

## **Economics of sub-clinical helminthosis control through anthelmintics and supplementation in Menz and Awassi-Menz crossbred sheep in Ethiopia**

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### **Abstract**

We evaluated the profitability of anthelmintic treatment and nutritional supplements using partial budget analysis on 108 weaned Menz ( $n=39$ ), 50% Awassi-Menz ( $n=38$ ) and 75% Awassi-Menz ( $n=31$ ) crossbred sheep genotypes kept on-station under sub-clinical helminthosis at Debre Berhan, Ethiopia. Data were collected on feed intake, live weight, eggs per gram of faeces (EPG), packed cell volume (PCV), fleece weight, slaughter weight, carcass weight, dressing percentage, and adult worm burden counts. Input and output prices were recorded. Anthelmintic treatment reduced EPG and worm burden, which was consistent with significantly higher PCV, slaughter and carcass weights for treated than for non-treated sheep ( $P<0.05$ ). Supplemented sheep had higher ( $P<0.0001$ ) weight gain, carcass weight and dressing percentage than non-supplemented sheep. Anthelmintic treatment resulted in a marginal profit (MP) of 13.46 ETB<sup>†</sup> per sheep whilst supplementation resulted in MP of 17.13 ETB per sheep. MP per sheep was higher for Menz than the crosses due to the higher skin price of Menz sheep. MP from anthelmintic treatment increased as exotic blood level increases suggesting the higher dependence of the crossbreds on anthelmintics. Sheep breeding objectives were discussed in relation to low input system.

**Keywords:** anthelmintics, disease resistance, economics, Ethiopia, nutrition, sheep

### **Introduction**

Helminthosis is of considerable significance in a wide range of agro-climatic zones in sub-Saharan Africa and constitutes one of the most important constraints to small ruminant production in Ethiopia (Bekele, 1991; Tembely *et al.*, 1998; Tibbo, 2000; Haile *et al.*, 2002; Rege *et al.*, 2002). The pervasive occurrence of parasitic infections in grazing animals, the associated loss of production, the cost of anthelmintics, death of infected animals and increasing frequency of drug resistance are all major concerns. Body weight losses in sheep due to endoparasitism in Ethiopia could range from 3-8% while liver fluke alone result in mortality of up to 28% (Bekele, 1991).

Control measures against internal parasites known so far include the use of chemotherapy (anthelmintics) and/or controlled grazing, exploiting genetic variation in host resistance to endoparasites and improved nutrition to aid the development of immunity (Wallace *et al.*, 1995). Supplementary nutrition may improve the response to

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<sup>†</sup> 1.00 USD = 8.64 Ethiopian Birr (ETB)

prophylactic or therapeutic intervention, or the effect of improved nutrition may vary between resistant and susceptible hosts. The interaction between the level of nutrition and the ability of animals to cope with internal parasites has long been recognized (Gibson, 1963; Dobson and Bawden, 1974; Mukasa-Mugerwa *et al.*, 1991; Haile *et al.*, 2002; Haile *et al.*, 2004). Exploiting genetic variation in host resistance to helminthosis is an alternative in controlling the challenge of parasites and thus improving the efficiency of production in small ruminants. There are extensive evidences for genetic variation in resistance to endoparasites among breeds of sheep (Baker *et al.*, 1994; Rege *et al.*, 1996; Baker *et al.*, 1998; Rege *et al.*, 2002).

Crossbreeding of indigenous Menz sheep with exotic Awassi sheep to increase growth and wool production by distributing 75% Awassi-Menz sires to farmers, which was started in early 1980's has not bare fruit due to mortality of the distributed sires. This study was undertaken on demand by farmers to investigate the profitability of anthelmintic treatment and nutritional supplements, and the differential responses of indigenous Menz and its crosses with Awassi (50% and 75%) sheep grazed under natural sub-clinical helminthosis challenge.

## **Materials and Methods**

### **Study area and animals**

This study was conducted in the Ethiopian highlands (2780m above sea level) at the Debre Berhan Agricultural Research Centre, located 130 km northeast of Addis Ababa, Ethiopia between March 2000 and February 2001. The climate is characterised by a biannual rainfall (average annual rainfall was 950 ml), a long dry season, and relatively cool temperature (average min. and max. ranges from 2.5-8.4°C and 17.6-22.5°C, respectively). A total of 108 sheep (Menz,  $n=39$ ; 50% Awassi  $\times$  Menz,  $n=38$ ; 75% Awassi  $\times$  Menz,  $n=31$ ) were used. Menz sheep is indigenous to the study area and has been described by Galal (1983). Awassi breed was imported from Israel in 1980 to improve wool and growth of indigenous sheep breeds through crossbreeding.

### **Experimental design**

The experiment was a  $3 \times 2 \times 2 \times 2$  factorial, involving genotypes (3 levels, indigenous Menz, 50% Awassi  $\times$  Menz, 75% Awassi  $\times$  Menz), nutrition (2 levels, supplemented and non-supplemented), anthelmintics (2 levels, treated and non-treated) and gender (2 levels, female and male). The allocation of sheep to the 24 combinations of treatments was made by simple randomisation.

### **Anthelmintic treatment**

Two anthelmintic treatment levels (treated,  $n=51$ ; untreated,  $n=57$ ) were applied. As recommended by Tembely *et al.* (1998), treated lambs were drenched against nematodes with fenbendazole (Panacur<sup>®</sup>, Hoechst Ltd, UK) at a dose rate of 7.5 mg kg<sup>-1</sup> live body weight on June 10, Sept 1 and Oct 15. They were also given triclabendazole (Fasinex<sup>®</sup>, CIBA-GEIGY, Switzerland) at a dose rate of 5 mg kg<sup>-1</sup> live body weight against trematodes on Aug 30, Oct 30, Dec 15 and Feb 2.

### **Feed treatment and parasitic infection**

Managed in two flocks by gender, the sheep were grazed on natural pasture for about 6 hours (from 9:00 to 15:00) to give them enough exposure time to natural parasitic infection. On their return from pasture, they were allocated to their respective pens.

The supplemented lambs ( $n=54$ ) were offered 250 gm of commercial concentrate feed daily on individual basis (in individual feed boxes fitted with yokes to harness the lambs in the feed boxes during feeding) and refusals measured to calculate intake. Total hay ration in each pen was provided to the lambs as a group in the afternoon. The hay ( $1000 \text{ gm head}^{-1} \text{ day}^{-1}$ ) was measured daily and a refusal was determined each morning before fresh amounts are added to the feeding troughs. The amount of hay and concentrates consumed every day was determined as the difference between what was offered and refused over 24 hours. Thus, the experimental design allowed for pen total hay intake and individual supplement intake to be measured daily. The non-supplemented lambs ( $n=54$ ) were given the same amount of hay only and intake calculated as above. Samples of hay and commercial concentrate were analysed for chemical and mineral composition (AOAC, 1990).

### **Sample and data collection**

#### *Haematocrit and parasites egg burden*

Blood samples for packed cell volume (PCV) were collected fortnightly from ear vein punctures into heparinised capillary tubes. The samples were analysed as described by Schalm *et al.* (1975). Faecal samples, for egg counts, were collected fortnightly from the rectum of experimental animals. Egg counts were made using the modified McMaster method (Whitelock, 1948) and expressed as eggs per gram of faeces (EPG). For trematodes, however, only prevalence was estimated (proportion of positive samples out of the total number sampled).

#### *Live body weight*

Animals were weighed at the start of the trial and at biweekly intervals thereafter. Average daily weight gain (ADG) was calculated from the difference between final and initial live body weights, and the number of days between the measurement dates.

#### *Worm counts and fleece weights*

Slaughter weight (SLWT) and carcass weight (CWT) was measured to calculate dressing percentage (DP). Necropsy was done (Hansen and Perry, 1994) on randomly selected 65% of the lambs for worm counts: 22% of them at the end of the main rainy season (i.e. two lambs per pen; one from treated and one from non-treated groups), and 43% at the end of the experiment (i.e. 3 to 4 lambs per pen from treated and non-treated groups). Necropsy was done according to Hansen and Perry (1990). In addition, 40% of the study lambs were shorn using a shearing machine and fleece weight (FWT) was measured (using a Salter scale) to investigate the fleece yield.

#### *Market price of inputs and outputs*

Data on variable costs was collected for partial budgeting. Input and output market prices are given as footnotes of Tables 1 and 2.

### **Statistical and economic analyses**

The experimental design has been described earlier. The experiment involved natural infection monitoring regimes. The dependent variables analysed were EPG, PCV, worm burden (WB), ADG, feed (total dry matter, hay, concentrate) intakes, SLWT and CWT, DP and FWT. Data were analysed using the MIXED and GLM procedures (SAS, 1998). The REPEATED measures analysis of the PROC MIXED was used for

all data except for WB, SLWT and CWT, DP and FWT. Repeated measures refer to data sets with multiple measurements of a response variable on the same experimental unit. In this experiment, repeated measures were taken (except for those indicated above) on individual animals at every 15 days. Worm burden counts, SLWT and CWT, DP and FWT were analysed using the RANDOM statement in PROC MIXED. PROC MIXED fits mixed (i.e., fixed and random effects) linear models. The random variable fitted was the effect of experimental animals due to the fact that animals were randomly selected to be representative of the pool of available animals of each breed and were assigned to the different experimental treatments randomly. Measurement dates were used as a within-subjects factor in cases where repeated measures were taken on individual animals, and their interactions with main effects were also fitted in all the models. The levels of repetitions for measurement dates were different for the variables. Thus, 'time' fitted in the models; to mean measurement dates could indicate different intervals between measurement dates.

The effects of nutrition, breed, gender, anthelmintic treatment and their first order interactions were fitted for all independent variables except for worm counts SLWT, CWT, DP and FWT. Interactions among the main effects were retained in the final models whether found significant or not in preliminary analyses. Preliminary analyses were done including such effects as gender, breed, treatment, and nutrition. Those found significant ( $P < 0.05$ ) in preliminary analyses were included in the final models. Lamb age was used as a linear covariate in the preliminary analyses in all the models and was retained in the final models whether found significant or not to account for age differences between experimental animals.

The covariance structure selected in these analyses was "unstructured". That is, no mathematical pattern is imposed on the covariance matrix. The decision process in choosing the covariance structure can be assisted by using two model-fit criteria computed by PROC MIXED, Akaike's Information Criterion (AIC) and Schwarz' Bayesian Criterion (SBC). These are essentially log-likelihood values penalised for the number of parameters estimated (SAS, 1998). The covariance structure with values of the criteria closest to zero is considered most desirable. Thus, based on this condition "unstructured" covariance was selected. Tukey-Kramer test was used to separate means of effects with three or more levels which were significant in the least squares analyses of variance.

Economic analysis was performed by employing partial budget analysis based on data collected on price of variable costs (feed and anthelmintics) and outputs (carcass, skin, fleece & manure). MR (marginal revenue) which is extra revenue obtained from selling an additional unit of a good is computed by calculating the change in total revenue associated with any given change in outputs and MC (marginal cost) which is the extra cost of selling an additional unit of a good calculated as total cost divided by total output (Hyman, 1989). Marginal profit (MP) is calculated as MR-MC.

## **Results and discussions**

### **Effects of anthelmintics, supplements and genotypes**

Detailed description of results on the effects of anthelmintics and supplements on EPG, PCV, WB, feed intakes, ADG, SLWT and CWT are presented in Tibbo *et al.* (2004). Briefly, anthelmintic treated lambs gained weight and this was consistent with the higher PCV ( $P < 0.0001$ ) for treated than for non-treated sheep. This, in turn, was

reflected on the higher ADG, SLWT and CWT in treated than for non-treated sheep ( $P<0.05$ ). Supplementation with 250 gm of a concentrate mix providing 170 gm of crude protein and 10 MJ of digestible energy per kg of concentrate dry matter had significantly ( $P<0.0001$ ) improved SLWT, CWT and DP although it did not have significant effect ( $P>0.05$ ) on the EPG and WB. The higher DM intake of lambs on the supplemental diet had an observable direct positive effect on performance, which is consistent with previous findings by Sudana and Leng (1986), Anindo *et al.* (1998), Haile *et al.* (2002) who reported increased daily DM intakes in lambs supplemented with high protein feeds. Many authors reported that an increase in the level of digestible protein of the diet in sheep would improve their resistance against nematodes (Singh *et al.*, 1995; Etter *et al.*, 2000; Khan *et al.*, 2000). Conversely, Blackburn *et al.* (1991, 1992) did not observe any effect of protein supplementation on the worm burdens in young meat producing goats infected with *H. contortus*, which is consistent with our present finding. Fleece weight of supplemented sheep was significantly higher ( $P<0.01$ ) than FWT of non-supplemented sheep and supplementation has increased fleece yield by 125% and is in agreement with findings by Huston *et al.* (1993) who reported a significant increase in clean fleece weight in supplemented goats grazing on rangeland.

Menz and 50% Awassi-Menz maintained their PCV at higher level than the 75% Awassi-Menz genotypes. The 50% Awassi-Menz sheep had significantly higher ( $P<0.05$ ) ADG than both 75% Awassi-Menz and indigenous Menz sheep. However, Menz sheep had significantly higher DP than both crosses ( $P<0.05$ ). The difference in PCV may partly be attributable to resistance of the indigenous Menz sheep to sub-clinical helminthosis. Previous studies by ILRI scientists (Haile *et al.*, 2000; Baker, 2002; Rege *et al.*, 2002) also found that the Menz sheep were relatively superior to another indigenous Horro sheep in maintaining their PCV and control EPG and WB although was not statistically significant to attributed the superiority to genetic resistance. Genotype difference ( $P<0.0001$ ) was observed in total dry matter intake, the intake of 75% Awassi-Menz sheep being highest ( $658.2 \text{ g day}^{-1}$ ) compared to 50% Awassi-Menz ( $614.3 \text{ g day}^{-1}$ ) and Menz sheep ( $554.7 \text{ g day}^{-1}$ ). Hassen *et al.* (2002) reported that 37.5% Awassi-Menz genotype were capable to increase weight rapidly until weaning but could not maintain that level of growth potential during post-weaning periods. Crossbreeding increased fleece yield of Menz sheep by 147% when upgraded to 50% Awassi-Menz and 218% when upgraded to 75% Awassi-Menz levels.

### **Profitability of the interventions**

Partial budget per sheep for the effect of anthelmintic treatment and nutritional supplements in the three sheep genotypes is given in Tables 1 and 2. Anthelmintic treatment resulted in a MP of 13.46 ETB per sheep whilst supplementation resulted in MP of 17.13 ETB per sheep. MP from anthelmintic treatment increased as exotic blood increases suggesting the higher dependence of the crossbreds on anthelmintics. This implies that crossbreeding with the Awassi sheep may not profit smallholder farmers in low input system in Ethiopia where input supplies such as anthelmintics and supplements are relatively expensive and often unavailable to farmers in rural areas. Our study disagrees with findings by Shapiro *et al.* (1994), who concluded that anthelmintics did not improve weight gains, but added production costs, thus reducing profits.

Table 1. Partial budget per sheep for the effect of anthelmintic treatment and nutritional supplements in three sheep genotypes

Factors	N	Input cost <sup>†</sup> (ETB*)			Outputs <sup>‡</sup> (ETB)				Partial budget analysis (ETB)		
		Hay	Concentrate	Anthelmintics	Carcass	Fleece	Skin	Manure	MR	MC	MP
Breed											
Menz	39	39.77	55.74	3.77	153.60	1.19	32.00	4.62	187.06	99.28	87.78
50% Awassi × Menz	38	45.15	55.76	3.77	169.60	4.06	10.00	5.24	183.97	104.68	79.29
75% Awassi × Menz	31	49.17	55.64	3.77	180.80	6.02	8.00	5.97	195.17	108.58	86.60
Gender											
Female	47	43.26	56.31	3.77	160.00	1.88	16.67	4.93	178.83	103.33	75.50
Male	61	46.13	55.12	3.77	177.60	1.80	16.67	5.63	196.40	105.02	91.38
Treatment											
Treated	51	44.71	55.64	7.53	179.20	1.86	16.67	5.53	198.05	107.88	90.17
Non-treated	57	44.68	55.79	0.00	158.40	1.82	16.67	5.01	177.18	100.47	76.71
Nutrition											
Supplemented	54	44.52	55.72	3.77	204.80	2.04	16.67	6.05	223.86	104.00	119.86
Non-supplemented	54	44.87	0.00	3.77	132.80	1.64	16.67	4.51	151.37	48.64	102.73

\* ETB, Ethiopian Birr (1 USD = 8.64 ETB); MR, marginal revenue; MC, marginal cost; MP, marginal profit

<sup>†</sup> Commercial concentrate per kg = 0.70 ETB; Hay per kg = 0.27 ETB; Anthelmintics per sheep per year = 7.53 ETB

<sup>‡</sup> Carcass per kg = 16.00 ETB; Skin per piece for Menz = 32.00 ETB, for 50% Awassi × Menz = 10.00 ETB, and for 75% Awassi × Menz = 8.00 ETB; Wool per kg from Menz = 1.50 ETB, and from 50% and 75% Awassi × Menz crosses = 3.50 ETB; Manure per kg = 0.05 ETB.

Table 2. Partial budget per sheep for the effect of anthelmintic treatment and nutritional supplements in three sheep genotypes (continued)

Factors	N	Input cost <sup>†</sup> (ETB <sup>§</sup> )			Outputs <sup>‡</sup> (ETB)				Partial budget analysis (ETB)		
		Hay	Concentrate	Anthelmintics	Carcass	Fleece	Skin	Manure	MR	MC	MP
Breed*Treatment											
Menz * Treated	20	39.72	27.62	7.53	161.60	1.14	32.00	4.78	195.02	74.87	120.15
Menz * Non-treated	19	39.82	27.87	0.00	147.20	1.23	32.00	4.47	180.69	67.69	113.00
50% Awassi × Menz * Treated	18	45.16	27.66	7.53	180.80	4.31	10.00	5.45	195.43	80.36	115.07
50% Awassi × Menz * Non-treated	20	45.15	27.97	0.00	160.00	3.85	10.00	5.05	174.15	73.11	101.03
75% Awassi × Menz * Treated	14	49.24	27.85	7.53	195.20	6.06	8.00	6.38	209.63	84.62	125.01
75% Awassi × Menz * Non-treated	17	49.09	27.65	0.00	168.00	5.99	8.00	5.53	182.31	76.73	105.58
Breed*nutrition											
Menz * Supplemented	20	38.42	55.47	3.77	185.60	1.32	32.00	5.16	219.22	97.66	121.57
Menz * Non-supplemented	19	41.12	0.00	3.77	123.20	1.05	32.00	4.08	156.49	44.89	111.60
50% Awassi × Menz * Supplemented	19	45.44	55.70	3.77	211.20	4.55	10.00	6.15	226.11	104.90	121.21
50% Awassi × Menz * Non-supplemented	19	44.87	0.00	3.77	129.60	3.57	10.00	4.32	143.42	48.64	94.79
75% Awassi × Menz * Supplemented	16	49.70	55.51	3.77	217.60	6.65	8.00	6.82	232.65	108.98	123.67
75% Awassi × Menz * Non-supplemented	15	48.63	0.00	3.77	144.00	5.39	8.00	5.09	157.69	52.39	105.30
Treatment*nutrition											
Treated * Supplemented	26	44.55	55.46	7.53	209.60	3.35	16.67	6.05	229.97	107.54	122.44
Treated * Non-supplemented	25	44.87	0.00	7.53	148.80	2.83	16.67	5.01	168.59	52.40	116.19
Non-Treated * Supplemented	28	44.49	55.66	0.00	200.00	3.43	16.67	6.05	220.45	100.15	120.29
Non-Treated * Non-supplemented	29	44.88	0.00	0.00	116.80	2.60	16.67	3.99	136.30	44.88	91.43
Overall	108	44.70	55.72	3.77	168.00	1.83	16.67	4.87	186.78	104.18	82.60

<sup>§</sup>ETB, Ethiopian Birr (1 USD = 8.64 ETB); MR, marginal revenue; MC, marginal cost; MP, marginal profit

<sup>†</sup> Commercial concentrate per kg = 0.70 ETB; Hay per kg = 0.27 ETB; Anthelmintics per sheep per year = 7.53 ETB

<sup>‡</sup> Carcass per kg = 16.00 ETB; Skin per piece for Menz = 32.00 ETB, for 50% Awassi × Menz = 10.00 ETB, and for 75% Awassi × Menz = 8.00 ETB; Wool per kg from Menz = 1.50 ETB, and from 50% and 75% Awassi × Menz crosses = 3.50 ETB; Manure per kg = 0.05 ETB.

MP per sheep was 87.78 ETB for the indigenous Menz, 79.29 ETB for 50% Awassi-Menz and 86.60 ETB for 75% Awassi-Menz genotypes (Table 1). The higher MP of Menz sheep was due to the higher price of skin of the Menz sheep, which was 3 to 4 times higher than both crosses.

Male sheep were more profitable by 15.88 ETB than female sheep although reproduction of female was not allowed in this experiment to make fair gender comparison.

As can be deduced from the interactions (Table 2), the MP per sheep in treated and supplemented animals was higher by 31.01 ETB compared to non-treated and non-supplemented controls.

The Menz breed was superior for helminth resistance as reflected by their higher PCV (data not shown). On the other hand, the crosses were superior in the MP from carcass and fleece than the indigenous Menz sheep. The indigenous Menz sheep, however, ranks first for overall MP followed by 75% Awassi-Menz and 50% Awassi-Menz crosses.

The tanneries and their agents in Ethiopia do not buy the skins of hybrids. According to Abera, technical expert and sales head for Ethio-Leather Industry PLC (ELICO) (personal communication), sheepskins of hybrids loses tear and tensile strength and grain quality and fibre structure compared to the Ethiopian highland hair sheepskins, traditionally known as "Abyssinians" or in short "Abyss". Ethiopian highland hair sheepskin is known for its high quality grain and compact fibre structure to be shaved down to the lowest possible thickness without losing their tear and tensile strength (ELICO, 2005).

## **Conclusion**

This study suggested that supplementation coupled with strategic anthelmintic treatment could be used to maintain high-grade sheep under sub-clinical helminthosis challenge in the highlands of Ethiopia. Nonetheless, sheep breeding objectives should be revised for such system, as crossbreeding may not profit smallholder farmers in the low input system in the highlands of Ethiopia. The higher skin price of the indigenous Menz sheep compared to skin price of crossbreds was the main cause for shift in marginal profit.

In the future, crossbreeding should be viewed not only on the short-term outputs but also in the context of conservation of indigenous animal genetic resources, as traits like skin quality and also others, which we have not yet explored, could be lost for ever. The introduction of the exotic Awassi breed to increase wool production and growth did not benefit the farmers under low input system but rather devalued the skin of the indigenous Menz sheep, worsening the situation. Assessment of economic returns from such interventions as these could help draw early decisions in livestock improvement programmes, reducing risks of genetic loss.

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