



Animal Production Society of Kenya

## Proceedings of the Annual Scientific Symposium 2010

Nomad Palace Hotel, Garissa, Kenya

20th to 22nd April, 2010



**“Driving Livestock Entrepreneurship towards Attainment of Food Sufficiency and Kenya Vision 2030”**



ASAL Based Livestock and Rural Livelihoods Support Project

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## **Table of Contents**

<b><i>Mycotoxins in Animal Feeds and their Implications on International Trade of Animals and Animal Products</i></b>	<b><i>iii</i></b>
<b><i>Risk-rated Economic Values for Traits of Meat Sheep in Smallholder Production System in the Tropics</i></b>	<b><i>5</i></b>
<b><i>Maintenance of Genetic Diversity in Livestock Populations Through Active Management of Inbreeding</i></b>	<b><i>9</i></b>
<b><i>Indigenous Chicken Improvement in Kenya: Past Efforts and Future Prospects</i></b>	<b><i>15</i></b>
<b><i>External Egg Grading Parameters of Indigenous Chicken in Kenya</i></b>	<b><i>19</i></b>
<b><i>Dry Periods: Is it Time to Re-think Our Strategies?</i></b>	<b><i>25</i></b>
<b><i>Evaluation of Maize Varieties for Food and Feed in a Maize-Dairy Production System in Kenya</i></b>	<b><i>29</i></b>
<b><i>Genetic Parameters for Egg and Body Weights of Indigenous Chicken in Kenya</i></b>	<b><i>36</i></b>
<b><i>Analysis of Adaptive Traits and Animal Survival as a Climate Change Adaptation Strategy in Extensive Livestock Production Systems</i></b>	<b><i>41</i></b>
<b><i>Growth Patterns and the Relationships Between Body Mass and Linear Body Parts Measurements of Indigenous Chicken in Kenya</i></b>	<b><i>46</i></b>
<b><i>Milk Quality Control and Regulation in Dairy Production: A Case of Dairy Producers in Kikuyu Division, Kabete District, Central Province, Kenya</i></b>	<b><i>52</i></b>
<b><i>Silage Fermentation Processes, Manipulation and Implications in the Dairy Sector</i></b>	<b><i>56</i></b>
<b><i>Use of Logistic Regression with Dummy Variables for Modeling the Use-No-Use of Technology in Dairy Farming in Five Districts in Kenya.</i></b>	<b><i>64</i></b>
<b><i>Social Capital and Livestock Entrepreneurship: The Role of Farmers' Dairy Groups in Western Kenya</i></b>	<b><i>72</i></b>
<b><i>Livestock Based Perceptions of Range Quality Change at Landscape Level Among Borana Community of Northern Kenya</i></b>	<b><i>78</i></b>
<b><i>The Performance of Weaner Goats (Capra Hircus) Fed Napier Grass (Pennisetum Purpureum) and Supplemented with Clitoria (Clitoria Ternatea) Forage or Mucuna (Mucuna Pruriens) Seed in Coastal Kenya</i></b>	<b><i>84</i></b>
<b><i>Functional Properties of Goat Milk: A Review Paper</i></b>	<b><i>91</i></b>
<b><i>Efficacy on Aloe Secundiflora Crude Extracts on Ascaridia Galli in Vitro</i></b>	<b><i>96</i></b>
<b><i>Impact of a Manual Hay Box Brooder on Management of Indigenous Chicken in Machakos District, Eastern Kenya</i></b>	<b><i>102</i></b>



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## **OPENING SPEECH BY HON. MOHAMMED ABDI KUTI, MINISTER FOR LIVESTOCK DEVELOPMENT**

Mr. Chairman,  
Members of the Animal Production Society of Kenya,  
Invited Guests,  
Ladies and Gentlemen.

It is my pleasure as your patron to be invited here to officiate at your 2010 Annual Scientific Symposium with the theme ***“Driving livestock entrepreneurship towards attainment of food sufficiency and Kenya Vision 2030”***

The choice of theme and the venue of the meeting are very appropriate at this time when, as a country we are faced with, not only the issues of productivity, but also the survival of our livestock. You are all aware of the difficult period we have gone through, experiencing frequent droughts in recent times within the region. The effects are so severe with the loss of livestock and wildlife due to devastation of the forage and water sources threatening the lives of communities, whose economic activities are mainly livestock production. It is therefore an opportune time that members of your Society address livestock productivity in Kenya, for food sufficiency and entrepreneurship development, and give an overriding focus and concern to sustainability and long term stabilization of livestock production in the areas where this is almost the only economic option for livelihood.

As you are aware, in Kenya only about 40% of the land is arable and less than 20% is of medium to high potential. This is to say that about 80% is either arid or semi-arid land (ASAL) and cannot economically support crop production without massive and at times prohibitive investment in irrigation. It is therefore only livestock, which would form viable options to support livelihoods in these areas which I am told we have about: 13 million head of cattle of which 10 million are the zebus and other local breeds; 14.4 million goats; 1.2 million camels; 10 million sheep; 29 million chickens; and eight hundred thousand donkeys.

To those living in those areas, drought is almost a permanent feature of life, although the suffering is more severe when droughts like the last year one occur. Even under normal conditions in those areas, the rainfall is on average below 625 mm per year, which can hardly support any form of agriculture other than livestock production. Except for the exotic breeds of livestock, which are also the most commercially exploited such as the grade dairy cattle and exotic chicken, most of the other livestock are in the ASALs with over 70% of the country's zebu cattle and indigenous goats found in those areas.

Ladies and gentlemen, the effect of drought is not only confined to the productivity of livestock but is also felt on the water supply, both for human consumption and their livestock. With scarcity of water and forages, the communities living in the ASALs are forced to move in search of the same. This not only affects their lives, but also contributes to conflicts, livestock diseases and other social problems, which have major consequences on the welfare of the affected people. We need to find lasting solutions that in the long run reduce the effect of drought, engender stability and have an overall positive impact on the communities in the area. The solutions should have sustainable improvement of incomes from livestock and related industries, which in the overall should lead to improved welfare.

The prolonged droughts have led to loss of livestock which has led to vulnerability of the communities due to loss of livelihoods. It is therefore imperative that ways be looked into to

protect these livelihoods. My ministry was able to buy animals from farmers to avoid massive losses of livestock and provide the farmers with some cash to support the family and restock after the drought. However, a more sustainable approach would be appropriate to address sustainability. My ministry together with other stakeholder and the private sector are exploring opportunities to introduce insurance cover that would assist the farmers to be paid in instances where there is prolonged drought and animal losses. The farmers would pay a small premium for the total number of animals in their herd and using the forage cover from satellite pictures determine when the payments would be done. This would create sustainable ways of addressing the drought challenge in the ASAL areas.

Issues of increasing livestock productivity are complex and challenging. Most of our livestock production systems are small-scale, which up to some level, are an efficient way of production. It has, however, been observed that the level of production per unit livestock and land is not at its maximal, and our livestock have more potential than they are delivering under our smallholder system. However, farming is complex and the objectives of the producer may not always be to maximize production. Instead, it may be to optimize profitability or to underwrite the probable risks. Maximization of production may require increased use of commercial inputs and this poses the challenge of farm liquidity and farm gate price guarantee.

It is, however, possible to increase livestock productivity through new and available technologies, without necessarily increasing the costs and risks. In some of the areas, we are aware that our livestock are not exploited to the full potential. These include: milk production, broiler weight by age to market, egg production, wool, hides and skins. Available information indicates that while most of our grade dairy cows can produce over 20 liters of milk per day, they are hardly producing 10 liters a day on average. Why then are our smallholder dairy farmers not producing at the highest level? The farmer, as a rational being, will only produce to meet his/ her needs at the minimum risk and in the most rational way. If increasing production means spending more money, which the market is not going to pay back, then there will not be any incentive to do so.

Ladies and gentlemen, I am, however, aware that to alleviate the drought situation and livestock productivity issues, we not only need to address the management of production resource but also the infrastructure and policy. I note that you intend to address these other issues through your sub-themes of: market, marketing and policies; information and technology transfer; and technology development. It has been stated that the failures in the livestock industry are as a result of non responsive government policies, which have translated into lack of adequate market infrastructures and other production factors, including inadequate and suitable livestock credit. We are addressing these issues and through the (i) National livestock policy session paper no. 2 of 2008, (ii) breeding policy, (iii) livestock feeds policy, (iv) poultry policy, (v) apiculture and (viii) dairy sub-sector policy. The ministry is currently reviewing the laws which have been non-responsive to the current livestock industry. To address the issues of market and infrastructure, the ministry will create disease free zones which are flagship project of Vision 2030. This would provide a market for our beef in the European market. It will also improve the infrastructure including developing new ones where necessary. It would also address the issues of frequent outbreak of diseases.

Ladies and gentlemen, over and above the livestock sector policies, you are all familiar with other recent government policy initiatives such as the “Vision 2030” and the “Agriculture Sector Development Strategy” (ASDS), which are an improvement and not a replacement of previous initiatives such as poverty reduction and the rural development strategies, which you are all familiar with. The primary goal of the “Vision 2030” is to achieve a middle level income country and recognizes that agriculture and rural development are critical in achieving



this goal through enhanced food security, increased social and physical well-being for the rural people in a more sustainable environment and natural resources.

I am therefore looking forward to this symposium's proceedings with full hope that you will examine, in reasonable depth, new ways to improve productivity and marketing of livestock products for the farmers and particularly the smallholder farmers. As a Ministry, our objective remains that of providing necessary contributions to the country's economic growth, poverty reduction, employment creation and contributing to food security through availability of quality and high value livestock products. This objective is even more challenging today when we appreciate the fact that diets of children and a majority of household members is deficient in foods and the associated micro-nutrients of animal source. We take this as a major challenge, in addition to the high cases of people living with HIV/AIDS, factors that slow our progress to achieving increased livestock productivity. We need professionals to provide us with advice. We are aware that we cannot achieve meaningful progress in development without making use of our professionals and we expect to expand our consultations with you in livestock production.

Ladies and Gentlemen, I once again wish to thank the organisers of this symposium, those who have contributed in various ways, especially those who funded the symposium and all the participants who spared their time to come and share their ideas, and whose presence will surely contribute to the deliberations and success of this symposium. I wish you fruitful deliberations and I look forward to receiving the symposium's proceedings.

It is now my ardent pleasure to declare The 2010 Animal Production Society of Kenya Annual Scientific Symposium officially open.

Thank you.

# MYCOTOXINS IN ANIMAL FEEDS AND THEIR IMPLICATIONS ON INTERNATIONAL TRADE OF ANIMALS AND ANIMAL PRODUCTS

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## INTRODUCTION

The Food and Agriculture Organization has estimated that about 25% of the world's harvest is lost due to damage by microorganisms (CAST, 2001). Of the microorganisms are the micro fungi which infest human food and animal feeds and produce toxic metabolites called mycotoxins. The mycotoxins are capable of causing diseases and death to humans, livestock and other animals. Diseases caused are called mycotoxicoses (Bennett and Klich, 2003). The micro fungi that produce mycotoxins occur in three major genera; namely: *Fusarium*, *Aspergillus* and *Penicillium*. Even with the best quality control system, animal producers find themselves owning mycotoxins contaminated grain and feed. Kenyans are generally unaware of mycotoxins. A greater awareness of mycotoxins by the international community and the development of the Codex Alimentarius Commission standards has resulted in over 100 countries specifying maximum acceptable limits for a number of mycotoxins. This poses serious challenges to producers targeting international markets as mycotoxins act as a non tariff barrier to international trade in animal and animal products.

### *Major feed mycotoxins and producing genera*

The micro fungi that produce mycotoxins occur in three major genera; namely, *Fusarium*, *Aspergillus* and *Penicillium*. *Fusarium* species produce a wide range of mycotoxins: deoxynivalenol (vomitoxin), fumonisins, zearalenone, T-2 and HT-2 toxin among others. Although the adverse effects of feeding mouldy feeds were known to livestock and poultry farmers for a long time, no specific mycotoxin was implicated. In 1960, an outbreak of 'Turkey X disease' in Great Britain was traced to contaminated peanut meal from Brazil. Aflatoxin was implicated as the cause of death of more than 100,000 young turkeys and some 20,000 ducklings, chickens and partridge poults. This problem simulated modern research on mycotoxins and the ecology of mycotoxin producing fungi (Jacobsen *et al.*, 2009).

The genus *Fusarium* is probably the most prevalent toxin – producing fungi in both the temperate and tropical regions of the world (Edmond, 2002, CAST, 2001). Among others, the species that produce mycotoxins include: *F. verticilloides*, (*F. moniliforme*), *F. proliferatum*, *F. graminearum*, *F. roseum* and *F. culmorum* (Mbogua and Gathumbi, 2004). Fumonisins, produced by *Fusarium* moulds, affect animals by interfering with the sphingolipid metabolism (Marasaset *al.*, 2001). They cause leukoencephalomalacia (hole in the head syndrome) in equines (Marasas *et al.*, 1988), and rabbits, pulmonary edema and hydrothorax and carcinogenic effects in rat liver. In humans there is a possible link with cancer; fumonisin B1 is correlated with the occurrence of a high incidence of esophageal cancer in regions of Transkei (South Africa), China, and North East Italy. The International Agency for Research on Cancer (IARC) has evaluated the cancer risk of fumonisins to humans and classified them as group 2B carcinogens - probably carcinogenic. Other important *Fusarium* toxins are zearalenone, deoxynivalenol, and zearalenol. These mycotoxins are produced almost exclusively by *Fusarium* species which causes corn ear and stalk rot in most maize growing areas of the world. When consumed by swine and dairy cows at more than 0.1 to 5ppm (mg toxin per kg body weight) these compounds cause the estrogenic syndrome, which is characterized in females by a swollen and edematous vulva with enlarged mammary glands and in young males

by a shrinking of the testes (Jacobsen *et al.*, 2009). In the temperate countries, the estrogenic effect in swine and dairy cow is usually more prevalent in winter and early spring because once the fungus is established in the grain, it generally requires a period of relatively low temperatures to produce significant amounts of zearalenone. Therefore the financial loss to farmers comes about primarily through poor reproductive performance.

The major species of *Aspergillus* known to produce mycotoxins are: *A. flavus*, *A. parasitica* and the rare *A. nomius*. *A. flavus* produces only the B aflatoxins, while the other two species produce both B and G aflatoxins. Aflatoxin M1 and M2 are the hydroxylated metabolites of B1 and B2. They occur in milk and milk products obtained from livestock which have ingested contaminated feed. The main source of aflatoxins in feeds are peanut meal, maize and cottonseed meal. They are both carcinogenic and hepatotoxic depending on the duration of exposure. Chronic exposure to aflatoxins is a major risk factor for liver cancer particularly in areas where hepatitis B virus is endemic. High doses of aflatoxins in the diet can result in acute aflatoxicosis which manifests as hepatotoxicity leading to liver failure (Fung and Clark, 2003). Aflatoxin B1 is a very potent carcinogen in many species including non human primates, fish, birds and rodents. No animal species is resistant to acute toxic effects of aflatoxins, hence it is logical to assume that humans may be similarly affected. The toxicity can be influenced by environmental factors, exposure level and duration of exposure, age, health and nutritional status.

The major *Penicillium* toxins are ochratoxin, produced by *Penicillium verrucosum* a common contaminant of barley and patulin, produced by *Penicillium patulum* (later called *P. urticae*, and now *P. griseofulvum*). Ochratoxin A is produced on a number of foods and feeds by members of the *Aspergillus ochraceus* group and a number of *Penicillium*, especially *P. Virridicatum*. Injury from ochratoxin poisoning has occurred chiefly in poultry and swine. Restlessness, huddling, diarrhea, tremors and other neural abnormalities are often encountered in poultry. Ochratoxin damage to kidney of swine is characteristic enough to be called "Porcine nephropathy" which is recognizable in commercial slaughtering. Regular consumption of a ration containing several hundred ppb of ochratoxin results in poor feed conversion, reduced growth rate and general unthriftiness accompanied by reduced immunity to infection by bacteria and viruses. Other prominent features of ochratoxin poisoning are increased water consumption and urine production because of kidney damage.

### ***Economic losses due to lack of awareness***

Kenyans are generally unaware of mycotoxins. For instance, harvested maize grain is sorted out into clean grain consumed by the family and rotten, moldy and discolored grain, fed to livestock and/or sold at only 15 percent less of the price of the good grain. The bulk of the rotten, mouldy and discolored grain is fed to livestock in the homestead or sold to livestock and poultry farmers. Maize and cottonseed cake; common ingredients of many commercially and home made poultry and livestock feeds are some of the most susceptible crops to pre-harvest contamination particularly during periods of moisture stress and when insect damage is prevalent. Both crops (maize and cottonseed cake) along with other hays and silages are susceptible to post harvest mycotoxin contamination which occurs when wet feeds are transported and stored in warm and damp environments. Mycotoxins produce a wide range of harmful effects in animals. The economic impact of reduced feed intake, reduced animal productivity, increased incidence of disease due to immunosuppression, damage to vital organs, and interferences in body metabolism and reproductive capacity is many times greater than the impact caused by death due to acute mycotoxin poisoning.

### ***Effect of mycotoxin regulation on price, trade and health status***

A greater awareness of mycotoxins by the international community and the development of the Codex Alimentarius Commission standards has resulted in over 100 countries specifying maximum acceptable limits for a range of mycotoxins. This poses serious challenges to producers targeting international markets as mycotoxins will act as a non tariff barrier to international trade of animal and animal products. The last survey of worldwide mycotoxins regulations was published by the FAO in 2003. The number of countries setting regulatory limits for mycotoxins in food and feed is rapidly growing. By the end of 2003 it had reached a level of approximately 100 countries which regulated aflatoxin B1 or total aflatoxins. The regulatory levels differ widely if we compare major economic communities: for example the European level for total aflatoxins in commodities like cereals for human consumption is 4ppm. This is five times lower than the U.S level of 20µg/Kg. There is no justifiable reason why the European level should be so stringent. Regulatory limits for mycotoxins have a complex effect on price, trade, public health, selling and purchasing decisions of nations. Developed countries face serious economic losses as a result of mycotoxin regulations. These losses are caused when disposing highly contaminated products or by lower productivity of livestock due to chronic intoxication. On the other hand, the effects on the economy in developing countries are more indirect ones but far more dramatic for the population: The highest quality crop is exported to the developed countries while the lower quality is consumed locally. In combination with the wide spread malnutrition and the lack of health care, this can lead to severe acute or chronic intoxication in the populations. But there is also a direct impact on the economy of developing countries: Due to a lack of monitoring at the export points, or if monitoring is present, a lack of confidence in the existing test management, exported goods get rejected at the importing points of developed countries leading to pricing pressure.

### **RECOMMENDATION**

There is an urgent need for a centre of excellence to be charged with the responsibility of continuous capacity building, surveillance and monitoring, research and extension services of mycotoxins on foods and feeds in Kenya. Such a centre of excellence will collaborate and benchmark with other international laboratories. The centre can then be used for the certification of exports of animals and animal products prior to shipping to international markets.

### **ACKNOWLEDGEMENTS**

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# **Animal Genetics Resources & Improvement**

# RISK-RATED ECONOMIC VALUES FOR TRAITS OF MEAT SHEEP IN SMALLHOLDER PRODUCTION SYSTEM IN THE TROPICS

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## ABSTRACT

This paper reports the effect of incorporating risk in the derivation of economic values (EVs) for traits of meat sheep in medium to high production potential areas of the tropics. A model previously used to derive EVs without considering risk (traditional EVs; TEVs) was revised to incorporate variances of profit and risk attitudes of livestock producers in estimation of risk-rated EVs (REVs). The REVs obtained were 12.84, 9.93, 0.16, 0.14, 0.19, 0.93, 0.07, 0.42 and 0.00 for litter size (LS), lambing frequency (LF), pre- and post-weaning lamb survival to 12 months (PRWS and PWS, respectively), ewe survival (ES), yearling weight (12mLW), consumable meat (CM), kg of manure DM sold per ewe per year (MS) and residual DM feed intake (RFI). In all cases, EVs differed based on whether risk and farmers' risk attitude was incorporated in the profit model.

## INTRODUCTION

Sheep production in the tropics has a significant economic role both at the household and national levels. It contributes significantly to the subsistence, economic and social livelihoods of a large population, in terms of meat, milk, skin, fibre, manure and cashflow (Kosgey, 2003). Sheep production is constrained by the amount, seasonality and annual variability of forage production (Peeler and Omore, 1997). This introduces the aspect of risk and/or uncertainty in sheep systems (Ramírez-Restrepo *et al.*, 2006) with the risk increasing in poor climatic years (Kosgey *et al.*, 2003). Kay and Edwards (1999) defined risk as a situation in which more than one possible outcome exists, some of which may be unfavourable. Risk in agricultural systems constitutes the uncertainty involved with the decision making process (Anderson *et al.*, 1977). Barry, (1984) summarised risk into production, price or market, currency, institutional, financial, legal, and personal.

To be useful, agricultural models must account for risk (variance in profitability) and risk attitude of the producers (Pannell *et al.*, 1995). Kosgey *et al.*, (2003) developed a bio-economic model to estimate economic values for traits of meat sheep in medium to high production potential areas of the tropics. However, the model did not directly account for the effect of incorporating risk as represented by variances of profit and risk attitudes of producers. The model, therefore, assumed perfect knowledge of the parameters used in derivation of the economic values and producers' indifference to risk. Consequently, the aim of the current study was to estimate economic values (EVs) using a profit model with and without accounting for risk and famers' risk attitude. Appropriate EVs are important for selection within a population as well as in choices among breeds or crosses, evaluation of gene effects and for design of optimum breeding programmes (Ollivier, 1986).

## MATERIAL AND METHODS

The procedure described by Kulak *et al.*, (2003) in derivation of risk-rated economic values was followed. The most basic assumption of a production function is that a mathematical relationship exists between inputs and output as shown in equation 1:

$$q = f(g_o, x) \quad (1)$$

where  $q$  is an output quantity,  $g_o$  a vector of genetic traits and  $x$  a vector of input variables. The profit equation is then as indicated in equation 2:

$$y_i = p_o [f(g, x)] - p_i x \quad (2)$$

where  $y_i$  is the profit,  $p_o$  a vector of output prices and  $p_i$  a vector of input prices.

The general formulation of risk-rated profit,  $y_r$ , following Robinson and Barry, (1987) as shown in equation 4:

$$y_r = E(y_i) - 0.5\lambda \text{var}(y_i) \quad (3)$$

where  $y_r$  is a risk-rated profit,  $E(y_i)$  the expected profit and  $\lambda$  the Arrow-Pratt coefficient of absolute risk aversion, and  $\text{var}(y_i)$  is the variance of profit. The Arrow—Pratt coefficient measures the intensity of an individual's aversion to risk. The variance of profit, based on variation in output and input prices is as shown in equation 4:

$$\text{var}(y_i) = E[y_i - E(y_i)]^2 \quad (4)$$

Then (equation 5):

$$y_r = E(y_i) - 0.5\lambda E[y_i - E(y_i)]^2 \quad (5)$$

A model and input variables utilised by Kosgey *et al.* (2003) in estimation of EVs for traits of sheep in medium to high production potential areas of the tropics were used in the current study. The model was revised to incorporate risk and producers' risk attitude. Equation 5 was used in derivation of risk-rated profit by incorporating Arrow-Pratt coefficient of risk aversion to represent farmers' risk attitude and variance of profit to represent risk. Individual input variable variances were aggregated into either feed, management or marketing related and they were 0.005\$/kg<sup>2</sup> DM roughage, 0.01 and 0.02\$/ewe<sup>-1</sup> year<sup>-1</sup>, respectively. Each variance was weighted according to its standard deviation before the aggregation to correct for the differences in the variances. The output prices variances were negligible and thus output price was considered to be constant.

## RESULTS AND DISCUSSION

Table 1 presents results for the costs and revenues per proportion of animals in each category to number of ewes present, and profits per ewe per year for traditional and risk-rated profit models. Kosgey *et al.* (2003) obtained a total profit of \$-34.16 per ewes per year. This was \$-30.93 and 24.80 per ewe per year for 0.0001 and 0.02 Arrow-Pratt coefficients of risk aversion. The 0.0001 coefficient represents a low level of risk aversion while 0.02 depicts a relatively higher level of aversion. More risk averse producers tended to engage less input compared to their counterparts who were less averse to risk. For example, there was 27.09% and 23.46% reduction in input going to lambs and yearlings, respectively. However, in all cases there was increase in profit in respective animal groups except in the case of breeding rams which recorded a drop of 14.10% in profitability.

Although the level of risk aversion was similar for all the classes of animals under either 0.0001 or 0.02 Arrow-Pratt coefficients of risk aversion, the pattern of change differed. Evaluation of farmers' risk attitude mostly address non-embedded risk where activities are assumed to have known resource requirements but to yield uncertain returns, as a result of physical yield or output price uncertainty (Dorward, 1999). In many situations, however, farmers face 'embedded risk' (Hardaker *et al.*, 1991), where they have the opportunity to make sequential decisions and adjust the timing and methods of their activities as a season progresses and more information on uncertain events or occurrences becomes available.

**Table 1: Costs and revenues per proportion of animals in each category to number of ewes present, and profits per ewe per year for traditional and risk-rated profit models considering two levels ( $\lambda = 0.0001$  and  $\lambda = 0.02$ ) of farmers risk attitude**

	Animal category							
	Lambs	Yearling off-take	Replacement		Breeding ewes	Cull ewes	Breeding rams	Cull rams
			Females	Males				
Proportion of animals to ewes	1.27	0.82	0.24	0.02	1.00	0.12	0.02	0.02
Traditional profit model (Kosgey et al., 2003)								
Input	6.50	29.48	4.28	0.40	28.17	-	0.52	-
Output	0.28	27.39	0.30	0.03	6.20	-	0.99	-
Profit	-6.22	-2.09	-3.98	-0.37	-21.97	-	0.47	-
Risk-rated profit model (current study)								
Input	6.35	29.71	3.82	0.30	29.23	-	0.58	-
	(4.63)	(22.74)	(2.78)	(0.27)	(26.76)	-	(0.36)	-
Output	0.25	26.79	0.28	0.01	10.37	-	1.36	-
	(0.18)	(22.90)	(0.21)	(0.02)	(8.45)	-	(1.03)	-
Profit	-6.10	-2.92	-3.54	-0.29	-18.86	-	0.78	-
	(-4.45)	(0.16)	(-2.57)	(-0.25)	(-18.31)	-	(0.67)	-

<sup>1</sup> $\lambda = 0.02$  in brackets.

Table 2 shows EVs derived with and without considering risk and producers' risk attitude. The order of importance of traits did not vary by either considering risk or the farmers' risk attitude. However, the value attached to different traits considered important in meat sheep enterprise in the way they affect profitability decreased when risk and risk attitude were incorporated in profit models used in their derivation.

**Table 2: The effect of risk ( $\lambda = 0.0001$ ,  $\lambda = 0.02$ ) on economic values (EVs) using profit and certainty equivalent profit models**

Trait <sup>1</sup>	Traditional EVs <sup>2</sup>	$\lambda = 0.0001$	$\lambda = 0.02$
LS	14.06	14.01	12.84
LF	11.06	11.03	9.93
PRWS	0.21	0.21	0.16
PWS	0.24	0.23	0.14
ES	0.32	0.31	0.19
12mLW	1.00	0.98	0.93
ELW	0.16	0.14	0.07
CM	0.48	0.47	0.42
MS	0.08	0.07	0.04
RFI	0.00	0.00	0.00

<sup>1</sup>See text for description of the trait.

<sup>2</sup>Obtained from Kosgey et al. (2003).

Risk averse decision makers exhibit a willingness to accept a lower expected return in order to avoid the opportunity of unfavourable outcomes (Kay and Edward, 1999). However, risk aversion in itself does not mean that individuals are not willing to take risks. Rather it means that individuals must be compensated for taking the risk and that the required compensation must increase as the risk and/or the level of risk aversion increases. This explains the difference in values obtained for the two levels of risk aversion considered in this study. As the risk aversion coefficient increased from 0.0001 to 0.02 EVs of different traits decreased drastically.



## CONCLUSIONS

The current research has demonstrated the need to consider risk and farmers' risk attitude in profit models designed to estimate economic values for traits in smallholder sheep production systems. However, it is important to recognise that although incorporating farmers' risk attitude is significant, the assumption in such cases is that farmers do not respond to opportunities provided by availability of information on uncertain events such as amount of rainfall within a season as the season progresses. Such an assumption is unreliable because farmers are known to respond tactically as information on such events become available. There is, therefore, a need to consider incorporating the effect of tactical adjustments by farmers in response to risk as the season progresses in estimation of economic values for improvement of livestock species.

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## MAINTENANCE OF GENETIC DIVERSITY IN LIVESTOCK POPULATIONS THROUGH ACTIVE MANAGEMENT OF INBREEDING

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### ABSTRACT

The long-term goal of a genetic improvement programme is to find an optimal balance between genetic progress and loss of genetic variability. This study assessed the use of increase in coancestry and average relatedness (*AR*) among individuals in a population as a means to control inbreeding and maintaining genetic variability in a population. A total of 18,315 pedigree records of Sahiwal cattle from the Kenya Agricultural Research Institute (KARI) herd at Naivasha were analysed to assess pedigree completeness and to estimate average relatedness of all individuals, coancestries between males and females and to derive their trends over time. A computer programme ENDOG was used. Pedigree completeness improved over time, while trends in *AR* and coancestries were undesirable. The average relatedness reached 1.72% in the whole pedigree, and was higher in inbred animals (2.4) and males (1.8) than in females (1.6). Coancestry estimates between any two mate pairs, which provides a measure of the expected inbreeding level in the progeny and *AR* demonstrated their practical application in controlling inbreeding levels in pedigreed populations.

**Key words:** *genetic diversity, inbreeding, coancestry*

### INTRODUCTION

Utilization of modern genetic evaluation procedures and reproductive tools has led to improvement in accuracy of genetic evaluations and increased annual genetic gains. Due to focus on a few genetically superior individuals, this often leads to increased inbreeding levels. Inbreeding should be monitored and controlled as it has a negative effect on economic traits and additive genetic variance (Kearney *et al.*, 2004; Falconer & MacKay, 1996). Inbreeding also increases chances of appearance of detrimental recessive alleles (Sorensen *et al.*, 2005), and the risk of breeding programmes due to the variance of genetic gain (Meuwissen, 1997). The long term objective of a breeding programme is therefore to find an optimal balance between genetic progress and maintenance of genetic diversity.

Genetic variability in Sahiwal herds is low and heritability estimates have been reported to range from 0.14 to 0.27 (Ilatsia *et al.*, 2007; Dahlin *et al.*, 1998). The low genetic variability could be due to inefficient genetic evaluation procedures and increased average relatedness among individuals. Genetic variability of a population can be also quantified through estimation of inbreeding levels, effective population sizes and probability of gene origin statistics (Muasya *et al.*, 2009). Analysis of the population structure of a breed in this manner provides an understanding of the development of inbreeding in a population and its effect on genetic variability. Inbreeding levels for the Sahiwal breed are increasing (Dahlin *et al.*, 1995; Muasya *et al.*, 2009) and if not controlled, may soon surpass the <1% annual increase

recommended by the Food & Agriculture Organisation (FAO). Similarly genetic variability as studied by probability of gene origin statistics (Muasya *et al.*, 2009) and effective population size (Dahlin, 1995; Muasya *et al.*, 2009) is low. Adverse effects in performance in the long term are expected given the upward trends of inbreeding reported (Rege and Wakhungu, 1992; Dahlin *et al.*, 1995; Muasya *et al.*, 2009).

Probability of gene origin statistics help in identifying changes in genetic variability after a recent change in the breeding programme (Boichard *et al.*, 1997; Sorensen *et al.*, 2005). These parameters provide historical perspectives (Baumung and Solkner, 2002; Boichard *et al.*, 1997) and are also dependent on the depth of the pedigree (Boichard *et al.*, 1997; Goyache *et al.*, 2003). Therefore they offer limited practical interventions for managing inbreeding in pedigreed populations. Estimates of the average relatedness of individuals in a population (Goyache *et al.*, 2003; Gutierrez *et al.*, 2003) and determination of the coancestry of possible pairs of mates can be used to plan matings within a population to give the least inbreeding (Colleau and Tribout, 2008). These parameters work from the current situation into the future and therefore offer more practical means in the management of inbreeding in populations.

The Sahiwal breed was introduced into Kenya from India and Pakistan in the late 1930s to improve the milk production potential of the local Small East African Zebu. The National Sahiwal Stud (NSS) was established in 1963 and a breeding plan based on closed nucleus was drawn up for the genetic improvement of the breed (Meyn and Wilkins, 1974). Since then apart from the introduction of imported sires from India and Pakistan in 1990, the stud has remained a closed nucleus sourcing breeding stocks from within. This has created a high risk of inbreeding and low selection intensities, hence depressed performance.

The objective of this study was to estimate the average relatedness and coancestry of individuals in the Sahiwal herd at KARI Naivasha as a strategy to control the increase in inbreeding levels.

## MATERIALS AND METHODS

Data for this study were obtained from the national Sahiwal stud at the Kenya Agricultural Research Institute Naivasha from 1961 to 2008. A total of 18315 animals with pedigree records were included in the study. Additional information included dates of birth and sex of each animal. The pedigrees of the animals were traced as far back as possible in the birth record book database. All ancestors and relatives of each individual were included in the analyses. Parameters estimated from the data were pedigree completeness, average inbreeding coefficient, average relatedness coefficient, and coancestries of all animals in the database.

### *Pedigree Completeness*

Pedigree completeness was estimated to provide information on the quality of pedigree. This was done by describing the completeness of each ancestor in the pedigree to the 5th parental generation using the coefficient for pedigree completeness (PEC) (MacCluer *et al.*, 1983), as follows:

$$PEC_{animal} = \frac{2C_{sire}C_{dam}}{C_{sire} + C_{dam}}$$

### *Average Relatedness*

The average relatedness coefficient (*AR*) of each individual was defined as the probability that an allele randomly chosen from the whole population in the pedigree belongs to a given animal. Average relatedness can then be interpreted as the representation of the animal in the

whole pedigree regardless of the knowledge of its own pedigree. The parameter was calculated as follows:

$c' = (1/n) 1'A$ , with  $A$  being the numerator relationship matrix of size  $n \times n$ .

### Coancestry

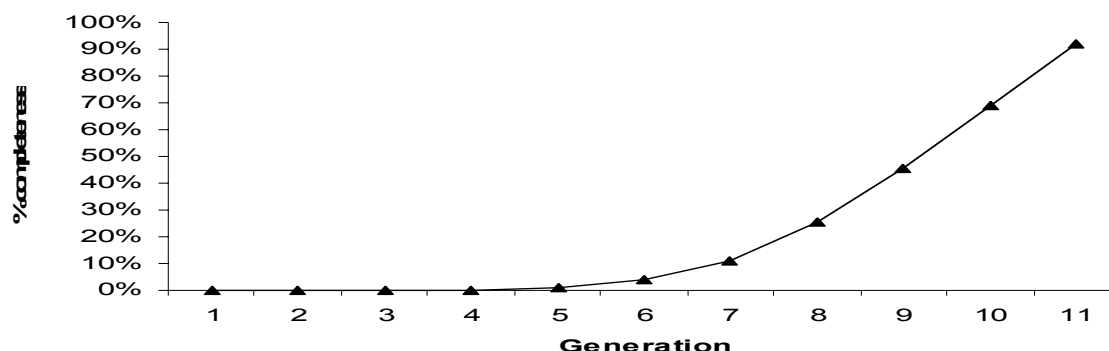
The coancestry or coefficient of kinship ( $f$ ) between any two individuals is the probability that any two gametes taken at random, one from each, carry alleles that are identical by descent. The coefficient of kinship provides a measure of the relationship by descent between any two mates. The coancestry of two individuals A and B, whose parents are respectively P and Q; and M and N is as follows;

$$f_{AB} = \frac{1}{4}f_{PM} + \frac{1}{4}f_{PN} + \frac{1}{4}f_{QM} + \frac{1}{4}f_{QN}$$

and the inbreeding coefficient of an offspring between A and B is the coancestry between A and B. Coancestry estimates between mate pairs were compared for groups of animals were compared against predetermined inbreeding levels. The levels of inbreeding considered in this study were; <1% and 5%. This way, possible mates for each individual can be identified at each level of inbreeding and average relatedness. The parameters estimated using ENDOG computer software (Goyache and Gutierrez 2005).

## RESULTS AND DISCUSSION

Pedigree completeness for all animals in the National Sahiwal Stud at KARI Naivasha is shown in Figure 1. The completeness of the pedigree ranged from 11% in the older generations to 91% in the current generation, and increased with generation.



**Fig. 1: Pedigree completeness for animals born in the Sahiwal herd at KARI Naivasha from 1961 to 2008**

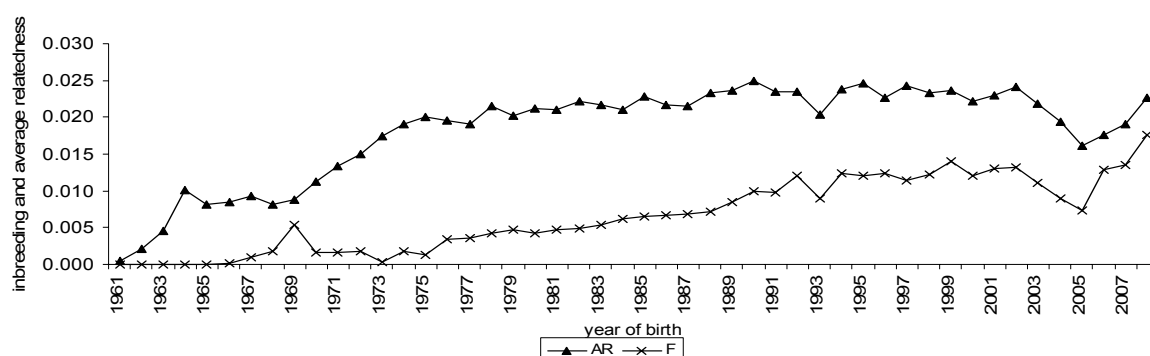
The low estimate of pedigree completeness in the earlier generations was due to the fact that many animals in the earlier generations did not have sire and dam records, and any individual with either of its parents unknown was taken as a founder (Gutierrez and Goyache, 2005). The pattern of pedigree completeness is similar to estimates reported elsewhere (Baumung and Solkner, 2002).

Estimates of average relatedness ( $AR$ ) are shown in Table 1. The mean  $AR$  of the whole pedigree was 1.72%. These values were higher in males and inbred animals and lower for female animals (Table 1). The higher  $AR$  estimates among males could be due to the use of fewer males that are often related (Kearney *et al.*, 2004). Inbred animals formed 24.5 % of the population (Table 1).

Table 1: Average relatedness ( $AR$ ) for the Sahiwal pedigree at KARI Naivasha				
	Whole pedigree	Inbred	Males	Females
N	18315	4497	9102	9207
AR %	1.72	2.4	1.8	1.6

As an alternative or complement to inbreeding, *AR* can be used to predict the long-term inbreeding of a population because it takes into account the percentage of the complete pedigree originating from a founder at population level. A practical application of *AR* is in the maintenance of genetic variability in a population through use for mating animals that have low *AR* values (Goyache *et al.*, 2003).

The trends in inbreeding (F) and *AR* are shown in Figure 2 for the period 1961 to 2008. There was a general increase in inbreeding at an annual rate of 0.03%. The increase in inbreeding may be attributed to increasing inbreeding level and declining effective population size (Muasya *et al.*, 2009) which could be due to increased focus on a few superior sires. Further, there have been no concrete efforts to control inbreeding or maintain genetic diversity of the population in the Sahiwal herd at KARI Naivasha.



**Fig. 2: Trends of Average Relatedness (AR) and inbreeding (F) by year of birth**

Up to 1990, *AR* increased consistently (Figure 1) but went down in 1993 due to importation of five sires from Pakistan (Ilatsia *et al.*, 2007). Thereafter there was a consistent increase in *AR* among individuals in the pedigreed population. *AR* was higher than 1% between 1971 and 2008, implying a possible rise in the overall inbreeding. *AR* acts as a good indicator of the long-term inbreeding of a population. When *AR* reaches high relative values (>1%), matings should be carefully planned, otherwise it will be easy to find matings between individuals showing a certain degree of relatedness. In livestock, inbreeding has been reported to always lag behind *AR* in pedigreed populations (Goyache *et al.*, 2003). In the current study, *AR* reached 1% 6 years before the genetic relationships existing between individuals could be measured as inbreeding (Figure 1).

In Table 2, coancestries between possible pairing of mates are given, together with the *AR* of each individual. The coancestry between any two individuals is identical to the inbreeding coefficient of their progeny if they were mated (Falconer, 1989).

Table 2: Coancestry between pairs of mates and individual <i>AR</i> in the pedigreed Sahiwal population						
Pairs of mates		Expected level of inbreeding in progeny				
Individual (Male)	Mate (female)	Individual <i>AR</i> (%)	Coancestry (%)	<1%	5%	
18123	17951	1.0	0.6	√	√	
18123	17952	1.1	0.7	√	√	
18123	17957	2.4	1.2		√	
18123	17963	1.5	1.4		√	
18123	17966	1.9	12.9			
18123	17967	2.2	3.0		√	
18123	17969	1.3	1.2		√	
18123	17975	0.3	0.1	√	√	
18123	17977	1.0	3.4		√	
18123	17982	2.4	14.9			
18123		1.0				

Key: the symbol √ means mating is acceptable

Thus, coefficients of coancestry between possible pairing of males and females can be used to plan matings such that inbreeding levels are kept at predetermined levels. If it was desired to constrain inbreeding at below 1% possible mates for bull number 18123 would be those females with whom the coancestry is below 1 % (Table 2). Thus, mating pairs of individuals with the least coancestry values the genetic variability in a population can be maintained (Goyache *et al.*, 2003; Colleau and Tribout, 2008). When used together with *AR*, which helps to manage or maintain genetic variability, it can be further seen that pairing this bull with female number 17952 would result in increased *AR*. Controlling increase of coancestries and inbreeding has been shown to achieve an optimal balance between expected genetic gain and genetic variability in dairy cattle (Colleau *et al.*, 2004b) and in selected pig populations (Colleau and Tribout, 2008).

Average Relatedness provides a measure of inbreeding of a population as it takes into account both inbreeding and coancestry coefficients (Gutierrez *et al.*, 2003). This parameter is therefore useful in maintaining the genetic diversity of a population by using for mating animals with the lowest average relatedness values. As *AR* increases, matings should be planned so as to result into the least inbreeding levels. *AR* coefficients of founders indicate the extent to which it has contributed to the population. The aim should be to use for mating progeny of founders with low *AR* values to ensure the original diversity of founders is effectively represented throughout the generations.

## CONCLUSION

This study has demonstrated that average relatedness of an individual and the coancestry between possible pairs of mates can be used to control inbreeding in breeding programmes. When the two parameters are controlled in selection programmes, this can lead to sustainable genetic improvement and maintenance of genetic variability of a population and therefore it fitness.

## ACKNOWLEDGMENTS

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# INDIGENOUS CHICKEN IMPROVEMENT IN KENYA: PAST EFFORTS AND FUTURE PROSPECTS

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## ABSTRACT

This paper reviews the past indigenous chicken improvement efforts in Kenya and suggests a possible approach for unlocking their potential to create wealth and supply animal protein to meet both national and household requirements. The origin and importance of indigenous chicken are mentioned. The past improvement efforts are reviewed and an approach to improve egg and meat production that encompasses utilization and genetic improvement is suggested. Finally, it is concluded that sustainable genetic improvement strategies are important for performance increase and conservation of the available indigenous chicken genetic resources and public resources should be invested in this endeavor.

## INTRODUCTION

The importance of indigenous chicken (IC) in wealth creation and animal protein supply at national and household levels is well recognised (Upton, 2000). However, low IC productivity reduces their contribution to rural development, despite a notable increase in the demand for their products. The low productivity is attributed to high disease incidences, inadequate nutrition and low genetic ability (Kingori, 2004). Efforts aimed at improving egg and meat production have been attempted with marginal success. Instead of improving productivity and rural livelihoods, the attempts have mostly resulted in creation of new challenges such as increased production costs, erosion of genetic diversity and threats of new diseases (Nyaga, 2007).

This paper examines the past improvement efforts and suggests a future improvement approach and utilization IC genetic diversity for sustainability, improved livelihoods and conservation.

### Origin of indigenous chicken in Kenya

Domestic chicken (*Gallus gallus domesticus*) are thought to have evolved from the jungle fowl (*Gallus gallus*) and domesticated in Southeast Asia from where they were distributed to all parts of the world (Moiseyeva *et al.*, 2003). Their arrival in Africa is thought to have been through Egypt via the Middle-east in the period between 1425 and 1123 BC (Maina, 2000). The chicken spread with human migration from Egypt to the south and eventually arrived in Western Kenya at around 100 BC and Eastern Kenya around 50 AD. In addition, the early Greco-Roman East-coast trade brought more chicken along the East African coast at around 100 AD (Blench and MacDonald, 2000). It is possibly at this period that the chicken gained their economic importance.

The migration from the north and along the coast brought all major types of chicken into Kenya. Since their arrival, the chicken have been mating randomly, sourcing own feed and receiving minimal healthcare. They have adapted to the various local climatic conditions and are therefore indigenous. Nevertheless, there has not been any development of a significant breed from the ancient times to date. However, they have been crossed with various specialized meat and egg breeds of European descent (Nyaga, 2007).



### **Importance of indigenous chicken**

In recent times, indigenous chicken production has been presented as a tool for poverty reduction and food security in developing countries (Mack *et al.*, 2005). In addition, they have been recognised as reservoirs for genomes and major genes conferring direct or indirect effects on productive adaptability (Horst, 1988). In Kenya, the IC have gained immense nutritional and economic importance both at national and household levels. Nationally, they account for over 61% of total poultry meat and over 47% of total eggs produced, and contribute over 4% of livestock gross marketed production (MOLD, 2006). At household level, over 18 % of eggs produced and 30% of birds kept are consumed by the household. It has been shown that with only 3 mature hens, a household is above poverty level and is nutritionally secure within one year (Kaudia and Kitanyi, 2002).

Indigenous chickens are also useful in a number of social, cultural and spiritual activities such as entertainment, gifts, funeral rights and spiritual cleansing (Maina, 2000). In some parts of the country, cock fighting is an exciting and popular entertainment. Other uses include manure production and being biological clocks for telling time of day especially in rural areas.

### **Past improvement efforts**

The first strategy aimed at increasing egg and meat production began in 1974 when the National Poultry Development Programme (NPDP) was initiated (Wainaina, 1994). The programme goals were to increase small-scale farmer's income and protein intake through commercialisation of rural chicken production. Indigenous chicken were focussed but their genetic ability was considered to be too low to meet the goals of the programme (Anonymous, 1985). Crossbreeding the IC using high producing European breeds was seen as the quickest way to achieving genetic improvement. Consequently, Rhode Island Red cockerels and pullets exchange programmes were started (Wainaina, 1994). However, lack of a constant supply of pure bred cockerels and pullets became a constraint soon thereafter, leading to the use of terminal hybrid cockerels from the commercial layer and broiler industries. As reported in Malawi, where a similar approach was used, egg production and growth rate improvements were not achieved mainly because most of the exotic cockerels and their progenies could not survive the prevailing backyard conditions (Hoyer, 1992; Safalaoh, 2001).

Feed supplementation using locally available feed ingredients to cover nutrient deficits, conventional disease control measures and proper housing strategies have been shown to improve growth rate, age at first egg and egg production, decrease mortality and lead to improved production (Okitoi *et al.*, 2000). However, these strategies were uneconomical mainly due to the high costs of inputs relative to incomes derived from the resultant outputs.

All the improvement strategies attempted to replace IC with European breeds and transform extensive and backyard production systems into intensive or semi-intensive systems without considering social, cultural and economic implications (Upton, 2000). The strategies were inappropriate and hence not widely adopted. Instead, new challenges such as high costs of production, biosafety concerns and biodiversity erosion emerged (Nyaga, 2007).

### **Future prospects**

Rural households are characterized by high levels of poverty and engage in production enterprises that require low capital investments (Mack *et al.*, 2005). An approach that increases productivity without increasing production costs or leading to loss of biodiversity must therefore be sought. Such an approach combining utilization of existing IC genotypes and sustainable genetic improvement is suggested.

#### ***a) Utilization of adapted genotypes***

Although IC are active and hardy, genotypes possessing major genes have added advantages. In hot environments, the naked-neck and frizzle genotypes have faster growth rates and superior body weights than normal counterparts (Nwachuckwu *et al.*, 2006). The dwarf genotype has increased feed efficiency and egg mass than their normal sized counterparts (Rashid *et al.*, 2005). The feathered-shank is heavier and produces more eggs than their normal counterparts (Fayeye *et al.*, 2006).

Utilizing the naked-neck and frizzle for meat or dual purpose production in hot environments would increase live bird offtake, while utilizing the dwarf would be expected to increase egg yield, without additional costs. Furthermore, the Kuchi genotype, a game chicken found in Lamu islands of Kenya would be ideal for meat production in hot and humid low-population density areas. On the other hand, bearded and feathered-shank genotypes are adapted to cold environments and would be expected to perform better than in hot environments (Bartels, 2003).

Utilizing these genotypes in environments where they are best adapted would not only be in tandem with the socio-cultural uses of IC but also increase their productivity and conservation. To achieve this, awareness creation and policy change is necessary. Non-governmental organisations and the public extension service should be used to popularise this concept.

#### ***b) Genetic improvement***

Vast changes in performance have occurred in most livestock species in recent decades. A major part of this change is genetic, realized through selection within populations (Maki-Tanila, 2007). Indigenous chicken can also be genetically improved through selective breeding. However, current performance levels, genetic parameters, clear breeding objectives and sustainable breeding strategies that address needs and circumstances of a particular production system utilizing particular genotypes must be well defined.

The relevant facilities, knowledgeable and manpower to undertake such an effort are available. However, capital resources to undertake research, formulate breeding objectives and implement a breeding programme are inadequate (Nyaga, 2007). An IC improvement programme would be a critical investment requiring public rather than donor financing. Donors have short horizons and change priorities too often and can therefore not be expected to finance a continuous and long-term breeding programme.

### **CONCLUSION**

To unlock the potential of IC, the use of adapted indigenous genotypes is necessary and their genetic improvement imperative. Apart from improving livelihoods, use of available and adapted genotypes would result in their conservation for future use. However, to sustain their utilization against the changing climatic and economic conditions, their ability to increase weight and lay more eggs with minimum input requirements must be genetically changed. Sustainable genetic change can only be achieved through selective breeding. Public funds should be used to run the genetic improvement programme while popularization of genotypes can be funded by willing bilateral or multilateral donors.

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# EXTERNAL EGG GRADING PARAMETERS OF INDIGENOUS CHICKEN IN KENYA

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## ABSTRACT

Some external egg parameters of indigenous chicken hens originating from various eco-climatic zones of the country were investigated. The parameters measured for each egg laid from the age of 28 to 35 weeks were eggshell appearance (AP), shell colour category (CC), egg weight (EW), length (LE), width (WI) and shape index (SI). The AP was visually determined while a paint colour chart was used to determine CC. EW was measured using a digital weighing scale, and LE and WI using a veneer calliper. SI was computed from LE and WI. Over 80% of all eggs were tinted while the rest were plain-shelled. There were 53 colour shades of brown, white, peach and pink. The ranges for EW (g), LE (cm), WI (cm) and SI (%) were 30.0 to 63.5, 4.0 to 6.2, 3.0 to 4.9 and 57.4 to 98.0, respectively. Their means and standard deviations were  $45.1 \pm 4.9$ ,  $4.95 \pm 0.24$ ,  $3.67 \pm 0.19$  and  $74.3 \pm 4.1$ , respectively. The possible egg grades based on EW, LE and WI were extra-small, small, medium, large and extra-large. Possible egg grades based on SI were sharp, normal and round. It was suggested that these grades may be used as standard guidelines for indigenous chicken table egg quality.

## INTRODUCTION

The market demand for consumable indigenous chicken table eggs has been increasing over time yet the supply has not adequately met this demand (Bett *et al.*, 2009). Commercialization of indigenous chicken egg production is feasible as the enterprise has been shown to be highly profitable (Juma and Ondwasy, 2002). However, as a natural product, eggs have high variability and hence need to be routinely graded and checked for quality standards demanded by today's quality conscious consumers (Shi *et al.*, 2009).

Egg standardization and grading consist of arranging eggs into a number of uniform categories according to physical and quality characteristics of economic importance (FAO, 2003). Some of the major exterior quality parameters used to standardize and grade table eggs include egg size, egg length, egg width, shape index, shell colour, shell strength and shell cleanliness (Stojcic *et al.*, 2009). Egg size is associated with internal quality, egg length and width with albumen and yolk quantity, respectively and shape index with shell strength (Altuntas and Sekeroglu, 2008; Shi *et al.*, 2009). On the other hand, shell colour is more associated with consumer preferences than quality.

Indigenous chicken egg standards and grades have not been developed in Kenya. The objective of the study was to determine possible standards and grades for indigenous chicken table eggs using external parameters.

## MATERIALS AND METHODS

The study was conducted at the National Animal Husbandry Research Centre (NAHRC), Naivasha, Kenya. The eggs were collected from offsprings of birds sourced from Kakamega, Bondo, Bomet, Narok, West Pokot, Taita and Mwingi areas. At 20 weeks of age, the offsprings were selected per source based on their average growth rate from hatch to 18 weeks. Each

selected cock was allocated between 3 and 8 selected pullets and housed in labelled deep litter pens. The birds were provided with clean water and fed a standard commercial layers mash *ad libitum*. For each egg collected daily, the pen number and date of lay were recorded on the egg's shell.

The labelled eggs were weighed (EW) and stored overnight at room temperature. On the following day, each egg's shell appearance (AP), shell colour category (CC), length (LE) and width (WI) were recorded. The AP was visually determined and classified as either plain or tinted. The CC was determined by comparison with a paint colour chart (Dura Coat Classic, Basco Products, Nairobi, Kenya) and the corresponding colour code and category recorded. The EW was measured using a digital weighing scale while LE and WI were measured using a Veneer calliper. The shape index (SI) was calculated as a ration of WI to LE as follows: -

$$SI = (WI/LE) \times 100\% \quad [1]$$

A total of 2,465 eggs were available for analysis. First, the number of eggs bearing a particular AP and CC, and the overall means and standard deviations of EW, LE, WI and SI were determined using means procedures of SAS (SAS, 2002). The effects of AP and CC on each of the measured parameter were then determined using the general linear models procedures and significant least squares means separated using Duncan's test. Finally, the overall means and standard deviations were used to determine possible grades.

## RESULTS AND DISCUSSION

The number of eggs and colour codes for the various eggshell appearances and colour categories are presented in Table 1. About 80% of the total eggs were tinted, while only about 20% were plain-shelled. In addition, about 50, 6, 7 and 30% were of various shades of brown, white, pink and peach colours, respectively. The eggs had a total of 53 different codes of brown, white, pink and peach colour categories. Whereas the plain shelled eggs had 40 different codes out of which 13.3% were 2072P ("*Flicker*"), tinted eggs had and 50 codes with 9.1% being 2080P ("*Sunstone*"). Both brown and pink categories had 14 colour codes, the white category had the highest number of codes (17) and peach the lowest (8). The most dominant brown, pink, white and peach codes were 2079P ("*Fantan*"), 2108P ("*Tangelo cream*"), 2071P ("*Marshmellow snow*") and 2086P ("*Peach blossom*"), respectively.

**Table 1. Number of eggs and colour codes for shell appearance and colour category levels**

Effect	Levels	Number of eggs	Number of colour codes	Dominant colour code
Shell Appearance	Plain	519	40	2072P – “Flicker” (13.3%)
	Tinted	1,946	50	2080P – “Sunstone” (9.1%)
Shell Colour Category	White	170	17	2071P – “Marshmellow snow” (26.5%)
	Brown	1,331	14	2079P – “Fantan” (18%)
	Peach	757	8	2086P – “Peach blossom” (24.8%)
	Pink	207	14	2108P – “Tangelo cream” (29.5%)
Overall		2,465	53	2079P – “Fantan” (9.7%)

Although consumers in some markets prefer either white or brown shelled eggs, shell colour and appearance have major effects on the visual appeal of an egg (FAO, 2003). Both egg shell colour and appearance are genetically controlled with colour intensities being influenced by nutrition and age of hen (Odabasi *et al.*, 2007; Shi *et al.*, 2009). Tinted eggs are a result of

crossing brown and white plain egg laying breeds or strains, while shell colours are due to deposition of various pigments on the eggshell during the process of egg formation (Odabasi *et al.*, 2007; Wang *et al.*, 2007). Whereas there is scarcity of available information on indigenous chicken egg appearance and colourations worldwide, Magothe *et al.* (2006) reported presence of plain and tinted eggs of indigenous chicken in Kenya. In this study, tinted eggs were more than plain shelled eggs. This may be an indicator of some level of preference for tinted against plain shelled eggs. Nevertheless, this may also be due to the chicken being crosses of the original birds and various brown egg exotic breeds and hybrids (Magothe *et al.*, 2006).

In the absence of sophisticated equipments, a simple comparison with a paint colour chart has been used to select and categorize eggshell colours (Shafey *et al.*, 2005). Whereas eggshell colours of unselected wild birds are diverse, the most common for artificially selected chicken breeds include brown, white and blue (Wang *et al.*, 2007). The brown, white, pink and peach colour categories and their various shades found in this study indicate wide egg colour diversity. Brown eggs were dominant, possibly due high presence of brown egg laying strains. Eggshell colour is moderately heritable and can therefore be selected (Zhang *et al.*, 2006). However, it is necessary to ascertain consumer preference for a particular shell colour to be used for egg grading.

The effects of AP and CC on EW, LE, WI and SI parameters are presented in Table 2. In agreement with Magothe *et al.* (2006), tinted eggs were significantly ( $P>0.05$ ) heavier than plain shelled. Although the reason for this was not clear, it may be due to increased shell weight, although the need to ascertain this is warranted. Both brown and peach coloured eggs were significantly heavier and longer than white, while pink were intermediate. The results were similar to Magothe *et al.* (2006) for brown and white shelled eggs. The longer brown eggs contain more albumin and are expected to be heavier (Shi *et al.*, 2009). However, the heavier weights of brown and peach eggs may also be due to heavier shells as a result of the deposited pigments (Ingram *et al.*, 2008). The shell weight and strength of the various coloured eggs need to be investigated further before a particular consumer preferred colour is used for grading.

**Table 2. Least squares means (LSM $\pm$ se) for egg weight (EW), egg length (LE), egg width (WI) and egg shape index (SI) parameters**

and egg shape index (SI) parameters						
Effect		Levels	LSM±se			
			EW	LE	WI	SI
Shell Appearance		Plain	43.8±0.4 <sup>b</sup>	4.90±0.02 <sup>a</sup>	3.63±0.02 <sup>a</sup>	74.2±0.4 <sup>a</sup>
		Tinted	44.6±0.2 <sup>a</sup>	4.92±0.01 <sup>a</sup>	3.65±0.01 <sup>a</sup>	74.3±0.2 <sup>a</sup>
Shell Category	Colour	White	43.1±0.4 <sup>b</sup>	4.87±0.02 <sup>b</sup>	3.62±0.02 <sup>a</sup>	74.6±0.4 <sup>a</sup>
		Brown	44.5±0.2 <sup>a</sup>	4.92±0.01 <sup>a</sup>	3.66±0.01 <sup>a</sup>	74.5±0.2 <sup>a</sup>
		Peach	44.8±0.2 <sup>a</sup>	4.95±0.01 <sup>a</sup>	3.67±0.01 <sup>a</sup>	74.2±0.2 <sup>a</sup>
		Pink	44.4±0.8 <sup>ab</sup>	4.91±0.04 <sup>ab</sup>	3.61±0.03 <sup>a</sup>	73.8±0.7 <sup>a</sup>
Overall*			45.1±4.9	4.95±0.24	3.67±0.19	74.3±4.1

<sup>abc</sup> means within column for each effect followed by different superscripts are significantly different ( $P<0.05$ ).

\* overall mean ( $\mu\pm$ sd).

The possible egg standards and grades are presented in Table 3a and b. Eggs were classified based on EW, LE and WI into five possible grades: extra small, small, medium, large and extra large with every two standard deviations constituting a grade. Egg standards are developed as a means of classifying individual eggs into groups based on characteristics known to be desirable to producers, merchants and consumers (USDA, 2000). Egg grades differ from country to

country. According to USDA (2000), there are 6 grades in the United States, namely; pewee (35-41.9 g), small (42-48.9), medium (49-55.9), large (56-63.9), extra-large (64-69.9) and jumbo (above 70 g). The European Union on the other hand has four grades (The Scottish Government, 2008), namely; small (below 53 g), medium (53-63 g), large (63-73) and extra-large (above 73 g).

Whereas a standard chicken egg has an elliptical shape, eggs of varying shapes are produced. The shapes are differentiated and classified into sharp, normal and round using the SI values of >72%, 72-76% and <76%, respectively (Altuntas and Sekeroglu, 2008). In the current study eggs with SI of less than one standard deviation were classified as sharp, within one standard deviation as normal and more than one standard deviation as round. Round and unusually sharp eggs are unattractive and do not fit properly when packaged. Furthermore, they are less resistant to rupture during transportation. The possible grades in this study are in close agreement with the most often encountered shapes (Altuntas and Sekeroglu, 2008).

**Table 3. Derived indigenous chicken table egg standards and grades based on egg weight (EW), egg length (LE) and egg width (WI)**

<b>a. Based on EW, LE and WI</b>				<b>b. Based on SI</b>	
Grades	Parameter measurements			Grades	Parameter measurements
	EW (g)	LE (cm)	WI (cm)		SI (%)
Extra small	<35	<4.5	<3.3	Sharp	<70
Small	35 - 44	4.5 - 4.9	3.3 - 3.7	Normal	70 - 78
Medium	45 - 54	5.0 - 5.4	3.8 - 4.2	Round	>78
Large	55 - 64	5.5 - 5.9	4.3 - 4.7		
Extra large	>64	>5.9	>4.7		

## CONCLUSION

This study has demonstrated that indigenous chicken eggshell colours are highly diverse. Consumer preferences need to be determined before developing a particular shell appearance and colour for standardization and grading. In addition, external parameters can be used for egg grading hence increase the economic returns of indigenous chicken production. It is therefore suggested that these grades may be used as standard guidelines for indigenous chicken table egg quality.

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# **Feeds and Feeding Systems**

## **DRY PERIODS: IS IT TIME TO RE-THINK OUR STRATEGIES?**

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### **ABSTRACT**

The 60-day dry period was adopted as a management practice during World War II. Since that time, there have been large production increases as a result of genetic improvements and advances in dairy management practices. These improvements have resulted in higher levels of milk production and lactation persistence compared to the time before the 60-day dry period was adopted. This creates a need to reconsider the optimal dry period length in dairy cows. Recent research on shortened dry periods in dairy cows has demonstrated equal or higher milk yields in 60-day compared to 30-day dry multiparous cows. Shortened dry periods negatively affect subsequent milk yield in primiparous cows. Primiparous cows continue to require a 60-day dry period. Reducing the length of the dry periods may improve dry matter intake (DMI) and minimize extremes in metabolic and physiologic changes throughout late gestation and early lactation. Diet changes during the last 60 days of gestation are minimized to one or eliminated, to reduce the level of stress that is associated with these changes. Mammary engorgement and involution at dry-off are lessened in shorter dry period. The economic advantages include increased lactation milk yield and reduced need for replacement stock.

### **INTRODUCTION**

The mean milk production per cow in Kenya is increasing at 4.1% per year. The Vision 2030 of the Government of Kenya puts a strong emphasis on commercialization of agriculture (Republic of Kenya, 2007) including dairy production. Commercialization is likely to lead to even greater increases in milk production per cow. In normal dairy herd management, it is recommended that cows should be dried off 60 days prior to calving. It is reasoned that this practice allows for regeneration of the mammary epithelial cells, repartitions nutrients in favour of the rapidly developing calf and builds up body reserves which will be useful in early to peak lactation. One literature review shows that the optimum length of the dry period has been debated since the early 1800s. At that time some English farmers believed that a two-month dry period was optimal while others thought that a two-week dry period was adequate (Annen and Collier, 2005). During World War II, the 60-day dry period was adopted as the optimal dry period length for maximal milk yield during this time of food shortage (Knight, 1998). The 60-day dry period has been maintained as one that best maintains the balance between lost milk income during the dry period and production levels achieved in the next lactation.

### **Biological changes during the dry period**

In animals that are not pregnant at dry-off or weaning of offspring, the mammary gland goes through a phase of extensive cell loss followed by gland remodelling to structural similarity to a virgin gland (Furth, 1999). Lactation during advanced pregnancy in dairy cows results in involution of mammary epithelial cells. During the dry period the process of mammary epithelial cell replacement and modest remodelling of the gland occurs (Capuco and Akers, 1999). Cessation of milking simulates mammary epithelial cell death (apoptosis), whereas the lactogenic and mammatogenic stimuli of advanced pregnancy oppose apoptosis (Capuco *et al.*, 2004). In dairy cows, extensive cell loss does not occur during involution, and mammary epithelial cell growth begins before the involution process is complete (Annen *et al.*, 2003). A transient and rapid increase in mammary epithelial cell apoptosis occurs during the first 72

hours after dry-off. This is followed by initiation of mammary epithelial cell proliferation and decreased apoptosis within 7 to 10 days after dry-off (Annen *et al.*, 2003). Mammary gland remodelling in dairy cows includes a reduction in luminal area of alveoli, an increase in stromal components, and synthesis of extra-cellular matrix (Holst *et al.*, 1987; Hurley, 1989; Capuco *et al.*, 1997). The involution process is complete by 25 days in the dry period and that mammary epithelial cell proliferation increased throughout the dry period (Capuco *et al.* (1997). At completion of involution, the mammary gland of dairy cows is non-lactating but has all the structures required for milk secretion (Annen *et al.*, 2003; Holst *et al.*, 1987).

### **Effects of shortened dry period on milk yield**

Earlier studies showed that shortening dry periods reduced subsequent milk by 0 to 10% (Coppock *et al.*, 1974; Lotan and Alder, 1976; Sorensen and Enevoldsen, 1991). The animals used in these experiments achieved much lower peak milk yields than today's high-producing cows. Peak milk yield in these studies was 18 to 34 kg/day compared to peak milk yields of 45 kg/day or more in today's cow. Recent studies reveal no differences in 305-day milk yield when the dry period was reduced to 30 days in cows with an average peak lactation yields of 46 kg/day (Bachman, 2002) or 44 kg/day (Gulay *et al.*, 2003). There are herds in this country where many animals peak at 45 kg/day and above. These high production levels and persistency of lactation provide good reasons for re-evaluation of the optimal dry period length.

### **Reasons for reduced milk production in lactation following shortened dry period**

*Nutritional limitations during late gestation:* It has been suggested that the reduction in milk yield in cows whose dry periods are shortened was caused by reduced replenishment of body reserves during the last 60 days of gestation, thus resulting in inadequate body reserves to partition to milk production in the subsequent lactation. This theory was not supported by studies demonstrating improved body weights but lower milk yields in continuously milked and 30-day dry cows compared to 60-day dry cows (Swanson, 1965; Lotan and Alder, 1976) and by a half-udder study demonstrating reduced milk yield in continuously milked quarters despite equal nutritional factors to all quarters (Smith *et al.*, 1967).

*Hormonal differences:* The hormonal theory suggested that the constant influence of galactopoietic and milking stimulus hormones associated with maintenance of lactation during the last 60 days of gestation caused reduced milk yields in the succeeding lactation. In a half-udder study, Smith *et al.* (1967) discounted this hypothesis when they demonstrated reduced milk yield in continuously milked quarters compared to 60-day dry quarters, although all quarters had equal exposure to endocrine hormones. Shortened dry periods may alter or inhibit the actions of hormones produced within the mammary gland that act locally within the gland. Thus the negative effects of shortened dry periods were within the mammary gland rather than on systemic factors regulating milk synthesis.

*Reduced mammary epithelial cells number:* Continuous milking (Capuco *et al.*, 1997) or a six-week difference in dry period length (Swanson *et al.*, 1967) did not alter total mammary DNA content (cell number) or parenchyma content during late gestation when compared to 60-day dry cows.

*Reduced synthetic and mitotic function of the mammary epithelial cells:* Mammary epithelial cells proliferation was reduced in continuously milked glands compared to non-lactating glands throughout the last 35 days of gestation (Capuco *et al.* 1997), suggesting increased carryover of old mammary epithelial cells into the next lactation rather than replacing them with new ones as occurs in non-lactating glands during late gestation. Reduced milk yield in cows with shortened dry periods are believed to be caused by larger populations of old mammary

epithelial cells compared to 60-day dry glands. This theory assumes that older mammary epithelial cells have decreased capacity for milk synthesis and reduced mitotic competence.

### **Benefits of shortened dry periods**

- Dry matter intake (DMI) declines by 30 to 35% during the last three weeks of gestation (Grummer, 1995). Reduced DMI during the final weeks of gestation occurs as nutrient demands for foetal growth and the onset of lactation increase, creating a state of negative nutrient balance by the last week of gestation and during early lactation (Bell, 1995; Grummer, 1995). Negative nutrient balance results in mobilization of body reserves to meet nutrient demands for pregnancy and lactation and predispose the animal to metabolic diseases (Goff and Horst, 1997). Parturition and the onset of lactation during a period of declining DMI results in increased risk of metabolic disease, such as ketosis, milk fever, retained placenta, and displaced abomasums (Goff and Horst, 1997). Thirty-day dry periods have been suggested to improve energy balance (Lotan and Alder, 1976; Remond *et al.*, (1992). Cows dried for 30 days tended to have increased DMI and lost less body condition than 60-d dry cows (Gulay *et al.*, 2003). Data of Rastani *et al.* (2003) demonstrated 21% greater DMI in 28-d dry cows compared to 56-d dry cows.
- Due to genetic improvements in milk yield and lactation persistency, cows that peak at above 45 kg /day are likely to be producing more than 30 kg/day at the time of dry-off. Additional days of lactation maximize income generated per cow per lactation and decrease the number of replacement animals needed to keep a dairy herd at the desired cow number capacity. For instance if a cow is producing an average of 25 kg milk per day over 30 days the 750 kg of milk at current KCC price of KSh. 24 per kg would raise KSh. 18,000, enough to pay one farm worker for at least three months.
- High yields at dry-off result in extreme changes in metabolic and physiological state, which are complicated by dramatic diet changes. In a 60-day dry period, a poor quality roughage diet is fed in the first 2 weeks. Such extremes from a highly nutritious diet to a very poor one result in the additional stress on the cow. There is also the discomfort of udder engorgement and involution during the early dry period. The teat canals of an engorged udder remain open, allowing in infections leading to dry cow mastitis. There is no flushing out of the bacteria that happens at milking. Delaying drying off of high yielding cows thus contributes to the cow's health and comfort.

### **CONCLUSIONS AND RECOMMENDATIONS**

Recent research shows no production losses following a 30-day dry period. This may be a viable management practice in high yielding multiparous cows. Other benefits of a 30-day dry periods in high yielding multiparous cows include improved dry matter intake and nutrient balance during the last three weeks of gestation and early lactation. These improvements result in a reduction in the incidence of metabolic disorders associated with late pregnancy and early lactation. Financial gains from shortening the dry period include gains from milk sales over the additional thirty days of lactation and reduced need for treatment of metabolic disorders. The losses due to reduced milk yield as a result of metabolic disorders are minimized. When these financial implications are considered along with the biological information reviewed in this paper, adopting a 30-day dry period is a production option of choice for the modern dairy farmers of Kenya.

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# EVALUATION OF MAIZE VARIETIES FOR FOOD AND FEED IN A MAIZE-DAIRY PRODUCTION SYSTEM IN KENYA

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## ABSTRACT

An evaluation of three maize varieties for food and fodder was carried out in intensive maize-dairy production system in Kenya. In this system, inadequate fodder is a major challenge for the smallholder dairy farmers. The experimental design was Complete Randomised Design replicated two times per site in six sites. Treatments were maize varieties Mu03036, Mu03017, Mu03022 and a local check hybrid in each site. Variables were yields of thinning, stover and grain. Farmers subjected the varieties to their own criteria. They scored for each criterion against the maize varieties on a scale of 1 to 10 where one was the worst and 10 the best. Mu03036 yielded higher biomass than the rest in the different sites that ranged 7.59 - 25.3 t ha<sup>-1</sup> against Mu03017 (5.67 - 16.7 t ha<sup>-1</sup>) and Mu03022 (6.16 - 18.1 t ha<sup>-1</sup>). Mu03036 had the highest weighted score in two sites and tied with Mu03017 in one site with the highest scores. Mu03017 lead in one site. There is potential of utilizing the maize varieties for food and feed. Mu03036 did better in the trial sites and could effectively be utilised in this area as a dual purpose maize variety.

## INTRODUCTION

Maize plays a critical role in food security in Kenya. However, research priorities have generally sought to optimise grain yields. Socio-economically, it is important not to ignore the value of the crop residue as forage, which has a value of between one third and one half that of the grain (McIntire *et al.*, 1992). In addition where land pressure is high, dense planting is a common practise since forage (thinnings and stover) as well as grain are important outputs from maize. Planting maize densely and feeding thinnings to livestock has been reported in western and central highlands of Kenya (Onim *et al.*, 1992; SDP, 2000; Lukuyu, 2000). In Kenya, maize contributes 24% of forage being second in importance to Napier (40% of supplies). The intensive crop-livestock farming systems are characterised by a large variation of agricultural activities including cultivation of cash crops, vegetables and staple food such as maize. As human population rises and land becomes a constraint, smallholder farmer's face many problems including livestock feed shortages (Staal *et al.* 1998). Due to intensification, crop-livestock interactions increase and forage from maize becomes a larger component of feed for livestock (Romney *et al.* 2003). Maize is grown as a dual purpose crop used to achieve multiple objectives of food and feed (Lukuyu, 2005). The purpose of the study was to evaluate for a dual purpose maize variety.

## MATERIAL AND METHODS

### *Site selection*

The trials sites were selected in four districts in Kenya. Altitudes in these sites ranged between 1785-2100 m and characterized by between 740 - 1200mm of rainfall in a year (Jaetzold, 2006). These included Nakuru, Machakos, Embu and Kiambu. The sites linked into existing farmers field schools (FFS) in the respective districts. These groups had been working with Land O' Lakes, a non-governmental organization, to improve dairy performance. The groups were visited by the animal production officers from research and extension to discuss the intended participatory trials and the roles the farmers were expected to play that included providing labour in activities required on the maize plots e.g. planting, weeding, evaluation, thinning, harvesting and most important owning the trials.

### ***Trial establishment***

Three maize hybrid varieties were evaluated (Mu 03 036, Mu 03 017, and Mu 03 022). The varieties had been developed by maize breeders at Kenya Agricultural Research Institute Muguga South. Alongside the three varieties, a hybrid variety commonly planted by the communities in the respective districts was included in the evaluation. This coincided with hybrids 6213, 614 and 6210 for Nakuru, 3253 and 628 for Kiambu, 8031 and 614 for Embu and 3253 for Machakos. This was to enable the farmers compare with what they are familiar with. Plot sizes varied per site depending on the land available. The size was 5 x 5 m in Nakuru, Embu and Machakos and 4 x 3m in Kiambu. All the plots dug by the groups in readiness for planting. Three seeds were planted per hill and spaced at 30 x 90 cm. This gave a plant population of 111,000 plants per ha.. The type of planting fertilizer varied per site and was guided by what the farmers use in that region depending on agricultural extension service recommendation. In Nakuru, Machakos, Kiambu and Embu, Diammonium Phosphate (DAP) was used at rate of 5g per hill except Wangige group in Kiambu that used organic fertilizer at rate of 10 g per hill. The treatments were replicated twice in each site. Top dressing was done after the second weeding using Calcium Ammonium Nitrate (CAN) fertilizer and common for all groups except Wangige group that practice organic farming using organic fertilizers only. First weeding was done three weeks post-mergence. After trial establishment the groups were encouraged to own the trials, make observations that later enabled them to evaluate the varieties at ear formation stage and just before harvesting.

### **Data collection**

#### ***Farmer evaluation***

The evaluations were carried out with full farmers' participation to enhance adoption. The groups were guided in developing a criteria that they scored on a scale of 1 to 10 where 10 was the best and 1 the worst. All the varieties were subjected to the criteria developed by each group and their weighted scores calculated. Weighted score was obtained by first getting the criteria totals. The score a variety obtained per criterion was then divided by the criteria total. This was done for all criteria per variety. The figures obtained were then summed up to give a weighted score for that variety. This was repeated for all varieties and by sites. The varieties were then ranked based on the weighted score where the highest score was ranked first and the least score was last.

#### ***Scientific data***

Scientific data was also collected on the thinnings made just before top-dressing, stovers after harvesting and the dry grain on plot basis. For the thinnings, each hill was thinned to 1 or 2 plants per hill. The farmers thinned plants that appeared weak and if two plants were weak in a hill, they were both removed and one left to grow to dry grain stage. They were all weighed using Avery spring balance and samples of about 1 kg of thinnings during thinning and stovers during harvesting taken for dry matter analysis that enabled dry matter yields to be calculated and leaf to stem ratio estimated. Leaf to stem ratio was based on dry matter basis. The samples were separated manually into leaves and stems and their dry matter determined according to AOAC, (1994). For the grain, all the cobs harvested per plot were weighed using the Avery spring balance. Average moisture per plot was determined by randomly selecting 6 cobs from the plot. Each cob was broken into two. Grains were hand-shelled from the broken side of each of the halves. This was done for the six cobs and all the grains mixed and placed into the moisture cup. The moisture readings were taken and recorded. These readings were used to estimate the grain yield in tons per ha using the formula (Lorroki, 2009).

$$\text{Yield (t)} = \frac{\text{Field weight (kg)}}{\text{Plot size (m}^2\text{)}} \times \frac{(100 - \text{MC \%})}{87.5} \times 0.8 \times 10$$

Where MC% is the Moisture Content

Yield (t) is the dry grain yield obtained in a plot in tonnes

Field weight was the weight of the harvested cobs per plot in kg

### Data analysis

Raw data was entered in Excel sheet and data set prepared. Data set was imported into Genstat software and analysis done according to Lawes Agricultural Trust,(1995). Analysis of variance was done (ANOVA) where factor was maize variety while variables were yields of thinnings, stover and dry grain.

## RESULTS AND DISCUSSIONS

Table I shows maize varieties performance in the different trial sites.

Table I. Performance of the maize varieties by the sites							
Site	Variety	Thinnings L:S ratio	Stover stem ratio	leaf: Thinnings DM	Stover (dry)	Grain t/ha	
Mwangaza Nakuru	Mu 03 017	7.4	0.793	0.064	5.01	8.29	
	Mu 03 036	5.51	0.765	0.088	6.34	9.52	
	Mu 03 022	7.42	0.673	0.133	5.03	8.63	
	Hybrid 6213	7.26	0.771	0.085	4.99	8.62	
	SED	1.641	0.0937	0.0362	0.518	1.56	
Wangige Kiambu	Mu 03 017	2.48	1.534	1.05	7.88	7.84	
	Mu 03 036	2.64	1.614	1.16	13.35	10.85	
	Mu 03 022	2.23	1.908	0.91	8.34	8.89	
	Hybrid 3253	0	0	0	0	0	
	SED	0.342***	0.2467***	0.317*	2.312**	1.572***	
Mwitha Embu	Mu 03 017	3.72	0.977	0.922	5.13	3.41	
	Mu 03 036	3.39	1.059	0.791	5.32	3.54	
	Mu 03 022	3.27	0.98	0.764	3.93	2.48	
	Hybrid 8031	2.73	1.201	0.511	4.44	3.07	
	SED	0.391	0.1163	0.0953*	0.457*	0.545	
Wiitikio Embu	Mu 03 017	5.94	1.105	0.345	7.38	3.59	
	Mu 03 036	4.99	1.353	0.296	6.17	3.37	
	Mu 03 022	5.28	1.082	0.309	7.11	3.18	
	Hybrid 614	5.86	1.214	0.208	10.37	4.6	
	SED	0.634	0.1971	0.0593	1.602	0.861	
Gikambura Kiambu	Mu 03 017	1.95	1.146	1.084	6.37	4.99	
	Mu 03 036	1.77	1.214	1.219	7.79	3.79	
	Mu 03 022	2.58	1.181	0.977	4.67	2.12	
	Hybrid 628	1.58	0.967	0.897	7.51	2.61	
	SED	0.295*	0.1441	0.2229	1.029*	0.906*	
Kambai Kangundo	Mu 03 017	2.27	1.071	0.61	3.61	1.455	
	Mu 03 036	3.4	1.363	0.508	5.4	1.684	
	Mu 03 022	1.62	1.081	0.473	4.19	1.503	
	Hybrid 3253	0	0	0	0	0	
	SED	0.257***	0.1265***	0.0833**	0.685***	0.2534***	
Nakuru Wamu	Mu 03 017	2.598		0.64			
	Mu 03 036	2.839		0.566			
	Mu 03 022	3.091		0.523			
	Hybrid 614	2.648		0.396			
	SED	0.2174		0.0821			
Nakuru sunset farm	Mu 03 017	2.269		0.392			
	Mu 03 036	2.077		0.318			
	Mu 03 022	2.33		0.306			
	Hybrid 6210	2.602		0.281			
	SED	0.2755		0.0576			

$P < 0.001$  \*\*\*



### *Farmer evaluations*

**Table II shows farmer evaluation by Mwangaza group in Nakuru.**

Criteria	Criteria score	036	022	017	H6213
Size of cob	10	8	6	7	9
Strong stalk	8	9	6	7	9
Ear closing	7	8	5	6	7
Dropping cobs	7	7	5	6	3
No. of cobs	7	6	5	8	5
Resistance to smut	8	9	6	7	8
Amount of forage	9	8	6	5	4
Grain weight	8	8	5	7	9
Stay green	8	8	5	6	9
Early maturity	4	8	9	8	6
No. of lines in a cob	9	8	9	9	8
Size of grain	8	7	6	9	8
	93				
Weighted score		1	0.8	0.9	0.9
Rank		1	4	2	2

Table III has seven criteria developed by Mwitha group in Embu and the scores attributed to the maize varieties in their own assessment.

**Table III. Mwitha (Embu) farmer group Evaluation**

Criteria	Criteria score	036	022	017	Duma 8031
Germination	9	9	9	9	2
Ear closing	8	6	7	9	3
Livestock feed	9	8	6	6	1
No. of Cobs	3	3	3	3	0
Barrenness	4	4	4	7	1
Cob size	10	9	7	6	5
Diseases	10	10	9	9	9
	53				
Weighted score		0.925	0.849	0.925	0.396
Rank		1	3	1	4

Table IV shows nine criteria developed by Kambai group in Embu and the scores attributed to the maize varieties in their own assessment.

**Table IV. Kambai (Kangundo) farmer group Evaluation.**

Criteria	Criteria score	036	022	017	Pioneer 3253
Germination	9	9	9	9	2
Ear closing	8	6	7	9	3
Livestock feed	9	8	6	6	1
Early maturity	4	4	4	7	4
No. of Cobs	3	3	3	3	0
Barrenness	4	4	4	7	1
Drought resistance	6	6	4	8	7
Height uniformity	5	5	6	7	1
Stalk size	7	7	5	6	2
	55				
Weighted score		0.945	0.873	1.127	0.382
Rank		2	3	1	4

<b>Table V Wiitikio (Embu) farmer group Evaluation</b>					
<b>Criteria</b>	<b>Criteria score</b>	<b>036</b>	<b>022</b>	<b>017</b>	<b>803 DK</b>
Germination	10	9	9	9	9
Ear closing	9	8	8	9	6
Livestock feed	10	9	5	6	8
Cob size	10	9	6	7	5
No. of cobs	10	6	5	5	5
Barreness	10	9	8	7	9
Diseases (MSV, aphids)	10	10	9	9	9
	69				
Weighted score		0.870	0.725	0.754	0.739
Rank		1	4	3	2

## DISCUSSIONS

The recommended plant population per ha is 44,444. In these trials the population was increased to 111,111 with the intention of thinning to get fodder. In Mwangaza Nakuru Mu03036 yielded the highest biomass. The same trend was observed in Wangige Kiambu, Kambai in Kangundo, Mwitha embu and Gikambura in Kiambu. However, the check hybrid in Kambai and Wangige never germinated indicating that the seed was dead though it was obtained from the market. In Gikambura Mu03036 had statistically more stovers ( $P < 0.05$ ) while Mu03017 had more grains ( $P < 0.05$ ) and Mu03022 had higher leaf: stem ratio ( $P < 0.05$ ) in the same site. In Wamu and Sunset sites in Nakuru, only thinning data was available. There was logistical problem and the data could not be collected and the same applied for farmer criteria evaluation in Wangige and Gikambura sites. In Wiitikio Embu, the check hybrid had the highest biomass compared to the test varieties though they were statistically similar ( $P > 0.05$ ). The results followed the trend of the participatory criteria analysis done by the farmers where Mu03036 ranked first (Table II, III and V). It was only in Kambai where Mu03017 had the highest weighted score.

Kenya Agricultural Research Institute maize breeding programme in Muguga South presented the three varieties for National Performance Trials (NPT) by Kenya Plant Health Inspectorate Service (KEPHIS) and they have been released. Further, the varieties have been licensed to seed companies that are expected to make seeds available in the market for farmers. Mu03036 is licensed to East Africa Seed Company and will be coded (KH500-43A), Mu03017 to Victoria Seeds Company coded as (KH500-44A) and Mu03022 to Olerai Seed Company (KH500-22A).

As the land holdings continue to shrink in Kenya, farming intensification becomes inevitable. Crop-livestock interaction also plays an important role in such a system. This is mainly because of nutrient cycling. Crops and crop residues provide fodder to the livestock and in turn the animals provide manure used to fertilize crop land for better crop performance. Maize crop is an excellent example for such scenario. Maize grain is still staple food for the Kenyans and is thus grown in the mixed farming systems. It provides fodder for livestock through thinning and dry and green stover. Further, by-products of maize grain at industrial level are used in formulation of livestock concentrates used to supplement the animal. This underscores the important niche maize plays as human food and fodder for livestock.

## CONCLUSIONS AND RECOMMENDATIONS

There is potential of utilizing maize varieties for food and feed. Mu03036 did well compared to the check hybrids in Embu, Nakuru, Kiambu and could effectively be utilised in these areas as a dual purpose maize variety.

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# **Animal Genetics Resources & Improvement**

# GENETIC PARAMETERS FOR EGG AND BODY WEIGHTS OF INDIGENOUS CHICKEN IN KENYA

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## ABSTRACT

Genetic parameters were estimated for egg and body weight traits of indigenous chicken using single and multiple trait derivative-free restricted maximum likelihood (DFREML) procedures fitting sire models. The traits evaluated using single trait analyses were egg weight (EW) and bi-weekly body weight from hatch (BW0) to 30 weeks of age (BW30). EW, juvenile-stage body weights at 2 (BW2), 4 (BW4) and 6 (BW6) weeks, grower-stage weights at 12 (BW12), 14 (BW14) and 16 (BW16) weeks and mature-stage weight at 26 (BW26) weeks of age were further re-evaluated simultaneously in a multiple trait analysis to re-estimate heritabilities and determine both genetic and phenotypic correlations. The single trait heritability estimate for EW was  $0.95 \pm 0.27$ . Body weight heritability estimates increased with age from  $0.05 \pm 0.09$  for BW0 to  $0.39 \pm 0.18$  for BW4 and then generally reduced gradually to  $0.01 \pm 0.04$  for BW30. The multiple trait heritability estimates for EW, BW2, BW4, BW6, BW12, BW14, BW16 and BW26 were higher than in single trait analyses and were  $0.98 \pm 0.26$ ,  $0.51 \pm 0.22$ ,  $0.65 \pm 0.24$ ,  $0.51 \pm 0.22$ ,  $0.35 \pm 0.20$ ,  $0.31 \pm 0.23$ ,  $0.29 \pm 0.20$  and  $0.11 \pm 0.10$ , respectively. Whereas all phenotypic correlations were low and ranged from 0.01 to 0.14, genetic correlations ranged from low (0.05) to near unity (0.99). Both genetic and phenotypic correlations between EW and BW2, BW4 and BW6 were negative and ranged from -0.13 to -0.15, and -0.02 to -0.03, respectively. The genetic correlations between EW and BW12, BW14, BW16 and BW26 were positive and increased with age from low (0.05) at BW12 to moderate (0.58) at BW26. Genetic correlations between body weights decreased with age. It was concluded that selection for BW12 would improve EW and all body weights traits.

## INTRODUCTION

The importance of indigenous chicken (IC) in wealth creation and animal protein supply at national and household levels is well recognised (Upton, 2000). However, low IC productivity reduces their contribution to rural development, despite a notable increase in the demand for their products. The low productivity is attributed to high disease incidences, inadequate nutrition and low genetic ability (Kingori, 2004). Efforts aimed at improving egg and meat production have been attempted with marginal success. Instead of improving productivity and rural livelihoods, the attempts have mostly resulted in creation of new challenges erosion of genetic diversity (Nyaga, 2007).

Despite their importance, no IC improvement in Kenya has ever focused on selection yet selection strategies have been used to improve growth and egg production of IC in Iran and other developing countries (Kamali *et al.*, 2007). Genetic improvement through selection requires estimates of genetic parameters necessary for formulation of breeding objectives and selection indices. The objective of this study was therefore to obtain heritability and correlation (genetic and phenotypic) estimates for egg weight and body weights of IC at various ages.

## MATERIALS AND METHODS

### *Data source*

The study was conducted at the National Animal Husbandry Research Centre, Naivasha. Thirty one cocks were randomly sampled from a random mating flock originating from various ecological regions of the country. Each cock was allocated between 5 and 10 randomly sampled and unrelated hens and housed together in deep litter pens. Each egg collected was labelled to identify its cock family before incubation. After the 2<sup>nd</sup> candling, each egg was placed into an individual compartment for hatching. At hatch, chicks were wing tagged and reared in electric brooders up to 6 weeks and in deep litter pens thereafter. Sex was determined on the 14<sup>th</sup> week of age. Standard commercial feeds and clean water were supplied *ad libitum* at all ages. Egg weight (EW) and bi-weekly body weights from hatch (BW0) to 30 weeks of age (BW30) were measured using a digital weighing scale. A total of 511 birds produced in 7 hatchings and with records up to 30 weeks of age were available for analysis.

### *Statistical analysis*

Significant fixed effects and covariates significantly influencing EW and each biweekly body weight were determined using the general linear model procedures (SAS, 1998). The derivative-free restricted maximum likelihood (DFREML) programmes (Meyer, 1998) fitting sire models were used to estimate heritabilities of, and genetic and phenotypic correlation between egg weight and body weights at various ages. In single trait analyses, variance components for EW and body weight at each age were individually estimated. Three juvenile-stage weights at 2 (BW2), 4 (BW4) and 6 (BW6) weeks, three grower-stage weights at 12 (BW12), 14 (BW14) and 16 (BW16) weeks, and one mature-stage weight at 26 (BW26) weeks of age with the highest single trait heritability estimates were further analysed in a multiple trait analysis and their (co)variances simultaneously estimated. In the analysis of EW and BW0, hatch (1, 7) was the only significant fixed effect fitted while for subsequent body weights an additional fixed effect of sex was added. In addition, EW was fitted as a covariate in the analysis of BW0, while BW0 was fitted as a covariate in the analysis of BW2 to BW10.

## RESULTS AND DISCUSSION

The single trait heritability estimates were high for EW ( $0.95 \pm 0.27$ ), moderate for BW2 to BW6 (between 0.28 and 0.39), low for BW8 to BW16 (between 0.12 and 0.16) and close to zero for BW0 (0.05) and BW18 to BW30 (between 0.01 and 0.07). The population in this study was unselected and exhibited high additive genetic variation for EW leading to high heritability estimate as expected (Iraqi *et al.*, 2002). On the other hand, EW is a trait of the hen and therefore non-additive, maternal additive, maternal environmental and common environmental effects highly contribute to EW variation (Bunter and Cloete, 2004). Maternal additive and environmental effects were not accounted for in the current study, thus causing a possible confounding of their variances with the sire variance hence leading to overestimation of the heritability. A comparable estimate of 0.91 has been reported using sire models not accounting for maternal or common environmental effects (Wei and van der Werf, 1995). However, lower ranges of between 0.43 and 0.68 estimated using either sire or animal models accounting for maternal additive and maternal or common environmental effects have also been reported (Kamali *et al.*, 2007; Lwelamira *et al.*, 2009).

In the current study, the sire component of variance explained less the variation of BW0. The genes of the hen determining EW have a large influence on chick weight at hatch, whereas the chick's own genes explain a very small part of its body weight (Hartmann *et al.*, 2003). Therefore, hatching weight is also a trait of the hen. Fitting EW as a covariate may have indirectly accounted for maternal and environmental effects thus leading to unbiased direct heritability for BW0 (Bunter and Cloete, 2004). The low heritability for BW0 was comparable

to 0.01 reported using models that included maternal and environmental effects (Hartmann *et al.* 2003; Le Rouzic *et al.*, 2008).

Heritability estimates are not only a property of a trait but also of a population and the environment in which the estimates are made (Falconer, 1989). The moderate heritability estimates for BW2, BW4 and BW6 were in agreement with Norris and Ngambi (2006). The low estimates for BW8 to BW16 were in agreement with Iraqi *et al.* (2002). However, estimates close to zero (ranging from 0.01 to 0.07) for BW18 to BW30 were at variance with several reports (Norris and Ngambi, 2006; Momoh and Nwosu, 2008). The low estimates in the current study may be attributed to the genetic backgrounds of the various unselected genotypes and increases in environmental effects occasioned by fluctuating daily ambient temperatures as indicated by Magothe *et al.* (2010).

The multi-trait heritability and correlation coefficients are presented in Table 1. All heritability estimates were higher than in single-trait analyses. Increases in heritability estimates as a result of analysing several traits or variates simultaneously have been reported in Ostriches (Bunter and Cloete, 2004). The higher heritability estimates are due to stabilizing effects that reduces environmental noise of correlated traits leading to increased additive and reduced residual variances. The heritability coefficients for the various traits were in agreement with estimates in literature (Chambers, 1990).

**Table 1: Multi-trait estimates of genetic parameters for EW, juvenile body weights (BW2 to BW6), grower body weights (BW12 to BW16) and mature body weight (BW26)<sup>a</sup>.**

	EW	BW2	BW4	BW6	BW12	BW14	BW16	BW26
EW	<b>0.98±0.26</b>	-0.13±0.28	-0.14±0.27	-0.15±0.28	0.05±0.32	0.17±0.32	0.25±0.30	0.58±0.36
BW2	-0.02	<b>0.51±0.22</b>	0.99±0.21	0.99±0.12	0.89±0.31	0.84±0.34	0.78±0.35	0.52±0.47
BW4	-0.03	0.14	<b>0.65±0.24</b>	0.99±0.26	0.85±0.25	0.80±0.38	0.74±0.30	0.47±0.47
BW6	-0.03	0.13	0.14	<b>0.51±0.22</b>	0.83±0.33	0.78±0.37	0.72±0.41	0.44±0.46
BW12	0.01	0.09	0.10	0.09	<b>0.35±0.20</b>	0.99±0.62	0.97±0.51	0.80±0.51
BW14	0.02	0.08	0.09	0.08	0.08	<b>0.31±0.23</b>	0.99±0.71	0.87±0.50
BW16	0.03	0.08	0.08	0.07	0.08	0.08	<b>0.29±0.20</b>	0.92±0.60
BW26	0.05	0.03	0.03	0.03	0.04	0.04	0.04	<b>0.11±0.10</b>

<sup>a</sup>Heritabilities on the diagonal and bold, genetic and phenotypic correlations above and below diagonal, respectively.

Whereas all phenotypic correlations were low (ranging from 0.01 to 0.14), genetic correlations ranged from low (0.05) to near unity (0.99). The low phenotypic correlations indicate a weak relationship between the phenotypic measurements. The population in this study comprised of various genotypes with differing growth patterns at various ages (Magothe *et al.*, 2010). This may have resulted to low relationships between body weight measurements at various ages. Both phenotypic and genetic correlations between EW and BW2, BW4 and BW6 were negative. This may be due to the confounding effects of maternal influences on EW as indicated earlier. In addition, fitting BW0 as a covariate for juvenile weights appears to have indirectly accounted for some maternal effects. Therefore, the genetic correlations between EW and juvenile body weights in this study may be indicating correlations between EW maternal effects and juvenile body weights direct additive effects. Comparable negative genetic correlations between maternal and direct additive genetic effects in chickens have been reported (Norris and Ngambi, 2006). The genetic correlations between body weights at various ages were all positive and decreased with age. The reduction in genetic correlations with age is explained by gene interaction effects being higher in traits close to each other than in traits further apart.

## CONCLUSION

Juvenile, grower and mature-stage body weights of IC in Kenya can be improved through selection. The moderate heritability coefficient of BW12 and high genetic correlations with both juvenile and mature body weights suggests this to be a possible selection point. However, since one of the positive attributes of IC is their adaptation to harsh environmental conditions, it may also be important to consider fitness traits in a breeding programme for their improvement.

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# ANALYSIS OF ADAPTIVE TRAITS AND ANIMAL SURVIVAL AS A CLIMATE CHANGE ADAPTATION STRATEGY IN EXTENSIVE LIVESTOCK PRODUCTION SYSTEMS

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## ABSTRACT

The harsh effect of climate change (CC) will have maximum impact on vulnerable pastoral communities engaged in extensive livestock production systems in the dry-lands. Questions arise concerning options and strategies for reducing vulnerability and building resilience among these communities. The design of intervention measures for CC adaptation for these communities, to be appropriate, has to be hinged on comprehensive knowledge of the overall structure and dynamics of these production systems, including key information about indigenous breeding strategies, animal adaptation and management in climate-sensitive dry-lands. This paper discusses some crucial preliminary steps as part of a conceptual framework for the design of breeding strategies for climate change adaptation in such environments. The approach involves a participatory action process involving herdsmen as project partners. Data capture involves the use of structured questionnaires complemented with focus-group discussion and key-informant interviews. Pertinent information from pastoralists include listing and ranking of key traits (e.g. qualitative, morphological and fitness) in relation to animal adaptation to highly unpredictable environments, climate impact and their effect on herd dynamics, vulnerability and adaptability ranking of livestock species to CC impact, livestock adaptive traits, indigenous practices in stock selection. Other records include proxy-indicator variables for animal adaptive traits, progeny histories, complemented with production environment descriptors. Statistical methods for the analysis of herders' responses, as well as data on animal morphology and performance-related characteristics (e.g. adaptive, fitness and functional traits) are discussed. Inferences generated will provide crucial information needed for the design of breeding strategies for animal adaptation to marginal lands in extensive livestock production systems.

**Keywords:** *Adaptive traits, climate change, low-input systems, dry-lands*

## INTRODUCTION

Globally, climate change (CC) represents a critical challenge to humanity in the 21<sup>st</sup> century. Reports have indicated that developing countries are more vulnerable to the effects of CC due to their high reliance on natural resources, very limited capacity to adapt institutionally and financially, and high poverty levels (Thornton *et al.*, 2006). According to Drucker *et al.* (2007), the harsh effects of CC are more likely to be felt in extensive livestock production systems, and consequently, questions arise regarding options and strategies for CC adaptation by pastoral communities whose livelihoods depend on climate-sensitive resources. Intervention measures for CC adaptation must, by necessity, contribute towards building adaptive capacity and resilience to climate oscillations in the short term and climate change in the long term.

In the face of climate challenges, adaptation of different livestock species to tropical conditions becomes highly imperative. A report by the FAO's CGRFA (CGRFA, 2009) observed that the management of animals under natural selection by pastoralists in marginal areas plays an essential role in their adaptation and fitness in such environments. Sansthan and Köhler-Rollefson (2005) reported that indigenous livestock management practices through social and rational breeding mechanisms among pastoral communities in India have contributed to breed adaptation to harsh environments. These authors noted that pastoral communities have clear-

cut breeding objectives which are often multi-faceted, and include the animal's ability to survive in harsh environments. Similarly, Lanari *et al.* (2005) reported that directional selection practices by herdsmen in Patagonia (Argentina) were the main factor in adaptation and micro-evolution of Criollo goat populations in their native environments.

From the foregoing, a clear understanding of indigenous practices and processes among pastoralists that have contributed to animal adaptation and survival in harsh environments are essential for the design of intervention strategies for adaptation to climate oscillations in such regions. According to Hoffmann and Scherf (2006), hard data are scarce and there is urgent need for more research in particular, about the genetic and functional mechanisms of adaptive traits.

Therefore, the objective of this paper is to outline a framework for getting the perspective of herders on animal characteristics related to adaptation to harsh environments, as well as the recording and evaluation of animal morphological, qualitative and functional traits that are related to animal adaptation and survival in the dry-lands.

## **METHODOLOGY**

### ***Research Locations***

By necessity, studies on climate change adaptation and livestock production are conducted in multiple, remote and dispersed locations in the dry-lands, where extreme climate oscillations exist. Some salient features of such locations could include: accessibility and pristine -ness (not over-researched). The full cooperation and participation of local communities from project inception is crucial for project success, while the adoption of the principle of 'prior informed consent' is necessary (Dossa *et al.*, 2009). This principle states that: (i) target communities are involved as equal partners, (ii) research objectives are explained as exhaustively as possible, (iii) the views and concerns of herders are accommodated in the overall research plan, (iv) research outcomes are shared with community members on a feedback basis.

### ***Research Methods***

Embrace a participatory approach, following the guidelines presented by FAO/WAAP (2008). These guidelines indicate detailed recording of production environment descriptors, including geographic location, and a full description of the 'management' and 'natural' environments where animal are raised. For traditional communities in pastoral systems, participatory research methods (Waters-Bayer and Bayer, 1994; Sansthan and Köhler-Rollefson, 2005; Scherf and Tixier-Boichard, 2009) are used to generate data on breeding objectives, breed and trait preferences, production system constraints, and the multitude of functions and services that breeds provide for their keepers.

*Data collection:* involves participatory surveys methods, complemented with focus-group discussions. Due to occasional biases by questionnaire respondents, some extra complementary procedures to cross-check and validate findings include: key-informant interviews and reporting-back sessions with respondent communities (Scherf and Tixier-Boichard, 2009). For the recording of traits related to animal adaptation to extreme environments, data collection largely follows the guidelines presented by FAO/WAAP (2008) and covers the following: General information: herd sizes, dynamics, ownership patterns, including the combination of livestock species kept, owned, shared and leased, and their distribution by age classes and physiological status; relative importance of different livestock species (through a ranking process); response strategies to climate variability and extremes; climate oscillations and animal performance; relative vulnerability/adaptability ranking of the different livestock species to climate oscillations (e.g. droughts and flooding); strategies for coping with droughts

(e.g. herd migration, destocking, species substitution, etc); novel animal management techniques in marginal lands. Adaptive traits: include all characteristics of livestock relevant to adaptation to harsh environments, breeding practices under climatic extremes (including a list of priority traits included in the selection criteria); indigenous knowledge in stock selection; records of proxy-indicator variables for animal adaptation; traditional breed characteristics in relation to survival in harsh environments, progeny history of dams (recall method), etc. Qualitative traits, including animal coat colour and texture, possession of beard, wattles, horns, super-numerary teats, etc; Animal morphology (e.g. body length, height at withers and rump, chest and abdominal girths, etc), and rectal temperatures at measured across seasons. Meteorological data (including temperature, relative humidity, rainfall patterns, etc) in the production environment, etc.

*Data analyses*: (a) Herders' responses on traits related to animal adaptation are analyzed through the calculation of indices representing weighted average of all rankings for each adaptive trait (Rowland *et al.*, 2003). Characteristics with indices  $\geq 0.20$  are considered important (Mbuku, 2006) and could be relevant to animal survival in the dry-lands. (b) For Focus-group discussions and key-informant interviews, Kendall's Coefficient of Concordance is used to determine to what extent, the views among herdsman in a community, as well as between groups of communities, are in accord. (c) For progeny history data, repeatability of kid survival to weaning age is determined by the partitioning of variance components (Falconer and Mackay, 1996). (d) Data on animal morphology and performance-related characteristics (e.g. fitness, survival, growth, body condition score, etc) are analyzed using principal component, factor and cluster analyses (Vukasinovic *et al.*, 1997). (e) Trend in animal survival, performance and herd dynamics across seasons) can be modelled using STELLA (Systems Thinking Experimental Learning Laboratory, Isee Systems, 2009).

## DISCUSSION

This paper discusses a conceptual framework for the recording and evaluation of animal adaptive characteristics, as a critical step for the design of breeding strategies for adaptation to climate oscillations (and change) in extensive livestock production systems in dry-lands. Such regions were described by Krätli (2008) as the harshest and most unpredictable environments on the planet. According to Drucker *et al.* (2007), extensive livestock production systems are expected to be the most vulnerable to climate change impacts. This has extreme livelihood implications for the preponderant pastoral communities in the region. Thus, urgent intervention steps are needed to minimize the harsh effects of extreme and severe climate to safeguard the livelihoods of pastoral communities. Thus, a clear understanding of herders' perceptions of traits related to animal adaptation to extreme environments is seen as crucial for the design of breeding strategies for climate change adaptation for these communities. Such measures have to be holistic, covering all facets of livestock production under unpredictable environments, including indigenous and novel methods of animal management and stock selection and animal adaptation in marginal lands. A justification for these steps is provided by Hoffmann and Scherf (2006), who noted that hard data are scarce and more research is needed in particular, about the genetic and functional mechanisms of adaptive traits.

The methodological framework emphasizes all-inclusive participatory research methods in project design and implementation. Such participatory approaches are useful in generating data relating to animal adaptation, including breeding objectives, breed and trait preferences by herders, as well as the multitude of functions and services that breeds provide for their keepers (Scherf and Tixier-Boichard, 2009). The proposed framework also prioritizes recording of type, morphological and performance-related traits of livestock in their homestead, in marginal environments, based on the standards and guidelines established by FAO/WAAP (2008).

MacManus *et al.* (2008, cited in FAO/WAAP, 2008) also suggested the inclusion of possible proxy-indicator traits (including fertility in hot months, kid survival, longevity of breeding dams, etc) to evaluate adaptability of livestock breeds in dry-lands. Further, breed performance records are complemented with a description of the environment in which animal measurements and records were taken (Scherf and Tixier-Boichard, 2009). These authors noted that without such a description, the results are likely to be of little practical use.

Records of animal adaptive characteristics also cover progeny histories of dams in marginal environments. According to Waters-Bayer and Bayer (1994), exploring dam progeny history in different herds permits a comparison of animal loss/survival rates across herds in such environments. Analysis of progeny history records also provide inferences relating to the repeatability of kid survival and a measure of the environmental variance and can be used to predict future performance of dams (Falconer and Mackay, 1996). All these represent useful information for the selection of dams in harsh environments. Potential outcomes will include (i) development of simple methods to characterize adaptive traits in marginal lands (Hoffmann, 2008); (ii) fostering participatory planning and the development of breeding goals and the design of breeding structures for community-based adaptation to climate change; (iii) understand herders perspective on how extensive livestock production systems are tailored towards exploiting structural and environmental unpredictability (Krätli, 2008). Ultimately, this approach will contribute to the strengthening of livestock keepers' adaptive capacity and resilience (Hoffmann, 2008).

## CONCLUSION

The paper presents a conceptual framework for the recording and evaluation of adaptive traits and animal survival in dry lands. The framework establishes a process for data capture, analysis and drawing of inferences on vital information relating to herders' perspective on indigenous practices with respect to animal adaptation in highly unpredictable environments. Inferences will provide a strong basis for the design of breeding strategies for climate change adaptation in extensive livestock production systems in arid lands.

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# GROWTH PATTERNS AND THE RELATIONSHIPS BETWEEN BODY MASS AND LINEAR BODY PARTS MEASUREMENTS OF INDIGENOUS CHICKEN IN KENYA

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## ABSTRACT

The objectives of this study were to describe growth patterns of the whole body mass and selected body parts, determine their relationships and derive linear equations for predicting live body weight from linear body parts measurements of indigenous chickens. Bi-weekly body weights (BW), shank length (SL), drumstick length (DL), drumstick circumference (DC) and chest circumference (CC) were individually measured from hatch to 30 weeks of age. Growth patterns were modelled using the Gompertz-Laird function. Pearson's correlations and multiple linear regressions were used to determine the relationships and derive predictive equations, respectively. Whereas sexual dimorphism for both body weight and body parts were in favour of males, the differences for BW and CC were significant ( $P < 0.05$ ) from week 2 onwards while for SL, DL and DC were from week 4 onwards. The whole body mass specific growth had a characteristic sigmoid pattern for both males and females, while all the body parts displayed diminishing returns patterns. There were significantly ( $P < 0.001$ ) high and positive correlations between BW and SL, DL, DC and CC. Although inclusion of all the linear measurements yielded the best equation ( $R^2 = 0.999$  and  $C_p = 5.0$ ) for predicting BW from 2 weeks onwards, it was suggested that due to their ease of measurements, DL, DC and CC may be used to predict BW especially under field conditions.

## INTRODUCTION

Indigenous chicken are kept for various uses. Currently their economic and nutritional importance has surpassed cultural, spiritual and recreational uses (Magothe and Kahi, 2009). They are therefore a valuable tool for economic growth and food security. They are also reservoirs for genomes and major genes conferring direct or indirect effects on productive adaptability and could hence form the basis for genetic improvement and diversification to develop higher carcass and egg producing breeds adapted to local conditions (FAO, 2007). For this to be realized, however, body and major body parts' growth patterns and their relationships must be clearly understood.

Growth patterns and relationships between body mass and body parts are described by mathematical equations. The Gompertz-Laird function is cited as the model of choice for chicken growth because of its overall fit and the biological meaning of the model parameters (Goliomytis *et al.*, 2003). Correlation and regression functions are used to describe relationships between variables. Regression functions have been used to derive equations for predicting body weights from linear body measurements in chickens and ducks (Guéye *et al.*, 1998; Téguia *et al.*, 2008). This study aimed at describing growth patterns of indigenous chickens' whole body mass and selected body parts, determine their relationships and derive linear equations for predicting live body weight at various ages.

## **MATERIALS AND METHODS**

### ***Data collection***

The study was conducted at the National Animal Husbandry Research Centre, Naivasha, Kenya. Thirty three cocks were randomly sampled from an indigenous chicken flock, each allocated between 5 and 10 hens and housed together in deep litter pens. Each collected egg was weighed (EW) and labelled before incubation. After the 2<sup>nd</sup> candling on the 18<sup>th</sup> day of incubation each egg was placed into an individual compartment for hatching. Chicks were wing-tagged at hatch, brooded in electric brooders and reared in deep litter pens. Genotype and sex were determined at 6 and 14 weeks of age, respectively. Standard commercial feeds and clean water were supplied *ad libitum*.

At hatch and bi-weekly up to 30 weeks of age, each bird was weighed (BW) and its shank length (SL), drumstick length (DL), drumstick circumference (DC) and chest circumference (CC) measured using an ordinary measuring tape. For ease of measurement, SL was taken from the base of the hallux (digit 1) to the hock joint, DL from the hock to the knee joint, DC around the widest part near the knee joint and CC under the wings anterior to the legs at the edge of the sternum. A total of 511 birds with records up to 30 weeks of age were available for analysis.

### ***Statistical analyses***

All analyses were performed using SAS procedures (SAS, 2002). In the analysis of variance for each measurement, the fixed effects of hatch, genotype and sex were fitted in each linear model. For measurements at hatch, EW was fitted as a covariate while for measurements up to 10 weeks of age, body weight at hatch (BW0) was fitted as a covariate.

Using non-linear procedures, the least squares means from the analysis of variance were fitted into the Gompertz-Laird function to model growth parameters. The modelled measurements were plotted against age to describe growth patterns.

Relationships were determined by Pearson's correlations and equations derived by linear regressions.

## **RESULTS AND DISCUSSION**

The least squares means of observed measurements are presented in Table 1. At hatch, all measurements were not significantly different ( $P \geq 0.05$ ) between sexes. Sexual dimorphism for BW and CC began from week 2 onwards, while for SL, DL and DC began from week 4 onwards. On average, males were about 13% heavier, had about 7% longer shanks, 5% wider and 6% longer drumsticks and 5% wider chests than females. Lack of body weight sexual dimorphism at hatch agrees with the findings of Mekki *et al.*, (2005). However, sexual dimorphisms for BW at hatch, CC at 3 weeks and SL at 6 weeks have been reported in broilers (Ajayi and Ejiofor, 2009). The start of CC sexual dimorphism at week 2 could possibly be due to the relatively large contribution to BW by CC consisting of bones, muscles and viscera. Superiority of males could be as a result of hormonal differences and their ability to dominate while feeding resulting in faster bone and muscle growth. Rearing males than females would therefore be expected to be more profitable to small scale commercial producers.

The growth patterns are presented in Figure 1. The whole body mass for both males and females displayed characteristic sigmoid patterns. The maximum growth rate for both males and females whole body mass was at week 13 of age whereby males and females were 824.9 and 698.7 grams, respectively. In contrast, the linear measurements displayed diminishing returns growth patterns with rapid initial growth that reduced towards maturity. Similar



patterns of growth for shank length, comb length, keel length and body circumference have been reported in broilers (Romero-Sanchez *et al.*, 2007; Ajayi and Ejiofor, 2009). Whereas SL for both males and females reached maximum growth rate at week 4 of age, CC for both males and females reached maximum growth at week 3. However, both DL and DC measurements for males reached maximum growth at week 4 and for females at week 3 of age. Although comparative studies for indigenous chickens are scarce in literature, the SL and CC in this study were shorter and narrower, respectively, at week 3 of age than reported for broilers (Ajayi and Ejiofor, 2009).

**Table 1: Least squares means (LSM±se) of observed body weights and linear measurements**

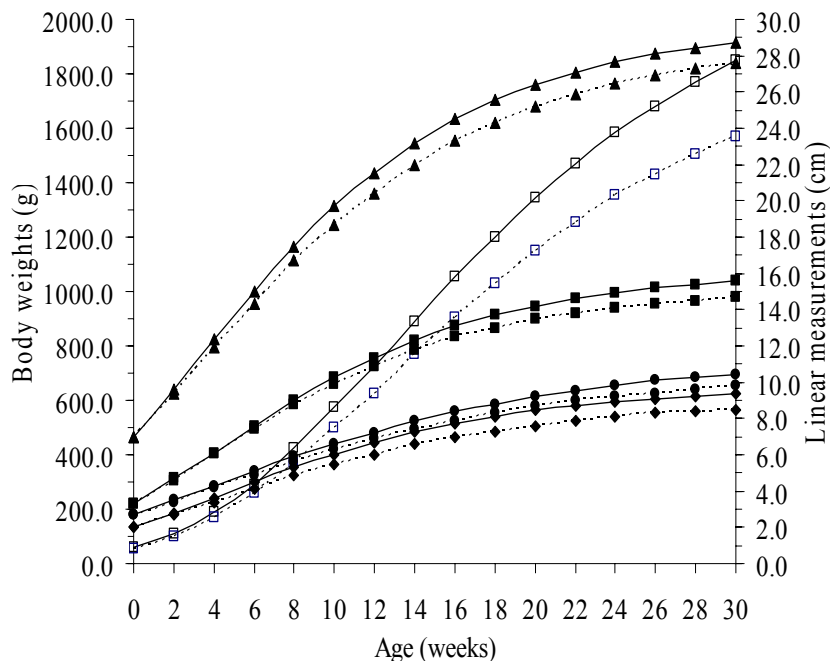
Age (weeks)	Sex <sup>1</sup>	Measurements <sup>2</sup>				
		BW (g)	SL (cm)	DL (cm)	DC (cm)	CC (cm)
0	M	33.0±0.18 <sup>a</sup>	1.9±0.01 <sup>a</sup>	3.2±0.02 <sup>a</sup>	2.4±0.02 <sup>a</sup>	6.4±0.02 <sup>a</sup>
	F	32.8±0.15 <sup>a</sup>	1.9±0.01 <sup>a</sup>	3.2±0.02 <sup>a</sup>	2.4±0.02 <sup>a</sup>	6.4±0.02 <sup>a</sup>
	M/F	32.7±0.13	1.9±0.01	3.2±0.01	2.3±0.01	6.4±0.01
2	M	78.1±1.10 <sup>a</sup>	2.6±0.02 <sup>a</sup>	4.4±0.03 <sup>a</sup>	3.2±0.02 <sup>a</sup>	9.2±0.05 <sup>a</sup>
	F	74.6±0.96 <sup>b</sup>	2.6±0.02 <sup>a</sup>	4.4±0.02 <sup>a</sup>	3.2±0.02 <sup>a</sup>	9.1±0.04 <sup>b</sup>
	M/F	77.9±0.79	2.6±0.01	4.4±0.01	3.2±0.01	9.1±0.03
6	M	319.5±5.09 <sup>a</sup>	4.6±0.04 <sup>a</sup>	7.9±0.06 <sup>a</sup>	5.6±0.05 <sup>a</sup>	15.5±0.10 <sup>a</sup>
	F	288.0±4.41 <sup>b</sup>	4.4±0.03 <sup>b</sup>	7.6±0.05 <sup>b</sup>	5.4±0.04 <sup>b</sup>	15.0±0.09 <sup>b</sup>
	M/F	309.5±2.61	4.5±0.02	7.8±0.03	5.4±0.02	15.2±0.05
12	M	725.6±10.87 <sup>a</sup>	6.4±0.05 <sup>a</sup>	11.1±0.08 <sup>a</sup>	7.4±0.06 <sup>a</sup>	21.5±0.16 <sup>a</sup>
	F	616.9±9.43 <sup>b</sup>	6.0±0.04 <sup>b</sup>	10.5±0.07 <sup>b</sup>	7.0±0.06 <sup>b</sup>	20.5±0.14 <sup>b</sup>
	M/F	668.8±6.11	6.1±0.03	10.9±0.05	7.1±0.04	21.0±0.09
20	M	1367.6±20.41 <sup>a</sup>	8.6±0.07 <sup>a</sup>	14.4±0.12 <sup>a</sup>	9.2±0.09 <sup>a</sup>	26.4±0.22 <sup>a</sup>
	F	1207.3±17.71 <sup>b</sup>	7.9±0.06 <sup>b</sup>	13.6±0.10 <sup>b</sup>	8.9±0.07 <sup>b</sup>	25.1±0.19 <sup>b</sup>
	M/F	1330.2±12.26	8.2±0.04	14.0±0.07	9.1±0.04	25.6±0.12
30	M	1812.6±27.31 <sup>a</sup>	9.1±0.08 <sup>a</sup>	15.4±0.13 <sup>a</sup>	10.8±0.10 <sup>a</sup>	29.2±0.23 <sup>a</sup>
	F	1608.2±23.70 <sup>b</sup>	8.5±0.07 <sup>b</sup>	14.4±0.12 <sup>b</sup>	10.2±0.09 <sup>b</sup>	27.9±0.21 <sup>b</sup>
	M/F	1741.0±14.49	8.7±0.04	14.9±0.08	10.6±0.06	28.4±0.15

<sup>1</sup>M = males; F = females; M/F = both males and females.

<sup>2</sup>BW = body weight; SL = shank length; DL = drumstick length; DC = drumstick circumference; CC = chest circumference.

<sup>ab</sup> = within a column and for the same age, means with the same subscript are not significantly different ( $P \geq 0.05$ ).

The correlations between BW and each linear measurement were high, positive and highly significant for both males and females. The correlations within linear measurements were also high, positive and highly significant. For each pair of measurements, the correlation in males was higher than in females. High correlations between body weights and various linear measurements have been reported in chickens and ducks, and could be good indicators of carcass characteristics and yields (Guéye *et al.*, 1998; Yang *et al.*, 2006; Téguia *et al.*, 2008). These measurements may therefore be used to develop indigenous chicken standards and criteria for selecting superior individuals especially under field conditions.



**Fig. 1: Growth patterns of whole body mass (□), shank length (◆), drumstick length (■), drumstick circumference (●) and chest circumference (▲) of males (solid lines) and females (dotted lines).**

The regression equations for predicting body weights of both males and females are presented in Table 2. The coefficients of determination ( $R^2$ ) for all models were high (0.959 to 0.999) indicating that any of the models could predict BW of both males and females with varying accuracy. All the models were however not good predictors of BW at hatch. Furthermore, when based on Mallows' Cp statistic, the three and four variable models were better predictors of BW from week 2 of age and above. In the absence of weighing scales, these models could be used to estimate BW of indigenous chicken. The possible use of more than one linear measurement in predicting BW of chickens and ducks under field conditions have been reported (Guéye *et al.*, 1998; Raji *et al.*, 2009). Due to the ease of measuring DL, DC and CC it is suggested that these variables may be used to predict BW of indigenous chicken especially under field conditions.

**Table 2: Regression equations for predicting body weights of both males and females**

Variables	Regression equation	$R^2$	C(p)
DC	$BW = -727.7 + 217.6 \times DC$	0.959	322.2
DC, CC	$BW = -533.5 + 593.7 \times DC - 143.0 \times CC$	0.994	36.4
DL, DC, CC	$BW = -238.3 + 610.1 \times DL + 561.4 \times DC - 469.1 \times CC$	0.998	9.6
SL, DL, DC, CC	$BW = -224.7 + 415.6 \times SL + 405.6 \times DL + 431.9 \times DC - 443.0 \times CC$	0.999	5.0

## ACKNOWLEDGEMENT

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# **Policy, Marketing & Socioeconomic Issues**

# **MILK QUALITY CONTROL AND REGULATION IN DAIRY PRODUCTION: A CASE OF DAIRY PRODUCERS IN KIKUYU DIVISION, KABETE DISTRICT, CENTRAL PROVINCE, KENYA**

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## **ABSTRACT**

Regulation in the dairy industry targets the small scale producers and milk traders with the aim of ensuring that they meet requirements for milk quality control. This paper presents results from a study carried out in Kikuyu Division, Central Province of Kenya that assessed the challenges and the benefits accrued to on farm clean milk production and the level to which farmers were aware of regulations governing the dairy sector. The farmers were producers of milk only and possessed no milk bar licenses, public health licenses, business producer licenses nor single business licenses. They had little knowledge of laws regulating dairying with 40% identifying Kenya Dairy Board (KDB) as law enforcers, 20% as law enforcers and educators while 40% had no knowledge of their mandate. Farmers adopt hygienic milk production and handling if the practices are cost effective and simple to understand. Those who carried out milk production, disease control and facility hygiene were 55% while 21.1% tested for mastitis and another 22.9% able to keep the zero grazing units clean. Information on milk quality control was acquired from extension workers from the Ministry of Livestock Development by 52% of the producers, 36% from the Veterinary Department and 12% through seminars. There is need to develop pro-poor interventions, strengthen infrastructure, farmer groups and security so as to maximize the production of quality and quantity of milk.

**Keywords:** *milk quality control, regulation*

## **INTRODUCTION**

Kenya is the leading milk producer in East Africa, producing an estimated 3.2 billion litres per year by approximately 600,000 small holder farmers producing an estimated 75% of Kenya's milk supply.(Mwambia, 2006).Commercialization of the dairy industry is only possible if the quality of milk and milk products is improved.Wahome, (2006) reported that dairying has a huge potential of turning around the economy in Kenya especially in the rural areas but is faced with hurdles particularly poor quality of milk and hygiene along the supply chain. In Kenya the quality of both formal and informally marketed milk in Kenya does not meet the Kenyan national quality standards and bacterial growth occurs before farmers sell their milk.(Mwangi *et al.*, 2000).The main role of the Government of Kenya is to create a conducive environment for private sector investment in milk production, processing, marketing and delivery of key support services. This function is carried out by KDB in collaboration with the Ministry of Livestock Development where their mandate is to improve producer price of milk, lower consumer price and increase milk intake by processors. According to Owango *et al.*, (1998), the sale of raw milk in urban areas was considered illegal and those found retailing milk in such areas were harassed. Only Kenya Cooperative Creameries (KCC) was licensed by Kenya Dairy Board (KDB) to retail milk to scheduled urban areas, however sale of raw milk was tolerated in other areas including retail sales by district dairy farmers cooperatives. However, over time the regulatory environment has changed with the informal milk market now licensed and the milk traders now paying KDB a cess fee of 20 cents per litre of milk produced on behalf of the producers. The quality of milk policy is such that the roles of KDB

are to be streamlined, self regulation enhanced and a transition towards a stakeholder managed institution.(MoLDF , Draft Sessional paper in dairy development 2007).

## **METHODOLOGY**

A total of 85 dairy producers were sampled from Kikuyu Division, Kabete District in Central Province, Kenya. The sample was selected in stages using purposive and stratified sampling. Farmers were drawn purposively from market outlets situated in three locations in the District. Samples were drawn from each stratum by simple random sampling. Sampling size was 10% representative of the target population of 850 dairy producers.

An interview guide was used to assist in the discussion with probing and clarification being made. The interviewers included officials from the Ministry of Livestock Development, KDB, cooperatives, self help groups and a milk traders group. An observation checklist was used to record events taking place on the farm from which general notes were made. The guidelines in the checklist generated information required such as the level of milk hygiene at farm level, milk handling practices, milking procedures and type of milking equipment in use.

### ***Data analysis***

Quantitative data was collected by use of questionnaires. These were checked to ensure that the questions were answered correctly. The open ended questions were summarized into meaningful variables and given variable values. Classification of variables was also done where this was required. This was then analyzed using Statistical Package for Social Scientists (SPSS) computer software. The data was presented in tables.

Qualitative data generated from key informants was analyzed by noting themes that emerged from their opinions. It also involved classifying information and organizing data according to research questions from which conclusions were drawn. The observations recorded in the field by the use of an observation checklist also enriched the quantitative data collected. These gave a reflection of similarities and differences in related information collected and offered a base for comparing data collected. This was used to better evaluate the extent to which findings were trusted and inferences made to them.

## **RESULTS AND DISCUSSIONS**

### ***Milk quality control by dairy producers***

Dairy production is a beneficial income generating activity in the area where there are established formal and informal markets in which milk quality control is emphasized. In the area the farmers breed kept good breeds of dairy cows that were high milk producers. Findings show that 55% practiced clean milk production, disease control and facility hygiene. Milkmen maintained personal hygiene and majority cleaned udder before milking. It was noted that most used aluminum containers for milking although plastic containers were also used. These containers were washed and dried in the sun. A relatively low percentage (22.1%) of respondents test for mastitis so as to control contamination of milk. Contamination of milk resulting from the farmers' lack of knowledge and poor hygiene of zero grazing units was high with only 22.9% able to keep the units clean. Units observed were dirty, this was attributed to lack of capital and labour for maintenance of concrete floors .The study established that producers get to know about milk quality control from government extension workers (52%), 36% through the veterinary officers and only 12% through seminars. Milk sold to the cooperatives was safe for consumption since it was free from antibiotic residues. A total of 83.5% of the participants observed withdrawal period of 3 days for those animals treated with antibiotics. In addition milk from animals that had calved down was not delivered to the cooperatives with 90.3% of the participants doing their deliveries after 7 days to avoid

contamination of milk with colostrums. Moreover those that deliver milk with colostrums have their milk tested, rejected and penalized by cooperatives. The majority of the farmers were in agreement that good quality milk stayed longer before spoilage and that it assured them of good markets since such milk was never rejected and therefore always paid for.

### ***Milk marketing and income***

The study established that most farmers sell their milk to the dairy cooperatives. However the same farmers sell some milk to other outlets like to milk hawkers in an attempt to secure a higher price for their produce. This explained the variation in price per litre of milk of between Kenyan shillings (KES) 29 – 40 with 67.1% farmers having sold their milk at a price of KES. 27 per litre. The findings also showed that most farmers retained on average of 4 litres of milk per day for feeding the calves and home consumption. About 12.9% of the respondents obtained on average KES. 20, 000 per month from sale of milk. Dairying is an income generating activity in which savings can be improved through proper feed management. The findings showed that milk was lost through accidental spillage rather than by spoilage with 77.6% losing 1 litre of milk per day, during milking while the cooperatives lose 300 litres per month through spillage during transportation. There were indications that milk spoilage occurs in the rainy season when conditions are conducive for bacterial growth.

### ***Regulation***

The Study found out that the dairy producers possessed no licenses being producers of raw milk only they did no venture into value addition that would necessitate that they acquire permanent business premises with white walls, water and electricity and therefore qualify for a public health license. Those handling 500-3000 litres of milk were classified as mini dairies and pay KDB Kshs 6000 for licensing. In addition KDB required a primary producer license of Kshs2500 from those who sell milk directly to consumers at farm-level and a cess fee of 20 cents per litre of milk produced. The farmers were not aware of regulations governing the dairy industry even if they are abiding to the laws through the cooperative societies. Some 40% of the farmers were aware that the KDB are law enforcers only while 40% they are educators and law enforcers while 20% have no knowledge of their mandate. This correlates with findings that farmers get to know about milk quality control measures through seminars. In spite of the fact that farmers abide by the dairy regulation through the cooperatives, they are not informed about them because they are at primary level of milk production. The farmers are aware that KDB is the regulatory authority in the dairy sector and have come in contact with them during seminars as educators.

## **RECOMMENDATION**

In order to improve milk quality from smallholder farms there is need to avail new designs of for small amounts of milk, affordable, stable and well suited for public mode of transport. Strengthening farmer and stakeholder groups will empower them to lobby for services such as credit, education, milk cooling facilities, roads and piped water all of which will improve the quantity and quality of product milk.

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# SILAGE FERMENTATION PROCESSES, MANIPULATION AND IMPLICATIONS IN THE DAIRY SECTOR

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## ABSTRACT

Livestock are an important part of the farming system in developing countries, particularly for commercial and subsistence farmers. There is good potential to improve food security and family incomes by improving livestock production. This applies particularly to milk production by rural and peri-urban farmers. However, shortage of affordable feeds of adequate quality and quantity, particularly during the dry season is a major obstacle to improving production. Fodder conservation as hay or silage offers an option in which feeds that are seasonally abundant can be preserved for later feeding during periods of feed shortage. In Kenya, Napier grass (*Pennisetum purpureum*) is highly preferred in the smallholder dairy farms due to its high yields per unit area. This grass is best preserved as silage due to its thick stems, even in countries with generally suitable weather conditions for hay making such as Kenya. Although a massive technology promotion was done in some parts of Kenya in the intensive and semi-intensive farming systems, high dry matter losses, an indication of poor fermentation of silages have been reported in the dairy farms of Kenya. Animal and human health problems and deaths associated with silage-fed cattle related to undesirable microorganisms such as moulds, *listeria* and clostridia and their undesirable chemicals such as mycotoxins and nitrogenous compounds have been reported in other countries. Metabolic disorders such as rumen acidosis, lameness, displaced abomasums, ketosis, impaired fertility, hypomagnesaemia and other mineral deficiencies have also been reported. It is thus essential to have a good microbial fermentation process to produce high quality silage. This paper reviews the current knowledge on silage microbiology with the aim to aid with the choice of the best ensiling strategy to produce high quality silage, various ways of controlling silage quality and risks associated with feeding animals with poorly fermented silage diets.

**Key words:** *Silage microbiology, Silage quality, Dairy products, Human pathogenesis .*

## INTRODUCTION.

Fresh forage crops such as maize, grasses, legumes, wheat and lucerne can be preserved by ensiling. It is essential to have a good microbial fermentation process to produce high quality silage. A good fermentation process is not only dependent on the type and quality of the forage crop, but also on the harvesting and ensiling techniques. According to Michael *et al.*, 1995, five bacterial species have been implicated in human disease outbreaks and deaths traced to dairy products. In this paper issues of the current knowledge on general silage microbiology, biochemical changes during ensilage and pathogenesis associated with silage feeding are reviewed with the aim to aid with the choice of the best ensiling strategy to produce high quality silage.

### *The ensiling process*

Ensiling is a forage preservation method based on a spontaneous lactic acid fermentation under anaerobic conditions. The epiphytic lactic acid bacteria ferment the water-soluble carbohydrates (WSC) in the crop to lactic acid, and to a lesser extent to acetic acid. Due to the production of these acids the pH of the ensiled material decreases and spoilage microorganisms are inhibited. Once the fresh material has been stacked and covered to exclude air, the ensiling process can be divided into 4 stages (Martin, 2005)

**Phase 1, aerobic phase:** This phase normally takes a few hours in which the atmospheric oxygen present between the plant particles is reduced, due to the respiration of the plant material and aerobic and facultative aerobic microorganisms such as yeasts and enterobacteria. Furthermore, plant enzymes such as proteases and carbohydrases are active during this phase, provided the pH is still within the normal range for fresh forage juice (pH 6.5-6.0).

**Phase 2, fermentation phase:** This phase starts when the silage becomes anaerobic, and it continues for several days to several weeks, depending on the properties of the ensiled forage crop and the ensiling conditions. If the fermentation proceeds successfully lactic acid bacteria develop, and become the predominant population during this phase. Due to the production of lactic and other acids the pH decreases to 3.8-5.0.

**Phase 3, stable phase:** As long as air is prevented from entering the silo, relatively little fermentation occurs. Most microorganisms of phase 2 slowly decrease in numbers. Some acid tolerant microorganisms survive this period in an almost inactive state, others such as clostridia and bacilli survive as spores. Only some acid tolerant proteases and carbohydrases and some specialized microorganisms, such as *Lactobacillus buchneri* continue to be active at a low level.

**Phase 4, feed-out phase or aerobic spoilage phase:** This phase starts as soon as the silage gets exposed to air. During feed-out this is unavoidable, but it can already start earlier due to damage of the silage covering (e.g. by rodents or birds). The process of spoilage can be divided into two stages. The onset of deterioration is due to the degradation of preserving organic acids by yeasts and occasionally acetic acid bacteria. This will cause a rise in pH, and thus the second spoilage stage is started, which is associated with increasing temperature, and activity of spoilage microorganisms such as bacilli. The last stage also includes the activity of many other (facultative) aerobic microorganisms such as moulds and enterobacteria. Aerobic spoilage occurs in almost all silages that are opened and exposed to air. However the rate of spoilage is highly dependent on the numbers and activity of the spoilage organisms in the silage. Spoilage losses of 1.5-4.5 % dry matter loss/day can be observed in affected areas. (Honig and Woolford 1980).

To avoid failures it is important to control and optimize each phase of the ensiling process. In phase 1 good silo filling techniques will help to minimize the amount of oxygen present between the plant particles in the silo. Good harvesting techniques combined with good silo filling techniques will thus minimize WSC losses through aerobic respiration in the field and in the silo, and in turn will leave more WSC available for lactic acid fermentation in phase 2. During phases 2 and 3 the farmer cannot actively control the ensiling process. Methods to optimize phases 2 and 3 are therefore based on the use of silage additives that are already applied at the time of ensiling. Phase 4 will start as soon as oxygen is available. To minimize spoilage losses during storage an airtight silo is required, and any damage to the silo covering should be repaired as soon as possible. During feed-out spoilage by air ingress can be minimized by a sufficiently high feed-out rate. In addition, at the time of ensiling silage additives can be applied that are able to decrease spoilage losses.

### ***The silage microflora***

The silage microflora plays a key role in the successful outcome of the conservation process. The flora can basically be divided into two groups namely the desirable and the undesirable microorganisms. The desirable microorganisms are the lactic acid bacteria. The undesirable ones are the organisms that can cause anaerobic spoilage (e.g. clostridia and enterobacteria) or aerobic spoilage (e.g. yeasts, bacilli, listeria and moulds). Many of these spoilage organisms do

not only decrease the feed value of the silage, but also have a detrimental effect on animal health and/or milk quality (e.g. listeria, clostridia, moulds and bacilli).

### ***Desirable microorganisms***

**Lactic acid bacteria. (LAB):** Lactic acid bacteria belong to the epiphytic microflora of plant material. Often the population of LAB increases substantially between harvesting and ensiling. Crop characteristics like sugar content, dry matter content, and sugar composition, combined with lactic acid bacterial properties such as acid and osmotolerance, and substrate utilization will decisively influence the competitiveness of the lactic acid bacterial flora during silage fermentation (McDonald *et al.*, 1991). Lactic acid bacteria that are regularly associated with silage are members of the genera *Lactobacillus*, *Pediococcus*, *Leuconostoc*, *Enterococcus*, *Lactococcus* and *Streptococcus*. The majority of the silage lactic acid bacteria are mesophilic, i.e. they can grow at temperatures between 5 and 50°C, with an optimum between 25 and 40°C. They are able to decrease the silage pH to pH 4-5, depending on the species and the type of forage crop. All lactic acid bacteria are facultative aerobes, but some have a preference for anaerobic conditions (Hammes *et al.*, 1992).

### ***Undesirable microorganisms***

**Yeasts:** Yeasts are eucaryotic, facultative anaerobic, heterotrophic microorganisms. In silages anaerobic as well as aerobic yeast activity is considered undesirable. Under anaerobic silage conditions yeasts ferment sugars to ethanol and CO<sub>2</sub> (McDonald *et al.*, 1991). This ethanol production in silage does not only decrease the amount of sugar available for lactic acid fermentation, but it can also have a negative effect on milk taste (Randby *et al.*, 1998). Under aerobic conditions many yeast species degrade the lactic acid to CO<sub>2</sub> and H<sub>2</sub>O. The degradation of lactic acid causes a rise in silage pH, which in turn triggers the growth of many other spoilage organisms (McDonald *et al.*, 1991).

Factors that affect the survival of yeasts during storage are the degree of anaerobiosis, and the concentrations of organic acids. The presence of oxygen enhances survival and growth of yeasts during storage (Donald *et al.*, 1995), whereas high levels of formic or acetic acid reduce survival during storage. Initial yeast activity appears to be enhanced in crops with a low initial pH (< 5), e.g. due to the addition of acid additives, and in crops with a high sugar content, e.g. potatoes, orange peels or sugar beets. These crops often result in silages high in ethanol and low in lactic acid (Driehuis and van Wakselaar, 1996). Some silage additives are developed to inhibit yeast activity (Table I).

**Enterobacteria:** Enterobacteria are facultatively anaerobic. Most silage enterobacteria are regarded to be non-pathogenic. Nevertheless, their growth in silage is undesirable because they compete with the lactic acid bacteria for the available sugars, and in addition they can degrade protein. This protein degradation does not only cause a reduction in feeding value, but also leads to the production of toxic compounds such as biogenic amines and branched fatty acids. Biogenic amines are known to have a negative effect on silage palatability (Woolford 1984; McDonald *et al.*, 1991) especially in animals that are not yet accustomed to the taste. Moreover, the ammonia formed through proteolysis increases the buffer capacity of the ensiled crop, thus counteracting a rapid decrease of silage pH. Another characteristic of enterobacteria is their capability to reduce nitrate (NO<sub>3</sub>) to nitrite (NO<sub>2</sub>) under silage conditions. In silage, nitrite can be degraded by enterobacteria to ammonia and nitrous oxide (N<sub>2</sub>O), but it can also be chemically degraded to NO and nitrate (Spoelstra 1987). With air NO is oxidized into a mixture of gaseous, yellow-brown nitrogen oxides (NO<sub>2</sub>, N<sub>2</sub>O<sub>3</sub>, N<sub>2</sub>O<sub>4</sub>). Gaseous NO and NO<sub>2</sub> have a damaging effect on lung tissue, and can cause a disease with pneumonia-like symptoms known as "silo filler's disease" (Woolford 1984). To prevent animals from getting in contact with gaseous nitrogen oxides they should not be housed in buildings adjoining silos during silo

filling or the first week of silage storage (O'Kiely *et al.*, 1999). Despite the above mentioned problems, a little nitrite reduction is considered positive for silage quality, because the formed nitrite and NO are very effective inhibitors of clostridia (Woods *et al.*, 1981).

Enterobacteria will not proliferate at low pH. Ensiling methods that induce a rapid and sufficient drop in silage pH will therefore help to decrease enterobacterial growth (McDonald *et al.*, 1991).

**Clostridia:** Clostridia are endospore-forming anaerobic bacteria. Many clostridia ferment carbohydrates as well as proteins, thus causing problems such as the reduction in feeding value and the production of biogenic amines, similarly as has been described for enterobacteria. In addition, clostridia in silage impair milk quality. This is due to the fact that clostridial spores can survive the passage through the alimentary tract of a dairy cow. Clostridial spores present in silage are transferred to milk, via feces and fecal contamination of the udder. The acid tolerant *Clostridium tyrobutyricum* is the most relevant species for the dairy industry. In addition to carbohydrate fermentation *C. tyrobutyricum* can degrade lactic acid to butyric acid, H<sub>2</sub> and CO<sub>2</sub> according to the following overall reaction:

**2 lactic acid --> 1 butyric acid + 2 H<sub>2</sub> + 2 CO<sub>2</sub>:** This butyric acid fermentation does not only counteract the lactic acid fermentation in silage and cheeses, but it also is responsible for a significant gas production, causing a cheese defect called "late blowing" in hard and semi-hard cheeses (Klijn *et al.*, 1995).

Some clostridia can cause serious health problems. An extremely toxic *Clostridium* sp. is *C. botulinum* which causes botulism, a deadly disease for cattle. However, *C. botulinum* has a limited acid tolerance, and does not grow in well-fermented silage.

A typical "clostridial silage" is characterized by a high butyric acid content of more than 5 g/kg dry matter, a high pH (over pH 5 in low dry matter silages), and a high ammonia and amine content (Spoelstra, 1987). Ensiling methods that cause a rapid and sufficient drop in silage pH will help to prevent the development of a "clostridial silage", because similar to enterobacteria, clostridia are inhibited at low pH. Additionally, clostridia are more susceptible to a low availability of water (i.e. a low water activity (a<sub>w</sub>) than lactic acid bacteria. For this reason decreasing the water activity value of a crop, e.g. by wilting to a higher dry matter content, can be a way of selectively inhibiting clostridial fermentation. Clostridia will also be inhibited by nitrite and NO or compounds that are degraded in silage to nitrite and NO (Spoelstra 1987).

**Acetic acid bacteria:** Acetic acid bacteria are obligate aerobic, acid-tolerant bacteria. Thus far all acetic acid bacteria that have been isolated from silage belong to the genus *Acetobacter* (Spoelstra *et al.*, 1988). The activity of *Acetobacter* ssp. in silage is undesirable because they can initiate aerobic deterioration, due to the fact that they are able to oxidize lactate and acetate to carbon dioxide and water. Generally, yeasts are the main initiators of aerobic spoilage, and acetic acid bacteria play only a minor role. However, for whole crop corn silages, it has been reported that acetic acid bacteria alone can initiate aerobic deterioration (Spoelstra *et al.*, 1987). On the other hand, selective inhibition of yeast also can increase proliferation of acetic acid bacteria in silage (Driehuis and van Wijkelaar 1996).

**Bacilli:** Bacilli, like clostridia are endospore-forming rod shaped bacteria. However, they can easily be distinguished from clostridia due to the fact that they are (facultative) aerobes, whereas all clostridia are obligate anaerobes (Claus and Berkeley, 1986). Facultative aerobic bacilli ferment a wide range of carbohydrates to compounds such as organic acids (e.g.,

acetate, lactate, and butyrate) or ethanol, 2,3-butanediol, and glycerol (Claus and Berkely 1986). Some specific *Bacillus* sp. are able to produce antifungal substances, and have been used to inhibit aerobic spoilage of silage (Moran *et al.*, 1993). Except for these specific strains, the proliferation of bacilli in silage is generally considered undesirable. Not only are bacilli less efficient lactic and acetic acid producers than lactic acid bacteria (McDonald *et al.*, 1991), but they can also enhance (later stages of) aerobic deterioration. High numbers of *Bacillus* spores in raw milk have been associated with high spore numbers in fresh cow feces (Waes 1987; Giffel *et al.*, 1995). Thus, bacillus spores are transferred from silage to milk via feces similar to clostridial spores. Psychrotrophic *B. cereus* spores are considered to be the most important spoilage organism of pasteurized milk (Giffel, 1997). High numbers of these (psychrotrophic) *B. cereus* spores have been isolated in silages (Giffel *et al.*, 1995). To decrease bacillus growth in silage, storage temperatures should not be too high and air ingress should be minimized. In addition, initial contamination of fresh plant material with soil or manure should be prevented (McDonald *et al.*, 1991).

**Molds:** Molds are eucaryotic microorganisms. Mold-infested silage is usually easily detected by the large filamentous structures and colored spores that many species produce. Molds develop in parts of the silage where (a trace of) oxygen is present. During storage, this is usually only in the surface layers of the silage, but during aerobic spoilage (phase 4) the whole silage can become moldy. Mold species that regularly have been isolated from silage belong to the genera *Penicillium*, *Fusarium*, *Aspergillus*, *Mucor*, *Byssoschlamys*, *Absidia*, *Arthrimum*, *Geotrichum*, *Monascus*, *Scopulariopsis* and *Trichoderma* (Woolford 1984; Frevel *et al.*, 1985). Molds do not only cause a reduction of feed value and palatability of the silage, but can also have a negative effect on human and animal health. Mold spores are associated with lung damage and allergenic reactions (May, 1993). Other health problems are associated with mycotoxins that can be produced by molds. Depending on the type and amounts of toxin present in the silages, health problems can range from minor digestive upsets, small fertility problems, and reduced immune function, to serious liver or kidney damage, and abortions. Some important mycotoxin producing mold species are *Aspergillus fumigatus*, *Penicillium roqueforti*, and *Byssoschlamys nivea*. Especially *P. roqueforti*, a species which is acid tolerant and can grow at low levels of oxygen and high levels of CO<sub>2</sub>, has been detected as the predominant species in different types of silages (Nout *et al.*, 1993). According to May, 1993, aflatoxin B1, a mycotoxin of *Aspergillus flavus*, is known to be transferred from animal feed to milk. Ensiling methods that minimize air ingress (e.g. good compaction and covering of the silo), and additives that prevent initiation of aerobic spoilage, will help to prevent or limit mold growth.

**Listeria:** Members of the genus *Listeria* are aerobic or facultatively anaerobic. Regarding silage quality the most important *Listeria* spp. is the facultative anaerobic *L. monocytogenes*, because this species is a pathogen to various animals and man. Especially animals with a suppressed immune system (e.g. pregnant females and neonates) are susceptible to *L. monocytogenes* infections (Frevel *et al.*, 1985). Silage contaminated with *L. monocytogenes* has been associated with fatal cases of listeriosis in sheep and goats (Wiedmann *et al.*, 1994). In addition, McDonald *et al.*, 1991 identified poor quality silage as one of the main sources of contamination of raw milk by *L. monocytogenes*. Growth and survival of *Listeria* in silage are determined by the degree of anaerobiosis, and the silage pH. *L. monocytogenes* can tolerate a low pH of 3.8-4.2 for long periods of time only if (small amounts) of oxygen are present. Under strictly anaerobic conditions it is rapidly killed at low pH (Donald *et al.*, 1995). Silages that have a higher chance of aerobic surface spoilage, such as trench and stack (above ground) silos, can be particularly liable to *Listeria* contamination. *L. monocytogenes* generally does not

develop in well fermented silages with a low pH. Thus far the most effective method to prevent growth of *L. monocytogenes* is to keep the silage anaerobic (McDonald *et al.*, 1991).

### **Silage additives**

Fermentation in the silo can be an uncontrolled process leading to less than optimal preservation of nutrients. Therefore, silage additives have been used to improve the ensiling process (better energy and DM recovery) with subsequent improvements in animal performance.

**Table 1: Categories of silage additives (Source: McDonald *et al.*, 1991).**

<b>Additive category</b>	<b>Selection of Active ingredients</b>	<b>Remarks</b>
Fermentation stimulants	Lactic acid bacteria Sugars (molasses) Enzymes	May impair aerobic stability
Fermentation inhibitors	Formic acid <sup>*</sup> Lactic acid <sup>*</sup> Mineral acids Nitrite salts Sulfite salts Sodium chloride	Formic acid <sup>*</sup> Lactic acid <sup>*</sup> Mineral acids Inhibition of clostridia
Aerobic deterioration inhibitors	Lactic acid bacteria Propionic acid <sup>*</sup> Benzoic acid <sup>*</sup> Sorbic acid <sup>*</sup>	
Nutrients	Urea Ammonia Minerals	Can improve aerobic stability Can improve aerobic stability
Absorbents	Dried sugar beet pulp Straw	

<sup>\*</sup>or corresponding salt

Between products of one category differences exist in product properties such as general effectiveness, suitability for certain crop type, and ease of handling and application. These factors, together with the price and availability, will determine what product will be the most adequate for a specific silage. A drawback of some of the chemical additives is that they can be corrosive to the equipment used, and/or can be dangerous to handle. The biological additives are non-corrosive and safe to handle, but they can be costly. Additionally, their effectiveness can be less reliable, since it is based on the activity of living organisms. Proper storage of these biological additives by the manufacturer, retailer and farmer is of vital importance. Despite these disadvantages, in developed countries such as Europe and USA, bacterial inoculants have become the most commonly used additives for corn, grasses and legumes that can be wilted to above 300 g DM/kg (Weinberg and Muck 1996).

In Kenya, the use of biological additives is not well documented. Molasses, a by-product of sugar industry is the commonly used silage additive. Current research findings have shown that (Effective microorganisms (EM), a recently introduced commercial product can be a potential biological silage additive in Kenya. However, there is no sufficient scientific information on its use in livestock production under the Kenyan conditions and thus more research is required on this product (Syomiti, 2009).

## **CONCLUSION AND RECOMMENDATIONS**

In order to achieve a successful ensiling of feeds, the following factors should be considered:

1. **Moisture content:** Ensiled material should contain more than 50% moisture so that it is easy to compress it tightly in order to get better compacting and to eliminate air.

However, excessive moisture more than 75% can be harmful leading to undesirable fermentation. Water can be added and/or wet and dry feeds can be mixed to get the desired moisture content.

2. **Length of chopping:** The finer the chopping, the better the compaction and therefore storage will be more successful due to the effective exclusion of air.
3. **The time it takes to fill a silo:** The rapid filling and sealing the silo is of high priority. Slow filling or delayed covering can easily increase the feed losses due to extended aerobic fermentation.
4. **Presence of enough easily fermentable energy (Naturally present or added):** The objective of silage fermentation is to achieve a stable low pH at which biological activity ceases. In this way preservation is obtained whilst minimizing nutrient losses and avoiding adverse changes in the chemical composition of the material. The final pH of the ensiled feed material depends largely on the carbohydrate contents in the original material. For this reason, protein-rich feeds with low content of energy are very difficult to ensile successfully and should be mixed with easily fermentable energy-rich products such molasses, maize germ, rejected bananas and root crops.

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# USE OF LOGISTIC REGRESSION WITH DUMMY VARIABLES FOR MODELING THE USE-NO USE OF TECHNOLOGY IN DAIRY FARMING IN FIVE DISTRICTS IN KENYA.

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## ABSTRACT

Logistic regression, being well suited for analyzing dichotomous outcome, has been increasingly applied in social science research. That potential expanded usage demands that researchers know what is expected when using the logistic regression technique. What tables should be included?, What assumptions tested?, What figures or charts should be expected? In this paper we seek to answer these questions with an illustration of logistic regression applied to a real data set. Results were evaluated and diagnosed in terms of the overall test of the model, interpretability and statistical significance of each predictor, goodness of fit statistics, predictive power, accuracy of prediction, and identification of potential outliers. Guidelines are offered for modeling strategies and reporting standards in logistic regression. Furthermore, many statistical packages can be employed to perform logistic regression. Their strengths and weakness can also be noted in terms of flexibility, accuracy, completeness and usefulness.

**Key Words:** *Logistic regression; goodness-of fit; Hosmer-Lemeshow test; deviance Pearson chi-square*

## INTRODUCTION

Logistic regression was first proposed in the 1970s as an alternative technique to overcome limitation of ordinary least squares (OLS) regression in handling dichotomous (binary) outcomes. It became available in statistical packages in the early 1980s. Logistic regression has been widely employed epidemiological research, where often the outcome variable is presence or absence of some disease state (Yarandi and Simpson, 1991). Meanwhile, the use of logistic regression continues to grow in social sciences Breslow, and Power,. 1978; Prentice, and Pyke, 1979) and educational research. Increasing volumes of literature written about logistic regression also contribute to the use of logistic regression in research (Allison, 2001; Pampel, 2000; Menard, 1995 and 2000; Christensen, 1997; Gould, 2000).

The tests of the regression parameter estimates are unreliable when linear regression is used with a binary dependent variable. An alternative distribution function that is very similar to the normal distribution is the logistic distribution function. Estimates of the parameters of the logistic response function are estimated with the method of maximum likelihood. Maximum likelihood estimates of the parameters in the logistic regression model are those parameter values that maximize the log-likelihood function. This method deals pretty well with the problems associated with the response being binary. For large samples under generally applicable conditions maximum likelihood estimators for logistic regression are approximately normally distributed, with little or no bias. However, one of the problems with the maximum likelihood estimation is that, no closed-form solution exists for the values of the parameters that maximize the log-likelihood function. Sophisticated computer-intensive numerical search procedures (i.e. Newton Raphson) with computer software are required to find the maximum likelihood estimates of parameters (Kutner *et. al.*, 2004).

The several steps that should be taken when fitting a multiple logistic regression model with a data set with dichotomous indicator response variable to evaluate the future probabilities of

events using PROC LOGISTIC in SAS® is presented and discussed. The several options available with PROC LOGISTIC in SAS® to improve the efficiency of parameter estimation and the adequacy of the model are presented. Solutions to the various problems encountered when fitting such as model is presented as sample SAS® codes and results obtained from SAS outputs wherever necessary. The logit link function was considered with a first order multiple logistic regression model, which was fitted using the maximum-likelihood estimation method. Data were corrected for missing values, tested for the presence of any influential observations or outliers that can reduce the accuracy of the maximum likelihood estimation. The best subset of predictor variables that fit the data adequately without loss of information was selected. Model diagnostic tests, residual and sensitivity analyses were performed to validate the model. The model thus built was used to estimate the variations in probabilities of using technology in the near future as functions of several useful predictor variables.

## MATERIALS AND METHODS

The objective of this study was to examine the proportion of technology usage among farmers in five dairy farming districts in Kenya. Logistic regression analysis is applied to data obtained from 420 dairy farmers from Nairobi, Thika, Machakos, Nyandarua and Bureti. Selected districts name and the number of dairy farmers questionnaires applied are given in Table 1.

**Table 1. Survey frame**

District name	Number of farmers interviewed
Nairobi	80
Thika	100
Machakos	100
Nyandarua	100
Bureti	40

**Table 2a. Explanation of variables**

EXPLANATORY VARIABLES	CATEGORICAL VARIABLES	Binary Response Variables Farmers using Technology (FUT)	Binary Response Variables Farmers requiring Training (FRT)
Site (SITE)	1. Nairobi 2. Thika 3. Machakos 4. Nyandarua 5. Bureti	0 = Not using Technology 1 = Using Technology	0 = Not Require Training 1 = Require Training
Farmer sex (FSEX)	1. Female 2. Male		
Farmer Previous Training on technology (FTT)	1. No 2. Yes		
Cattle breeds (CBR)	1. Zebus 2. Crosses 3. Dairy		
Dairy Cattle Feeding System (DCFS)	1. Stall Feeding 2. Stall Feeding and grazing 3. Free grazing		
Milk Market (MM)	1. Poor 2. Fair 3. Good		
Dairy Production Cost	1. Low 2. Average 3. High		
Farmer Understanding of Technology (FUT)	1. Poor 2. Fair 3. Good		
Technology Providers (TP)	1. Farmer 2. Extension Officers		

3. Researchers
4. Private Organizations
5. Others

**Table 2b.. Explanation of variables**

**CONTINUOUS EXPLANATORY VARIABLES**

1. Farm size (Acres)
2. Farmer with improved fodders (%)
3. Farmer Education (years) (FED)
4. Farmer Age (years) (FAGE)
5. Milking cows (Numbers) (MC)
6. Herd size (HS)
7. Rate of Concentrate supplementation (Kg/cow/day) (RCS)
8. Rate of mineral supplementation (Kg/cow/day) (RMS)
9. Average milk yield (Kg/farm/day) (MYPF)
10. Average milk yield (Kg/cow/day) (MYPC)
11. Average marketed milk (Kg/farm/day) (MKT)
12. Milk price (KSh/litre) (MP)

Coded values of 9 independent variables thought to affect dependent variable are given in Table 2

## METHODOLOGY

In Logistic regression, there is a (binary or dichotomous) response of interest, and the predictor variables are used to model the probability of that response. In this study, binary response variable was of interest.

Consider a collection of  $p$  independent variables denoted by the vector  $x' = \{x_1, x_2, \dots, x_p\}$ . Let the conditional probability that the outcome is present be denoted by Eq. (3.1) given below:

$$P(Y = 1 | x) = \pi(x) \quad (3.1)$$

The logit of the multiple regression model is given by

$$g(x) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p \quad (3.2)$$

In which case the logistic regression model is

$$\pi(x) = \frac{e^{g(x)}}{1 + e^{g(x)}} \quad (3.3)$$

where the outcome variable,  $\pi(x)$ , is the probability of having one outcome or another based on a nonlinear function of the best linear combination of predictors with two outcomes [2, 3]. Since the model produced by logistic regression is nonlinear, the equations used to describe the outcomes are slightly more complex than those for multiple regression [6].

This linear regression equation creates the logit or log of the odds:

$$\ln\left(\frac{\hat{\pi}}{1 - \hat{\pi}}\right) = \sum_{j=1}^p \beta_j X_j \quad (3.4)$$

That is, the linear regression equation is the natural  $\log(\log_e)$  of the probability of being in one group divided by the probability of being in the other group.

The procedure of estimation that leads to the least squares function under linear regression model, when the error terms are normally distributed, is maximum likelihood, and the goal is to find the best linear combination of the predictors to maximize the likelihood of obtaining the

observed outcome frequencies. Maximum likelihood estimation is an iterative procedure that starts with arbitrary values of coefficients and determines the direction and size of change in the coefficients that will maximize the likelihood of obtaining the observed frequencies.

There are three types of estimation tests for logistic regression: (i) Wald test, (ii) Score test, (iii) Likelihood ratio test.

### **Wald Test**

Solving for logistic regression coefficients  $\beta_j$  and their standard errors involves calculus, in which values are found using maximum likelihood methods. These values, in turn, are used to evaluate the fit of one or more models. If an acceptable model is found the statistical significance of each of the coefficients is evaluated using the Wald test.

$$W_j = \frac{\beta_j}{SE_{\beta_j}} \quad (3.5)$$

given above where the j-th coefficient is divided by the standard error. The resulting ratio, under the hypothesis that  $\beta_j = 0$ , will follow a standard normal distribution.

### **Goodness-of- Fit**

Logistic regression assumes a linear relationship between continuous predictors and the logit transformation of the dependent variables, although there are no assumptions about linear relationships among predictors themselves.

For a candidate model, a log-likelihood is calculated, based on summing the probabilities associated with the predicted and actual outcomes for each case i:

$$L(\beta) = \ln[l(\beta)] = \sum \{y_i \ln[\pi(x_i)] + (1 - y_i) \ln[1 - \pi(x_i)]\} \quad (3.6)$$

Two models are compared by computing the difference in their log-likelihood and using chi-square. The comparison of observed to predicted values using the likelihood function is based on the statistics, D, Eq (7) called deviance [5].

$$D = -2 \sum [y_i \ln\left(\frac{\hat{\pi}(x_i)}{y_i}\right) + (1 - y_i) \ln\left(\frac{1 - \hat{\pi}(x_i)}{1 - y_i}\right)] \quad (3.7)$$

For purposes of assessing the significance of an independent of an independent variable, the value of D is compared with and without the independent variable in the equation as given below:

$$G = \chi^2 = D(\text{model without the variable}) - D(\text{model with the variable}) \quad (3.8)$$

This Good-of-fit  $\chi^2$  process evaluates predictors that are eliminated from the full model, or predictors (and their interactions) that are added to a smaller model. In general, as predictors are added/deleted, log-likelihood decreases/increases. The question in comparing models is whether the log-likelihood decreases/increases significantly with the addition/deletion of predictor(s).

A number of measures have been proposed in logistic regression as an analog to  $R^2$  in multiple linear regression. None of these measures has the same variance interpretation as  $R^2$  for linear regression, but all approximate it. The logistic regression in SAS and SPSS uses  $R^2$  like measures as Nagelkerke and Cox and Snell. The Cox and Snell measure is based on log-likelihoods and takes sample size into account.

$$R_{CS}^2 = 1 - \exp \left[ -\frac{2}{n} [D(\text{model without the variable}) - D(\text{model with the variable})] \right] \quad (3.9)$$

Cox and Snell  $R^2$ , however, cannot achieve a maximum value of 1.

The Nagelkerke measure adjust Cox and Snell so that a value of 1 could be achieved. The Nagelkerke measure is as follows:

$$R_N^2 = \frac{R_{CS}^2}{R_{MAX}^2} \quad (3.10)$$

where

$$R_{MAX}^2 = 1 - \exp[2(n^{-1})D(\text{model with the variable})] \quad (3.11)$$

The final measure of model fit is the Hosmer and Lemeshow goodness-of-fit statistic, which measures the correspondence between the actual and predicted values of the dependent variable. In this case, better model fit is indicated by a smaller difference in the observed and predicted classification. A good model fit is indicated by a non-significant chi-square value.

## RESULTS AND DISCUSSION

The results (use-no-use) in Technology under the different environmental conditions were used to construct the X (predictors) and Y (response) matrices, which were subjected to statistical analysis (logit regression).

Estimation of the global and specific models. The retained coefficients of the logit regression (7 plus intercept) selected by the backward stepwise option are shown in Table 5. Seven of these coefficients were significant.

**Table 3.**

Effect Entered	DF	Score Chi-Square	Pr > ChiSq
FTU	2	140.18	0.0001
FTT	1	60.69	0.0001
CST	2	18.56	0.0001
MP	1	8.10	0.0044
SITE	4	40.75	0.0001
DCFS	2	7.11	0.0267
FED	1	3.89	0.0486

**Table 4. Type III Analysis of Effects**

Effect	DF	Wald ChiSquare	Pr > ChiSq
SITE	4	29.35	0.0001
DCFS	2	6.11	0.0471
FED	1	3.69	0.0547
FTT	1	4.63	0.0315
FTU	2	5.49	0.0063
MP	1	31.58	0.0001
CST	2	10.82	0.0045

**Table 5. Significant coefficients of the global logistic regression for the estimation of the use-no use of technology**

Parameter	DF	Estimates	Standard	Wald	Pr>ChiSq	Exp(Est)
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			Error	ChiSquare		
Intercept	1	19.82	3.16	39.35	0.0001	4.05 <sup>E8</sup>
SITE 1	1	5.13	1.04	24.14	0.0001	168.25
SITE 2	1	-3.07	0.73	17.61	0.0001	0.05
SITE 3	1	3.10	0.78	15.96	0.0001	22.19
SITE 4	1	-2.58	0.70	13.44	0.0002	0.08
DCFS 1	1	1.05	0.43	6.06	0.0138	2.85
DCFS 2	1	-0.28	0.38	0.52	0.4691	0.76
FED	1	-0.13	0.07	3.69	0.0547	0.88
FTT 1	1	0.59	0.27	4.63	0.0315	1.81
FTU 1	1	1.73	0.80	4.68	0.0305	5.66
FTU 2	1	-0.41	0.47	0.76	0.3845	0.67
MP	1	-0.73	0.13	31.58	0.0001	0.48
CST 1	1	-1.99	0.61	10.81	0.0010	0.14
CST 2	1	0.46	0.41	1.24	0.2658	1.58

### Estimates of parameters

Estimates for the parameters obtained through the maximum likelihood estimation method with 95% Wald's confidence limits for the final model are shown in Table 5. Negative parameter estimates were obtained for the variables SITE2, SITE4, DCFS, FED, FTU2, MP and CST1. These variables negatively influence the probability of using technology in the dairy farming in the areas. Larger odds ratios were obtained for SITE1, SITE3, FTU1 and FTT (Table 6). Odds ratios were close to or greater than 1 for most of the variables except for MP, and CST. These variables increase the probability of using technology more than other variables with smaller odds ratios.

**Table 6. Odd Ratio Estimates**

Effect	Point Estimate	95% Wald	Confidence Limits
SITE1 vs 5	>999.999	99.63	>999.999
SITE2 vs 5	0.62	0.09	4.06
SITE3 vs 5	293.81	22.61	>999.999
SITE4 vs 5	1.01	0.17	5.93
DCFS 1 vs 3	6.16	1.14	33.14
DCFS 2 vs 3	1.64	0.34	7.81
FED	0.88	0.77	1.00
FTT1 vs 2	3.26	1.11	9.57
FTU1 vs 3	21.36	1.61	283.60
FTU2 vs 3	2.52	0.66	9.61
MP	0.48	0.37	0.62
CST1 vs 3	0.03	0.003	0.282
CST2 vs 3	0.34	0.06	1.83

### Model goodness of fit statistics

All of the goodness of fit tests suggests that the model is significant and adequate. The AIC, SBC and - 2Log likelihood (lower the better) values indicate that the model with the selected covariates is superior to the model with intercept only (Table 7). As in linear multiple regression, covariates can control for possible confounding effects, and account for other sources of variation in multiple logistic regression models. Hosmer and Lemeshow goodness-of-fit test (Hosmer and Lemeshow, 2000; Kutner *et. al.*, 2004) performs the Hosmer and Lemeshow goodness-of-fit test for the binary response logistic model. In this test the subjects are divided into approximately ten groups of roughly the same size based on the percentiles of the estimated probabilities. The discrepancies between the observed and expected number of observations in these groups are summarized by the Pearson chi-square statistic, which is then compared to a chi-square distribution with k degrees of freedom, where k is the number of groups (=10) minus n (=2). A large p-value (>0.05) usually suggests that the fitted model is an

adequate model. In this study the test is large p-value (0.9545) indicates that the model predicts the data very well (Table 7). R-square and the maximum rescaled R-square values of the model are high enough (Table 8). The overall logistic regression model was highly significant at the 5% level as indicated by the Likelihood ratio, Wald and Score tests of the global null hypothesis that the model parameters are significant (Table 8).

**Table 7. Model Fit Statistics**

Criterion	Intercept only	Intercept and Covariate
AIC	402.19	160.44
SC	406.23	198.92
-2Log L	400.19	126.44
Hosmer and Lemeshow		

**Table 8. Testing Global Null Hypothesis: BETA = 0**

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	273.75	11	0.0001
Score	243.45	11	0.0001
Wald	79.47	11	0.0001
Residual	12.51	9	0.1863
General R <sup>2</sup>	0.4789		
Max-rescaled R <sup>2</sup>	0.7795		

**Table 9. Association of Predicted Probabilities and Observed Responses**

Percent Concordant	95.9	Somer's D	0.920
Percent Discordant	3.9	Gamma	0.922
Percent Tied	026411.2	Tau-a	0.276
pairs		c	0.960

PROC LOGISTIC provides four indices of rank correlation for assessing the predictive ability of a model: i) C, ii) Somer's D, iii) Goodman Kruskal Gamma (Gamma), and iv) Kendall's Tau (Tau-a). Values for the fitted model are shown in Table 9 along with the percent discordant and concordant pairs of event and nonevent observation. Values indicate the predictive ability of the model is adequate. 96% of the pairs are concordant. Values of Sommer's D, Gamma and C statistics are high enough.

## CONCLUSION

The proposed test statistics are intended for use in assessing lack of fit in logistic regression models containing both categorical and continuous covariates. The test statistics attempt to draw on the strengths of the existing Pearson chi-square and deviance tests, while incorporating an adjustment for continuous covariates similar to that of the Hosmer-Lemeshow statistics. They are not suggested for use when only continuous variables are modelled and the Hosmer-Lemeshow test would be preferable, or when only categorical variables are modelled and the standard Pearson or deviance chi-square would be appropriate.

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# **SOCIAL CAPITAL AND LIVESTOCK ENTREPRENEURSHIP: THE ROLE OF FARMERS' DAIRY GROUPS IN WESTERN KENYA**

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## **ABSTRACT**

The low productivity of smallholder dairy farms and high poverty levels can be addressed by strengthening the role of farmers' dairy groups so as to benefit from social capital in business development. Majority of the dairy groups aim at poverty reduction. However, their reasons for formation appear to be diverse. A large proportion, 38% of the dairy groups use revolving fund/merry go round and contributions to achieve their objectives. There is a need to increase savings and investments so that there is output to be marketed and employment to be created. Most of the DGs hold their meetings monthly. There is need for regular elections. Annual investments range from Kshs. 1000 to Kshs. 200,000 while annual income varies from Kshs.50 to Kshs. 144,000. Thus more work is still needed to bring about the benefits of social capital through joint investment. The objective of this paper was to document on the social capital and livestock entrepreneurship in western Kenya. More specifically the paper identifies the distribution of dairy groups, reasons for the formation of those groups, their enterprise development and constraints facing them.

## **INTRODUCTION**

Smallholder farmers in developing countries have to cope with the risks of small businesses and have long faced heavy challenges. Indeed, half of the world's undernourished people, three-quarters of Africa's malnourished children, and the majority of people living in absolute poverty live on small farms (IFPRI, 2007). Globalization and the integration of international markets are stimulating intense competition, offering some opportunities but also new risks. Improving agricultural productivity is key to achieving the Millennium Development Goals (MDGs) of cutting the proportion of people living in poverty from 22% to 11% by 2015 and achieving Kenyan Vision 2030 (Republic of Kenya, 2005; Amoako, 2003; Actionaid International, 2005; Pingali, 2004). Methods used by governments to change the environment within which livestock production takes place include the following: i) Influencing the prices of farm inputs and outputs; ii) modifying agricultural institutions in which farm input and output markets operate; and iii) promoting new technologies in agriculture (Ellis, 1992). However, price intervention is likely to have more distorting side effects and less predictable outcomes than non-price interventions. This result in misallocation of resources because farmers are not making their production decisions according to the opportunity cost to society of the resources employed (Ellis, 1992). The farmers' groups can act as institutions for input provision, output marketing and promotion of new technologies. This ability was recognized by Poulton *et al.*, (2004) who stressed that investment in human and organizational capacity of small-holder farmers is key in generating agricultural growth and poverty reduction.

Therefore emphasis should be placed on the development of competitive markets for both inputs and outputs. In this regard, formation and strengthening of farmers' groups is crucial. The Kenyan government recognizes that poor governance in key institutions supporting agriculture is among the key factors affecting livestock performance (Republic of Kenya, 2005). To transform Kenya's livestock sector, the strategy calls for drastic changes in the management, which includes encouraging participatory approaches to development through the empowerment of local communities to initiate and implement their priority projects. The groups will also play a major role in natural resource and environment management to ensure

sustainable development. In addition, educational opportunities for farmers will lead to initiative, innovation and improvements (Bertini, 2001). Such a holistic approach to development using the groups will then lead to substantial reduction in poverty; agricultural output will rise leading to higher incomes and increased consumption.

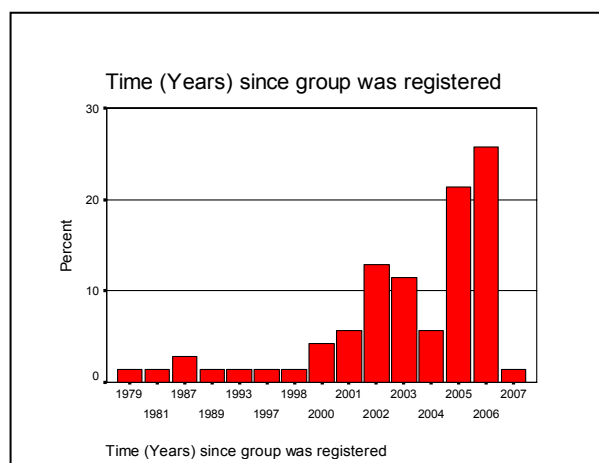
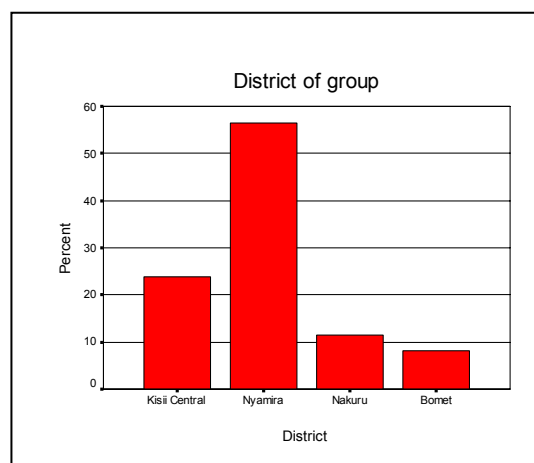
The objective of this paper was to document the social capital and livestock entrepreneurship in western Kenya. More specifically the paper identifies the distribution of dairy groups, reasons for the formation of those groups, their enterprise development and constraints facing them.

## METHODOLOGY

The sampling frame was all the dairy groups (DGs) in the first Dairy Commercialization Area (DCAs) of Nakuru, Kisii Central, Nyamira and Bomet districts of Kenya. A dairy group is made up of a number of farmers, usually about 20, who are registered with the Department of Social Services. A DCA is typically an administrative location within a district that was selected based on its milk production potential, poverty level of its population and market access. Primary data resulted from a survey of 150 dairy groups using structured questionnaires to collect data. A list of all DGs in the first DCAs of the four districts from the District Social Development Office was used to identify the respondents. The data collected were cleaned, coded and then analyzed using the Statistical Package for Social Scientists (SPSS) 11.5 for windows. Descriptive statistics consisting of frequency tables and general statistics was used in this paper.

## RESULTS

The four districts have farmers who have formed dairy groups, with Nyamira leading with over 50%. Most of the DGs were formed between the year 2000 and 2006.



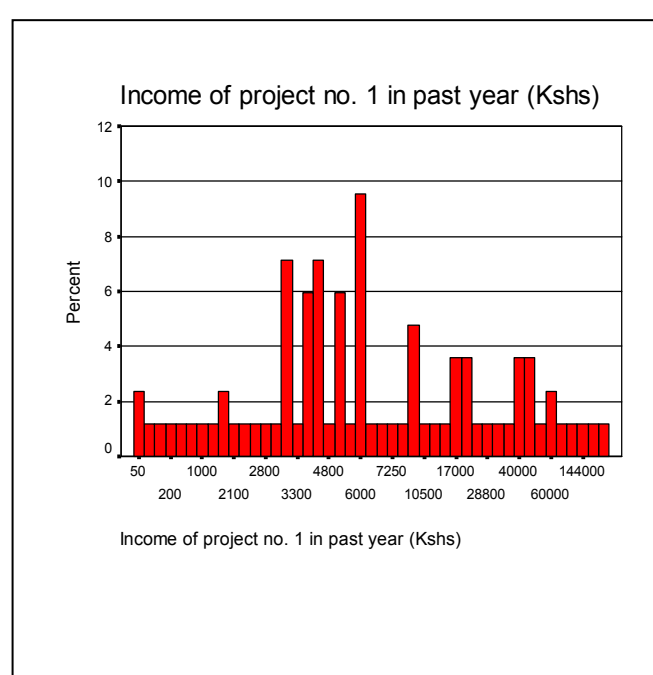
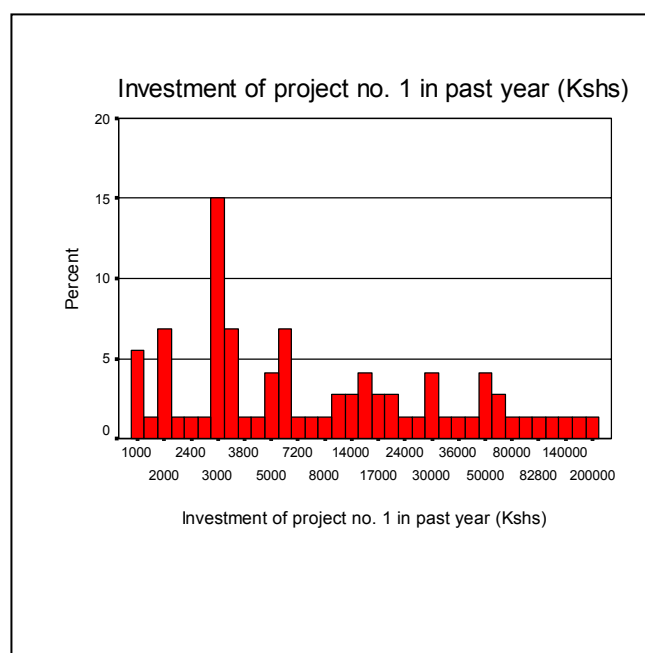
**Table 1. Reason for formation of dairy group**

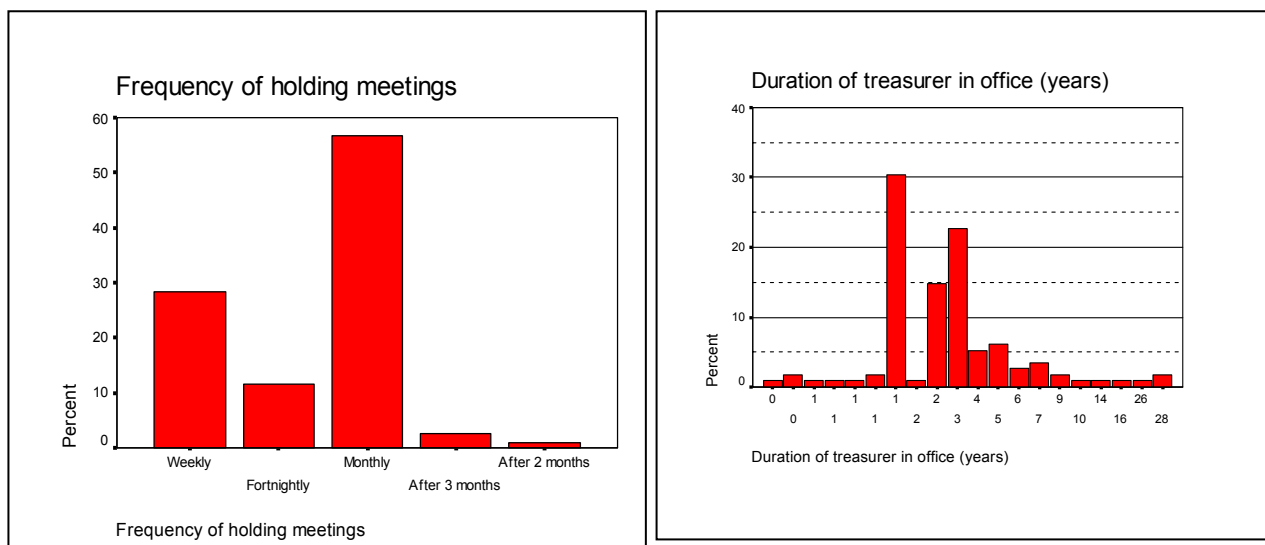
Reason for formation of DG	No of dairy groups	Percentage
Poverty reduction	94	85.5
Support to HIV/AIDS victims and develop viable project for members	1	0.9
Share ideas that promote agriculture	4	3.6
Provide support during funerals	1	0.9
Dairy production	3	2.7
Water harvesting	1	0.9
Farming	3	2.7
Market produce	2	1.8
Make and sale jikos	1	0.9
Total	110	100

Majority of the dairy groups aim at poverty reduction. However, their reasons for formation appear to be diverse.

**Table 2. Activities identified by the Dairy Groups to realize their objectives**

Activity identified by DG	No.	%	Cumul. %
Tea nursery	6	5.9	5.9
Napier grass production	11	10.9	16.8
Fish farming	4	4.0	20.8
Tree nursery	3	3.0	23.8
Poultry	9	8.9	32.7
Selling milk	8	7.9	40.6
Tea picking	10	9.9	50.5
Revolving fund	20	19.8	70.3
Monthly contribution	17	16.8	87.1
Stock market	4	4.0	91.1
Livestock production	2	2.0	93.1
Farming	4	4.0	97.0
Fodder production	1	1.0	98.0
Dairy goat rearing	1	1.0	99.0
Merry go round	1	1.0	100.0
Total	101	100.0	





A large proportion, 38% of the dairy groups use revolving fund/merry go round and contributions to achieve their objectives. There is a need to increase savings and investments so that there is output to be marketed and employment to be created. Most of the DGs hold their meetings monthly. It was interesting to see a Treasurer who had been in office for 28 years. There is need for regular elections. Annual investments range from Kshs. 1000 to Kshs. 200,000 while annual income varies from Kshs.50 to Kshs. 144,000. Thus more work is still needed to bring about the benefits of social capital through joint investment. It is interesting to note that these DGs are involved in other social welfare activities like weddings (2%), funerals (43%). The important issue again is for the DGs to generate profits to support the social activities.

## CONCLUSION

In conclusion, the case for smallholder development through dairy groups as one of the main ways to reduce poverty remains compelling. The challenge is to strengthen entrepreneurship amongst group members and improve the workings of markets for outputs, inputs, and financial services to overcome market failures. Meeting this challenge calls for innovations in institutions, for joint work between farmers, private companies, and NGOs, and for a new, more facilitating role for ministries of livestock and other public agencies. New thinking on the role of the state in agricultural development, wider changes in democratization, decentralization, and participatory decision making processes, and a renewed interest in livestock development and group approach among major international donors do present opportunities for greater support to small-farm development.

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# Policy, Marketing & Socioeconomic Issues

# LIVESTOCK BASED PERCEPTIONS OF RANGE QUALITY CHANGE AT LANDSCAPE LEVEL AMONG BORANA COMMUNITY OF NORTHERN KENYA

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## ABSTRACT

Participatory monitoring of rangeland quality to reverse deterioration has not being possible. Generally, disagreements exist on what indicators to be used and how the generated data can be linked to management related information and whether the methods can be replicated across different grazing areas. Range quality monitoring has hence focused on conventional scientific method while the role of indigenous knowledge of local resource users such as pastoral herders has being given less emphasis. This study explored Borana herders' knowledge of monitoring range quality at landscape level in the rangeland of Marsabit central, northern Kenya. In a joint survey with local herders, the study area was classified into landscape units and indicators used by the herders in range quality monitoring identified. The herders identified indicators based on livestock productivity performance as such increased milk yield, exhibition of good health, high mating frequency and more successful calving rates. Herders were also knowledgeable in monitoring trend of livestock preferred forage plants in a given landscape. The study concludes that pastoral herders have vast knowledge of range quality monitoring which can be integrated with conventional methods to monitor range quality in pastoral areas.

**Key words:** *Borana Herders, landscape level, range quality monitoring, Livestock productivity, preferred forage plants*

## INTRODUCTION

Rangeland quality change mainly in terms of loss of vegetation diversity and cover has continued unabated in the African communal rangelands (Vetter *et al.*, 2006). The change has often associated with intensive livestock grazing (Darkoh 2002; Rodriguez 2003; Bowman 2002) and change in land use from livestock grazing to crop farming and settlement. The latter does not only reduce vegetation cover and diversity but also disrupts seasonal livestock movement necessary for sustainable and opportunistically exploitation of spatially and temporally distributed range resources (Byakagaba 2005).

Monitoring of the rangeland quality change with the objective establishing actual status and reverse the loss has not been successful using conventional scientific method alone. This is simply because the method is not participatory. Participatory range quality monitoring which tend to integrated indigenous ecological knowledge of local resource users with conventional scientific method seems to be the appropriate method to adopt. In monitoring of pastoral range quality, such integration effort has being impaired by limited understanding of appropriate indicators used by pastoral herders (Oba *et al.* In Press; Yoccoz *et al.*, 2001) and the perception that the knowledge is locally specific and lack impartiality (Oba and Kaitira 2006). However, pastoral herders have been known to have vast knowledge of rangeland monitoring (Peden 2005; Mauro and Hardison 2000; Berkes 1999) and uses monitoring indicators which are based on landscape level (Mapinduzi *et al.*, 2003, Fernandez-Gimenez 2000; Oba *et al.*, 2000). The landscape level range quality monitoring considered spatial ecological variability of rangeland (Niamir-Fuller and Turner 1999; Scoones, 1999) which creates spatial and temporal variation of indigenous vegetation distribution and productivity (Scholes and Archer 1997; Boeken and Shachak 1994; Byakagaba 2005). The ecological variability of rangeland which is mainly

terms of micro-climate, soils and topography generally form the basis of landscape classification and naming by pastoral herders for the purpose of landscape level range quality monitoring (Oba and Kaitira 2006).

Pastoral herders' landscape level knowledge of monitoring of range quality is built upon the relationship between vegetation and livestock (Bolling and Schulte 1999; Reed and Dougill 2002). Desirable forage plant species which are normally palatable to livestock could be used as indicators of favourable range quality while undesirable plants would indicate degradation (Mapinduzi *et al.*, 2003). All the desirable and undesirable plant species are recognised by local name (Gemedo-Dalle *et al.*, 2005) and change in the composition monitored over time based on historical knowledge (Oba and Kaitira 2006). Low livestock productivity could be attributed to changes in range vegetation composition from desirable to undesirable forage plants. This study aimed at understanding Borana herders' knowledge of range quality monitoring and integrates into the convectional method for establishing range quality status of Marsabit central.

## **MATERIALS AND METHODS**

### ***Study site***

Study was conducted in Central Division of Marsabit Central District, located at about 37°c to 28°30' E and 2°c to 2° 45' N (Warui, 2001). The area is inhabited by pastoralists and agro-pastoralists groups with diverse ethnic background such Borana, Rendille Gabra, Burji and others. This study focused knowledge on Borana community for range assessment. The study site is geographically located along a gradient from the highlands of Mount Marsabit towards the transitional zone between the mountain landscapes and arid plains. The site stretches from elevation of 1,300 m above sea level in the upper part of Mount Marsabit and gently slopes into open woodland or savannah at the foot of the mountain. The areas has bimodal annual rainfall of 300mm to 800mm

### ***Data collection***

Focus group discussion on indigenous knowledge of range quality monitoring was held with 12 Borana key informants. Discussion was followed by group selection of knowledgeable herders to survey and assess various landscapes to be able understand range quality status. The criteria of herders selection were age and experience of livestock herding in the study area. Joint team of selected four knowledgeable herders and researchers did a reconnaissance survey of study area and classified it into different landscape units using traditional indicators. Qualities of classified landscape units were also assessed by the herders. Joint vegetation assessments were further done by researchers and herders to verify range qualities attributed to each landscape unit. Vegetation assessments were done along transects placed on micro-landscapes (landscape patch within a bigger landscape). Assessments were done using nested plots [1 x 1m for herbaceous species, 4 x 4m for shrubs and 10 x 10m for trees] along 240 m long-transect, placed at 40 m intervals. A total of 84 nested plots were assessed. Herders made folk identifications of the plant species present in each plot, their livestock preference and trend over the years. Plant preference to livestock was indicated as Desirable (D), Very Desirable (VD), Partly Desirable (PD) and Undesirable (U) to cattle, camel or goats and categorised as Increasers, Stable or Decreasing based on their trend over the years.

### ***Statistical analyses***

Both qualitative and quantitative statistical analyses were used. Qualitative analyses involve recording of herders narratives while quantitative data analysed through application of SPSS statistical package. Descriptive statistics were used to generate frequencies of Desirable (D),



Very Desirable (VD), Partly Desirable (PD) and Undesirable (U) forage plants to cattle, camel and goats on each landscape units and comparison made on bar chart.

## RESULTS

### *System of landscape classification for range use and quality monitoring*

Borana herders categorised study area into two macro landscapes namely; *Badhaa* and *Gamoji*. Macro-landscapes were divided 12 micro-landscapes which are patches within macro-landscapes and includes; Gar Folqolcha, Diid ogoono, Qaa wachu, Kooticha amnessa, Kootich sapansa, Kootich fullesa, Thir sarima, Gar thakara, Qaa abrata, Diid abrata, Warama Sigiriso and Thir ghoolole.

### *Livestock productivity performance as range quality indicators*

The herder concept of range quality change closely relate to livestock productivity response to landscape grazing resources. Livestock grazed on landscapes with good quality are expected to increase milk production, exhibit good health, high mating frequency and more successful calving or kidding rates. The texture of animal dung and fur condition could also be used to determine landscape with quality forage. Livestock fur lay flat on the skin and sometime were shed off and replaced with smoother fur when landscape has quality forage but maintained shaggy fur for long period when it has poor quality forages. Herders believe that livestock instinctively knew which landscape had quality forage by refusing to graze in landscapes that have poor forage quality. Herders sometimes relied on such clues from livestock to decide where to graze animals. Nonetheless, range quality is not constant condition of landscape and could be affected by certain factors such as biting flies, ticks, poisonous plants and increased bush cover. The condition may also vary with livestock species and might not necessary correlate with availability of grazing resources. Some landscapes might have good quality forage but they are not favourable to livestock, similar to those that could be rated as poor range. The table below indicates herders range quality perception of different landscape units in the study area rated based on experiences of livestock productivity performance.

**Table 1; Herders' quality perception of different landscape units in the Marsabit central**

	Landscape name											
	GF	DO	QW	KA	KS	KF	TS	GT	QA	DA	WS	TG
Herders' quality perception	2	1	1	1	2	2	1	1	2	2	2	1

GF= Gar Folqolcha, DO= Diid ogoono, QA= Qaa wachu, KA=Kooticha amnessa, KS=Kootich sapansa, KF=Kootich fullesa, TS=Thir sarima, GT=Gar thakara, Qaa abrata, DB=Diid abarata, WS=Warama sigiriso, TG=Thir ghoolole

1=Good quality, 2=Poor quality

### *Livestock preferred forage plants as range quality indicators*

Availability of preferred forage plants indicate range quality of given landscape while undesirable plants indicate poor range condition. Change in composition of preferred plant species and trend on given landscape is monitored based on historical knowledge. Preference varied for different kind of livestock. Most landscapes have relatively high frequency of cattle preferred forages (Fig. 1) but trend indicates that larger proportion of cattle preferred forages are decreasing over time (Fig. 2). However, greater percentage compositions of increasing plants were desirable to goats and camels.

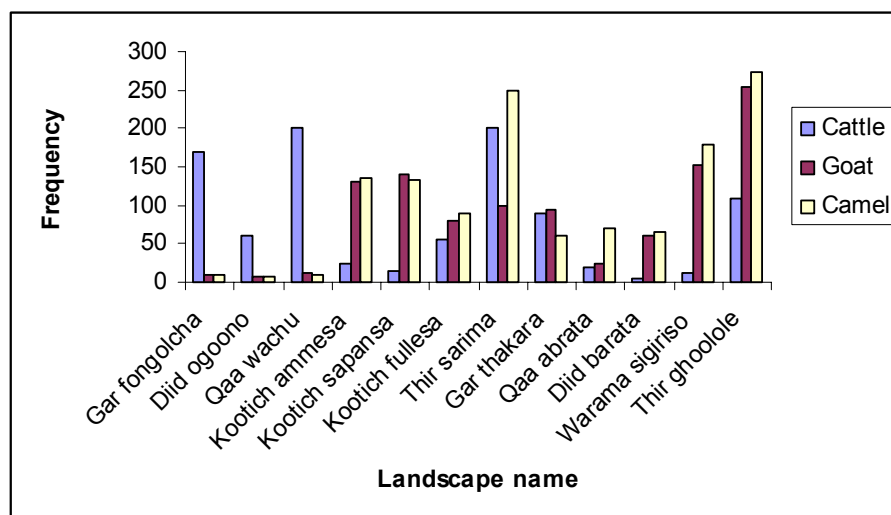


Fig. 1: Frequencies of desirable forages to different kind of livestock across various landscape units

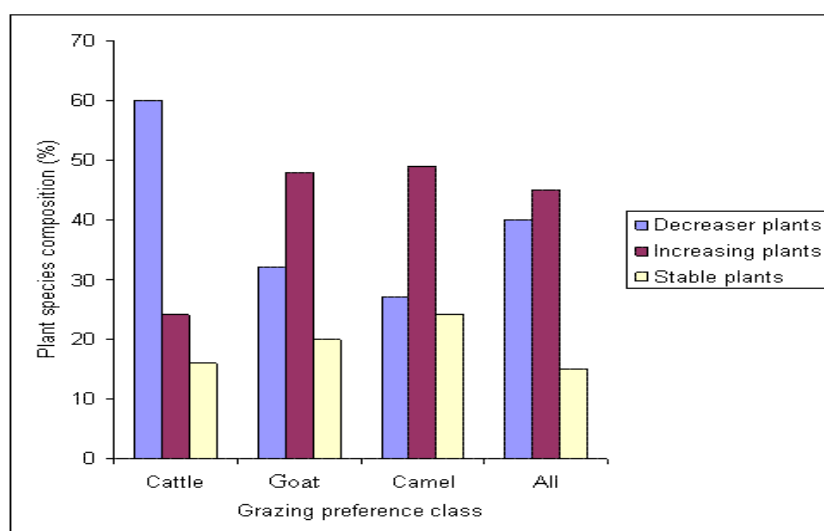


Fig. 2: Livestock grazing preference of decreaser, increaser and stable plants

## DISCUSSION

Borana herders had rich knowledge of classifying landscape based on certain traditional criteria. Macro-landscapes were classified based on micro-climates while classifications of micro-landscapes were based upon diverse environmental indicators such as topography, soil, and dominant vegetation. Naming of landscapes usually reflects the criteria used in the classification. The Borana herders' knowledge of classifying landscapes using traditional criteria showed similarity between several pastoral communities such as those found in southern Ethiopia (Oba and Koitile, 2001), northern Tanzania (Mapinduzi *et al.*, 2003), north central Namibia (Verlinden and Dayot 2005) and Mongolia (Fernandez-Gimenez, 2000). Their system of naming landscapes is also similar to what had being earlier reported for Maasai pastoralists (Oba and Kaitira, 2006) and Owambo agro-pastoralists (Sheuyange *et al.*, 2005) of Northern Tanzania.

Landscape classification and naming was necessary for the purpose of range quality monitoring and direction of livestock movement for daily and seasonal grazing (Oba, 1994). The two macro-landscapes in the study area represented seasonal patterns of resource use aimed at spatial distribution of grazing pressure. *Badhaa* is used as dry season grazing while

*Gamoji* is used for wet season grazing. Micro-landscapes represent daily grazing resources which determine daily livestock movement.

In addition to determining livestock daily and seasonal movement, classified landscapes also form the basic unit of monitoring range quality among pastoral communities. Certain indicators which gauge dynamic relation of landscape vegetation and livestock productivity performance are used to monitor rangeland. The monitoring indicators used by Borana herders are similar among other pastoral societies. For example, the Kenyan Pokot and Namibian Himba were reported to have good knowledge of vegetation change based on livestock productivity (Bolling and Schulte 1999). The concept is also comparable to similar concept used by other pastoral communities in northern Kenya such as the Rendille, Ariaal and Gabra of northern Kenya (Oba 1985).

Historical knowledge of monitoring changing composition of livestock preferred forage species for rangeland quality change among Borana community complement the knowledge of relating livestock productivity response to landscape forage. The concept has also been identified with other pastoral communities such as Maasai pastoralists of northern Tanzania (Mapnduzi *et al.*, 2003). High proportion of desirable plants to cattle, decreasing in the rangeland of Marsabit central showed deteriorating trend of range condition, although, the change is suitable camels and goats productivity due to increasing shrubs composition. Similar trend of range condition has earlier been reported in South West Marsabit (Lusigi, 1984) and Borana region of Southern Ethiopia (Gemedo-Dalle, 2005).

## CONCLUSION

This paper showed that Borana community had rich knowledge of monitoring range quality change at landscape level which can be used to establish range condition and trend. The knowledge which uses livestock-based indicators could play important complementary role with conventional ecological method of range quality monitoring. Study recommends participatory range monitoring with local resource users in order to incorporate their knowledge for appropriate range quality determination.

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# THE PERFORMANCE OF WEANER GOATS (*Capra hircus*) FED NAPIER GRASS (*Pennisetum purpureum*) AND SUPPLEMENTED WITH CLITORIA (*Clitoria ternatea*) FORAGE OR MUCUNA (*Mucuna pruriens*) SEED IN COASTAL KENYA

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## ABSTRACT

Protein deficiency is a major nutritional limitation among the coastal Kenya human population. Goats are a potential source of protein through meat and milk. Although feed quality and quantity are a major constraint to ruminant production in the coastal Kenya region, no goat feeding package has been developed. Napier grass, which is recommended as a basal diet for ruminants, requires protein supplementation for optimal animal production. Forage legumes are used as protein supplements because the commercial supplements are costly and not readily available in small holder farms. Mucuna seed is also usable as a protein supplement but has a higher content of L-Dopa antinutrient than the forage. There are conflicting reports about the seed's potential detrimental effects to animals. A study was therefore conducted at KARI-Mtwapa, using Clitoria forage and ground Mucuna seed to supplement Napier grass with protein, and fed to weaner Kenya Dual Purpose Goats. Napier grass alone was fed as a control. Maize bran was used as an energy supplement to all the experimental goats. Four weaner goats were used in each of the three treatments and the diets fed for 8 weeks. The objectives were to determine the effect of using locally adapted legumes as protein supplements to Napier based diets for goats, and to find out if Mucuna seed has any adverse effect on goats. Results indicated that goats supplemented with the legumes had higher ( $P < 0.05$ ) total DM intake (mean 472.8 vs 389.4 g) and tended to gain more weight (mean 262.5 vs 175.0 g) compared to the unsupplemented goats. Mucuna seed did not cause any observed adverse effect on goats' performance. Use of the two legumes is therefore recommended as protein supplements to goats.

**Key words:** Goats weight gain, Mucuna seed, Clitoria forage.

## INTRODUCTION

Protein deficiency is a major limitation among the coastal Kenya human population, as evidenced by the nearly 40% of the children who are stunted (Nicholson *et al.*, 1999). Ruminant livestock contribute to protein deficiency alleviation through their milk and meat products. Goats (*Capra hircus*) have the ability to transform fibrous feeds into these human foods of high nutritional value. There are about 1.30 m goats in the Coast province of Kenya, which produce an annual revenue of about Ksh 457 m (Anon., 2009). Inadequate feeds in coastal Kenya is the most limiting production constraint for dairy goats, and second to diseases in meat goats (Kiura *et al.*, 2003). The goats are fed on natural pastures which are of variable quality, resulting in low production of milk ( $0.75\text{--}2.0\text{ l goat}^{-1}\text{ d}^{-1}$ ) and meat. No feeding package exists for goat production in the coastal Kenya region. Better quality roughages and appropriate supplementation are required for higher production to satisfy the domestic protein needs and also generate income from animal products. Napier grass, which is the recommended fodder for basal diet for the "cut-and-carry" cattle production system in the region (Muinga, *et al.*, 1999), could also benefit goats. Feeding nitrogen-rich supplements in addition to the Napier grass is necessary for improved goat production and especially to alleviate the negative production effects of the dry season. Gryseels (cited by Muinga, 1992) noted that protein concentrates in the coastal Kenya region were often in limited supply and costly. Therefore, evaluation of alternative protein sources was necessary.

Clitoria (*Clitoria ternatea*) and Mucuna (*Mucuna pruriens*) are among the recommended forage legumes for protein supplementation in coastal Kenya (Muinga *et al.*, 1999). Mucuna seeds are rich in crude protein (Siddhuraju *et al.*, cited by Matenga *et al.*, 2003) but contain L-Dopa as the most potent antinutrient (Ezeagu *et al.*, 2003). There are conflicting reports about the potential detrimental effects of feeding Mucuna seed due to the antinutrient. Matenga *et al.*, (2003), citing Topps and Oliver, reported an unduly laxative effect in cattle fed more than 2 kg pods day<sup>-1</sup>. Buckles (cited by Matenga *et al.*, 2003) reported no ill effects of feeding Mucuna seed in ruminants. Work on the feeding value of Mucuna seed has not been done in coastal Kenya.

The objectives of this study were therefore to determine the effect of using locally adapted legumes as protein supplements to Napier grass based diets for goats, and to find out if Mucuna seed has any adverse effect on the goats.

## MATERIALS AND METHODS

### *Site*

This study was carried out in 2007 at KARI-Mtwapa, in coastal lowland Kenya. The area has an average annual rainfall of 1200mm, mean monthly minimum and maximum temperatures of 22 and 30°C, respectively, and a high relative humidity of more than 80% (Jaetzold and Schmidt, 1983).

### *Experimental design and feeding procedures*

Twelve weaner female and male goats balanced for age (19 weeks), initial liveweight (13.2 kg), sex, and dam (doe) parity were selected from the KARI-Mtwapa's Kenya Dual Purpose Goat flock. They were divided into three groups (of four goats each) and fed three diets. The diets were allocated to the three weaner groups in a completely randomized design. The weaners were fed individually in pens for 8 weeks, after a three week adaptation period. Napier grass (two and a half months regrowth) was the basal diet, fed either alone or supplemented for protein with legume diets of Clitoria forage or ground Mucuna seed allowing for digestible crude protein (CP) of 3.4 g kg W<sup>-0.75</sup> (Norton, 1985). All the weaners received a diet of Napier grass *ad lib* and 1 kg of Leucena forage legume during the adaptation period. The Clitoria crop had been established two years earlier and maintained by regular cutting. The Mucuna seeds were purchased from the Natural Resource Management Research Programme at KARI-Mtwapa, and ground in a hammer mill with a sieve of 1 mm diameter. Maize bran energy supplement and a mineral lick were offered to all weaners at 200 g and 10 g per weaner per day, respectively. The diets were:

- (i) Napier grass *ad libitum* + 200 g maize bran (control)
- (ii) Napier grass *ad libitum* + 1,380 g fresh Clitoria forage + 200 g maize bran
- (iii) Napier grass *ad libitum* + 240 g ground Mucuna seed + 200 g maize bran

Clean water was provided at all times.

Napier grass was hand-chopped with a panga daily into pieces of about 30 mm and fed twice a day, ensuring availability at all times. The Clitoria forage, maize bran, ground Mucuna and mineral lick were offered twice a day in two equal amounts, at around 0730 and 1400 h, respectively.

### *Sampling and Analysis*

The feeds were sampled fortnightly throughout the experimental period for dry matter (DM) determination and chemical composition analysis. Data was collected on feed intake and weekly live weights. Samples were collected from the feed offered and feed refused for DM

and CP analysis. Ash and Nitrogen contents were measured according to AOAC (1990). Neutral and acid detergent fibres (NDF and ADF) were determined according to the procedure of Van Soest *et al.* (1991). The total weight gain was calculated as the difference between the final and initial live weights. The average daily gain (ADG) was calculated as the mean of the weekly weight gains over the experimental period.

Statistical analysis was done by analysis of variance (ANOVA), using the General linear model (GLM) procedures of Statistical Analysis System (SAS 1997). Means were separated using the least significant difference (LSD, when ANOVA indicated statistical significance ( $P < 0.05$ )).

## RESULTS

The chemical composition of the feed ingredients used is shown in Table 1.

<b>Table 1. Mean chemical composition of the diet components</b>							
Feed sample	DM	% in DM*					
		CP	NDF	ADF	Lignin	Ash	Tannin
Napier foliage	18.0	4.2	70.2	43.0	6.6	7.3	
Clitoria forage	26.5	12.8	66.7	52.1	12.9	5.6	
Maize Bran	89.0	7.8	55.7	12.9	2.1	4.1	
Mucuna seed	92.7	29.4	23.9	10.6	1.0	2.9	7.6

DM=dry matter, CP=crude protein, NDF=neutral detergent fibre ADF=acid detergent fibre  
 \* Samples for chemical composition analysis for the experimental period were pooled, hence no means separation was done

NB: L-Dopa content in Mucuna seed was not determined due to unavailability of the analyzing equipment in the laboratory used.

Mucuna seed had the highest DM content while Napier grass forage had the lowest. Clitoria forage and Mucuna seed which are leguminous, had relatively higher CP content than Napier grass and maize bran. Mucuna seed had relatively lower NDF, Lignin and Ash contents than the other feed samples.

The feed intake and weight gain by the weaners is shown in Table 2.

<b>Table 2. Mean daily feed intake (DM) and total weight gain for weaner goats fed Napier grass <i>ad libitum</i>, or supplemented with fresh Clitoria or ground Mucuna seed, and maize bran for weeks</b>					
Treatments (Diets)	DM Intake (g)			Total	Total weight gain (g)
	Napier (Basal diet)	Legume	Concentrate (maize bran)		
Napier foliage alone	308.9 <sup>a</sup>	0 <sup>a</sup>	80.5 <sup>b</sup>	389.4 <sup>a</sup>	175.0
Napier + Clitoria forage	256.4 <sup>b</sup>	204.5 <sup>c</sup>	74.5 <sup>a</sup>	530.7 <sup>c</sup>	200.0
Napier + Mucuna seed	312.8 <sup>a</sup>	29.9 <sup>b</sup>	72.2 <sup>a</sup>	414.9 <sup>b</sup>	325.0
LSD	15.7	2.3	5.3	17.3	1725.7

LSD = Least significant difference between means  
 Means bearing the same superscript within a column are not significantly different ( $P > 0.05$ )

Goats supplemented with Clitoria forage had lower ( $P < 0.05$ ) basal diet DM intake than those on Napier alone and Napier plus Mucuna seed, but consumed more ( $P < 0.05$ ) total DM. Goats that did not have a legume supplement consumed more ( $P < 0.05$ ) energy supplement (maize bran) (80.5 vs 73.4 g). The mean intake of maize bran and ground Mucuna was 42.5 and 13.4%, respectively, of the amount targeted. Intake of Clitoria was 55.9% of the targeted amount. The total DM intake was 3.0, 4.0 and 3.1% of live body weight for goats fed Napier alone, Napier plus Clitoria and Napier plus Mucuna, respectively.

Goats supplemented with Clitoria forage or Mucuna seed had higher weight gains than those unsupplemented (262.5 vs 175 g, respectively), though the difference was not significant. Goats supplemented with Mucuna seed tended to gain more weight than those supplemented with Clitoria (325 vs 200 g). The ADGs were low at 0.4, 7.6 and 10.3 g for goats fed Napier alone, Napier plus Clitoria and Napier plus Mucuna, respectively. There were no signs of abnormal behaviour or neurological symptoms in goats attributed to L-Dopa in Mucuna seed.

## DISCUSSION

The DM content of Napier grass compared well with that reported by Muinga (1992) at the same site. The CP and ADF contents obtained were lower (4.2 vs 6.0 and 7.6%, and 43.0 vs 50.1 and 45.9%, respectively), than those reported at the same site by Kiura *et al.*, (2007) and Juma *et al.*, (2004), respectively. The lower CP value obtained compared to that reported by Juma *et al.*, (2004) could have been due to a higher age of regrowth (two and a half months) at the commencement of feeding compared to the two months old Napier grass used by Juma *et al.*, (2004). The Napier grass CP content was below the required 7% (Minson and Milford, 1967) for optimal ruminant performance, making the Napier grass a poor quality roughage. The Napier grass NDF content compared well with that obtained by Juma *et al.*, (2004) but was lower (70.2 vs 81.2%) than that reported by Kiura *et al.*, (2007).

The CP content of Clitoria was within the range reported by Humphreys and Partridge (1995), of 10.5-25.5%. However, it was lower than that reported by Njuguna *et al.*, (2006) at the same site (12.8 vs 21.8%), and also below the expected 14-24% reported by McDonald *et al.*, (2002). The lower CP content value obtained compared to that reported by Njuguna *et al.*, (2006) or McDonald *et al.*, (2002) could have been because the Clitoria regrowth used was from an old crop established two years earlier.

The CP content of Mucuna seed was slightly higher than that reported by Nyirenda *et al.*, (2003), Sandoval-Castro *et al.*, (2003), and Ayala-Burgos *et al.*, (2003) (29.4 vs 24-27, 27.3 and 27.9%, respectively). It was slightly lower than the 31.4% reported by Matenga *et al.*, (2003). The NDF content of the Mucuna seed was lower than that reported by Ayala-Burgos *et al.*, (2003) and Sandoval-Castro *et al.*, (2003) (23.9 vs 26.0 and 40.7%, respectively). The Ash content was slightly lower than that reported by Sandoval-Castro *et al.*, (2003) and Ayala-Burgos *et al.*, (2003) (2.9 vs 3.4 and 3.5%, respectively). The ADF content was higher (10.6 vs 8.8%) than that reported by Ayala-Burgos *et al.*, (2003). The differences observed in the CP, NDF, Ash and ADF contents of the Mucuna seed used with what was previously reported could have been due to climatic differences in the ecozones outside Kenya where the crop was grown, compared to that at KARI-Mtwapa.

The DM content of maize bran compared well with that reported by Kiura *et al.*, (2007) but was higher (89.0 vs 86.7%) than that reported by Juma *et al.*, (2004). The CP and NDF contents obtained were lower than those reported by the two authors (7.8 vs 9.4 and 13.5, and 55.7 vs 58.3 and 78.3%, respectively).

It was noted that feed DM intake did not achieve the higher limit of the potential 3-7% of live body weight (Devendra and Burns, 1970; Harris and Springer, 1992; Steel, 1996). This could have been attributed to the stress emanating from confining the weaners that were previously free grazed. Steel (1996) reported that in intensive units, goats could refuse and spoil a high percentage of forage offered. Maize bran and ground Mucuna seed, which were in powder form, were the least consumed. Preference for forage was demonstrated by the consumption of a higher ( $P < 0.05$ ) legume DM from Clitoria compared to Mucuna seed (204.5 vs 29.9 g, respectively). This negative effect on DM intake could be corrected by the addition of 60 to



200 g fresh matter molasses per kilogram of the ground supplement, to reduce dustiness and improve palatability (Perez-Hernandez *et al.*, 2003). That goats supplemented with Clitoria forage consumed less ( $P < 0.05$ ) basal but more ( $P < 0.05$ ) total DM than those unsupplemented, shows that Clitoria substituted Napier grass in the diet. It could therefore be more cost-effective to feed only a little of the day's Clitoria forage at first to enhance rumen microbial activity and feed the rest much later after a substantial amount of Napier grass has been consumed.

The low feed intake was reflected in the low ADGs ( $0.4$  to  $10.3 \text{ g d}^{-1}$ ) and total weight gains ( $175$  to  $325 \text{ g}$ ). The goat growth rates reported by various authors (Steel, 1996; McGregor, 1985; Khusahry and Yusuff, 1985) range from  $20$  to  $291 \text{ g d}^{-1}$ , and are highest among the growing goats for a certain breed and sex. Therefore the low feed intake was just enough for maintenance requirements but not enough to satisfy requirements for growth. The tendency towards higher weight gains for goats supplemented with Clitoria forage and Mucuna seed ( $200$  and  $325 \text{ g}$ , respectively) compared to those unsupplemented ( $175 \text{ g}$ ) suggests that protein supplementation would be useful for small ruminants on poor quality roughage diets.

Despite the higher total DM and protein consumption for goats fed on Clitoria forage than those on Mucuna seed ( $530.7$  vs  $414.9 \text{ g}$ , and  $26.2$  vs  $8.8 \text{ g}$ , respectively), those on the latter diet tended to gain more weight ( $325$  vs  $200 \text{ g}$ ), possibly due to Mucuna's higher CP and lower NDF contents ( $29.4$  vs  $12.8$  and  $23.9$  vs  $66.7\%$ , respectively), resulting in better diet digestibility (Van Soest, cited by Sandoval-Castro *et al.*, 2003). The Mucuna seed DM and organic matter *invitro* digestibilities are reported to be  $97.9$  and  $96.0\%$ , respectively, with a high metabolizable energy (ME) of  $13.9 \text{ MJ Kg}^{-1} \text{ DM}$  (Sandoval-Castro *et al.*, 2003). Therefore the seed can be considered as an alternative source of fermentable nitrogen and energy to the rumen microorganisms (Ayala-Burgos *et al.*, 2003). The absence of adverse effects on goats fed Mucuna seed was also reported by Castillo-Caamal *et al.*, (2003), Matenga *et al.*, (2003), Mendoza-Castillo *et al.*, (2003), Perez-Hernandez *et al.*, (2003), and Sandoval-Castro *et al.*, (2003).

## CONCLUSIONS

This study shows that protein supplementation to weaner goats using Mucuna seed or Clitoria forage legumes tends to improve their performance and is therefore beneficial. Furthermore, Mucuna seed did not lead to any deleterious effect to the goats and is therefore a suitable protein supplement. Though the feed intake was low, the goat responses gave an indication on how the use of each of the legume supplements could be improved to get a feeding package.

## RECOMMENDATIONS

A longer adaptation period is needed where goats that were free grazed are to be confined. Mucuna seed is a good protein source but may need better packaging to improve on its intake, especially being fed with molasses. Conducting a milk production experiment will give more information on the potential of the legumes used for a more complete feeding package.

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# FUNCTIONAL PROPERTIES OF GOAT MILK: A REVIEW PAPER

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## ABSTRACT

The growing awareness of the relationship between diet and health has led to increased demand for food products that support health beyond providing basic nutrition. Demand for *caprine* milk has been rising steadily due to its good nutritional value and the possibility that it confers physiological benefits. While dairy products in general provide health benefits, research has shown that goat milk confers more functional benefits than any other milk. The milk fats and protein molecules have structures that facilitate high bioavailability and absorbability which contribute significantly to the nutritional requirements of man. The milk contains physiologically bioactive compounds like free amino acids, polyamines, medium chain fatty acids, oligosaccharides and trace minerals which help to boost the immune system and mitigate occurrence of certain diseases. Clinical trials have shown that nutraceuticals derived from goats' milk proteins have potential to correct metabolic syndromes, lower cardiovascular disorders and mitigate onset of various terminal diseases. Due to low incidences of allergenic reactions production of infant formulas from goats milk has grown significantly replacing cow and soy formulas in most developed countries.

## INTRODUCTION

The demand for functional foods has been rising steadily over the last few years. Functional foods are those foods which provide health benefits beyond the normal nutritional requirements. These foods contain physiologically-active food components (Hasler, 1998). Traditionally all foods were thought to be functional on the basis of their nutritive value. However, the term “functional” as it applies to food has nowadays adopted a different meaning - that of providing an additional physiological benefit. More significant is their potential to mitigate diseases, promote health, and reduce health care costs.

Dairy products belong to this category of functional foods. They contain nutrients which aid in preventing occurrence or development of certain diseases to critical levels where they can cause death. In recognition of the role dairy products play in human health, the American National Academy of Sciences has recommended use of dairy products for most age groups with more focus being on probiotics (Fuller, 1998).

The effect of fermented milks was discovered more than 40 years ago in studies conducted among the Maasai people in East Africa. Through consumption of high amounts of fermented whole milk (4 – 5 litres per day), the Maasai were found to have low levels of serum cholesterol and low incidences of clinical coronary heart disease despite living on a diet rich in meat.

While dairy products in general confer functional benefits to the body, goat milk has specifically been singled out as conferring more functional benefits compared to milks from other dairy animals.

### ***Functional benefits of goats milk***

Goat milk and its products have been increasingly popular in developed countries because of the recent trend in demand for health foods as well as hypoallergenic foods for those who

suffer from cow milk allergy. In underdeveloped countries it provides basic nutrition and subsistence to the majority of their populations.

Goat milk serves human nutrition in 3 important ways: (a) home consumption, (b) specialty gourmet interests and (c) medical-therapeutic applications.

Goat milk differs from cow or human milk in higher digestibility, distinct alkalinity, higher buffering capacity which is good for treatment of stomach ulcers thus conferring therapeutic values in human medicine (Haenlein, 2004).

Digestibility of goat milk is highly enhanced by nature of the proteins and the fat molecules. Protein molecules are thinner and fat molecules have more fragile membranes. The increased digestibility of protein is of more importance to infants, invalids and convalescent diets.

The Goat milk has a low curd tension of 36g (range 10-70g) while cow milk has 70g (range 15-200g) (Sanders, 1994). Low curd tension is attributed to low levels of  $\alpha$ -S1 casein and higher levels of A<sub>2</sub> beta-casein and makes the milk easily digestible.

Goat milk is the only dairy product with the highest amount of the amino acid L-glutamine an alkalinizing amino acid. Acidic blood and low intestinal pH levels have been associated with fatigue, headaches, muscle aches and blood sugar imbalances.

Goat milk has higher digestibility than cow milk, because of smaller fat globules size (naturally homogenized), and more friable milk proteins when acidified due to very low  $\alpha$ <sub>s1</sub>-casein and higher  $\alpha$ <sub>s2</sub>-casein, compared to cow milk (Haenlein, 2004)

**Table 1. Comparison of Casein Contents between Goat and Cow milk**

	Goat milk	Cow milk	Range in goat milk
Casein (g/l)	21.1	27.0	15.8-26.0
Casein fractions (% of total)			
$\alpha$ <sub>s1</sub>	5.6	38.0	0-20
$\alpha$ <sub>s2</sub>	19.2	12.0	10-30
B	54.8	36.0	43-68
K	20.4	14.0	15-29
$\alpha$ -Lactalb/ $\beta$ -Lactogl	0.63	0.4	0.33-1.1

(Reneuf and Lenoir, 1986)

**Table 2. Average amino acid composition (g/100 g milk) in proteins of goat and cow milk**

Essential amino acids	Goat milk	Cow milk	% Difference for GM
Tryptophan	0.044	0.046	
Threonine	0.163	0.149	+9
Isoleucine	0.207	0.199	+4
Leucine	0.314	0.322	
Lysine	0.290	0.261	+11
Methionine	0.080	0.083	
Cystine	0.046	0.030	+53
Phenylalanine	0.155	0.159	
Tyrosine	0.179	0.159	+13
Valine	0.240	0.22	+9

(Haenlein (2000)

GM has higher levels of short and medium chain fatty acids (MCT), which have the unique metabolic ability to provide energy in growing children, and has also been used for treatments of many clinical lipid malabsorption disorders (Chyluria, Steatorrhea, Coronary bypass

Hyperlipoproteinemia, Premature infant feeding, Childhood epilepsy, Cystic fibrosis, and Gallstones) in infants and adult human patients.

GM has low cholesterol levels compared to cow, sheep and human milk.

**Table 3. Cholesterol and Fatty Acid composition of Different Species Milks**

Species	Fatty acids (g/ml)			Cholesterol (mg/100g)
	Saturated	Monounsaturated	Polyunsaturated	
Cow milk	2.4	1.1	0.1	14
Goat milk	2.3	0.8	0.1	10
Human milk	1.8	1.6	0.5	16
Sheep	3.8	1.5	0.3	11

(Haenelin 2000).

GM has higher iron bioavailability (Hasler, 2002). Children fed on goat milk have higher weight gain, skeletal mineralization, bone density, blood plasma vitamin A, calcium, thiamine, riboflavin, niacin and haemoglobin concentrations ((Alferez *et al.*, 2003).

Presence of high levels of MCT reduces total cholesterol levels and the Low Density Lipoprotein (LDL) fraction (hypocholesteric effect), which decreases the synthesis of endogenous cholesterol by 36% in goat milk compared to 21% in cow milk (Alferez *et al.*, 2003).

MCT up to C<sub>14</sub>, are not incorporated into body lipids as is the case with the longer chain fatty acids, hence GM does not significantly contribute to obesity and other heart related problems. Goat milk MCT, such as caprylic and capric acids (C<sub>8</sub> & C<sub>10</sub>) are highly antimicrobial. They have been used in dietary supplements to inhibit the growth of *Candida albicans* and other yeast species.

Goat milk contains A<sub>2</sub> Beta-Casein, while cow milk contains A<sub>1</sub> Beta-Casein. Protein A<sub>1</sub> beta casein has been cited as a trigger for type 1 diabetes (Hasler, 2000).

Goats' milk oligosaccharides particularly 6-sialyl lactose provide nutrients for colonic bacteria. When included in infant formula they stimulate growth of bifidobacteria to levels similar to those in the GI tracts of breast-fed babies thus providing prebiotic and anti-infective properties. Prebiotic oligosaccharides inhibit pathogens such as *Campylobacter jejuni*, *Streptococcus pneumonia*, enteropathogenic *Escherichia coli* and neutralizes effects of *Escherichia coli* toxin (Newburg, 1999).

Goats' milk proteins, both caseins and whey proteins, are a rich source of ACE inhibitory peptides. These peptides have not been associated with statistically significant hypotensive effects or changes in potassium and renal function (Meynen *et al.*, 2007, Geerlings *et al.*, 2006)

### **Limitations**

Goat milk contains virtually no folic acid. To be adequate as an infant formula it has to be fortified. Lack of folic acid has been linked to congenital defects such as malformation of spinal cord associated with Siamese twins.

GM is an Apocrine secretion. The secreting cell is released along with the milk. This type of secretion produces milk with high levels of cytoplasmic debris and epithelial cells (SCC which are not desirable).

Maligned image of goat milk and its products by consumers.

Development of superior quality dairy goat products yet to be realized.

Low volumes of goat milk making it quite expensive and uneconomical to process.

### ***Current Trends***

Goat milk formulas are currently replacing cow milk and soy formulas as an alternative for infant diets. The milk is being promoted as an essential diet for invalids, convalescent, infants and the immune -compromised.

Due to high digestibility and absorption rates the milk is being used in many developing countries as a source of nutrients for patients with full blown AIDS, which in most cases is characterized by intestinal disorders.

In developed countries such as New Zealand and Australia more focus is geared towards production of nutraceuticals from goats milk.

### ***Strategies to Enhancing Dairy Goat Industry***

Sensitization of consumers on functional (nutritional and physiological) benefits of goat milk.  
Process and promote specialty goat cheeses to consumers.

## **CONCLUSION**

Confirmation of health benefits is not a simple task. It needs conceptual process and product development, validation, efficacy analysis and clinical studies. The biological markers of either health improvement or disease risk-reduction are not unanimously recognized. Health involves many complex and interactive functions. It is usually rare to find uncomplicated mechanisms that involve simple molecules acting in isolation. For the food industry to claim physiological functions of certain foods, it must have quantifiable indicators of bioactive molecules and interaction that controls biological functions related to physiology.

More research is needed to give conclusive evidence on physiological and nutritional benefits, particularly the effects of goat milk on promotion of immune systems. Whereas cow and human milk components have been sequenced and characterized, more research needs to be done to give direction on the role of specific goat milk components in mitigating diseases and preventing allergies.

As world populations expand with more competition for land, milk production from goats is bound to increase significantly. Economically, there are more returns from goat milk per unit quantity than from milks of other commercial animals. The cost of general management and feeding of dairy goat is fairly low.

The need for improved nutrition and functional benefits will continue to have significant impact on the growth of the goat milk industry.

Due to its high nutritive value and physiological properties, goat milk should be promoted in the developing countries, where malnutrition and diseases are more prevalent and the cost of healthcare is prohibitive due to high poverty levels.

Dairy goat farming is a vital sector of agriculture in developed countries especially in the Mediterranean region such as Italy, Spain, Greece and France.

This proves that goat dairying is not necessarily synonymous with poverty or an underdeveloped business sector.

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# EFFICACY ON ALOE SECUNDIFLORA CRUDE EXTRACTS ON ASCARIDIA GALLI IN VITRO

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## ABSTRACT

*Aloe secundiflora* with synonyms: *Aloe floramaculata*, *Aloe marsabitensis*, *Aloe engleri* belongs to the family *Asphodelaceae*. Two major components of the leaf include gel from parenchymatous cells and the exudates from the inner epidermal layers; the gel consists of mainly polysaccharides while the exudates comprise a mixture of phenolic compounds mainly anthrones, chromones and phenyl pyrones with a low content of polysaccharides or aliphatic compounds. Leaf components of *Aloe* have been credited for antibacterial, antifungal and antiviral and anthelmintic medicinal properties. The effectiveness of *Aloe secundiflora* extracts on the most prevalent nematode *Ascaridia galli* was conducted *in vitro*. The results of this study indicate that Hexane, Ethylacetate, Acetone, Methanol and chloroform extracts were found active in hindering the development of *Ascaridia galli* eggs to larval stage three (L<sub>3</sub>), and this was dependent on the concentration of the crude extract. The lowest concentration of the various extracts (5 mg/ml) had an inhibition percent (IP), 75.52%, 79.60%, 87.21%, 86.13% and 43.6% respectively. The highest concentration of the extracts was (50 mg/ml), in this level the inhibition percent was found higher than in the lowest extracts concentrations i.e., 91.84%, 97.55%, 100%, 99.46% and 91.29% respectively. *Aloe secundiflora* extracts have inhibitory effects on the *Ascaridia galli* larval development *in vitro*. Phytochemical tests on the extracts revealed the presence of various chemical compounds i.e. tannin, terpenoids, terminal alkynes and aliphatic compounds. Some of these compounds especially tannins and terpenoids are known to have biological activities against helminthes.

## INTRODUCTION

*Aloe secundiflora* Synonym: *Aloe floramaculata*, *Aloe marsabitensis*, *Aloe engleri* belongs to the family *Asphodelaceae*. It's a green foliage, cactus succulent plant with a scarlet (dark red) bloom colour. It's a dry tolerant plant occurring in dry semi-arid and open grasslands of both Kenya and Tanzania (Carter, 1994). Two major components of the leaf include gel from parenchymatous cells and the exudates from the inner epidermal layers; the gel consists of mainly polysaccharides (Femenia *et al.*, 1999), of which the acetylated mannose sugar is the major bioactive component. Analytical High Performance Liquid Chromatography-Mass Spectrometry (HPLC-MS) studies of the exudates have revealed that it comprises of a mixture of phenolic compounds mainly anthrones, chromones and phenyl pyrones with a low content of polysaccharides or aliphatic compounds (Waihenya *et al.*, 2003).

*Aloe* species have been known for their medicinal uses since the 4<sup>th</sup> century. Leaf components of *Aloe* have been credited for medicinal properties antibacterial, antifungal and antiviral (Avilla *et al.*, 1997). The leaf exudate of this species has found ethno-veterinary use for treatment of bacterial diseases and parasites and in management of viral diseases. In poultry for example the exudates has been extensively used as prophylaxis for Newcastle virus and as therapeutic for fowl typhoid, coccidiosis and other enteric conditions (Waihenya *et al.*, 2003). In search of plant based anthelmintics extracts of different medicinal plants have been tested

for action against flatworms and roundworms *in vitro* and *in vivo* and have been found to possess anthelmintic activity. The present study was therefore carried out to assess the anthelmintic activity of *Aloe secundiflora* extracts *in vitro* using the nematode parasite *Ascaridia galli* larval development assays.

## **MATERIALS AND METHODS**

### ***Plant collection and identification***

*Aloe secundiflora* leaves were collected from Chemeron Research substation in Marigat location Baringo District. They were identified at Egerton University, Njoro, and the voucher specimen number SK62, stored in the herbarium. A total of 5kg fresh of *Aloe secundiflora* leaves were chopped using a machete. The materials were put in a rotary blender and blended to slurry and transferred to Winchester glass bottles.

The extraction of the various fractions was carried as follows: To each Winchester bottle containing the crude extract of *Aloe secundiflora* was added to one liter Hexane solvent and thoroughly mixed then left overnight at room temperature. The following day the solute was decanted into 2 clean half liter beakers and to each were added three spatulas of sodium sulphate and four spatulas of activated carbon charcoal. Then filtration followed using a filter paper of gauge 1-215mmØ to obtain a clear filtrate. The filtrate was concentrated in a round bottomed flask at temperature of 50<sup>0</sup>C using a rotavapor machine connected to a vacuum pump and a condenser machine to recover the hexane solvent. The concentrated solution was put in small glass universal bottles and covered with perforated aluminum foil for air drying the samples. A cream extract was obtained and denoted ASH (*Aloe secundiflora* Hexane extracts). The same procedure was used to obtain Ethyl acetate, Chloroform, Acetone and Methanol extracts).

A total weight of 5.164 kg of fresh *Aloe secundiflora* leaves were chopped and blended to slurry material to obtain the five solvent extracts. A crude extract was also obtained by crushing fresh leaves using a blender and squeezing the fresh crude extract viscous juice and stored in a refrigerator. This is neat extracts, without solvent extraction processes.

### ***Parasite collection***

Specimens of adult *Ascaridia galli* were collected in 0.9 phosphate buffered saline (PBS, pH 7.3) from intestines of freshly necropsied domestic fowl (*Gallus gallus domesticus*). The method used to obtain *Ascaridia galli* larvae for *in-vitro* larval migration inhibition test was modified as that described by Permin *et al.*, (2002). Briefly, adult *Ascaridia galli* parasites were collected from intestines of indigenous birds, from Nakuru Indigenous Chicken abattoir. Parasites were washed with distilled water and diluted using formalin solution to avoid contamination. The worms were opened under a dissecting microscope; their uteri were located and squeezed to liberate the ova (eggs). The ova were washed several times with phosphate buffered saline (PBS), then sedimented by centrifugation and finely dispersed in 2% hydrated copper sulphate (CuSO<sub>4</sub> 7H<sub>2</sub>O) solution. The eggs were kept at room temperature before use after viability test was done.

### ***Phytochemical tests***

The following phytochemical tests were performed to detect the presence and absence of chemical compounds in *Aloe secundiflora* extracts. Polysaccharides (acid hydrolysis test), Aliphatic compounds test (bromine test) and acetylde test, Phenolic compounds test, Terpenoids test (salkowski test) with warming and non-warming tests, athracene test and glycosides test. Thin layer chromatography analysis was also performed on the extracts.

### ***In vitro* screening of plant extracts**

Laboratory evaluation of anthelmintic activity of *Aloe secundiflora* extracts was done using *Ascaridia galli* viable eggs recovered as described earlier. The Percent Inhibition (PI) of larval development was calculated using the formula (Rabel *et al.*, 1994):

$$\text{Percent Inhibition} = \left\{ 1 - \frac{T}{C} \right\} \times 100$$

where C is the number of eggs that developed to L<sub>3</sub> in the control incubations and T is the number of eggs that developed to L<sub>3</sub> larvae in incubations containing different concentrations of various plants extracts tested.

Five types of extracts were used: Hexane extract, Ethylacetate extract, Acetone extract, Methanol extract and Chloroform extract. In each extract the following concentrations were used: 5mg/ml, 10mg/ml, 20mg/ml, 40mg/ml and 50mg/ml. Each concentration was replicated four times. There were three control groups: neat, dimethylsulphoxide (DMSO) and phosphate buffer saline. Each well had a total volume of 1ml with 100 viable eggs of *Ascaridia galli* which were incubated at a temperature of 25-26°C for 28 days. The contents in each well were microscopically examined using an inverted microscope; developed L<sub>3</sub> larvae and undeveloped/destroyed eggs were counted and recorded. Averages on the four replicates were used to calculate the Inhibition Percent (IP) of each extract and compared to the controls.

## **RESULTS AND DISCUSSION**

### ***Phytochemical analysis***

The phytochemical tests were performed to detect the presence of chemical compounds. Table 1 shows the types of chemical compounds found in *Aloe secundiflora* extracts. The test for the presence of tannins in *Aloe secundiflora* extracts by the use of 0.1% Ferric chloride was undetectable in four extracts, which were pale brown in color, while methanol extract was brown greenish in colour, indicating the presence of tannins. Acid hydrolysis test was used to test the presence of polysaccharides in *Aloe* extracts. Two tests were performed for polysaccharides test; the bromine test which test the presence of multiple bonds (double or triple bonds) and the acetylide test which tests the presence of a triple bond (alkynes), *Aloe secundiflora* chloroform extract and *Aloe secundiflora* acetone extract tested positive for the presence of terminal alkynes by forming grayish white precipitate. Phenolic compounds were found positive in *Aloe secundiflora* methanol extract, the Ferric chloride solution turned to a blue green colour, this indicated the presence of phenolic compounds, and the rest of the extracts tested negative. Salkowski test was used to test the presence of terpenoids. Two test were used; with warming and non-warming. The five extracts namely methanol, acetone, chloroform, ethyl acetate and hexane extract had a red to reddish brown color, this is a positive test for the presence of terpenoids, all extracts had terpenoids compounds. Glycosides compounds were only present in *Aloe secundiflora* acetone extract, which formed a red precipitate, while the other four extracts tested negative.

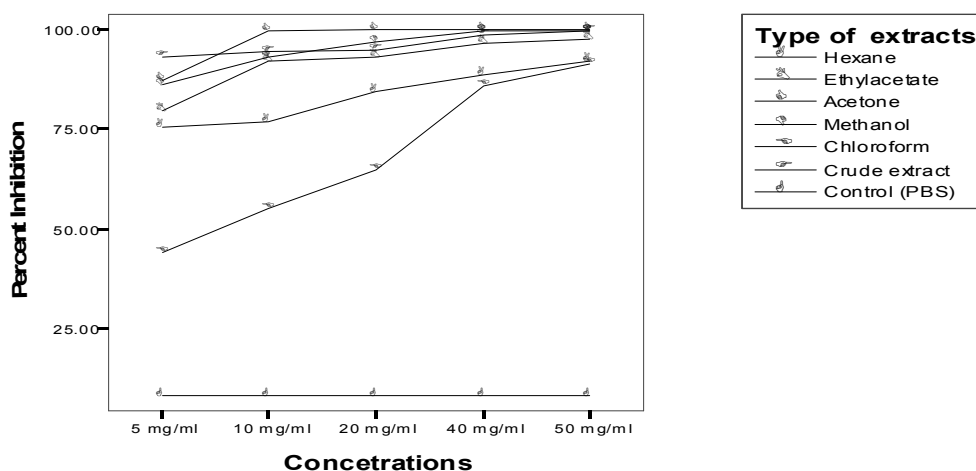
**Table 1 Types of chemical compounds found in *Aloe secundiflora* extracts.**

Compound test	<i>Aloe secundiflora</i> extracts				
	Hexane	Ethylacetate	Acetone	Methanol	Chloroform
1 Tannin test	(-ve)	(-ve)	(-ve)	(+ve)	(-ve)
2 Aliphatic compounds	(+ve)	(+ve)	(+ve)	(+ve)	(+ve)
3 Acetylide test/Terminal alkynes	(-ve)	(-ve)	(+ve)	(-ve)	(+ve)
4 Phenolic compounds	(-ve)	(-ve)	(-ve)	(+ve)	(-ve)
5 Terpenoids test (salkowski test).	(+ve)	(+ve)	(+ve)	(+ve)	(+ve)
6 Athracene test	(-ve)	(-ve)	(-ve)	(-ve)	(-ve)
7 Glycosides test	(-ve)	(-ve)	(+ve)	(-ve)	(-ve)

KEY : ( +ve ) = detectable, (compound present); (-ve) = undetectable, (compound absent).

In the *in vitro* tests with Hexane, Ethylacetate, Acetone, Methanol and chloroform extracts inhibited larval development of *Ascaridia galli* eggs. This inhibition was dependent on the concentration of the extract. The lowest concentration of the various extracts (5 mg/ml) had an inhibition percent (IP), 75.52%, 79.60%, 87.21%, 86.13% and 43.6% respectively. The highest concentration of the extracts was 50 mg/ml. At this level percentage inhibition was found higher than in the lowest extracts concentrations i.e. 91.84%, 97.55%, 100%, 99.46% and 91.29% respectively. The crude aqueous extract was a natural extract from *Aloe secundiflora*, it is composed of all the five types of extracts. It had an inhibition percent ranging from 93.05%-99.46%. Phosphate Saline Buffer (PBS) acted as the negative control. The 100 *Ascaridia galli* eggs incubated in phosphate saline buffer (control) had an average of 91.9% developing to larval stage three (L<sub>3</sub>). This control mean was used to calculate percent inhibition (Rabel *et al.*, 1994).

Figure 1 shows the percentage inhibitions of various extracts in different concentrations. The activity of *Aloe secundiflora* acetone (ASA) extract increased exponentially from 87.21%-100% with an increase of concentration 10 g/ml. The higher the activity of an extract at lower dose concentrations, the more effective the extract. Further increase of the concentration of the ASA had no effect as the graph from this point reaches the plateau phase, a steady straight line. The activity of the ASA extract could have been a result of the anthelmintic active ingredients; glycosides and terpenoids as determined by the phytochemical tests that were performed (Table 1). Glycosides and terpenoids are active principles against nematodes (Mwamachi *et al.*, 2003).



**Fig. 1: Percentage inhibitions of various extracts in different concentrations**

*Aloe secundiflora* methanol (ASM) extract inhibition percentage increased at a rate from 86.13% at 5mg/ml to 96.74% at 20mg/ml, increasing the concentration to 40mg/ml increases the inhibition percent to a plateau phase of the graph at 99.5%. The activity of ASM extract on the larval stages of *Ascaridia galli* may be due to the active ingredients (Table 1). Tannins are active ingredients against nematodes (Onyelili *et al.*, 2001). Terpenoids are also known to be active principles against nematodes (Jovellanos, 1997; Vierra *et al.*, 1999).

*Aloe secundiflora* ethyl acetate (ASE) extract inhibition line graph increased at an increasing rate from 91.84% at 5mg/ml to 96.46% at 40mg/ml and thereafter increased at a decreasing

rate to 97.55% at 50mg/ml. The activity of ASE extract could have been contributed by the chemical compounds present i.e. aliphatic compounds and terpenoids (Table 1). Comparing the activities of *Aloe secundiflora* chloroform (ASC) extract and *Aloe secundiflora* hexane (ASH) extracts, though ASC activity is very low at 5mg/ml at 43.6%, in contrast ASH extract high at 75.52%, the two extracts rise steadily to converge to a common point at 92% inhibition percent at highest concentration of 50mg/ml (Figure 1). The activity of these two extracts could have been contributed by the chemical compounds present (Table 1). The IP in natural crude extracts was found high, 93.05% even at the low concentration of 5mg/ml, the IP increased with increase in concentration to 99.46% at 50mg/ml. The control used was Phosphate Buffered Saline. The PBS is conducive for larval development.

## CONCLUSIONS

Crude extracts of *Aloe secundiflora* have an inhibitory effect on the development of larval stages of *Ascaridia galli* *in vitro*. Acetone and crude aqueous extracts had the highest anthelmintic activity with lyses of larval stages and highest inhibition percentages. The inhibitory effect depends on the concentration of the extract used. The five solvent extracts used have different active principles and thus difference in activity against the larvae stages of *Ascaridia galli* *in vitro*. The use of crude aqueous extracts of *Aloe secundiflora* as an anthelmintic by the poor resource farmer is highly recommended; though the study was based on *in vitro* experiments the results can be inferred for application in the indigenous chicken (*in vivo*). Further *in vivo* experiments on *Aloe secundiflora* extract or possibly bioactive compounds that will incorporate toxicology /residue studies are required before it can be recommended for safe use in poultry and other domestic animals. Dose determination and confirmation studies are necessary further anthelmintic evaluation.

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# IMPACT OF A MANUAL HAY BOX BROODER ON MANAGEMENT OF INDIGENOUS CHICKEN IN MACHAKOS DISTRICT, EASTERN KENYA

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## ABSTRACT

The study was carried out in the Machakos district in Kenya in the month of July to August 2009. It was aimed at evaluating the efficacy of a manual hay box brooder by comparing with chicks that are not kept under a hay box brooder. To achieve this data was collected on 300 indigenous chickens within ten farmers for 8 weeks. The ten farmers were categorized into two and sampling of the farmers was done purposively based on their ability to keep chicken. The first category was five control farmers from Machakos central division, who were supplied with 30 day old chicks each and feeds that, could sustain the chicks up to 8 weeks of age. The second category was five test farmers from Kalama division in Machakos district and was supplied with 30 day old chicks each, a manual hay box brooder and feeds that could sustain the chicks for 8 weeks. Results indicated that mortality was 23% for chicks raised without a hay box brooder (control farmers) compared to only 5% for chicks raised under a hay box brooder (test farmers). For the chicks raised by control farmers, death was due to suffocation and predation, while for those raised by test farmers, deaths were due to drowning and cold. On weekly basis test chicks (under hay box brooder) recorded higher weight gain compared to control chicks (without hay box brooder) by an average of about 30 grams in the 1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> 4<sup>th</sup> 5<sup>th</sup> 6<sup>th</sup> week and 7 grams in the 7<sup>th</sup> and 8<sup>th</sup> week respectively. It was concluded that by improvising appropriate technologies productivity of indigenous chicken can be enhanced... However, there was congestion in the brooder from the fourth week.

**Key words:** *Indigenous chicken, day old chicks, hay box brooder,*

## INTRODUCTION

Agriculture contributes 25-26% of Gross Domestic Product (GDP) in Kenya with poultry playing a major role, representing 30% of the agricultural contribution to GDP (FAO, 2007). The poultry sector is important for income-generation for small holder farmers especially in rural areas, food security and economic growth. Poultry population in Kenya is nearly 29 million, 68% of which are indigenous chicken (MOLD, 2008).

Considered as an alternative source of livelihood, poultry are generally maintained by rural women and children that generate cash revenue but basically to supplying adequate eggs and meat for subsistence purposes. The indigenous chicken generally scavenge around the homestead areas during the daytime, where they eat kitchen leftovers, cereal grains, green grasses, insects and other valuable foodstuffs waste (Das *et al.*, 2008, Ndegwa *et al.*, 1998). The waste foodstuffs are utilized by the birds to produce a good quality, cheap source of animal protein.

Broodiness a trait that retards laying performance is common in indigenous birds. Native hens become broody after laying a small number of eggs in separate clutches (Das *et al.*, 2008). Chick brooding refers to the early periods of growth (0-8 weeks), when young chicks are unable to maintain their normal body temperature without aid of supplementary heat (Demeke, 2009). It is by natural brooding that day chicks are raised in most parts of the country.

Normally, a broody hen lays and brood her eggs until they hatch. After hatching she continues to rear the chicks and during entire period of brooding and rearing, she ceases to lay eggs and this may take upto 81 days. A broody hen rears her chicks, provides the needed warmth and protects against predators such as birds, pets and small wild animals all of which are major causes of premature death of chicks when a natural brooding is employed.

If an artificial chick brooding system is adopted, it will relieve the hen from long broody period and the hen would come into laying again within a short period and hence increase poultry production among the rural livelihoods (Demeke, 2009).

## OBJECTIVE

The main objective is to test the impact of the Hay Box Brooder on management indigenous chicks

## METHODOLOGY

Ten farmers were selected on the basis of their status and capability of keeping poultry. The selection was done by the District Livestock Production Office in Machakos. Two divisions, in Machakos district were targeted for the project namely Machakos Central and Kalama. In each division five farmers were randomly selected. In Kalama Division five farmers were issued with thirty day old chicks each, a hay box brooder and feeds that could sustain the poultry for 8 weeks after then the farmers were expected to sustain the chicks on local feeds. Machakos Central Division was a control whereby the farmers were given thirty day old chicks each and feeds that could sustain the poultry for 8 weeks after then the farmers will be expected to sustain them on local feeds. Data was analyzed using Excel and simple descriptive statistics was done.

## RESULTS

As shown in Figure 1 below increase in weekly average increase in weight for Chicks kept on a manual hay box brooder was slightly higher than chicks that were not kept on brooder. In the six and 8<sup>th</sup> their weights were almost the same. The trend in weight gain was gradual in the second and third week. From the third week on wards the trend of increase was fast.

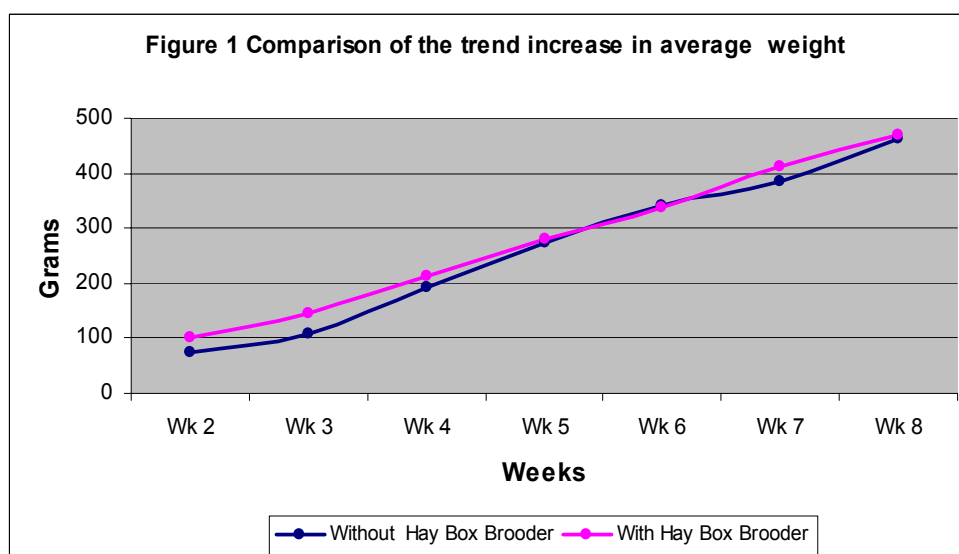




Figure 2 indicates that mortalities were higher for chicks reared without a hay box brooder compared to the ones under a hay box brooder by about 50%. There was no reported mortality in the eight week.

Overall mortality was 23% for chicks raised without a hay box brooder (control farmers) compared to only 5% for chicks raised under a hay box brooder (test farmers).

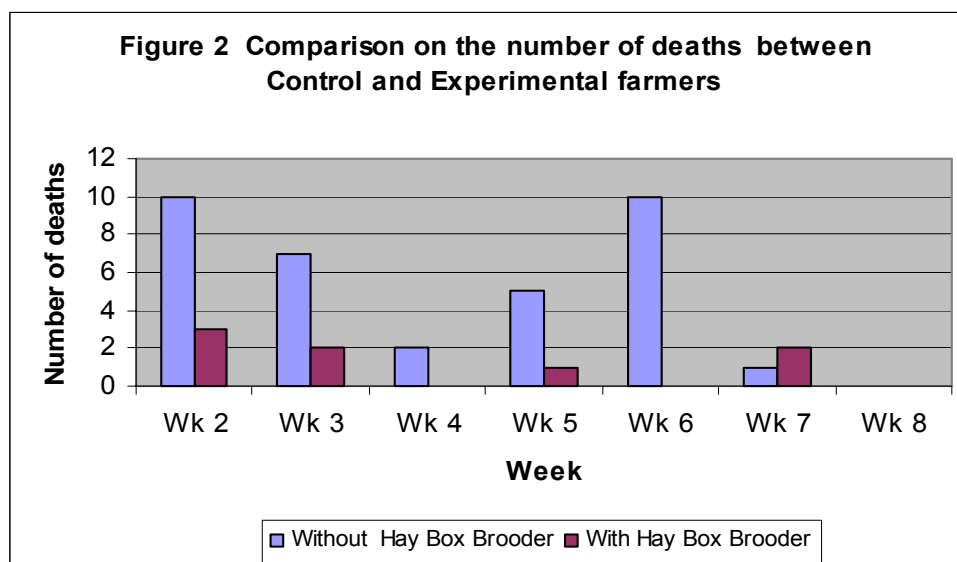


Plate 1 below shows a runner with chicks confined inside while Plate 2 below shows a brooder connected to a runner the chicks can move into the brooder box when in need of warmth and can move out into the runner when there is warmth outside.



**Plate 1 Runner**



**Plate 2. Brooder and a Runner**

#### **Feedback discussion with farmers without a hay box brooder (Control Farmers)**

- In Week one most of the farmers lost at least one chick due to suffocation and cold weather there was difficulty in providing warmth
- All the farmers lighted a charcoal stove to provide warmth (brooding) for the chicks since there was no housing.

- After two weeks started providing the chicks with kales and left-overs from the house
- Immediately after the eighth week changed feeds to growers' marsh and this led to constipation.
- One farmer lost more than half of the chicks to predators in the sixth week due to lack of an appropriate housing
- Some improvised a brooder by using cartons and rags. Further constructed a housing to isolate them from others
- Due to lack of housing some of the chicks incurred bacterial infections and had to be provided with antibiotics
- Most farmers were forced to change their duty pattern since they were forced to keep watch the chicks while on free range.

### **Feed back discussion from Farmers with a hay box breeder**

The Hay box brooder reduced labour and cost of the farmers. The artificial brooder did provide warmth and there was no need to improvise a charcoal stove.

- The chicks were kept off from the predators and they could easily be isolated incase of sickness using the brooder
- The chicks were confined and were being fed directly without interference from outside
- However due to faster growth rate, there was congestion in the brooder from the fourth week.
- There was no predation since the chicks were enclosed in the runner during the day and the brooder during the night.
- The growth was very fast and some farmers had to remove the chicks into a bigger house while they introduced other chicks in the brooder.
- Whenever new chicks are being introduced the farmers had been advised to disinfect the brooder and they remembered to do this.
- Two farmers had other social groups coming to learn from them and so they became contact farmers.
- One farmer fabricated his own brooder from ply wood and was able to brood chicks hatched at home and at the same time release the mother hen back to lay again.

### **DISCUSSION**

The highest losses were incurred in Machakos central where farmers were not given a Hay box brooder. This concurs with explanation of Sonaiya, (1995), that productivity of indigenous chickens could be improved by management systems and quality and quantity of feed supply. The farmers had a difficult time trying to provide warmth to the chicks by placing them near charcoal stoves and constructing housing for them. The study was undertaken at a time when there is a severe drought resulting to scarcity of natural feeds like green grass grains or vegetables. The chicks were mainly dependant on chick marsh and left over (wastes) from the house.

### **CONCLUSION**

Indigenous chicken production should be supported by proper management strategies and inputs such as housing, feed formulation and protection from predators. Any plan for poverty alleviation or reduction through poultry rearing must be prepared, implemented, monitored and modified in line with appropriate technologies that are localized and can be adoptable. However more studies on broodiness and growth performance of indigenous chicken at household level need to be carried out in order to ascertain economic advantage of using the manual hay box brooder.

## **RECOMMENDATIONS**

There is need to train poultry farmers, women in particular, on basic techniques of brooding and rearing of chicks, proper nutrition and feed requirements during different growth stages as well as disease prevention and management, to reduce the losses and maximize the returns under this system of poultry production.

Despite slow growth rate and low laying performance, indigenous birds are still considered as the fundamental resources of so many invaluable genetic and non genetic economic traits. In-depth studies are needed for identification, selection, accumulation and conservation of the genetic resources distributed in the country for their development.

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