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The effects of prophylactic anthelmintic treatment on the productivity of traditionally managed Djallonke sheep and West African Dwarf goats kept under high trypanosomosis risk

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Abstract

The effects of a prophylactic anthelmintic intervention on the productivity of village based sheep and goats was studied in an area of high trypanosomosis risk in The Gambia during 2 and 3 years, respectively. In total, 223 sheep and 385 goats from five villages were included. Allocation to treatment groups (treated-control) was randomised by village, based on age and sex. Three treatments per rainy season were applied with Fenbendazole (Panacur®, Hoechst, 2.5%, 5 mg/kg). Mean nematode egg excretion per gram faeces (EPG) of the treated groups were significantly reduced by prophylactic anthelmintic treatment, indicating the efficiency of the treatment despite the risk of rapid reinfestation. Weight gain benefits of anthelmintic treatment were observed in all age categories (> 6 month) of sheep but not in goats. Kidding rates were significantly increased whilst the same positive trends were observed for other reproductive parameters (litter size, parturition interval) in both goats and sheep without reaching statistical significance. Birth weights of offspring born out of treated does and ewes were higher ($P < 0.05$) than those from the controls. In contrast, growth rates until 3 months of age were not influenced by the treatment status of the dam. Mortality rates until the age of 3 months of kids from treated does were significantly lower than of those from control does. Mean Packed Red Cell Volume (PCV) levels during the rains were significantly higher in treated goats than in control goats. The same trend was observed in sheep. In general, there were no interactions between trypanosome infections and effect of anthelmintic treatment, thus both factors acted independently. Finally, the live weight productivity index (12 months old-offspring in kg/year per dam) for treated dams was 24% and 47% higher than in control ewes and does, respectively. It can be concluded that, despite the continuous risk of trypanosome infections which has a negative impact on their productivity, a beneficial effect of anthelmintic treatment was observed in both species but most obviously in goats, measured as an increased production and improved health status. A cost-benefit

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analysis should be carried out in order to confirm whether prophylactic anthelmintic treatment can be recommended to farmers to increase their income from small ruminant production. Nevertheless, anthelmintic treatment will certainly optimise the trypanotolerance in these breeds. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Sheep; Goats; Anthelmintic treatment; Trypanotolerance; Productivity; Rural development

1. Introduction

Traditional sheep and goat production in different parts of Africa is a very profitable enterprise but returns are strongly determined by biological performance (Sumberg and Mack, 1985; Upton, 1985; Itty et al., 1997; Panin and Mahabile, 1997). For the Gambia, sheep production is even more favourable than cattle production from a financial, gender and equity point of view (Itty et al., 1997). There are more goats (213 017) than sheep (155 132) (DLS/ITC census, 1993). The Djallonke sheep and West African Dwarf (WAD) goats are the main breeds in the Gambia and their trypanotolerant nature has been described as an ability to maintain production under infection (Mawuena, 1987; Osaer et al., 1994, 1997; Goossens et al., 1997a). However, trypanotolerance is not absolute and stress or disease factors such as helminth infections, which coincide with trypanosome infections in field situations may interact with their resilience to the effects of trypanosomosis. Under experimental conditions, a *Trypanosoma congolense* infection in Djallonke sheep combined with natural helminth infections, resulted in a more severe anaemia and reductions in weight gain, (Goossens et al., 1998b). Similarly, concurrent infections of *T. congolense* and *H. contortus* in controlled experiments have proven the severeness of the mixed infections as opposed to both single infections on haematological parameters in sheep (Goossens et al., 1997b).

Gastro-intestinal parasitism in ruminants contribute greatly to production losses and even death (Barger, 1982; Thomas and Ali, 1983; Parkins and Holmes, 1989; Cobon and O'Sullivan, 1992; Tillard et al., 1992; Hoste and Chartier, 1993; Tillard et al., 1997). One of the possible interventions to reduce the impact of gastro-intestinal parasitism in developing countries are prophylactic anthelmintic treatments (Bullerdieck, 1996). However, treatment is often expensive for the small scale farmer and incorrect usage can induce drug resistance. Grazing management techniques can support worm control programmes, and therefore reduce the reliance on anthelmintic treatments (Waller, 1997; Barger, 1998, 1999). A good knowledge and understanding of the epidemiology of helminth infections is a prerequisite for any anthelmintic intervention. Epidemiology of helminth infections in sheep and goats have been well studied in the Gambia (Greenwood and Mullineaux, 1989; Fritsche et al., 1993; Ankers et al., 1994; Osaer et al., 1999). Over an 1-year study period, it was found that over 95% of sheep and goats of all age classes harboured nematodes (Fritsche et al., 1993). *Trichostrongylus colubriformis* and *Oesophagostomum columbianum* were most prevalent while *Haemonchus contortus* had an annual prevalence of 67%, but with the adult population peaking during the rainy season (July till October) (Fritsche et al., 1993). Ankers et al. (1994) observed that re-infestation with helminths was negligible during the dry season. Nematodes survive the long dry season either as hypometabolic adults or as hypobiotic larvae (Kaufmann and Pfister, 1990; Ankers et al., 1994; Zinsstag et al., 1994).

Few reports are available on the effects of prophylactic anthelmintic treatments in small ruminants kept under traditional, extensive management in developing countries. In The Gambia, intervention schemes based on two anthelmintic treatments during the rains have been tested in Djallonke sheep, and resulted in increased lambing rates and average litter size whilst mortality and weight at 12 months were not affected (Ankers et al., 1998). Despite its large variations, the rate of return was high and therefore this treatment scheme was highly recommendable

(Ankers et al., 1998). In Senegal, biannual anthelmintic treatment lead to improved weight gains and lowered mortality in young sheep (Vassiliades, 1984), whereas Tillard et al. (1992) reported on an improvement of the productivity index in both adult sheep and goats following three Fenbendazole treatments.

Because of concurrent infections with trypanosomes and other environmental stress factors, the possible benefits of anthelmintic treatment on productivity and health in sheep and goats might be different. In addition, the expression of trypanotolerance should be preserved as much as possible in an area with high trypanosomosis risk, so that intervention against helminth infections might be one way to reduce stress factors known to reduce resilience in those breeds. The effects of trypanosomosis on health and productivity of sheep and goats kept in the same area and studied during the same period have been described earlier (Osaer et al., 1999) and will not be discussed in this paper.

Whether goats have similar benefits from a prophylactic anthelmintic treatment as sheep has not often been studied under field conditions. The present study aimed at testing a prophylactic anthelmintic treatment scheme on-farm on indigenous goats and sheep kept under high trypanosomosis risk.

2. Materials and methods

2.1. Study site

The study took place in Central River Division South, The Gambia, between July 1996 and December 1998. The study site is situated in the Niamina East area (13°40′N, 14°58′W), at 200 km from the Atlantic coast. This area is highly infested with the tsetse fly *Glossina morsitans submorsitans*, the major vector of animal trypanosomosis in the Gambia (Rawlings et al., 1991). Niamina East region was ranked as an area of high trypanosomosis risk which was expected to remain the same for at least 5–10 years, despite influence of demographic, climatic and environmental factors on tsetse populations (Rawlings et al., 1993). Peak trypanosome infections in small ruminants occurred in the early dry season but annual infection rates for the study years 1996 and 1997 were 4.0% and 7.1% in goats and 5.6% and 7.1% in sheep, respectively (Osaer et al., 1999). For the year 1996 these figures are incidence rates, because trypanocidal treatments were given to infected animals at monthly intervals. In the subsequent years, no trypanocidals were applied thus prevalence rates were measured (Osaer et al., 1999). In the third year 1998, the mean prevalence rate in goats was 10%. In the Gambia the wet and humid season lasts from June to the end of October, with annual rainfall for the years 1996, 1997 and 1998 in the study site being 701, 638 and 593 mm, respectively (Goossens, unpublished results). The dry season lasts for 7 months, from November till May. The study site comprises five adjacent villages situated 1.5 km apart. Flocks of sheep and goats are managed in a traditional extensive way. During the dry season, most of the animals roam freely but sheep staying closer to the villages than goats. During the cropping season, starting with planting in July and lasting till after harvest and threshing in November, grazing of small ruminants is restricted in time and area (tethering).

2.2. Animals and treatments

At the start of the intervention in July 1996, 130 sheep and 180 goats from the five villages were selected, followed by a random allocation to treatment groups (T = treated; C = control) per village and based on age and sex. Lambs/kids born during the trial were ear tagged and allocated to the same treatment group of their dam. Both sheep and goats were treated with anthelmintics during the rainy season of 1996 and 1997 and goats also during the third rainy season in 1998. In total, individual records of 223 sheep and 385 goats were included in the study which fulfilled the conditions for analysis. Three anthelmintic treatments were applied, using Fenbendazole (Panacur®, Hoechst; 2.5%) at 5 mg/kg: the first two treatments were given during the rains to decrease the pathogenic effects of the nematodes by removing the adult and larval populations under constant infection pressure. The third treatment, given at the start of the dry season, would eliminate all nematodes, including the hypobiotic larvae, with negligible risk of reinfection (Ankers et al., 1994). In 1996, the three consecutive treatments were given in mid July, mid September and early November. In 1997 and 1998 the first treatment was postponed till early August, whilst the second and third treatment remained as in 1996. Animals were vaccinated against Peste des petite ruminants (PPR) at 6 monthly intervals. Between control groups and groups treated with anhelminthics of both species, there were no differences found in trypanosome infection rates. No routine acaricide treatments were applied. Apparently, tick infestation was low and only associated with limping problems.

2.3. Sampling methods

The monitoring began in July 1996 and lasted 24 months and 30 months for sheep and goats respectively. Data on new entries, birth weights and exits were obtained at weekly intervals. Animals older than 5 months were bled monthly from the jugular vein into ethylene diamine tetra-acetic acid (EDTA)-coated vacutainer tubes (2–3 ml) for assessing Packed Cell Volume levels (PCV) and trypanosome infections. The latter were diagnosed using the buffycoat dark ground technique (DG) (Murray et al., 1977) and the number of trypanosomes was scored by the method of Paris et al. (1982). From the total sheep and goats in the trial, for each species 20% randomly selected faecal samples were collected monthly during the rainy season and every 2 months during the dry season. The number of strongyle eggs per gram of faeces (EPG) was determined using a McMaster technique with a sensitivity of 100 EPG (Thienpont et al., 1979). Monthly weighing was done with Salter spring balances (50 kg/200 g accuracy).

2.4. Productive performance analyses

Traits on health and productive performance (EPG, PCV, live weight gain, parturition interval, parturition rate, average litter size, birth weight) were analysed by linear model techniques (GLM procedure; SAS, 1998). Parturition rate (number of parturitions/year per female) was calculated as the total number of parturitions divided by the number of years of presence per breeding female. Breeding females were considered as from their theoretical age at first parturition of 300 days (doe) to 350 days (ewe). The former ages were based on baseline data from the site and to avoid seasonal effects (Osaer et al., 1999), only dams present for at least 1 year were considered in the analyses. Apart from the main effect anthelmintic treatment (treated = T/control = C), trypanosome infection status (infected/not infected) and the following effects were included in the model: age-class (6–12/12–24/ > 24 months), sex, village, and the interactions treatment × trypanosome infection and treatment × age–class. Additional factors, inherent to the observed trait, were included. Individual daily weight gains (linear regression, $Y = b_0 + b_1$ days) were calculated and analysed per season, which were also defined as loosing and gaining period, based on earlier observations (Osaer et al., 1999). The model for the estimated regression coefficient (b_1) fitted, apart from the above mentioned effects, also the effect 'lambed/kidded status'. For the analysis of the parturition interval, censored data were taken into account following the methodology suggested by Tanner (1993). These data were derived from dams which lambed/kidded only once during the first half of the survey but not a second time, despite their continuous presence in the flock. The analysis was carried out with programs specifically written for these data sets (Simianer, 1998, personal communication). All hypothesis were tested by the F-test (Snedecor and Cochran, 1980). Means of the different groups are presented as least square means ± standard error (mean ± S.E.). Offspring performance data (< 3 months) were analysed by taking into consideration the treatment status of their dams. Estimates for mortality included also, apart from reported mortalities, animals which disappeared from the monitoring without reporting but which were assumed to have died. Mortality rates (up to 90 days and 90–365 days) were compared between treatment groups using χ^2 tests.

Table 1
Effect of prophylactic anthelminthic treatment[a] on daily weight gain (age-classes > 6 months) in the different periods (seasons): least square means ± S.E. (in g/day)[b]

Treatment group	Goats					Sheep			
	Rains 1996 ($n = 146$)	Dry 96/97 ($n = 119$)	Rains 1997 ($n = 226$)	Dry 97/98 ($n = 122$)	Rains 1998 ($n = 130$)	Rains 1996 ($n = 105$)	Dry 96/97 ($n = 82$)	Rains 1997 ($n = 132$)	Dry 97/98 ($n = 75$)
Control	13.9 ± 7.3	59.9 ± 6.2	11.2 ± 7.3	59.2 ± 5.6	−5.5 ± 8.5	19.2 ± 7.2	38.1 ± 7.2	8.4 ± 8.9	45.7 ± 12.3
Dewormed	13.4 ± 7.8	55.5 ± 7.5	19.1 ± 8.0	57.9 ± 6.2	−4.7 ± 7.9	24.9 ± 7.0	59.5 ± 7.1	26.9 ± 7.7	63.3 ± 9.6
Significance	ns	ns	ns	ns	ns	ns	$P < 0.01$	$P < 0.06$	ns

[a] Anthelmintic interventions during the rainy seasons of 1996 and 1997 for both species, for goats also in 1998.
[b] Other effects included are trypanosome infection status, sex, age-class, village, interactions deworm × age-class and deworm × infection status.

3. Results

3.1. Nematode egg excretion

The effect of anthelmintic treatment on the mean nematode egg excretion (EPG) was evaluated by comparing treated groups with controls. The overall means were for goats C: 516.6 ± 73.3 versus T: 319.6 ± 74.3 and for sheep C: 834.2 ± 162.8 versus T: 471.4 ± 166.4, for their respective study period. To approximate the normal distribution, data on EPG were logarithmic (ln) transformed. For both species, anthelmintic treatment reduced EPG significantly ($P < 0.001$), but with highest effect during the rains when peak excretion occurred (interaction month × treatment). ln sheep, the reduction in EPG due to treatment was greatest in sheep aged 12–24 months (interaction age × anthelmintic treatment; $P < 0.01$). The village effect ($P < 0.05$) indicated important variations in levels of EPG between the villages included in the study. Differences between species were not significant.

3.2. Weight changes

Mean daily weight gains for both species during the different seasons are presented in Table 1. In general, a beneficial effect of anthelmintic treatment was present for sheep, especially in the dry season 1996/97 where the increase in weight gain was significant ($P < 0.01$). The interaction age × treatment was not significant, indicating that the positive effect of anthelmintic treatment was equal for all involved age categories. In contrast, there was no such positive effect of treatment on weight gain in goats. Generally, weight gains were considerably higher in the dry season than in the rainy season, especially in the rainy season 1998 when weight losses were observed in goats. The interaction of the anthelmintic treatment with trypanosome infection status of the animal was not significant except in sheep during the rainy season'97, where a positive effect of anthelmintic treatment ($P < 0.05$) was mainly seen in the trypanosome infected sheep (T-infected: 33.0 ± 12.2 g versus C-infected: -6.8 ± 14.4 g).

3.3. Reproductive performance

The mean parturition rate and litter size per breeding female for both species and for the different treatment groups are presented in Table 2. Whilst a positive influence of anthelmintic treatment was observed for both parameters in both species, only kidding rates were significantly ($P < 0.01$) increased due to prophylactic anthelmintic treatment. Parturition intervals, including censored animals, were shortened due to treatment but differences were for neither species significant. Interactions of anthelmintic treatment with their trypanosome infection status were not significant, indicating that both factors were acting independently.

3.4. Offspring performance

Birth weight and daily weight gain of offspring born during the study out of treated or control dams are presented in Table 3. In addition, the

Table 2
Effect of prophylactic anthelminthic treatment[a] on reproductive parameters in sheep and goats in an area of high trypanosomosis risk:least square means ± S.E.[b]

Parameter	Cases (*n*)	Goats			Cases (n)	Sheep		
		Control	Dewormed	Sign		Control	Dewormed	Sign
Parturition rate	141	1.00 ± 0.06	1.21 ± 0.06	$P < 0.01$	85	1.15 ± 0.09	1.26 ± 0.12	ns
Average litter size	141	1.57 ± 0.07	1.61 ± 0.08	ns	85	1.15 ± 0.06	1.22 ± 0.08	ns
Parturition intervals	143	267.4 ± 10.4	251.1 ± 6.6	ns	118	254.3 ± 11.7	236.9 ± 12.1	ns

[a] Anthelmintic interventions during the rainy seasons of 1996 and 1997 for both species, for goats also in 1998.
[b] Other effects included are trypanosome infection status, village, interaction deworm × infection status.

Table 3
Effect of prophylactic anthelminthic treatment[a] of sheep and goats on the performance of their offspring in an area of high trypanosomosis risk: least square means ± S.E.[b]

Parameter	Kids				Lambs			
	Cases	Control	Dewormed	Sign	Cases	Control	Dewormed	Sign
Birth weight	273	2.4 ± 0.1 kg	2.7 ± 0.1 kg	$P<0.05$	111	2.6 ± 0.2 kg	3.1 ± 0.2 kg	$P<0.05$
Daily gain till 3 months	105	67.9 ± 4.8 g	66.3 ± 7.0 g	ns	57	122.4 ± 10.4 g	108.1 ± 13.6 g	*ns*
Mortality till 3 months in	410	31.2%	22.4%	$P<0.05$	247	28.6%	32.2%	*ns*
% (no./no. total)		(68/218)	(43/192)			(36/126)	(39/121)	

[a] Anthelmintic interventions during the rainy seasons of 1996 and 1997 for both species, for goats also in 1998.
[b] Other effects included are sex, type (single/multiple birth), dam's trypanosome infection status, village, age at birth weight-recording.

Table 4
Effect of prophylactic anthelminthic treatment on packed cell volume (PCV) levels in sheep and goats during the rainy seasons of 1996, 1997 and 1998 (goats only) in an area with high trypanososomsis risk: ls means ± S.E.[a]

Treatment group	Goats			Sheep	
	Rains 1996 ($n=$ 138)	Rains 1997 ($n=$ 189)	Rains 1998 ($n=$ 144)	Rains 1996 ($n=91$)	Rains 1997 ($n=138$)
Control	20.8 ± 1.2%	19.4 ± 0.9%	21.0 ± 0.7%	20.5 ± 1.1%	20.9 ± 0.8%
Dewormed	23.3 ± 1.3%	21.2 ± 1.0%	21.3 ± 0.8%	23.1 ± 2.2%	22.7 ± 0.8%
Significance	$P<0.05$	$P<0.05$	ns	ns	ns; $P<0.06$

[a] Other effects included: trypansome infection; age-class; village; sex; age × deworm treatment; deworm treatment × trypanosome infection.

influence of treating the dam on the offspring's mortality rates till 90 days are presented. In both species, birth weight of offspring of treated dams were significantly higher than those of control dams ($P < 0.05$). There was no significant interaction between treatment status and trypanosome infection status of the dam. Thus, the positive effect of anthelmintic treatment was similar in trypanosome infected or negative dams. Daily gain till 3 months was not influenced by the treatment status of the dam. In contrast, a reduction of the mortality rates in kids up to 3 months was observed ($P < 0.05$) due to anthelminthic treatment of their dams (see Table 3).

3.5. Mortality and packed cell volume levels

Mortality rates between 3 and 12 months of age did not differ between treated or control animals with respective means for goats and sheep:
$C = 31.9\%$ versus $T = 38.9\%$ (G; $n = 146$) and $C = 33.3\%$ versus $T = 34.8\%$ (Sh; $n = 79$). Most mortality ($>75\%$) occurred during the rainy season.

Mean packed cell volume levels (PCV) of both control and treated groups of goats and sheep are presented in Table 4 for the consecutive rainy seasons during which anthelmintic treatments took place. PCV-values were significantly higher in treated goats than in control goats in the first two grazing seasons; the same trend, though not significant at the 5% level probability, was seen for goats in the third and sheep in both grazing seasons. The effects of trypanosome infection and anthelmintic treatment on PCV were acting in an additive way (interaction: ns).

3.6. Productivity index

A mean live weight productivity index was calculated for both dewormed and control groups of sheep and goats, based on the following formulae (Ankers et al., 1998): parturition rate × litter size × (1 − mortality rate till 3 month) × (1 − mortality rate 3–12 months) × weight at 365 days. In both species, the productivity index was considerably increased in the groups receiving anthelmintic treatments, but with the greatest increase for the goats. Productivity indices in goats were: $T = 21.2$ kg and $C = 14.4$ kg and in sheep: $T = 17.6$ kg and $C = 14.2$ kg for treated and control groups, respectively.

3.7. Flock structure

The average relative flock structure for both species is presented in Fig. 1. It shows that male offtake rate is high in both species but highest in sheep with the majority of the outflow occuring before the age of three years. For both species, the number of males older than 4 years is neglible, whilst there are still high number of females in that age category. The ratio of females per male above 2 years was 3 to 1 for both species.

4. Discussion

The results of the present on-farm trial demonstrated beneficial effects of prophylactic anthelmintic treatment on production and health parameters in both species but most clearly in goats, in spite of a continuous risk of trypanosomosis, contaminated environment (helminths) and the presence of other environmental stress factors.

4.1. Nematode egg output

Nematode egg excretion (EPG) was significantly reduced in the treated groups in spite of the immediate risk of reinfection with infective larvae from the communal pastures. During this study animals from both treatment groups were commingled and therefore contributed greatly to rapid reinfestation. Moreover, the usual management practises applied under these conditions have proven to play a role in the re-infection of helminths as observed in cattle (Kaufmann et al.,

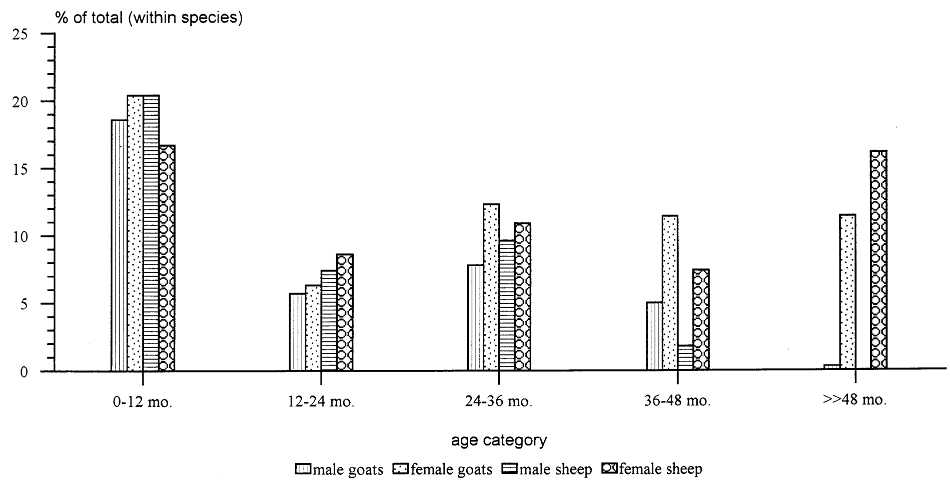

Fig. 1. Average flock structure for sheep and goats: percentages for both sexes of the different age categories within species.

1993) and small ruminants (Osaer et al., 1999). The concept of strict separation of treatment groups was not withheld because it would not be feasible in the existing traditional production systems. Therefore, the benefits of the anthelmintic treatment may have been underestimated in this study. Nevertheless, based on previous epidemiological studies (Fritsche et al., 1993) it can be assumed that the applied treatment scheme in the present trial had suppressed considerably the worm burden in both sheep and goats.

4.2. Weight gain

Weight gain advantages of treated versus control sheep were observed at a similar scale in all age classes, but this trend was not observed for goats. When the same prophylactic treatment scheme was applied under controlled conditions in the Gambia, treated Djallonke sheep had on average 1.1 ± 0.1 kg better weight gain than the controls while grazing on the same pastures (Goossens et al., 1998b). In 6–12 month old sheep treated twice a year with an anthelmintic (once in the dry-once in the rainy season), Vassiliades (1984) reported on a 40% improvement of weight gains. Contrary to the present study, there was little risk of reinfection since all animals in the village were treated. In addition, the trial was carried out in the Louga region, which is a more northern, dryer zone in Senegal and where Sahelian sheep are present (Vassiliades, 1984). A biannual treatment scheme was also tested in village-based Djallonke sheep in the Gambia by Ankers et al. (1998), with two Fenbendazole treatments given during the rains, but mean weight at 12 months was not significantly higher in the treated groups. This is in contrast with the present study, where a third treatment at the start of the dry season gave clearly improved weight gains in the sheep of all age categories, also during the following dry season. This last treatment was probably the most efficient with respect to remanence since it was given at a time with low risk of reinfection. Moreover, it supports the recommendations of Ankers et al. (1994) who stressed the importance of an early dry season treatment both in sheep and cattle and of Ndao et al. (1995) who measured a significant weight increase in cattle following a single dry season treatment. The negative effect of gastro-intestinal parasitism on weight gain in sheep has been extensively reported following artificial helminth infections (Albers et al., 1984; Kimambo et al., 1988a,b) and under natural infections in young grazing sheep (Barger, 1982) with a 32–79% weight gain reduction in the untreated groups. ln this study, an improvement in weight gain was observed not only in the growing sheep but also in the adult stock while this was not apparent in the goats.

4.3. Reproductive performance

Kidding rates in treated goats were significantly higher than in control goats while in sheep, the same trend was observed but the difference did not reach significance. Moreover, there was a positive effect of anthelmintic treatment on litter size and parturition intervals in both species. Improved reproductive performance as a result of prophylactic anthehmintic treatment has also been reported in Djallonke ewes by Ankers et al. (1998), with significantly increased lambing rates and litter size. Compared with this trial, the early dry season treatment did not bring in extra benefits for the reproductive performance in sheep. However, a different study area and time, less observations on sheep and uncontrolled environmental effects make it difficult to compare both results. Moreover, the negative effects of trypanosome infection on reproduction in both species (Osaer et al., 1999) were diminishing the beneficial effect of anthelmintic treatment although both factors were acting in an additive way (interaction ns). Anthelmintic treatment of the dam significantly increased effect on the birth weights of their lambs and kids. A large proportion of the females were pregnant at the start of the rains when treatment commenced, since a higher frequency of parturitions occurred between September–November (Osaer et al., 1999), and therefore direct benefits from treatment were reflected in a better production at birth. Additional beneficial effects in the treated does were seen in increased survival rates of their kids. Offspring did not receive treatment before the age of

3 months, and because of the seasonal peak of parturitions, a large number of offspring did not receive treatment until the next rainy season. The effect of treatment status in the dam on offspring growth rates until 3 months did not reveal any improvements for either species, thus, not confirming the findings of Cobon and O'Sullivan (1992) who observed increased milk yield in ewes receiving anthelmintic treatment and subsequently higher weight gains in their lambs. In these management conditions, other intrinsic effects (sex, litter size) and environmental effects (village) were significant factors influencing the growth rates. Trypanosome infection during late pregnancy and lactation did not significantly influence offspring growth (Osaer et al., 1999). Mean live weight productivity at 12 months, which captures the measured traits and therefore implies a good measurement of overall productivity, was considerably increased in the treated sheep and goats compared to their controls but most obviously in the latter species. with an improvement of 24% and 47%, respectively. These results are not entirely in line with those found by Tillard et al. (1992), who reported an increase of the productivity index of 33% in sheep and only 13.5% in goats in the Kolda area, using a comparable treatment scheme but with a different calculation of the index (dam's production of 3 months-old offspring). Ankers et al. (1998) reported a similar increase of 25% in the live weight productivity index (of 12 month-aged lambs) of Djallonke sheep in the Gambia following a biannual anthelmintic treatment. For the sheep in this study, there was no extra productivity gain derived from the three treatments versus the bi-annual scheme. Yet, the foregoing criteria may explain why results of both trials did not differ.

4.4. Packed cell volume

Treated groups had higher PCV levels during the rains than control groups. The effect of trypanosome infection and anthelmintic treatment on PCV level were found to act independently in the present study (interaction; ns). Apart from these two disease factors, seasonal effects indicated significantly lower PCV levels during the rains, attributable to the nutritional stress in small ruminants under these management conditions (Osaer et al., 1999).

The erythropoiesis responding to anaemia can only be efficient when sufficient nutrients are available and will cause a metabolic shift at the cost of production. If the nutritional supply is very low, the anaemia can become non-regenerative because of erythropoietic failure. In that respect, the decline in PCV following artificial infection of *H. contortus* was more severe in lambs not supplemented with protein-rich pellets (Shaw et al., 1995). Naturally infected Djallonke sheep fed low levels of supplement had lower PCV levels than those fed high levels (Goossens et al., 1998b). From the present study, it was clear that helminth infection combined with inadequate nutrition and trypanosome infections contributed to the lower PCV levels and consequently higher frequencies of mortality observed during the rains.

4.5. Age at off-take

The flock structure in the present study showed that male off-take at a relatively young age was high for both species, corroborating earlier observations in the Gambia (Greenwood and Mullineaux, 1989) and in Nigeria by Sumberg and Mack (1985). The proportion of females older than 4 years remained high. An abattoir survey in the Gambia revealed that the majority of small ruminants brought to slaughter were females whereas the males constituted only a small proportion, because they are rather kept for house slaughtering and religious or ceremonial feast (Goossens et al., 1998a). This supports the recommendation of treating all age classes of both sexes, since the Gambian farmers not only profit from selling young males but also adult females on the local markets (lumo's). Therefore, as a follow-up, it is envisaged to calculate the cost/benefits of such prophylactic anthelmintic treatments for goats and sheep kept under low-input traditional management.

5. Conclusions

From the present results it can be concluded that in spite of a continuous risk of trypanosome infections and other environmental stress factors, the anthelmintic treatment scheme increased production and improved the health status of these indigenous sheep and goats. Compared with a biannual treatment scheme, extra benefits from the third treatment in sheep were observed as improved weight gains in the dry season but not on reproductive performance. A cost–benefit analysis will need to confirm whether this treatment schedule can be recommended to farmers to increase their income from small ruminant production. Nevertheless, anthelmintic treatments certainly optimise the trypanotolerance in these breeds.

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