THE EFFECTS OF OVERNIGHT HOUSING, DEWORMING AND SUPPLEMENTARY FEEDING ON WEIGHT GAIN AND ECONOMIC VIABILITY OF WEANER GOATS

BY

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(B.Sc. Range Management)

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
RANGE MANAGEMENT
FACULTY OF AGRICULTURE,
UNIVERSITY OF NAIROBI

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DECLARATION

I hereby declare that this thesis is my own original work and has not been presented for a degree in any other university.

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DEDICATION

To my parents Mr. and Mrs. Paul Sitienei and my beloved wife Jennifer. Thank you all for being there for me and for your consistent prayers.

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ACKNOWLEDGEMENT

Many people contributed to the success of this work. I thank my supervisors Dr. R. Kinuthia Ngugi and Prof. D.M. Nyariki for their guidance and counsel during the entire period of training.

Special thanks go to the staff of Kenya Agricultural Research Institute (KARI), particularly those of the training division, for being helpful throughout. Thanks to the KARI Assistant Director (Range Management), for advising me to be patient; for sure this has paid off. I cannot forget the Centre Director, National Range Research Centre-Kiboko, for nominating me for this scholarship and for allowing me to use the facilities at the centre.

To the family of Mr. Kanchory, Chief of Kinyawa Location, Kajiado District, I say thank you for allowing me to use your goats for my research. May God bless you. I am also greatly indebted to Mr. Lila Kanchory, John and the late Mr. Mbithi for looking after the experimental animals. Many thanks are due to the staff of KARI and ILRI libraries. I also thank Dr. Eric Ruto and his wife Irene of the University of New Castle Upon Tyne and Mwacharo Joram for their support.

I am indebted to the World Bank through the KARI/IDA program for awarding me the scholarship that enabled me to do this work. I thank the members of the Bible Study group of ANP Hostel (particularly Dr. Karimi, Majourine and Betty) for their constant encouragement and prayers. To all those mentioned and the many others who have not been mentioned, I say thank you and may God bless you all.

ABSTRACT

The study was conducted to determine the effects of overnight housing, supplementation, endo-parasite control and combinations of these husbandry practices on the growth rate of weaner Galla goats in the southeastern rangelands of Kenya. The study further sought to evaluate the economic viability of these husbandry practices through a cost-benefit analysis. The experiment involved 40 weaner Galla goats of similar age (7±1 months) and weights (21±3 kg) which were randomly assigned to eight treatments of five weaners each. The treatments were housing (T_h), supplementation (T_s), deworming (T_d), housing combined with supplementation (T_{hs}), housing combined with deworming (T_{hd}), supplementation combined with deworming (T_{sd}), housing combined with supplementation and deworming (T_{hsd}) and a control (T_c). Supplementation involved providing the goats with 100g of *Acacia tortilis* pods per day at 08.00hrs, while deworming involved administration of a commercial dewormer at the recommended dose at the beginning of the experiment and at three month intervals thereafter. Housing involved sheltering the goats overnight to protect them from cold and rain. The animals were weighed every week and weight gain calculated as the difference between previous week's weight and the current week's weight. The experiment lasted for 18 weeks. Overall, all the treatment groups exhibited higher average weekly weight gains than the control throughout the trial period. However, none of these accelerated growth rates was statistically significant ($P<0.05$) for the first three weeks. From the fourth week, however, all the treatment groups, except housing, had significantly ($P<0.05$) higher average growth rates than the control group. Overall, T_{hsd} exhibited the highest weight gain (6.95kg), followed by T_{sd} (6.65kg). The cost-benefit analysis indicated that it is profitable for farmers to supplement and/or deworm goats. The benefit-cost ratio (BCR) for the different treatments showed that the most cost-effective treatment was deworming with a benefit-cost ratio of 9.45. Supplementation and a combination of supplementation and deworming were also cost-effective with a BCR of 2.35 and 2.75 respectively, but at a lower level. These results show that supplementing and/or deworming weaned goats increases their growth rates. It is therefore recommended that farmers supplement and/or deworm their animals to realize increased growth rates.

CHAPTER ONE

INTRODUCTION

1.1 General introduction

The domestic goat (*Capra hircus hircus)* is probably the most popular domesticated animal in the world, with its meat and milk being the most widely consumed animal products. Of the approximately 0.8 billion goats in the world today (FAO, 2008), the largest concentration is found in Africa. Compared to the rest of the continent, eastern Africa has the greatest concentration of goats (Williamson and Payne, 1978, FAO, 2008) being more than 74 million. Ethiopia has the highest number of goats (18 million), Kenya (10 million), Tanzania (12 million) and Uganda (8 million). They produced over 0.7 million tons of milk and 0.2 million tons of meat in the year 2006 (FAO, 2008), besides mohair, cashmere, leather, and dung for fuel and fertilizer. The majority of these animals are found in small holder farms in dry pastoral areas and in the highlands (Sibanda *et al.,* 1999).

Available statistics indicate that goats produce about 17 and 12% of tropical Africa's meat and milk, respectively (Lebbie, 1996). In Sub Saharan Africa (SSA), goats account for about 11% of the total meat output (Rege and Lebbie, 2000). There are currently no accurate estimates of the contribution of goats to human food security and general livelihoods. This is largely because use of goat products at the rural household levels is not recorded and at the national level more goat products flow through the informal markets than the formal markets (Dubeuf, *et al.,* 2004). Moreover, in the African context, as is true in most developing countries, the conventional concept of dressing percentage is inappropriate because almost all parts of the animal are consumed. What is important though is the fact the goats provide food for poor households where it is most needed.

Goat Meat is the most widely consumed meat in the world. There are few, if any, religious taboos limiting goat meat consumption. In other words, many people prefer goat meat to mutton, beef, or pork. It is the principal source of animal protein in many African and West Asian countries. It is relatively more important in the developing tropical countries than in temperate regions. In several countries such as Kenya, Nigeria, Rwanda and Ghana, there is a rapid increase in consumption of goat meat in the growing urban areas. Trade in goat hides and skins bring in much needed foreign exchange.

The special attributes of goats that make them particularly important among the rural resource-poor communities, as compared to other domestic ruminants, include ability to graze and utilize a wide range of poor quality forages and browse, ability to walk long distances in search of forage and water, short generation intervals and high turnover rates on investment and hence low risk on investment. Other amiable characteristics include high energy efficiency in milk production, efficient utilization of marginal lands, smaller carcasses which are conveniently marketed or consumed over a short time period, and flocking instinct which makes herding even by young children possible (Lebbie, 2004; Herlocker, 1999).

Goat meat has unique attributes that make it command a bigger market share. For instance, it is leaner, higher in iron and lower in cholesterol than beef, pork and even poultry. Research has shown that goat meat has a balanced proportion of saturated to unsaturated fatty acids and it is a rich source of conjugated linoleic acid that has been associated with a reduction in cancer, heart disease, onset of diabetes and accumulation of body fat. Goat milk, on the other hand, greatly improves the diet of many rural families. It is traditionally valued for the elderly, the sick, children who are allergic to cow's milk, and patients with ulcers. In addition, it is richer than cow's milk in important nutrients such as vitamin A, niacin, choline, and inositol; it is poorer in folic acid.

1.2 Problem Statement

Despite the huge contribution that goats make to the world economy and particularly to the tropical nations, their off-takes remain extremely low. The principal biological factors which limit goat production include substandard and inefficient management, high infestations of endo- and ecto-parasites, poor nutrition and high disease infections. This implies that opportunities for increasing off-take from these animals can be substantially increased by giving more attention to these factors.

Although goats, like all other animals (wild and domestic), have the capacity to cope with adverse environmental factors, minimization of the stresses associated with them has the potential of enhancing their health and productivity in terms of milk yield and growth rate. The success of any herd depends on the survival and growth of its young stock which later replaces the mature stock that leave the herd through sale, death or any other cause. It is also true that a flock or herd is as dynamic as its young stock. However, the young stock is the most vulnerable class of livestock to the vagaries of the environment. High mortalities in young stock of cattle, sheep, goats and camels in eastern Africa have been documented by Sacker and Trail (1966), Dahl and Hjort

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(1983). Therefore, any intervention management and husbandry practices that are directed at the young stock will ultimately boost the performance of the entire herd or flock.

1.3 Objectives

The broad objective of this study was, therefore, to determine the effects of improved overnight housing, supplementation, endo-parasite control and combinations of these husbandry practices on the growth rate of weaner goats on the southeastern rangelands of Kenya. The study further sought to evaluate the economic viability of these husbandry practices through a simple cost-benefit analysis.

The specific objectives of the study were to determine the following:

1. The effect of housing, supplementation and deworming separately on weight gain of weaner kids.
2. The effect of a combination of housing and deworming on the weight gain of weaner kids.
3. The effect of a combination of housing and supplementation on weight gain of weaner kids.
4. The effect of a combination of supplementation and deworming on weight gain of weaner kids.
5. The effects of a combination of housing, supplementation and deworming on weight gain of weaner kids.
6. The cost-effectiveness of the treatments.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Over 50% of the world's livestock, mainly cattle, sheep, goats and camels, is found in the tropics, the majority of which is found in arid and semi arid zones (Devendra, 1882). This translates to over 160 million cattle and 264 million small ruminants. Sheep represent 46% and goats 54% of the small ruminant population. In addition, there are about 12 million camels. However, it is now common knowledge that livestock production is seriously retarded in the tropics compared with the temperate regions. This large number of farm animals in the tropics contributes less than 25% of the world's demand for animal proteins for human consumption (Yousef, 1982). The key factor limiting animal production is inadequate nutrition. The retarded livestock development in the tropics is further exacerbated by a serious lack of research inputs necessary to reduce the constraints imposed by poor feeding on the productivity of animals. Research programmes are needed to develop appropriate technology for the tropics. Young stock is deemed to be the most vulnerable class of livestock. A previous survey in the study area had shown that very few agropastoralists routinely supplement, house or deworm their livestock, especially the young stock. The ultimate objective of the study is to answer the question: Does it pay to house, supplement and/or deworm young stock?

Since livestock are kept for their products, good husbandry demands that they be managed in such a way that they produce the highest possible amounts of those products under the available management. Furthermore, animals are living organisms which are not only aware of their 'surroundings' (defined as all aspects of the space which the animal occupies – housing, other animals, feeds, water, people, management, etc.), but also respond to them. Thus, if the surroundings are not conducive, the reactions may be negative, characterized by reduced productivity. If they are favourable, the reactions will be generally positive, characterized by increased production. This means that the environment of the animal should be one that provides for optimum production.

The main environmental factors that depress animal productivity in the tropics include climate, nutrition and pastures, diseases and parasites, and animal management practices such as housing (Hahn, 1982). The direct climatic influence is mainly through the thermal balance, which affects the physiological processes. The major climatic factors directly affecting livestock are temperature, humidity, air movement and radiation. The major indirect effect of climate on livestock is on the quality and quantity of feed and water available to them. In the subsequent sections, previous research work that has been conducted in the tropics in general and eastern Africa in particular is reviewed, focusing on the effects of housing, supplementation and endoparasite control on goat productivity.

2.2 The effects of housing on performance of goats

The primary function of housing or sheltering of livestock is to protect them from the effects of climate: cold, rain, wind or the sun. Lack of some form of shelter or housing in cold regions during periods of extreme weather/climatic conditions, exposes animals to diseases like pasteurella pneumonia (ILCA, 1988). Thus, housing or sheltering of animals coupled with good husbandry practices can greatly reduce mortality due to unfavourable environmental conditions (Devendra and Burns, 1983), while allowing for earlier identification of sick animals and more effective intervention (Charray *et al.*, 1992). However, despite the huge positive impacts that sheltering of livestock is likely to have, especially in the tropics and subtropics, very few studies have been conducted to quantify its impacts particularly among the young stock.

Kusiluka *et al.*, (1998) working in Tanzania, concluded that management practices such as housing and house hygiene, influence the prevalence of diseases and that these factors need to be considered when advising animal owners on appropriate animal husbandry and disease control strategies to be adopted. There is however a serious paucity of data on the effects of housing on the performance of kids, especially in the arid and semi arid lands of the tropics. Proper housing will lead to healthy goats and also help the farmer to maintain profitable operations. However, this investment must not bring an imbalance to the future financial stability of the enterprise (Toussaint, 1997).

2.3 The effects of supplementation on performance of goats

Normally, goats in the tropics are browsed on available natural pastures. However, the quantity and quality of fodder available from natural pasture exhibit seasonal fluctuation. During the dry season, there is an acute shortage of feed and available forages are of very poor nutritive quality (low in CP and high in fibre), which results in low voluntary intake and low digestibility. Poor pasture quality and parasitic infestation are reflected in low production and reproductive performance as well as slow growth rate in goats especially when grazing/browsing is the main feed. Adequate nutrition is, therefore, essential to exploit the genetic potential of the animals.

The available feed resources such as natural pastures and/or crop residues are often low in nitrogen and digestible nutrients, resulting in low intake and sub-optimal animal production (Abdulrazak, 1995; Norton and Waterfall, 2000; Aregheore, 2000; Salem and Nefzaoui, 2003). Deficiency in nutrients means that the growth of animals is retarded and animals become highly susceptible to diseases and parasite infestations (Chakeredza *et al.* 2001; Awemu *et al.*, 1999; Kaitho *et al.*, 1998). According to Devendra (1982), the level of protein in tropical fodders appears to be the principal constraint to sheep and goat production. He further observed that the voluntary intake of feed is adversely affected and confounded by low digestibility. Supplementation of livestock in order to bridge such nutritional 'gaps' is one method of dealing with the problem (Shepherd and Hughes, 1970). Supplementation is defined as the process of implementing practices specifically aimed at improving the nutritional status and/or efficiency of converting available forage into animal products in a given circumstance.

According to Kebede (2002), if the feed consumed by goats is of low crude protein content, there may not be sufficient rumen degradable protein (RDP) for microbial growth and so the number and activity of rumen microbes are low and limits the rate at which feed particles are broken down, digested, absorbed and subsequently passed out of the rumen. This will limit the metabolic energy available to the animal and consequently reduce the rate of rumen digestion and feed intake. A combination of these factors would cause kids on low protein diet to progressively lose weight.

Protein supplementation is often a practical means of improving livestock production and effective utilization of range forage especially when grass is deficient in protein. Ensuring optimal efficiency of rumen fermentation in animals given low-quality tropical forages requires an adequate supply of fermentable RDP, minerals and metabolisable energy (ME).

A high quality forage for ruminants should possess the following characteristics: high palatability to the animals, with resultant high feed intake; optimum levels of various nutrient components in proper ratios during periods of use; high apparent digestibility of the nutrient components with an optimum ratio of nitrogenous to non-nitrogenous components; adequate levels of minerals, vitamins, and trace elements; and efficient convertibility into components necessary for the animal body over sustained periods (Dietz,1970).

Range livestock production is an extensive operation based on low-cost feed. Supplemental feeding on the range, therefore, is essentially an economic question to be decided upon by balancing the costs against additional production. Supplementation is profitable when it increases the reproductive rate of breeding herds, reduces death losses, and permits replacements of more costly sources of feeds or forage on the range. In most climates, pasture production will vary markedly from season to season. In the humid tropics, this makes the management of feed supply and demand difficult (Martin *et al.*, 1999). In spite of efforts to match feed demand with feed supply, animal production from pastures will inevitably result in some periods of feed deficits and other periods where the rate of pasture growth is in excess of feed requirements.

In periods of excessive plant growth, pastures should preferably be managed to avoid rapid accumulation of biomass, as this is associated with deterioration in feed quality and decay of pasture. One approach is to concentrate the herd on a limited area of the farm, thus, in effect, increasing the stocking rate to maintain pasture quality in this area. Put simply, if pasture production is double, the stock must be concentrated on half the grazing area available. The forage on the remainder of the farm may be harvested as hay or silage if conditions and profitability allow, or grazing can be done later as feed resources decrease.

Manipulation of post-weaning feeding systems, based on locally available feeds, including provision of sown pasture, can be used to produce consumer-acceptable carcasses at much heavier weights (Zygoyiannis *et al.*, 1999; Momanyi, 1993; Bwire and Wiktorson, 1996).

2.4 The effects of endo-parasite control on performance of goats

Gastrointestinal parasitism is one of the major constraints to the production of small ruminants under production systems heavily dependent on pasture grazing. Parasitic infestation, both external and internal, depresses the performance of host animals as it affects feed ingestion, feed digestibility and other physiological processes, which can be manifested in many forms. These include premature death, change in the value of animals and their products at slaughter, reduced live-weight gain, reduced yield and quality of products such as milk, reduced capacity for work, altered production of dung for fuel and fertiliser, and altered feed conversion efficiency (Stien *et al.*, 2002). These, in turn, can reduce the productivity of the flock and its capacity to improve.

The burden of helminthosis varies between areas, depending on the relative importance of several factors related to the level of agriculture in the area. In a study by Odoi *et al.,(* 2007), it was concluded that the two most important factors that impact live weight gain of small ruminants in small holder production systems in Kenya are faecal egg count (a proxy of nematode parasite infection), and lack of supplementation. The worm burden of grazing animals is mainly influenced by the infection rate from pastures, which is, in turn, determined by the climatic conditions that favour hatching of eggs as well as development and survival of larvae.

In an experiment carried out in Banjul, Gambia, Faye *et al.* (2003) concluded that a combination of restricted feeding with helminth infections aggravated weight losses in animals. Devendra (1982) indicates that where chronic malnutrition is evident, heavy parasitic burdens effectively reduce productivity. Within the tropics, livestock generally suffer much greater damage from a host of different external and internal parasites. This is attributed largely to a combination of high temperatures and rainfall, which generally favour the proliferation and survival of these organisms.

With the advent of the broad spectrum anthelmintics, mortalities of livestock attributed to parasites have decreased in the temperate regions of the world. However, this is not so in the tropics and subtropics. In the extreme situations of subsistence farming, where anthelmintics are either unaffordable or of such inferior quality that they are not used by the stock owners, massive mortalities of young stock caused by internal parasites are still tragically a common phenomenon, particularly in Africa and Asia (Waller, 1997). At the other extreme, where anthelmintics have been used intensively, high levels of resistance have developed to such an extent that total chemotherapeutic failure to control worm parasites of ruminants is now a common problem. Between these two extremes, farmers face challenges in their efforts to reduce mortalities, diseases and production losses due to parasites. This almost always requires frequent use of anthelmintics (Waller, 1997).

An experiment carried out in Gambia by Osaer *et al*., (2000) concluded that in spite of the continuous risk of trypanosome infections and other environmental stress factors, anthelmintic treatment schemes increase production and improve the health status of indigenous sheep and goats. Knox and Steel (1996) concluded that in situations where nutritional deficiencies are likely to exacerbate the detrimental effects of parasitic infestation, low cost non-protein nitrogen supplements can enhance the efficiency of feed utilization and assist the animals to withstand infections. Such supplementation programmes should therefore be integrated into strategic worm control programmes in conjunction with some chemotherapy and appropriate grazing management practice to achieve increased productivity.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

This study was carried out in Makindu division of Kibwezi district. The district is located at the southern tip of Eastern Province of Kenya, about 160km southeast of Nairobi along the Nairobi-Mombasa highway. It lies between latitudes 2^0 10'S and 2^0 25'S and longitudes 37^0 40'E and 37^0 55'E with an altitude varying between 900m and 1100m above sea level. The district borders the following districts: Machakos and Makueni to the north, Kitui to the east, Kajiado to the south and west and Taita Taveta to the south east.

The district has diverse Agro-ecological Zones (AEZ), dominated by zones IV and V (Pratt, *et al* 1966) and receives bimodal rainfall with a mean of 615mm annually and a mean monthly temperature range of 26.9^0 C to 30.8^0 C. The short rains fall between October and December, while the long rains fall between March and May. This low rainfall translates to poor quality and quantity of feeds for livestock in the area.

The soils are well-drained, moderately deep, dark reddish brown in colour with a well-developed A-horizon. *Acacia, Commiphora* and other woody species of shrubby stature dominate the vegetation (Michieka and Van der Pouw, 1977). *Acacia senegal* dominates the tree layer, while *Hermania alhiensis* dominates the shrub layer. Other woody species include *Acacia tortilis*, *Commiphora* sp., *Cordia* sp., and *Balanites aegyptiaca*. However, in the shrub layer, *Solanum incanum, Tephrosia villosa,* *Duosperma kilimandsharicum, Omorcarpum kirkii, Maerua triphylla* and *Salvadora persica* dominates (Too, 1995).

The herbaceous layer is dominated by *Digitaria macroblephara, Chloris roxburghiana, Sporobolus pellucides, Enteropogon macrostachyus, Bothriocloa insculpta, Themeda triandra, Cenchrus ciliaris,* and *Panicum maximum*. The forb layer is dominated by *Talium portulacifolium* with *Commelina bengalensis, Barleria micrantha* and *Tephrosia villosa* as subordinate species (Too 1995).

The main types of livestock kept by farmers in the area are the East African Short Horned Zebu cattle, the Small East African goats and the Red Maasai sheep.

3.2 The experiment

An on-station experiment was carried out to determine the effects of housing (T_h), supplementation (T_s), helminth control or deworming, (T_d) and the combinations of these three treatments with a control (T_c) on the growth rate of weaner Galla goats. The combined treatments were as follows: supplementation combined with housing (T_{hs}), supplementation combined with deworming (T_{sd}), housing combined with deworming (T_{hd}), housing combined with deworming and supplementation (T_{hsd}). The control treatment involved normal grazing and watering, without supplementation and deworming. Supplementation involved providing the goats with 100g of *Acacia tortilis* pods per weaner per day in the morning before taking them out for grazing. The nutritive value (nitrogen content) of the various batches of *Acacia tortilis* pods was determined to ensure they were of high quality. Helminth control involved drenching the goats with valbazen® anthelmintics at the beginning of the experiments and after every three months. Housing involved sheltering of the goats during the night. It comprised one long (rectangular) open shed completely covered on three sides. The fourth wall was covered with chain-link wire (see Plate 1). The shed was provided with a roof made of corrugated iron sheets. The shed floor was earthen and no beddings were provided. This type of construction ensured adequate ventilation.

Plate 1: Experimental kids inside their over-night house

Forty weaned Galla goats of similar age (7±1 months) and weights (21± 3 kg) were randomly assigned to the eight treatments in a completely randomized experimental design (CRD). Over and above the treatments, the experimental goats were herded together and accorded the other routine husbandry care. For instance, they were watered and sprayed against external parasites normally. The experiment lasted for 18 weeks.

Plate 2: Weaned goats browsing in the range

3.3 Data collection and analysis

The experimental animals were weighed individually once a week. The weights were taken in the morning before the kids were fed or watered. Weekly weight gains were calculated by subtracting the initial goat weight from the weight reading obtained at the end of each week. The weight gains were then tabulated according to treatment and subjected to analysis of variance (ANOVA) (Steel and Torrie, 1980) to determine the treatments which had significant effects on the rate of weight gain of the goats. Where treatment effects were statistically significant, mean separation tests were

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conducted to determine which means were significantly different using Duncan's New Multiple Range Test (Steel and Torrie, 1980), at 5% level of significance.

Cost-benefit analysis was done using the benefit-cost (B/C) ratio formula given by the expression below:

$$\frac{B}{C} = \frac{\sum_{t=1}^{t=n} B_t (1+i)^t}{\sum_{t=1}^{t=n} C_t (1+i)^t}$$

where

B_t =benefit at time t

C_t = cost at time t

i = prevailing interest rates

t= 1, 2..., n

n= number of years

The selection criterion for B/C ratio is to accept the investment with a ratio equal or greater than one. The expected lifespan of similar houses is about 20 years (Kigerar: personal communication). Thus all benefits and costs spread over 20 years were used to compare the different treatments.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Main treatment effects

Table1 and figure 1 represent the average bi-weekly body weight gains of the weaner goats under the main treatments during the eighteen week trial period. Overall, all the treatment groups exhibited higher average weight gains than the control throughout the trial period. However, none of these treatments had statistically significant ($P<0.05$) effect during the first three weeks. However, from the fourth week up to the end of the study period, all the treatments, except housing, registered significantly ($P<0.05$) higher growth rates than the control.

Table1: Mean bi-weekly live weight gains (kg) of weaner goats that were housed, supplemented or dewormed for 18 weeks (kg)

Week	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
T_c	0.55	0.70^{b}	1.15^{a}	1.50^{a}	1.55^{a}	1.70^{a}	1.95^{b}	3.30^{b}	4.15^{b}
T_h	0.80	1.20^{ab}	1.85^{ab}	3.10^{ab}	2.00^{ab}	2.45^{ab}	4.00^{ab}	4.35^{ab}	4.90^{ab}
T_s	1.05	1.45^{a}	2.90^{bc}	2.70^{bc}	2.80^{b}	3.40^{b}	4.10^{a}	5.35^{a}	6.00^{a}
T_d	0.90	1.40^{ab}	2.15^{bc}	2.65^{bc}	2.80^{b}	3.50^{b}	4.20^{a}	5.25^{a}	5.45^{a}

Treatment means in the same column with different superscript are significantly different ($p<0.05$).

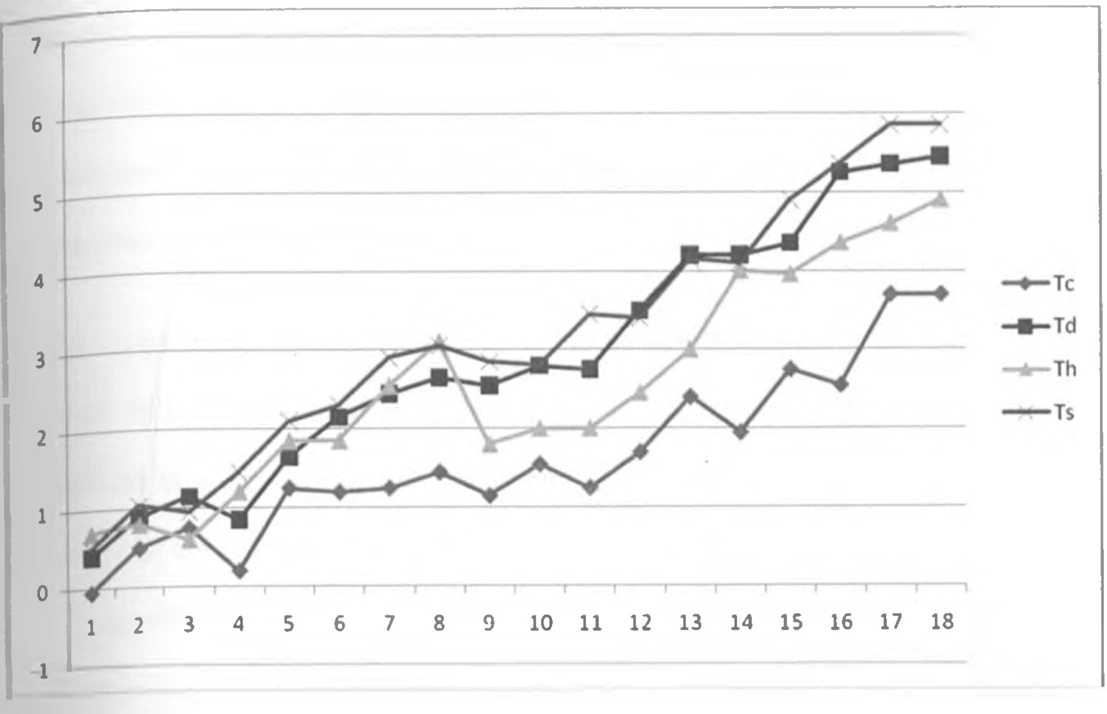

Figure 1. Mean weekly body weight gain of weaned kids under housing, supplementation and deworming.

4.2 Effects of supplementation (Ts)

Supplementation (T_s) significantly ($P<0.05$) increased the weekly weight gains of the weaner goats. This was achieved at the end of week 4 and remained so throughout the trial period.

Slow growth rate is widely known to be the major limiting factor in goat production. It is attributed largely to poor quality forage, and supplementation is one of the practical ways of correcting the situation (Devendra and Burns, 1983). It involves implementation of practices specifically aimed at improving the nutritional status and/or efficiency of converting available forage into animal products under a given set of circumstances. It is, therefore, a viable option when the forage fails to attain an adequate quantity and/or quality to meet the nutritional requirements of the grazing animal. It enables animals on poor quality forage to obtain the lacking nutrients such as protein to sustain optimal rumen function. In N-deficient diet regime, provision of additional N can have a dramatic impact on digestibility of the feed and subsequent improvement in animal productivity.

The superior growth rate observed in the supplemented animals in this study can be attributed to the additional crude protein (15%) supplied by the *Acacia tortilis* pods provided as a supplement. The *Acacia tortilis* pods had approximately twice the CP content of the available grass at the time of the year. The findings of this study were in line with those of Knox and Steel (1996) where weaned lambs and kids were supplemented with urea molasses blocks (UMB). As expected, the supplemented animals gained weight much faster than those that were not supplemented.

In livestock production enterprises that rely on low quality roughage for provision of digestible nutrients, the most critical nutritional deficiency is often dietary N. Feeds rich in N such as the supplements provided to goats in this study will, therefore, improve the digestibility of the basal diet, leading to increased intake and hence more nutrients. Research by Mahgoub *et al.*, (2005) aimed at assessing the effects of feeding various dietary energy densities on growth, feed conversion and carcass composition of Omani goats demonstrated that supplemented goats performed better than those that were not.

The improved weight gain by the supplemented weaner goats shows the potential of using *Acacia tortilis* pods and other leguminous tree pods/leaves as supplements for goats under ordinary grazing conditions. Other studies have recently shown the importance of trees and shrubs in increasing milk production and live weight gain (Borens and Poppi, 1990; Becholie *et al.*, 2005).

4.3 Effects of deworming (Td)

Deworming (T_d) attained statistical significance (P<0. 05) in terms of increased weight gain of weaner goats at the end of the 6th week (Table 1) and remained so up to the end of the study. The positive impact of deworming on the goats' growth rate in this study was consistent with the results of Faizal *et al,* (2002), who reported that dewormed goats had significantly higher average weight gains than the control animals. In another study, Osaer *et al.*, (2000) concluded that in spite of the continuous risk of infections and other environmental stress factors, regular deworming improved the growth rate and health status of indigenous sheep and goats. Parasitic infestation ranks high among the factors that constrain livestock production especially in the tropics. Biologically, they reduce the productivity of animals through reduced efficiency of nutrient utilization, reduced growth rate, and ultimately death of animals that occurs at very severe infestation levels (Shavulimo, 1989). Therefore, careful use of knowledge on the epidemiology and immunology of various helminths, combined with strategic use of available drugs, makes it possible to limit the infestations to levels which are harmless (Provost, 1989).

4.4 Effects of housing (Th)

Overnight housing (T_h) of the weaner goats spurred improved weight gains throughout the trial period. However, the improvement never attained statistical significance (P<0.05) at any time during the trial period. These findings were consistent with those of Xiccato *et al.* (2002), whereby a study to compare the effects of housing (traditional rearing in individual stalls versus group rearing in collective pens) on veal calf growth performance, carcass characteristics and meat quality found that the effect of feeding was more pronounced than the effect of housing. Poor housing or the absence of it altogether exposes animals to adverse weather conditions which forces animals to 'burn' extra energy to maintain normal body temperature and physiological processes. Exposure to these factors may also predispose the animals to diseases such as pasteurella pneumonia (ILCA, 1988). Furthermore, housing facilitates earlier detection of sick animals and faster intervention (Charray *et al.*, 1992). During the time of this study, the weather conditions were neither too cold nor too hot, which could have partly accounted for the moderate increase in weight gains of the housed goats compared to those supplemented or dewormed.

4.5 Combined treatment effects

Table 2 and figure 2 represent the average bi-weekly body weight gains of the weaner goats for the combined treatment groups during the eighteen week trial period. All the combined treatment groups exhibited higher average weekly weight gains than the control throughout the trial period. However, like the main treatments, none of these treatments had a statistically significant ($P<0.05$) effect for the first three weeks.

Table2: Mean weekly live weight gains of weaner goats that had combinations of housing, supplementation and deworming up to week 18 (kg)

Week	2	4	6	8	10	12	14	16	18
T_c	0.55	0.70	1.15^a	1.50^{aa}	1.55^a	1.70^a	1.95^b	3.30^b	4.15^b
T_{hs}	0.60	1.00	1.80^b	3.25^b	2.95^b	3.60^b	4.30^a	5.75^a	5.95^a
T_{hd}	0.85	1.30	2.10^b	2.95^b	2.75^b	3.80^b	4.00^a	5.50^a	5.95^a
T_{sd}	0.70	1.15	2.15^b	3.15^b	3.50^b	4.20^b	4.75^a	6.00^a	6.65^a
T_{hsd}	0.85	1.40	2.85^b	3.55^b	3.85^b	4.85^b	5.40^a	6.25^a	6.95^a

Treatment means in the same column with different superscript are significantly different ($p<0.05$).

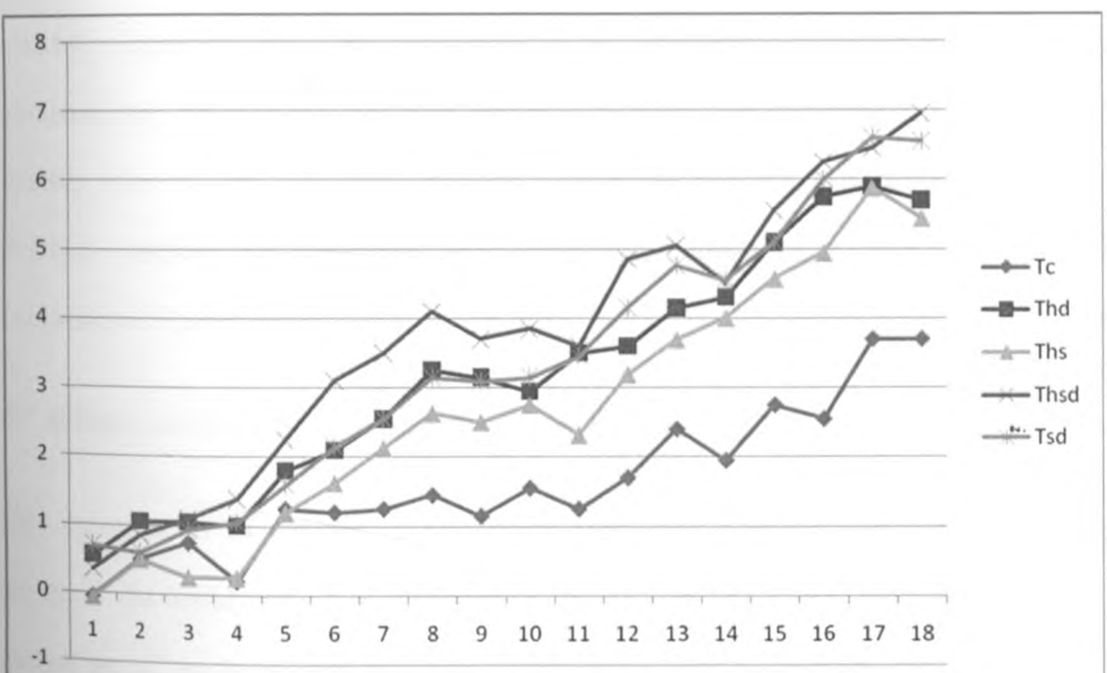

Figure 2. Mean weekly body weight gain of weaned kids under combined treatments

4.6 Effects of housing and deworming (Thd)

Unlike housing alone, housing and deworming combined (T_{hd}) significantly ($P<0.05$) increased the weekly weight gain of the experimental animals. This was evident by the end of week six. The higher rate of weight gain when goats were both housed and dewormed can be largely attributed to the control of helminths since housing alone did not stimulate it to a significant level. This outcome indicates that goats infested with worms cannot gain as much weight as their contemporaries that have been dewormed even if they were both housed. Reducing the impact of helminths on the weight gain of animals requires regular helminth control practices that combine strategic anthelmintic treatments with other husbandry practices such as grazing management and exploitation of resistant breeds. Animals have marvelous homekinetic phenomena which enable them to be resilient in the face of adverse weather conditions, thus permitting them to be profitable in a wide range of circumstances. The response flexibility that animals demonstrate in the face of myriad stresses such as lack of housing is more remarkable than those instances when defensive reactions are inadequate, and environmental complex drastically reduces performance (Curtis, 1983).

4.7 Effects of housing and supplementation (Ths)

The combination of housing and supplementation (T_{hs}) significantly ($P<0.05$) increased the weekly rate of weight gain of weaner goats. This was apparent at the end of the 6^{th} week and was sustained for the entire study period. The interaction effects between housing and supplementation were not significant. As discussed earlier, housing alone did not significantly impact the growth rate of the weaner goats.

Thus, the improvement in the weight gain can be, to a large extent, attributed to the supplementation treatment.

Slow growth rate is acknowledged to be the major limiting factor in goat production and the improved plane of nutrition can markedly improve the situation. The degree of response to nutrition varies with the breed of the animal (Devendra and Burns, 1983). The nutrient requirements of animals depend on body size and growth or production potential, environmental conditions and quality of feed. Temperatures, humidity, sunshine and wind velocity may increase or decrease nutrient needs (NRC, 1981). During the time of this study, environmental conditions were favourable and, therefore, housing could not have a major influence on the rate of the weight gain of kids.

4.8 Effects of supplementation and deworming (Tsd)

The combination of supplementation and deworming (T_{sd}) had significant ($P<0.05$) effects on the growth rate of the weaned kids. This treatment had the second highest effect on the weight gain of the goats. While the results suggest a strong interaction between nutrition and parasitism, this was statistically not significant.

That there exists an interaction between the nutritional status of an animal and its endo-parasite load is indisputable. Literature shows that nutrition can influence the development and consequences of parasitism in three different ways: i) it can increase the ability of the host animal to cope with the adverse consequences of parasitism (resilience); ii) it can improve the ability of the host animal to contain and eventually overcome parasitism (resistance) by limiting the establishment, growth rate, fecundity and/or persistence of the parasite; and iii) it can directly affect the parasite population through the intake of antiparasitic compounds. Coop and Kyriazakis (1999) argue that the ability of an animal to withstand the stress of gastrointestinal parasites competes with other bodily functions when nutrient resources are scarce. Therefore, animals will invariably give priority in nutrient partitioning to the maintenance of body protein, since this guarantees the individual's survival in the short term. It is proposed that growth and reproduction, which ensure the survival of the species in the long term, are given the second-highest priority. This implies that functions such as the expression of immunity to, or ability to fight, gastrointestinal parasites and increment of body weight are given a relatively low priority in the allocation of scarce resources (nutrients). According to Wallace *et al.* (1998), supplementing the diet of parasite-loaded animals can only marginally improve their growth rates.

4.9 Effects of housing, supplementation and deworming (Thsd)

The combination of all three treatments resulted in a significant ($P<0.05$) increase in the goats' weekly weight gain. The treatment had the highest improvement on the performance of the goats throughout the trial period. Although interaction effects were not significant, this treatment benefited from supplementation, deworming and housing, and hence superior weight gain rates were obtained. Parasitic infestation reduces an animal's appetite, leading to decreased feed intake. Therefore, when the parasites are effectively controlled, the animal is able to increase the feed. The increased feed intake translates to higher growth rates as happened in this study.

The use of low-cost supplements has been shown to be effective in enhancing an animal's ability to utilize the basal diet and assist the animal to withstand parasite infestation. Wallace *et al.* (1998) found that infected animals on supplementary diet had similar performance to uninfected animals. They further found that infected animals on the basal diet had substantially lower feed conversion ratios than uninfected animals on the same diet. They concluded that the differences in weight gain among the animals on the basal and supplemented diets reflected the differences in the appetite as well as the quality of diets.

Knox and Steel (1996) concluded that in situations where nutritional deficiencies are likely to exacerbate the detrimental effects of parasitic infestation, low cost non-protein nitrogen supplements can enhance the efficiency of feed utilization and assist animals to withstand infestations. Although housing alone did not have significant effects on weight gain in this study, it is important to note that its impact depends on the prevailing weather conditions. Care should, therefore, be taken to ensure that gains attained through one of the interventions (housing, supplementation and/or deworming) are not lost through compromising one or both of the others.

4.10 Cost-benefit analysis of the treatments

While it is important to assess the productivity improvement of any action, the more important question to the farmer or livestock producer is not whether it works (physically), but rather whether it pays to do so. The more it pays to make certain changes, the more attractive and practical to the producer. The cost-benefit analysis helps to determine whether it pays.

Supplements are fed to improve production efficiency and to meet production targets that are expected to optimize gross margins for the specific production in question. However, the marginal costs and benefits of the supplements depend largely on their effect on roughage intake. The economic advantage of using optimum amounts of feed depends on how much such feed affects intake and performance. A cost benefit analysis finds, quantifies, and adds all the positive factors. These are the benefits. Then it identifies, quantifies, and subtracts all the negative factors, the costs. The difference between the two indicates whether the planned action is worthwhile.

Growth performance results showed that there were significant differences ($P<0.05$) between supplemented goats and those not supplemented. Similarly, there were significant differences ($P<0.05$) between the dewormed goats and those not dewormed. The total costs for supplementation and deworming were obtained by estimating the operating costs. The operating costs consisted of the costs of the variable inputs used. These costs included the expenses of dewormers and the supplements. The benefits were the incremental weight gain due to treatments. Market prices of inputs and meat products prevailing in the study area in 2004 were used. The decision criterion is that for the various treatments to be shown to be economically viable, a benefit-cost ratio (BCR) of one or more must be realized.

Table 3 below shows that, with a BCR of 9.45, the most cost-effective treatment is deworming (T_d) followed by supplementation combined with deworming (T_{sd}), supplementation T_s, and combined housing, supplementation and deworming (T_{hsd}). Combined housing and deworming (T_{hd}) leads to a break-even situation. The rest of the treatments lead to loss-making.

Table 3: Cost-benefit analysis of the effect of the different treatments on weight gain by weaner goats

Trt	Weight increase	Expected benefits[1]	Expected Cost[1]	BCR
T_c	4.15	-	-	-
T_h	4.90	6873	15235	0.45
T_s	6.00	16953	7216	2.35
T_{hs}	5.95	16495	22451	0.73
T_d	5.45	11913	1260	9.45
T_{hd}	5.95	16495	16495	1
T_{sd}	6.65	22910	8477	2.70
T_{hsd}	6.95	25659	23712	1.08

Trt— treatment

[1]Benefits and costs are spread over 20 years

As shown in table 3 above, housing reduces the benefits when it is combined with the other treatments. This outcome is due to the high initial cost of the house. Farmers therefore should consider the cost of the materials they use to construct houses for their animals so that it does not reduce the profitability of the enterprise. Alternatively, the value of the products has to be high enough such that it can offset the costs incurred.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

The results of the study clearly demonstrated that weather, nutrition and/or parasites are important components of a goat's environment. The performance of these animals can be substantially increased if farmers paid some attention to these elements. Specifically, the results showed that supplementation and/or deworming of young (weaned) goats can significantly increase their growth rates. Protection of the goats from the vagaries of weather also proved to be beneficial, but was not dramatic because the weather during the time of the study was within the comfortable limits. Supplementation essentially involves raising the levels of the nutrients that are required by an animal above the minimum level. For instance, 6% is the minimum dietary crude protein content for normal rumen function. Therefore livestock producers must ensure that the pastures that livestock are utilizing at any time can furnish the animals with this minimum protein, in order for the animals not to lose weight. To most farmers, the term 'supplementation' conjures up the idea of buying some commercial feed. This should be the last result. Otherwise, plant resources available on or around the farm should be utilized. These include crop residues such as cow peas, bean, and dolichos hulls; leaves/twigs of trees and shrubs such as mulberry, leucaena, Grevillea; and/or leguminous fodder crops such as Stylosanthes and Lucerne.

The results demonstrated some complementarities among the three management practices and their combinations. Supplementation and helminths control markedly improved the rate at which the goats gained weight. With the increasing consumer demand for animal products (meat and milk) with no or minimum chemical residues, one must however be wary of intensity of antihelmintics application. By maintaining 'clean' pastures (pastures devoid of parasites) livestock farmers can produce livestock or livestock products with minimum chemical residues.

The complementary roles of supplementation and endoparasite in goats (and other kinds and classes of livestock as well) has other benefits, though rather implicit, especially in the semi-arid environments where scarcity of feeds is the order of the day. For instance, where the farmer is not able to supplement the goats, it will still be possible to achieve better growth rates if they are able to maintain low levels of endoparasite infestations.

The economic benefits accruing from any husbandry practice should be used to guide the decision making process. Cost-benefit analysis of the treatments indicated that deworming was the most cost-effective way of improving the growth rate of the goats, with the other treatments enhancing that benefit.

From the results of this study, the following recommendations were found plausible:-

- That livestock farmers should be advised to supplement their goats particularly during the dry season.
- That helminths control should be emphasized in the routine management of goats.
- That housing or some form of protection of the animals at night should be considered particularly during the cold and rainy seasons.

- That some cost-benefit analysis should be done on any recommended improvement in livestock management to assure the farmers gain on their investment.

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APPENDICES

Appendix 1: Rainfall in KARI Kiboko for the year 2003

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
0	35.6	38.4	52.9	39.9	6.7	0	0	0	5.9	113.8	27.4

Appendix 2: Chemical composition of the Acacia tortilis pods used as the supplement

	DM	ASH	E.E	C.F%	CP%	NFE	NDF	ADF	LIGNIN
Acacia tortilis pods	93.76	6.27	2.48	20.64	14.76	49.61	36.76	26.92	7.10

DM=dry matter, NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre, EE=ether extract, CP=crude protein, NFE=Nitrogen Free Extract.

Appendix 3: Analysis of variance (ANOVA) of housing, deworming, supplementation and their interactions

Source	Df	Type III SS	Mean Square	F Value	Pr > F
Housed	1	1.252			
Dewormed	1	13.746	13.746	8.41	0.0068
Supplemented	1	15.380	15.380	9.40	0.0045
Housed*Dewormed	1	0.011	0.011	0.01	0.9338
Housed*supplemented	1	1.296	1.296	0.79	0.3802
Dewormed*Supplemented	1	1.296	1.296	0.79	0.3802
Housed*Supplemented*Dewormed	1	1.883	1.883	1.15	0.2916

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