastures, high stocking densities and endoparasitism, which seems to be the underlying factor causing hypoalbuminaemia. This is responsible for the widespread subcutaneous oedema typical of the disease from which the disease gets its name (Bath and De Wet, 2000). Treatment is based mainly on giving anthelmintics, coccidiostats, and protein supplements, but it should be noted that many goats recover spontaneously. Prevention is aimed at lowering the risk factors outlined above, especially the control of brown stomach worms (*Ostertagia* and *Teladorsagia* species), coccidiosis, protein supplements and avoiding inbreeding.

5.5. Predation

It is particularly the young kid that is susceptible to predation, mainly by the Black-backed Jackal (*Canis mesomelas*) and Caracal (*Felis caracal*). Many control measures have been used but the best consist of farming to avoid the problem, and can be summarised as follows: The use of electric or jackal-proof fencing; a large guard dog or donkeys or ostriches in the paddock; lights, noise or movement; hard neck collars on kids; toxic pouches on collars on kids. Less acceptable are toxic guns (coyote getters); individual shooting, cage traps, and single dose poison baits. Not recommended are carcass poisoning, poison scattering, gin traps, and hunting packs. The aim should be to remove only the predators responsible for the killing, or minimising the chances of predation, rather than aiming for eradication, which despite all attempts has not been achieved, also it is not desirable (Bath and De Wet, 2000).

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