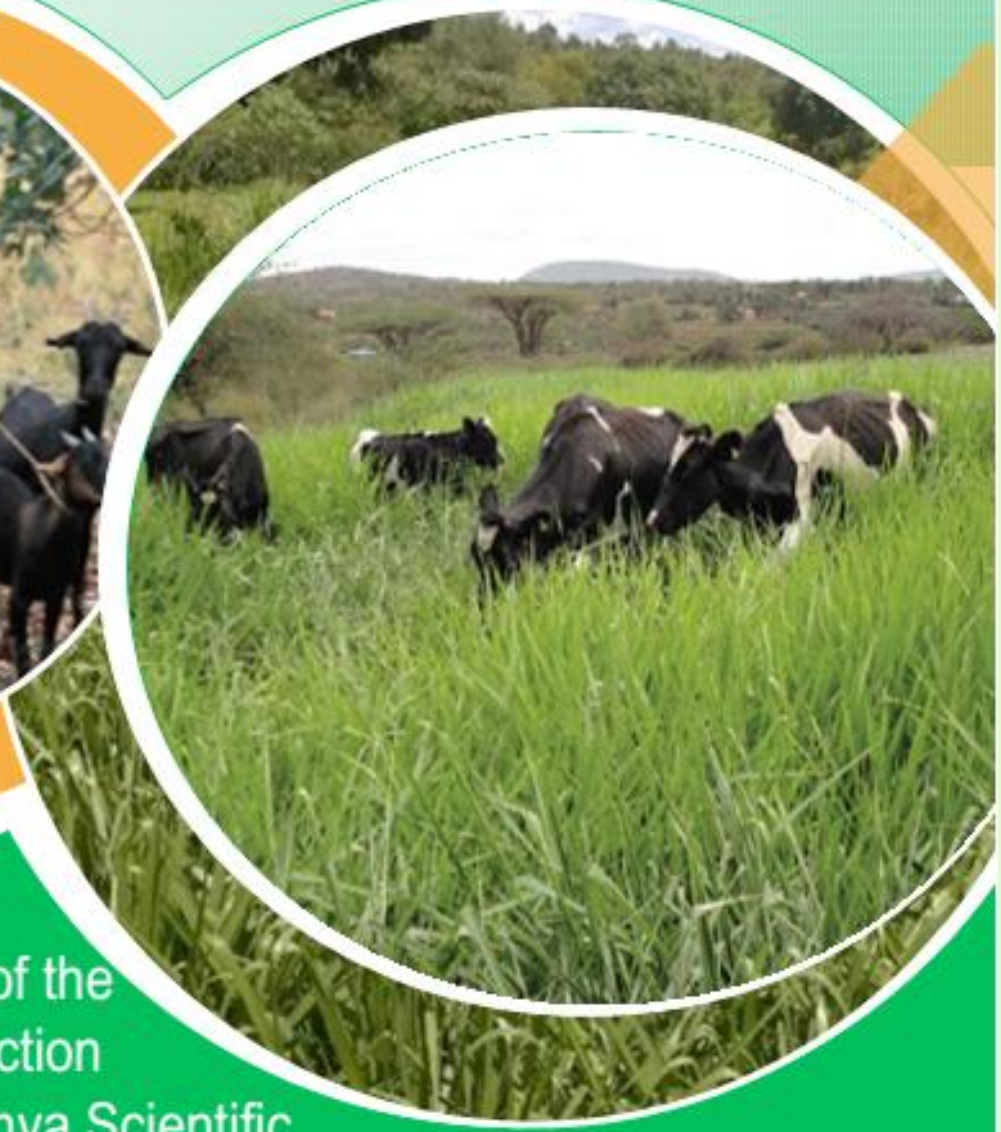
Kenya's Animal Agriculture: Macro-Trends and Future Prospects



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E-Mail: apskkenya@gmail.com

Overall Coordination

Rophin K. Nyange — Ministry of Agriculture, Livestock and Fesheries

Editor in Chief

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Design and layout

Nathan M. Maweu — Kenya Agricultural & Livestock Research Organization

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Preface

The annual scientific symposium is the main mechanism through which the APSK objectives are met, that is, providing a forum for stakeholders – professionals and practitioners - to get together and share views on issues germane to livestock production. Therefore, every one of these annual meetings focuses on a major contemporary issue or sets of issues which require attention. These may be new technologies or approaches, emerging challenges, controversial issues with implications for livestock production that require rational conversation, national or regional trends which may have consequences for animal agriculture. The APSK 2016 symposium focused on examining macro trends that underpin livestock production in Kenya.

The livestock sub-sector contributes over 30% of the farm gate value of agricultural commodities, about 10% of the national GDP, and at least 50% of the agricultural GDP. Domestic livestock also supply the local requirements of meat, milk, dairy products and other livestock products while accounting for about 30% of the total marketed agricultural products. However, the supply and demand for livestock products is affected by increasing population, urbanization, policy environment and, the import/ export markets among other factors. Particularly, urbanization will offer opportunities for business throughout the country and will require the development of innovative products to meet the specific needs of an emerging consumer class. At the same time, it is clear that rural incomes will not be substantially increased by exclusive emphasis on subsistence livestock production; rather, more market-oriented production systems will be needed. This, therefore, implies that revitalization of livestock industry is likely to yield a wide range of positive impacts/ effects throughout the country.

The APSK 2016 symposium provided opportunity for rational discussions on these livestock trends and sought ways of addressing the associated challenges while harnessing existing opportunities. Under the overarching theme "Kenya's Animal Agriculture: Macro-Trends and Future Opportunities", specific attention was given to: Dairy and poultry production systems, Alternative livestock feed resources, Animal Genetic resources, Pastorals systems; options for tomorrow, Emerging livestock and alternative sources of livelihood and, Policy, value chains and markets.

We would like to express our gratitude to the sponsors of the conference. Special thanks are due to presenters and authors of papers and posters, our colleagues on the symposium organizing committee, institutions and individuals who assisted in one way or the other, and the esteemed conference participants. The venue, setting and the overall conference atmosphere provided opportunity for networking by participants from across the country. After the symposium, presenters were asked to submit or revise their papers, taking into account the issues raised during the symposium discussions. The papers were then subjected to light technical reviews and language editing, therefore, ensuring that intellectual content remains that of the authors. APSK does not necessarily share the views expressed in this proceedings; responsibility for its content rests entirely with the authors.

It is our hope that the APSK 2016 symposium proceedings will provide useful reference material for those interested in understanding the major trends and associated issues covered during this conference.

Rophin K. Nyange
Chairman, Animal Production Society of Kenya (APSK)

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Animal Genetic Resources

The National Strategy and Action Plan for Management of Animal Genetic Resources in Kenya

Samuel M. Mbuku

Kenya Agricultural and Livestock Research Organization, Beef Research Institute,
P.O. Box 3840-20100 Nakuru, Kenya

Abstract

Kenya is endowed with a rich diversity of livestock genetic resources which are of great economic, social and cultural importance. They are an important component of food security and human livelihood in the provision of both tangible (milk, meat, eggs, manure, hides and skins) and collateral (insurance against economic bottlenecks, risk aversion, prestige, dowry, cultural values) benefits. Despite their importance, many of indigenous breeds are either facing extinction or are undergoing steady and continuous genetic dilution. Driven by the need for rapid gains in productivity and production levels, livestock improvement programs by government, non-governmental organizations, development partners and private sector have tended to favor the use of exotic breeds in crossbreeding, upgrading, and/or replacement. The continuation of this trend may lead to complete loss of indigenous animal genetic resources that have resilience to adverse effects of climate change. Therefore, the national strategy and action plan gives guidance on the management, sustainable use and conservation of animal genetic resources.

On Farm Performance of Artificial Egg Incubators and its Implication on Indigenous Chicken Production in Kilifi County, Kenya

Lewa K.K.[#1], Wahome P.K. [1], Maritim B.A. [2] and Farra[3], C.N.

[1]Kenya Agricultural and Livestock Research Organization, Industrial Crops Research Institute; PO Box 16 Mtwapa (80109), Kenya
[2]Kenya Agricultural and Livestock Research Organization, Dairy Research Institute; PO Box 344 Malindi (80200), Kenya
[3]Agricultural Sector Development Support Programme, Kilifi County, PO Box 937 Kilifi (80108), Kenya
[#] Corresponding author: Lewa.Kadenge@kalro.org; lewakk@yahoo.com

Abstract

One of the key challenges to indigenous chicken (IC) production is the low egg production capacity of local chicken breeds. The situation is exacerbated by the time taken by hens during brooding. While improved IC breeds such as the KALRO Kienyeji chicken have high egg production potential they are poor brooders. Through artificial egg incubation therefore, eggs can be hatched thus allowing hens to continue laying and at the same time free them from brooding. Artificial egg incubators were introduced to enhance rapid multiplication of indigenous chicken and thereby increase household stock numbers in Kilifi County. However, the on farm performance of the incubators is not known. This study, therefore, investigated the productivity of artificial egg incubators and the constraints and opportunities associated with their use at the farm level. A census of the incubators was carried out in February 2016. A pre-tested structured questionnaire was used to collect data. The study found that there were 27 incubators in the County, out of which only 16 were operational. Two thirds of the incubators were group owned while the others were owned by private individuals. The incubators had total egg setter and hatcher capacities of 11,085 and 5,730 respectively. The mean hatch rate was 43.4%, and annual hatch cycles ranged from 1-8 with a mean of 3.3 cycles year^{-1}. Probability estimate showed that at least 18 hatchings were required to meet a standard 75% hatch rate. Constraints to the use of the incubators were largely associated with inadequate knowledge on how the artificial egg incubators work. The study recommended capacity building of the operators both before and after purchase of the incubators.

Introduction

Indigenous chicken (*Gallus domesticus* L.*)* (IC) are very important in Kenya's rural development. The IC population in Kenya is about 35 million (GoK 2015); and IC are kept by 90% of the rural communities in small flocks of up to 30 birds mainly under free range management system which involves minimum resource input. In the rural areas they play important cultural roles besides being a source of food and income (Ondwasy et al., 2006, Danda et al., 2010). Further, IC have a great potential to generate higher incomes and transform living standards of smallholder farmers (KIPPRA, 2009). This is due to the increased demand resulting from increased incomes of the middle class and changing food habits that favour consumption of white meat (Bett et a.,l 2012).

More than 90% of the households in Kilifi County keep IC (GoK, 2015, Danda et a.,l 2010). Productivity of IC is however very low due to poor quality local breeding stocks. The average flock size per household is 4-7. The number of eggs hen-1laying cycle-1 is 13 with 3 laying cycles year-1. Local hens spend substantial time during brooding. Efforts have been made to increase household stock numbers through the introduction of improved IC breeds especially the KALRO Kienyeji chicken. Breeding of the KALRO Kienyeji chicken focused on egg production at the expense of brooding, thus they are poor brooders but have a high egg yield potential of upto 240 eggs year-1.

Government and non-Governmental development agencies promoted the artificial egg incubation technology in Kilifi County as a strategy towards commercialization of IC. Artificial egg incubators were intended to take advantage of the improved IC breeds and also reduce the time lag taken by local breeds during brooding thereby giving them more laying time. The ultimate objective was to enhance rapid multiplication of breeding stock and also increase household stock sizes. Thus, farmers both individually and in groups acquired the artificial egg incubators through private purchase or as grants. The performance of these artificial egg incubators is however, not known.

This study therefore sought to investigate the on farm performance of artificial egg incubators and its implication on IC production in Kilifi County. The objective was to establish the performance of artificial incubation and specifically to answer three research questions: i) Who operate artificial egg incubators in Kilifi County? ii) What is the productivity of the artificial egg incubators; and, iii) what are the major constraints facing egg incubation in Kilifi county?

Methodology

Study area

The study was conducted in Kilifi County located in the coastal region of Kenya. Agriculture is a major source of livelihood and employment in the County with livestock farming being an important socio-economic activity providing income and food. The main types of livestock kept include cattle, sheep, goats and poultry. The IC population is about one million.

Data collection

A census of the existing artificial egg incubators was conducted in Kilifi County. The incubators were identified through assistance of the County department of livestock production, KALRO centres at Mtwapa and Msabaha, NGOs dealing with IC production and marketing, and IC farmers. Data was collected using a pre-tested structured questionnaire from the incubator operators on their demographic characteristics, egg and hatch capacities of the incubators, and the constraints faced.

Data analysis

Incubator productivity

Productivity was determined by estimating percent hatch rate, calculated as

$$\text{Hatch rate \%} = \frac{\text{Number of chicks hatched}}{\text{Number of eggs set in the incubator}} \times 100$$

Production gap

The production gap was considered to be the number of hatched chicks and was estimated as the difference between the mean annual production of the operational and the non operational incubators, using the following formula:

Production gap (chicks) = HCop x HRc x MAC – HCnop x HRc x MAC

Whereby
HCop = Total hatcher capacity of the operational incubators
HRc = the calculated mean hatch rate of the operational incubators
MAC = the calculated mean number of hatch cycles per year based on the operational incubators
HCnop = Total hatcher capacity of the non operational incubators

Production potential

The production potential of the incubators was considered to be the number of chicks that would be produced if all incubators were operational at the recommended standard hatch rate of 75%.

$$\text{Production potential} = \frac{\text{Total hatcher capacity of all the 27 incubators} \times 75}{100}$$

The DeMoivre-Laplace Theorem (DLT) equation was used to estimate the minimum hatching count in order to meet the requirement of a standard 75% hatch rate as follows:

$Z = (X + np) / \text{sqrt}(npq)$

Where Z = Z table score for 75% which is 0.67
X = number of hatchings required to attain 75% hatch rate
n = total number of incubators
p = probability of achieving a 75% hatch rate
q = probability of failing to achieve the 75% hatch rate (1-p)

Results and discussion

Distribution of artificial egg incubators in Kilifi County

There census identified 27 artificial egg incubators in all the seven sub Counties of Kilifi County. Most of the incubators were located in Malindi and Kilifi North sub Counties, while Kaloleni and Kilifi South had the least numbers with two incubators each (Table 1). The egg incubators had egg and hatcher capacities ranging from 40–3,167 and 40–2,540 respectively. About 33.3% had an egg capacity of 528 eggs. The incubators were mostly electric operated with a few being paraffin operated.

Table 1. Distribution of the egg incubators by sub County in Kilifi County

Sub County	*Number of egg incubators*	*Percentage*
Malindi	6	23.1
Magarini	3	11.5
Rabai	3	11.5
Kaloleni	2	7.7
Kilifi North	7	23.1
Kilifi South	2	7.7
Ganze	4	15.4
Total	27	100.0

Source: Survey data

Characterization of the artificial egg incubator operators

The socioeconomic characteristics of the egg incubator operators considered in this analysis comprised gender, age and education. Other characteristics considered were group membership and ownership of the incubator (Table 2). The study showed that male artificial egg incubator operators were more (57.7%) compared to the female operators. The mean age for all the artificial egg incubator operators was 44.4 years. However, about three quarters were in the productive age range of 36 – 55 years. Egg incubation is an enterprise that has not yet picked among the youth who were only 7.4%. In terms of education, 76.9% of the operators had attained secondary school level.

Table 2: Demographic characteristics of the incubator operators in Kilifi County

Variable	result
Gender	
Female	42.3%
Male	57.7%
Age	
Average age (years)	44.4
<35 years	7.4%
36-55 years	74.1%
>56 years	18.5%
Education	
Primary	15.4%
Secondary	76.9%
Post-secondary	7.7%
Group membership (%)	
Yes	85.2
No	14.8
Ownership of the incubator	
Private individual	33.3%
Group	66.7%

Two thirds of the incubators were group owned while the rest were privately owned. Operations of the group owned incubators were assigned to selected group members, usually two who managed them on behalf of the group. The group members contributed egg which would be hatched at a lower fee compared to non members.

Of the group owned incubators 77.8%were operational (in use), as compared to only 50% of those that were group owned (Table 3). This showed that the private owners had better incentives to get output from their investment. Indeed most of the groups reported to have got their incubators through government, NGO projects such as KAPAP, ADS and State department of livestock

Table 3. Ownership of the egg incubators by their use in Kilifi County

Ownership of incubator	Egg incubator in use		Total
	No	Yes	
Private	2 (22.2)	7 (77.8)	9 (100)
Group	9 (50)	9 (50)	18 (100)
Total	11 (40.7)	16 (59.3)	27 (100)

Numbers in parethesis are % within Ownership of the incubator

Productivity and potential of the artificial egg incubators

The study found that only 16 (59.3%) of the incubators were operational and being used for hatching while 11 (40.7%) were non operational. The total setter and hatcher capacities for the operational incubators was 8,011 and 4,478 eggs respectively compared to 3,074 and 1,252 eggs for the non operational (Table 4). Operational incubators had a hatch rate of between 0–88% and a mean of 43.4%; while the annual hatch cycles achieved ranged from 1–8 with a mean of 3.3 cycles year^{-1}.

Operational incubators thus contributed an average of 6,413 chicks in Kilifi County per year, valued at KES 769,560. The number of chicks could be increased through measures that increase the hatch rate and the hatch cycles per year. The recommended hatch rate for incubation in Kenya is about 75% (Wachira, 2015). Through observation and inquiry the study found that most of the operators who had low hatch rates were not aware of the need for candling of the eggs to identify those that are fertilized. Further they had multiple sources of the eggs which increased the chances of poor quality eggs resulting from unfertilized eggs, dirty eggs and those that had overstayed and thus were not suitable for incubation.

Table 4: Actual and potential productivity of the incubators

Egg Incubator status	*Number of egg*	*Total setter capacity*	*Total hatcher*	*Total chick production/hatch*	*Total annual chick production*
Operational	16	8,011	4,478	1,943	6,413
Non operational	11	3,074	1,252	543*	1,793*
Total	27	11,085	5,730	1,943	8,206

**Estimated potential production of the non operational incubators*

The calculated potential annual chick production of the non operational incubators was 1,793 chicks conservatively estimated using the mean hatch rate of 43.4% and 3.3 hatch cycles achieved by the operational incubators.

Using the The DeMoivre-Laplace Theorem (DLT) equation it was estimated that at the current level, the probability of achieving the standard hatch rate of 75% requires at least 18 hatches or about 5.5 years. This can be drastically reduced by putting the non operational incubators into use.

Constraints to artificial egg incubation

The main constraints to incubator use were lack of electricity, lack of a thermometer, inadequate eggs and inadequate knowledge on how to operate the incubator. The thermometer is supposed to measure the temperature so that the operator can be able to maintain the optimum temperatures required during the incubation process. Further inquiry revealed that the operator was unaware that a simple alcohol thermometer could be used.

All the constraints essentially revolved around inadequate knowledge and awareness of the operators on the artificial egg incubation technology. For instance, with adequate knowledge prior to purchase of the incubators, the 36.4% of operators who cited lack of electricity as the reasons for failure to use their incubators could have opted for solar or paraffin operated incubators which are readily available in the market. Incubator suppliers should also be able to provide adequate information at the point of sale to enable buyers to make informed decisions. Similarly government and non governmental agencies that provide incubator grants to the farmers should be able to provide both the hardware and software necessary to enable operators make maximum use of their incubators. With about 85.2% of the operators belonging to an agricultural group, they could be easily reached for capacity building through the group approach. Also of the 11 incubators that were not being used, nine were owned by groups, which also lends more strength into the use of group approaches.

Table 5: Reasons for not using the incubator * Ownership of the incubator

Reasons for not using the incubator	Ownership of the incubator		Total	Percentage of the total
	Private	Group		
Don't have thermometer	1	1	2	18.2
no electricity	1	3	4	36.4
inadequate eggs	0	1	1	9.1
inadequate knowledge	0	3	3	27.3
the incubator is new (just delivered)	0	1	1	9.1
Total	2	9	11	100

Conclusions

On farm productivity of the artificial egg incubators is low, achieving a hatch rate of only 43.4%. About 41% of the incubators were not operational thus reducing the County's potential annual chick output by 1793 chicks. More group owned incubators were not operational compared to the privately owned ones.

Recommendations

Building capacity of incubator operators prior to and after purchase to enhance knowledge of the incubator operations.

Encourage the use of the incubators that are currently non operational.

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GoK. 2015. Economic Review of Agriculture. Ministry of Agriculture Livestock and Fisheries.

Bett, H. K., M. P. Musyoka, K. J. Peters, and W. Bokelmann. 2012. Demand for Meat in the Rural and Urban Areas of Kenya: A Focus on the Indigenous Chicken. Economics Research International. Volume 2012, Article ID 401472, 10 pages doi:10.1155/2012/401472. Hindawi Publishing Corporation

Danda M. K., Mwamachi D. M., Lewa K. K. and Jefa F. 2010. Analysis of the indigenous chicken sub-sector in the coastal lowlands of Kenya: a socio-economic perspective. Paper presented at the 12th Biennial KARI conference at KARI headquarters, 8th-12th November 2010.

Kenya Institute for Public Policy Research and Analysis (KIPPRA). 2009. Kenya Economic Report 2009. Building a Globally competitive economy. Nairobi.

Ondwasy H., et al. 2006. Indigenous Chicken Production Manual. KARI Technical Note No. 18, February 2006. KARI.

Wachira A. M. 2015. Personal Communication, KALRO Naivasha.

Preferred phenotypic traits by zebu cattle farmers for dairy production in Kenya

IlatsiaE.D[1]., K'Oloo T.O[1], Mbuthia J.M[1], Ole PuleiR.N[1]., Mbuku S.M[2], Nyambati E. [1] and Indetie D[3]

[1]Kenya Agricultural and Livestock Research Organization, KALRO-Naivasha Centre, P.O. Box 25 – 20117, Naivasha, Kenya
[2]Kenya Agricultural and Livestock Research Organization, KALRO, Nakuru Centre, Kenya
[3]Eastern Africa Agricultural Productivity Project, Project Coordination Unit, Nairobi, Kenya
[*]Correspondence: evansilatsia@yahoo.com

Abstract

Despite the growing demand for livestock products and the subsequent response by farmers to increase productivity, about 70% of the cattle in the Eastern Africa region are indigenous and unimproved. Most of the countries in the region are implementing crossbreeding programmes to upgrade the local cattle population towards exotic genotypes. However, adequate and quality feeding, animal health and other allied services are lacking to support optimal production from these improved breeds. This study provides the findings of a broad project that aims to improve Zebu cattle *(Bos indicus)* for dairy production through targeted selection and systematic crossbreeding programmes in Kenya. The study aimed at analysing the existing farmers' trait preference of indigenous cattle for milk production in Kenya. Logistic regressions were carried out using SAS computer package and comparisons done across counties. Body frame for bulls and udder size and placement for cows, were the most important traits in selection decisions across counties. Other important traits in cow selection included; teat size, tail length and rumen depth. Traits considered important in bull selection were appearance, tail length and scrotal size. Despite lack of performance records, performance of relatives was considered important while selecting bulls. Traits like backline and coat colour were perceived to be of lower importance. Drought and disease tolerance were ranked as important attributes preferred by farmers across the counties. Basically, there was a lower perception of indigenous over exotic cattle traits for mature weight, watering frequency and feed requirements. There was no difference in the perception for reproductive performance in Busia and West Pokot, and watering frequency in the latter between indigenous and exotic cattle.

Keywords*:* Body frame, Udder size, body frame, rumen size, selection criteria

Introduction

Despite the growing demand for livestock products and the subsequent response by farmers to increase productivity, about 70% of the cattle in the Eastern Africa region are indigenous and unimproved, meaning that less than 30% have seen some level of improvement (Rege *et al*., 2011). This is because there has been no deliberate breeding programme to improve indigenous stock (Ouma *et al*., 2005). This has been compounded by non-existence of herd recording, lack of efficient breed improvement programmes and non-availability of proven superior quality breeding animals, thus contributing to the slow progress for genetic merit of local cattle populations (Rege and Wakhungu, 1992). According to Trivedi (1998), animal recording is very important because it provides information that can enable farmers to compare performance of their own herds and those of other farmers in the community, in order to stimulate competition and provide incentives to improve production.

Most of the countries in East Africa implement crossbreeding programmes to upgrade the local cattle population towards exotic genotypes (Rege *et al*., 2011). However, adequate and quality feeding, animal health and other allied services are lacking to support optimal production from these improved breeds. In Kenya, the trend has been that in the high rainfall Kenya highlands, most of the livestock keepers have opted to change from indigenous breeds to exotic *Bos Taurus* dairy breeds, such as Friesians, Ayrshires, Guernsey and Jersey breeds and their crosses with *Bos Indicus* cattle, with increasing intensification (Bebe

et al., 2003). In the Southern rangelands of Kajiado, Narok and Trans Mara in Kenya, most of the Maasai pastoralists have opted to upgrade from the indigenous East African Zebu to the Sahiwal, which has its origins in India and Pakistan (Ilatsia *et al.,* 2012).

Most of the farmers in the medium rainfall areas have also been upgrading towards exotic dairy breeds. However, a vast majority of cattle in Kenya have not been upgraded (Rege *et al*., 2011). The State Department of Livestock estimates that 72% (9 million out of 12.5 million) of cattle in Kenya are Zebu (MoLD 2010). However, in some production systems, the pace of introgression has been too rapid to the extent of endangering the indigenous breeds with threats of extinction (FAO, 2007; Rege *et al*., 2011). Since 1990, 300 out of 6,000 breeds identified by FAO have become extinct and many more are at risk, mainly because of unplanned intensive selection and cross-breeding (Cardellino, 2006). Traditional breeds, which have evolved over generations and have become well adapted to the local conditions are being lost in the process of cross-breeding. The resultant short term increase in productivity of marketable products such as milk and meat from these exotic breeds and their crossbreds have often resulted in genetic erosion of adaptability traits that allow the very existence of these cattle in these harsh environmnets (Conway and Waage, 2010). This is largely due to lack of proper implementation design and organisation and management of breeding programme schemes for the indigneous tbreeds. There is, therefore, need for better understandinging of the livestock genetic characteristics, to inform their proper improvementment (Gamba, 2006).

The livestock systems are faced with a myriad of production constraints, such as harsh environmental conditions, prevalence of pests and diseases, frequent droughts and low input management, hence lowered productivity. Understanding the traits preference among cattle keepers will support improvement of indigenous cattle genotypes that are well adapted to the environment and capable of dairy production and performing the multiple roles that cattle play in these production systems. The national programmes can also prioritise local needs for productivity, adaptability and genetic conservation and find ways of extending this information to the local owners. This study evalutes different traits prefered by indigenous cattle farmers and crossbred cattle in selected arid and semi-arid lands (ASAL) in Kenya.

Materials and Methods

A household survey was conducted using personal interviews with a structured questionnaire in Kitui, West Pokot, Busia and Homa Bay Counties in semi-arid Kenya, because of the significant presence of indigenous cattle. Kitui County is located in Eastern part of Kenya. The daily temperatures range from 14 to 34 °C, and the rainfall is distributed in two seasons and ranges from 500 to 1050mm per *annum* (FAO, 2008).

West Pokot County is located in the northern part of the Rift Valley. The vast part of the County is arid and semi-arid. However, there are some parts of the county that are highly elevated and receive a considerable amount of rainfall. The rainfall ranges from 400mm in the lowland areas to 1500mm in the highlands. The daily temperatures range from 10 to 30°C.

Busia County is located in the western part of Kenya and borders Uganda to the west and Lake Victoria to the South. It is a medium potential agricultural area, with annual rainfall ranging from 750 to 1,800mm per *annum*. Average daily temperatures is 22 °C.

Homa Bay County, the fourth study site, is located in the south western part of Kenya. The annual rainfall ranges from 250 to 750mm per *annum.* Daily temperatures range from 17.1 to 34.8 °C.

This study was conducted with a household sample of 360, randomly selected households. A structured questionnaire was designed to capture information on farm characteristics, production and breeding objectives and practices. The farmer was asked to rank ordinal responses on a scale ranging from a score of 1for less important to 3for very important. For the questions pertaining to traits preference and selection criteria, the farmer was asked to rank, from 1=least important to 3=most important traits that he/she considered to be either less important, important or very important for dairy productivity.

Descriptive statistics were computed using the Statistical Package for Social Science (SPSS) version 17 and logistic regression were carried out using Statistical Analysis Systems (SAS) Version 2003 and results presented in tabulated summaries. Logistic regression in terms of trait preference and selection criteria was used to compare the preferences across counties. A cumulative logit model was used to analyze the importance of the animal characteristics on selection or preference of various traits across the regions. Indices were calculated to provide an overall ranking for constraints to production in each county. The indices represent weighted averages of all rankings for a particular constraint. The following equation adopted from Bett et al (2009) was used to calculate the index (I_i) for each trait or purpose:

$$I_i = \begin{pmatrix} 3 \\ 2 \\ 1 \end{pmatrix} \left[\sum_{j=1}^{3} X_j \right]_i \Big/ \sum_{k=1}^{n} \left[\begin{pmatrix} 3 \\ 2 \\ 1 \end{pmatrix} \sum_{j=1}^{3} X_j \right]_k$$

Where X_j is the percentage of respondents ranking the trait i in the jth rank and k is the sum of ranks for n number traits or purposes.

Results

Socio-economics and characteristics:

Of the 360 households surveyed, 60% of the respondents were males and 40% females. However, 87% of the sampled households were headed by men. Kitui had the highest percentage of female headed households at 22% and West Pokot had the least number of female headed households (Table 1).

Table 1: Socio-economic characteristics of respondents in parts of Kenya

Characteristic (%)	Category	Kitui	West Pokot	Busia	Homa Bay	Overall %
Gender of respondent(%)	Male	51	77	45	69	60
	Female	49	23	55	31	40
Gender of the household head(%)	Male	78	94	88	87	87
	Female	22	6	12	13	13
Age group of household head(%)	<25	0	3	4	0	2
	25 to 35	8	37	30	20	24
	36 to 45	24	30	24	24	26
	46 to 65	52	25	32	41	37
	> 65	16	5	9	15	11
Education level of household head(%)	No education	10	16	5	7	9
	Lower Primary	11	9	7	8	9
	Upper Primary	46	51	38	37	43
	Secondary	30	19	39	38	31
	College/University	4	5	12	10	8
Mean household size		7±3	9±5	7±3	8±3	8±4

Most of the household heads (37%) were aged between 46 to 65 years, followed by 36 to 45(26%). West Pokot had the highest proportion of youth household heads (37%) aged between 25 and 35 years, while Kitui had the highest proportion of old household heads (16%) aged over 65 years of age and 52% of household heads aged between 46 and 65 years. The highest proportion of household heads with higher

level of education was recorded in Busia County, with 12% having attained post-secondary level of education, and a total of 51% of the household heads having attained secondary school and above. However, the situation was rather different in West Pokot County, where 16% of the household were illiterate, and up to 60% had only basic primary education. The household sizes were found to be highest in West Pokot, with an average household size of 9±5 members. This was followed by Homa Bay County with an average household size of 8±3. Busia and Kitui Counties had 7±3.

Livestock breeding systems

Most of the farmers (60%) across the survey sites mainly use borrowed bulls or communal bulls for breeding. However, the practice is more prevalent in Busia and West Pokot, where up to 69and 56% of the farmers, respectively, used borrowed bulls for breeding (Table 2). There were also high chances of inbreeding, as 24% of the farmers both in West Pokot and Homa Bay use bulls that were born and bred within their homes.

Table 2. Livestock breeding systems attributes by various farm households in parts of Kenya

N=360 Attribute (%)		Kitui	West Pokot	Busia	Homa Bay	Overall % in all the counties
Source of breeding bull	Own bull (bred)	19	24	13	24	20
	Own bull (bought)	27	15	8	26	18
	Donated bull	3	1	4	2	3
	Borrowed bull	49	56	69	35	53
	Communal bull	3	3	5	11	6
	Farmers group	0	0	0	2	1
Access to breeding services	Yes	9	7	14	12	11
	No	91	93	84	88	89
Source of breeding service	Bull scheme	0.6	0.8	2.8	2.2	6.4
	AI service	1.4	0.3	1.4	0.6	3.6
Sale of milk	Yes	49	49	59	37	49
	No	51	51	41	63	51
Average land holding (SD/SE?)		10.1±16.5	12.9±16.1	4.8±4.3	5.2±6.9	8.2±12.5
Average herd size		5±4	13±19	4±3	10±12	8±12

Access to improved breeding services such as artificial insemination and well organized bull scheme by the farmers across all the counties was relatively poor (11%). It was only in Busia and Homa Bay Counties, where there was about 14 and 12% access to improved breeding services, respectively. The level of access to such services in the other Counties was less than 10%. However, most of the households which had access to breeding services used the bull services rather than artificial insemination as only 3.6% used A.I. services.

The largest herd sizes were reported in West Pokot County, where the average herd size was 13 heads of cattle, with some households having herds of more than one hundred heads of cattle. This was followed by Homa Bay County with an average herd size of 10 heads of cattle. The County with the lowest herd size per household was Busia, with an average herd size of 4 per household. Herd size seems to be directly related to the average land holdings, where households in West Pokot are reported to have the highest land holding of around 13 acres (5.3 hectares) per household. The smallest land holding being reported in Busia, with an average land holding of 2 hectares per household (Table 2).

Traits preference

In ranking the important criteria for cattle selection, farmers were provided with most of the phenotypic characteristics that would be considered important in selection for milk production. Tables 3 and 4 presents the odds ratio estimates and their 95% confidence intervals from logistic regression, for the ordinal ranks of traits considered while selecting for bulls and cows, respectively across the various counties. In this study, there was a better perception when the odds ratio was greater than one and a lower perception when it was less than one. The odds ratio is significant when its 95% confidence interval excludes one. The odds ratio estimates for bulls represent a measure of the relative importance when ranking a characteristic, relative to body frame which was the most highly ranked characteristic across all the Counties.

Table 3: Odds Ratio Estimates and their 95% Confidence Intervals for Phenotypic Characteristics for Bulls

Characteristic	Kitui	West Pokot	Busia	Homa Bay
Body frame[a]	Ref	Ref	Ref	Ref
Scrotal size	1.17 (0.80, 1.69)	1.08 (0.77, 1.52)	1.37 (0.96, 1.95)	1.67 (1.13, 2.47)
Appearance	1.39 (0.96, 2.01)	1.56 (1.12, 2.19)	1.80 (1.28, 2.53)	2.08 (1.41, 3.04)
Tail size	1.18 (0.81, 1.71)	1.27 (0.91, 1.78)	1.69 (1.19, 2.41)	1.73 (1.16, 2.56)
Performance of relatives	1.26 (0.87,1.82)	1.30 (0.93, 1.82)	1.59 (1.13, 2.24)	1.90 (1.30, 2.78)

[a]*Body frame was the reference characteristic in the model comparison because it was the most frequently ranked criteria for bull selection*.

In all Counties, body frame ranked highly as criteria for bull selection, hence its assignment as the reference body characteristic in the model. Bulls were selected more based on their appearance than on performance of relatives and phenotypic characteristics, such as scrotal size and tail length in all counties. Despite the lack of records, farmers had a high preference for bulls whose lineage and performance could be traced (1.26, 1.30, 1.59 and 1.90 for Kitui, West Pokot, Busia and Homa Bay) (Table 3).

While selecting cows for dairy purposes, farmers in Kitui and Homa Bay Counties ranked highly (1.67 and 1.39) teat size as opposed to West Pokot and Busia Counties where body shape took precedence (Table 4). In addition to a well-placed udder, farmers associated big teat with more milk and ease of milking. Rumen depth was ranked highly in Kitui and West Pokot Counties compared with Busia and Homa Bay. Farmers perceived that cows with big rumen capacities would tend to eat more and probably convert the feed to more milk and meat.

Table 4: Odds ratio estimates and their 95% confidence intervals of phenotypic characteristics for selection of cows in parts of Kenya

Characteristic	Kitui	West Pokot	Busia	Homa Bay
Udder and teat Placement[b]	ref	ref	Ref	ref
Tail Length	1.32 (0.91, 1.91)	1.35 (0.96, 1.90)	1.18 (0.83, 1.66)	1.18 (0.82, 1.71)
Teat Size	1.67 (1.15, 2.43)	1.38 (0.98, 1.93)	1.34 (0.96, 1.87)	1.39 (0.96, 2.01)
Dewlap Size	1.44 (0.10, 2.07)	1.39 (0.99, 1.95)	1.30 (0.93, 1.83)	1.26 (0.87 1.83)
Rumen Depth	1.63 (1.13, 2.36)	1.49 (1.06, 2.10)	1.26 (0.990, 1.75)	1.28 (0.89, 1.85)
Body Shape	1.49 (1.02, 2.17))	1.56 (1.11, 2.20)	1.59 (1.13, 2.24)	1.11 (0.76, 1.61)
Back line	1.42 (0.99, 2.01)	1.29 (0.93, 1.80)	1.26 (0.90, 1.77)	1.05 (0.72, 1.52)
Coat colour	1.12 (0.77, 1.62)	0.91 (0.65, 1.29)	1.05 (0.74, 1.47)	0.99 (0.68, 1.45)

[b]Udder and teat placement was the reference body characteristic in the model comparison because it was the most frequently ranked criteria in cow selection.

In all counties, coat colour was considered less important (1.12, 0.91, 1.05 and 0.99) in selecting for dairy characteristics across all the study sites (Table 4). Other traits namely, tail length, dewlap size and backline were perceived to have little influence for selecting dairy traits. However, some farmers associated a long tail with a thick tail brush to more milk.

In terms of preference between the Zebu and exotic genotypes, the frequencies were 58%, 37, 46 and 23% in Kitui, Homa Bay, West Pokot and Busia respectively in favour of the zebu cattle. Table 5 presents the odds ratio estimates and their 95% confidence intervals from logistic regression for the ordinal ranks of traits that farmers consider when selecting between Zebu and exotic genotypes. The odds ratio represents a measure of the relative importance when ranking characteristics relative to drought tolerance. Results indicate an overlapping ranking of both drought and disease tolerance, traits which make farmers prefer zebu to exotic or crossbred cattle. Preference for different indigenous over exotic or crossbred cattle traits varied with region (Table 5).

Table 5: Odds ratio estimates and their 95% confidence intervals for preference of Zebu to exotic genotypes in parts of Kenya

Characteristic	Kitui	West Pokot	Busia	Homa Bay
Drought Tolerance [c]	Ref.	Ref.	Ref.	Ref.
Mature Weight	0.79 (0.55, 1.15)	0.84 (0.57, 1.23)	0.84 (0.54, 1.31)	0.83 (0.56, 1.22)
Watering Frequency	0.93 (0.65, 1.34)	1.00 (0.69, 1.44)	0.96 (0.90, 0.58)	0.96 (0.67, 1.37)
Feed Requirements	0.71 (0.49, 1.04)	0.87 (0.59, 1.27)	0.90 (0.58, 1.38)	0.85 (0.56, 1.24))
Reproductive Performance	0.91 (0.64, 1.31)	1.00 (0.70, 1.46)	1.00 (0.68, 1.46)	0.97 (0.68, 1.39)

[c] Drought tolerance was the reference Trait of comparison in the model because it was the most frequently preferred characteristic for Zebu Cattle.

Livestock keepers perceive that exotic cattle performed well in terms of mature body weight, and unexpectedly, feed requirements. Considering region-wise comparisons, Kitui could be influenced by the frequent droughts. It follows that there was no difference in preference for reproductive performance in Busia and West Pokot counties and watering frequency in the later for indigenous over exotic cattle (Table 5).

Constraints to production:

Farmers were faced with a number of production constraints, ranging from lack of feeds, disease prevalence to lack of breeding materials as well as poor market access. Some of the constraints are presented in Table 6.

Table 6: Rank Indexd of constraints to cattle production in the four Counties in semi-arid Kenya

	Rank Index				
Constraint	Kitui	West Pokot	Busia	Homa Bay	Overall ranking
Lack of feed	0.28	0.23	0.21	0.20	0.23
Frequent drought	0.26	0.12	0.03	0.12	0.13
Lack of water	0.26	0.12	0.04	0.11	0.13
Disease prevalence	0.09	0.28	0.33	0.32	0.26
Breeding stock	0.02	0.14	0.12	0.06	0.09
Inadequate extension services	0.04	0.10	0.24	0.14	0.13
Lack of market	0.01	0.05	0.03	0.03	0.03
Cattle theft	0.00	0.00	0.03	0.01	0.01
Lack of credit	0.04	0.06	0.08	0.05	0.06

[d] *1=less important, 2=important, 3=Very important*

In Kitui county, lack of feed, water and frequent droughts were the major constraints. These factors reflected the harsh environmental conditions experienced in this semi-arid region. In the other Counties, disease prevalence was the main constraint. Diseases mentioned were mainly tick-borne such as East Coast Fever (ECF) and anaplasmosis and frequent Foot and Mouth Disease (FMD) outbreaks. This aspect of disease prevalence is also attributed to inadequate extension and veterinary services to deter disease prevalence. Lack of quality breeding animals was also viewed as a constraint in West Pokot and Busia Counties.

Discussion

Socio-economics and characteristics

The generally higher proportion of male respondents in the sample size (Table 1) is understandable because cattle production and ownership have always been culturally associated with the male gender in most African communities (Amimo *et al.,* 2011; Ilatsia *et al.,* 2012). Men are also the heads of most households, therefore it is only natural that they respond to matters pertaining to livestock, save for the exceptional situations when they may not be present at home. However, the glaring disparity between the female headed households in Kitui and West Pokot counties can be attributed to the socio-cultural attributes of the communities living in those counties. The Pokot people come from a pastoral background where polygamy is acceptable and there is male dominance in livestock farming activities. This observation is consistent with what was reported in earlier studies (Mwacharo and Drucker 2005; Kosgey *et al*., 2008; Ilatsia *et al.,* 2012). Most of the Pokot men have a special attachment to livestock that is why very few of them migrate to urban areas in search of jobs. Most men in Kitui County on the other hand move to the nearby towns in search for jobs, some leave their women to take care of their homes, giving rise to the high proportion of female headed households (22%) as compared to other counties.

Many studies have shown that education plays a very important role in the livelihoods of the livestock keeping households (Tambi et al., 1999; Ilastia et al., 2012). It influences their judgement and decision making process at the household level. Education levels of the household heads in the study counties varied, with Busia County having on average higher levels of education as compared to their counterparts in West Pokot County. Tambi *et al.,* (1999) reported education to significantly influence the type of decisions made at the household level including adoption of livestock upgrading programs. This could explain the slightly higher level of adoption of improved breeds and use of AI and other breeding services in Busia County compared to other counties where education levels of household heads is comparatively lower. Similar observations were made by Ilatsia *et al.,* (2012) between the Maasai pastoralists of Kajiado County and those of Narok County. In this study, it was evidenced that farmers with higher levels of education had higher rate of adoption of the improved cattle genetic resource.

Livestock breeding systems

From the results, big cattle body frame (Table 3), which is also believed to translate into heavier body, is the main focus in bulls preference as it was most preferred trait, hence the reference phenotypic trait. Bulls provide draught power in the crop-livestock systems, in which case good traction ability is important since bulls are used for ploughing and pulling carts (Ouma *et al.,* 2005). In addition to high traction ability, a bigger bull would also mean a higher market sale value. This is important in the slaughter market or to other farmers for production which is common practice (Bebe *et al*., 2003). Similar observations were made by Ilatsia *et al.*(2012) among the Maasai pastoralists of Kajiado and Narok Counties, who have a higher preference for the sahiwal breed of cattle, which are relatively bigger in size than the East African short horn zebu (EASZ). In most of the study areas, all categories of livestock were communally grazed, where cows were mixed with bulls. Castration of bulls was not common, and therefore, making controlled mating difficult to implement. This hampers efforts to utilize bulls with preferred traits. This form of communal grazing is a major hindrance to the traceability of performance of bull sibs and their relatives.

Traits preference:

In cow trait preference, traits that farmers associated with high milk yield had the highest odds ratios (Table 4). These traits included udder size and teat placement, which was the preference body characteristic and teat size. It has been reported that high preference for milk traits is common among many traditional African cattle owners, because they keep cattle primarily for milk, with accumulation of stock as a form of investment playing secondary role (Garoma *et al.,* 2013). Milk sales were considered as a possible incentive for the farmers to upgrade their livestock to higher milk producing breeds. More farmers (59%) in Busia County sold milk as compared to their counterparts in the other counties. This was presumed to have a positive correlation with access to breeding services; however it had a negative correlation with the number of people owning bulls for breeding purposes. This can only be a clear indication that milk is a major production objective for the cattle keepers in this region and most of the farmers kept female cattle mainly for this purpose.

Considering that a large herd size is an indicator of wealth among pastoralists in kenya, reproductive performance becomes highly valued because it ensures fast herd increases (Ouma *et al.,* 2005). Cows that can produce a calf per year become more valued in some communities than a cow yielding more milk per lactation. This complements the reason for higher preference for cows with higher reproductive performance besides milk produced during lactation.

In all counties, coat colour was mainly ranked as the less important trait in selecting for dairy characteristics (Table 4). This is in contrast with Garoma *et al.*(2013) who reported high preference for coat colour in Kereyu cattle citing ecological significance in the region. Although not mentioned, this was observed in the current study whereby most of the cattle in Kitui were light coloured. It was also only in Kitui County where a large proportion of farmers (58%) still preferred rearing indigenous cattle. This is probably due to ecological suitability and demand for draught animals, in mixed crop-livestock systems. According to Otieno (2013), this may be explained by the adaptation of the local breeds to the limited pasture and water supply, and harsh conditions as a result of the relatively dry and hot climate. However, there was no colour preference in relation to dairy productivity.

The constraints reported here are in line with other reports in the Kenyan ASALs (e.g. Mwacharo and Drucker, 2005; Otieno, 2013). Due to these constraints, rearing of exotic breeds has been low in the ASALs because of their low adaptability. This explains the reasons behind the high population of indigenous breeds in most ASAL areas. For this reason, appropriate policies should be developed and effectively implement taking into consideration the major constraints to production in various agro-ecological conditions. As a result, this will propel the livestock sector to reach its full potential to contribute to economic growth and poverty alleviation through trans-boundary trade (Rege*et al.,* 2011).

Conclusion

Many farmers lay great emphasis on traits such as udder and teat placement, teat size and tail length while selecting for cows with high dairy productivity potential. However, empirical studies to demonstrate whether these traits are associated with high dairy productivity are yet to be done. Therefore, further research should be done to ascertain correlation between the phenotypic characteristics that the farmers select for and the level of dairy productivity of a cow.

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References

Amimo, J.O, Thumbi, S., Inyangala,B.O, Junga,J.O. and Mosi,R.O 2011. Socio-economic characteristics and perceptions of cattle keepers and constraints to cattle production in Western Kenya.Livestock Research for Rural Development 23(6).

Bebe, B.O., Udo H M J, Rowlands G.J. and Thorpe W., 2003. Smallholder dairy systems in the Kenya highlands: cattle popuation dynamics under increasing intensification. Livestock Production Science, 82, 211-221.

Cardellino, R. 2006. Status of the world's livestock genetic resources: preparation of the first report on the state of the World's animal genetic resources. In: The role of biotechnology in exploring and protecting agricultural genetic resources. FAO.

Conway, G. and Waage, J. 2010. Science and Innovation for development. UK Collaborative on development science.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. 1999. Livestock to 2020.The next food revolution.Food, Agriculture and the Environment Discussion Paper No. 28. Washington DC. International Food Policy Research Institute, Rome, FAO, and Nairobi, International Livestock Research Institute.

FAO, 2007.The state of the world's animal genetic resources for food and Agriculture. Rome, Italy.

FAO, 2008. Food security outlook, Kitui District, Kenya

Gamba, P. 2006. Beef and dairy cattle improvement services: A policy perspective. Tegemeo Working Paper 23/2006.

Garoma, S., Ayalew, W. and Hegde,P.B 2013. Pastoralists and agro-pastoralists preferences for cattle breed and traits in Fentalle district of East Shoa zone of Oromia, Ethiopia. African Journal of Agricultural Research8(45): 5645-5650

Ilatsia,E.D., Roessler, R., Kahi,A.K.,Piepho, H. and Vale Zárate, A. 2012.Production objectives and breeding goals for Sahiwal cattle keepers in Kenya and implications for a breeding programme.Tropical Animal Health and Production 44 (3): 519 – 530

Kosgye, I. S., Mbuku,S.M., Okeyo,A.M., Amimo, J., Philipsson, J. and Ojango, J.M. 2011. Institutional and Organizational framework for dairy and beef cattle recording in Kenya: Areview and opportunities for improvement. Animal Genetic Resources 28 Pp 1-11

MoLD, 2010.Ministry of Livestock Development. Strategic Plan 2008 – 2012.

Mwacharo,J.M. and Drucker,A.G. 2005. Production objectives and management strategies of livestock keepers in South-Eastern Kenya: implications for breeding programme. Tropical Animal Health and Production 37: 635 – 652.

Otieno, J. D. 2013.Market and non-market factors influencing farmers' adoption of improved beef cattle in arid and semi-arid areas of Kenya.Journal of Agricultural Science5: (1) 32 – 43.

Ouma, E., Abdulai, A. and Drucker, A. 2005.Assessment of farmer preferences for cattle traits in cattle production systems of Kenya.11th congress of the European Association of Agricultural Economists. (pp. 1-14). Copenhagen, Denmark.

Rege, J. E. O., Marshall, K., Notenbaert, A., Ojango, J. M. K. and Okeyo, A. M. 2011. Pro-poor animal improvement and breeding – what can science do? Journal of Livestock Science136:15 – 28

Rege, J. E. O. and Wakhungu, J. W. 199.2 An evaluation of a long term breeding programme in a closed Sahiwal herd in Kenya. Genetic and phenotypic trends and levels of inbreeding.Journal of Animal Breeding and Genetics109:374-384.

Tambi,N.E., Mukhebi,W. A., Maina, W. O. and Solomon, H. M. 1999. Probit analysis of livestock producers' demand for private veterinary services in the high potential agricultural areas of Kenya.Agricultural Systems59:163 – 176.

Trivedi,K.R. 1998 In. International workshop on Animal Recording for Smallholders in the Developing countries, Anad, India, 20-23 October 1997. ICAR Tech. Series, Vol. 1. ICAR, Rome, Italy, pp. 436)

Wakhungu J.W., Mosi R.O. and Charles A.B. 2000 Dairy cattle breeding policy for Kenyan smallholders: Evaluation based on demographic stationary state productivity model. Proceedings of Dairy Cattle Breeding in East Africa Sustainable Artificial Insemination service, KARI HQs, Nairobi, Kenya. Pp 17-18.

Prevailing Growth Rates and Performances of Pigs Raised by Smallholder Farmers in Teso Sub-County

Njanja J C[1], Ogali IN[1], Emongor, R A.[2]Kundembule P[3]

[1]Kenya Agriculture &Livestock Research Organization (KALRO)-Veterinary Sciences Research Institute (VSRI), VSRI-Muguga North, P.O. Box 00902-32, Kikuyu, Kenya
Corresponding author, Email: njanjachomba@yahoo.com
[2] KALRO, National Agricultural Research Laboratories (NARL), P.O. Box 5711-00200, Nairobi, Kenya
[3]Busia County Department of Veterinary Services, Teso South Sub county, P.O. Box 50-50403, Amukura, Kenya

Abstract

This study was carried out to estimate the performance of pigs in a free range and tethered production system of Teso South, Kenya in order to establish prevailing levels as basis for designing appropriate improvement programmes. One hundred and seventy nine pigs of known age and weight above one month old were distributed to 60 farmers. Pig liveweights (LW) were recorded at ≥1, 5 and 12 months of age. The farmers, distributed in five sub locations had expressed a willingness to rear more pigs and manage them by keeping written records of activities. Mean pig LW was 4.0±1.0, 27.9±12.7 and 34.6±8.2 kg at 1,5 and 12 months of age respectively. The pigs achieved mean average daily gain (ADG) of 145.2 ±75.4 g/day and 33.7±/74.6 g/day from 1 to 6 months and from 7 to 12months of age respectively. Overall mean ADG from 1 to 12 months of age was 88.9 ±23g/day. From the beginning of the trial, 81.6% of the farmers fed pigs with "farm feeds" which comprised mainly of sweet potatoes, cassava and kitchen leftovers while 33% in addition bought "commercial by products" of ground maize and *omena (Rastrineobolaargentea)*. This practice was maintained to the end of the trial where "farm feed farmers" comprised 73.0% and the latter 27.0%. Overall survival rate of pigs was 35.2% and most deaths (27.9%) occurred during the first month post weaning while that of heavy piglets at weaning was 52%. On the basis of these findings any pig production improvement initiative should be able to quantify its efficiency in productivity as a factor of economic success.

Introduction

Pig production is one of the fastest growing livestock sector worldwide and the Kenyan government has continued to encourage it as it plays a major role in the smallholder economy (MoLD, 2009; FAO 2012; Mutua *et al.,* 2012). In Kenya, up to 70% all pig farmers are engaged in small-scale production. Western Kenya has 87,838 pigs and 48,788 of these are found in Busia County mainly under traditional free range and tethering production systems (KNBS 2009, Njanja *et al.,* 2015). A baseline survey carried out in this area showed that pig production was profitable but the management systems needed improvement (Emongor *et al.,* 2014).

The smallholder pig farmers in this area keep local breeds without any formal breeding strategies. Mature gilts and baconers are sold at two years of age between 50 and 70 kg live weight. The farmers have the will to improve pig production and this great potential can be exploited for development (MoLD, 2009; Njanja *et al.,* 2015).

Growth rates and performances are important prerequisites as basis for designing appropriate pig production improvement programmes for finished pigs to achieve market weight early in life. However this data is lacking in many production systems including Teso area. By establishing the prevailing performance of pigs fed on available feeding systems, it will be possible to promote alternative rations for improved production. This work was part of the process to provide baseline data on growth rates and performances of pig in Teso Sub County in order to empower farmers and their livelihoods.

Materials and Methods

Study area and trial design

The study was carried out in Teso South sub county in Busia County which was purposively chosen because it has high number of households keeping pigs and farmers had shown interest of participating in improvement interventions. Farmers for this study were selected from Amukura and Chakol divisions. Sixty three farmers who had shown interest in keeping additional pigs were selected from three sub locations division(Ngelechom, Amaase and Adungosi) in Chakol and two (Apokor and Odioi)in Amukura division. One hundred and seventy nine piglets aged between 1 and three months sourced from the neighbouring county were provided to the farmers who managed them in their own practices from November 2013 to September 2014. The pigs were ear tagged and initial liveweights taken in October, 2013 and subsequently at 6 and 12 months of age respectively. Each farmer signed a memorandum of understanding to rear the pigs uninfluenced in his or her own way and to allow access for observation and taking of measurements. The farmers were given books to record activities carried out and during the visits. Live weights (LWs) in kilograms (kg) were taken in March 2014 and September 2014 by actual weighing of the pigs or estimation using the weigh band. Average daily weight gain (ADG) in gramms per day (g/day) were calculated for all pigs that were weighed during the study period ADG (g/day) from 1 month of age to 6 months , from 6 months to 12 months and from 1 month to 12 months ADG per day (g/day) were calculated as follows:

ADG g/day= (LW at visit − initial LW*1000) / [days initial (1^{st}) and follow-up visit (2^{nd})]

Data records and analysis

Farmers' records were appraised to determine types of feed given, health applications or any other activity of relevance to them. Pig feed was any feedstuff provided to the pig by the farmer. Data was analysed using statistical package. Sample means and variances were calculated on LWs and ADGs then disintegrated by sex, pig group, feed type and location. Descriptive statistics were also carried out on qualitative data. Factors were subjected to "t" and "f" statistical tests and considered significant at p (<0.05) level.

Results

The overall post weaning mean live weights of pigs after 1 month of age was 4.0±1.0 kg. The pigs grew and gained weight, attaining mean live weights of 27.9±12.7kg at six months of age and 34.6±8.2 kg at twelve months of age. The overall mean ADG from 1 to 12 months of age was 88.9 ±23g/day. The mean ADG from weaning up to six months of age was 145.2 ±75.4 g/day. The mean ADG for pigs from 6 to 12 months of age was 33.7±74.6 g/day and it was significantly lower than that of the early life age category (p<0.05) (Table 1).

Table1. Overall growth performance of pigs in farmers' fields in Teso sub county upto 12 months of age

Description	Liveweight- kg			g/day		
	LW_1	LW_6	LW_{12}	ADG_{1-6}	ADG_{7-12}	ADG_{1-12}
n	63	53	45	63	37	45
Mean	4.0	27.9	34.6	145.2	33.7	88.9
Std Dev	1.0	12.7	8.2	75.4	74.6	23

Male pigs at 1 month of age had live weights of 4.1±1.0 kg while that of females was 3.8±1.1. The post-weaning daily gain up to6 months of age was 138.6 ±73.2g/day while that of females was 157±79.72g/day. At this early age male pigs weighed 26.9±12.6 and the females 29.7±13.2kgs. Growth rates of both sexes was slow in the second phase of upto 12months of age. The daily gain of males was 40.2±71.4g/day while that of females was 18.2±83 g/day. The male pigs attained live weights of 35.1±9.1 kg and females had 33.6±6.6 kg. Male pigs had significantly higher growth rates than the females (p<0.05).

From the analysis made on farmers' records, at the beginning of the trial, 81.6% fed pigs with "farm feeds" while the others 33% in addition bought "commercial by products". This practice was maintained up to the end of the trial where "farm feed farmers" were 73.0% and the latter 27.0%. The "farm feed" comprised of pigs grazing on pasture, feeding on crop by-products such as cassava, sweet potato vines and tubers, bananas, and kitchen leftovers. "Commercial by products" comprised of ground maize and *omena (Rastrineobolaargentea)* the small sized fish, brewers waste *"machicha"* and hotel waste. Mean growth rate of pigs fed on "farm feed" only was significantly lower (33.7±8.3kg) than that of pigs additionally given "commercial by products".(35.1±8.2kg) ($p<0.05$)

Performance of pigs by liveweights of three age groups from post weaning to 12 months of age are presented in Figure 1.Pigs weaned at early age of 1 month with mean pre weaned liveweights of 3.6±0.8kgand at 1.5 months with mean liveweights of4.1±0.7kg were slower in growth than those with higher age of 2 months with liveweights of 4.7±1.4kg during the early post weaning phase of life of up to 6 months. Pigs weaned at early age of 1 month and 1.5 months achieved similar liveweigths of 33.7±8.3kg and 32.5±8.8kg respectively which was significantly lower than that of pigs weaned at older age of 2 months with 39.8± 5.7kg ($p<0.05$).

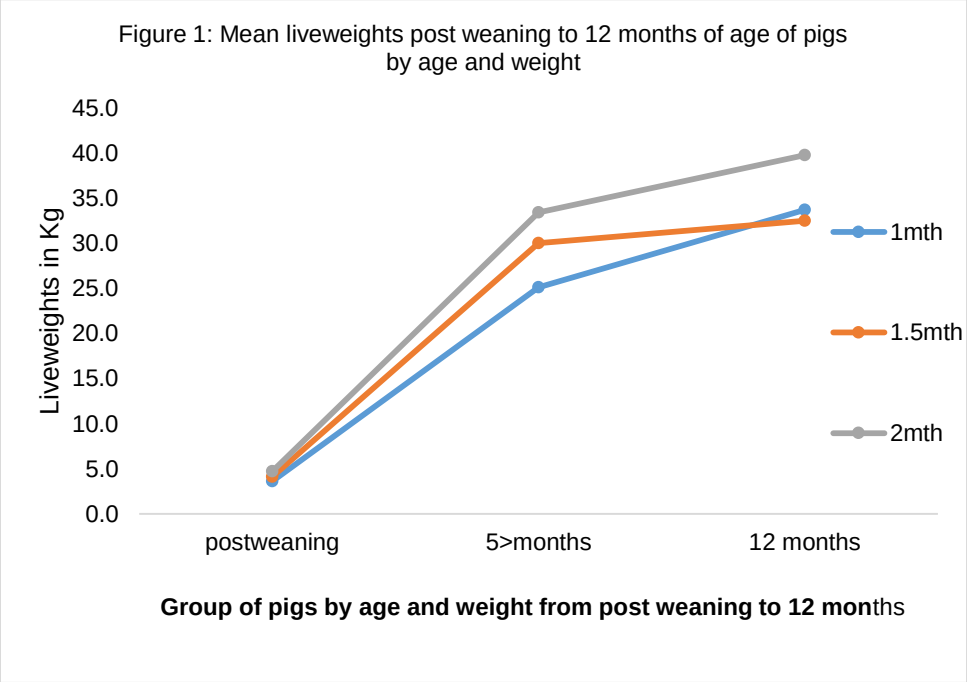

Figure 1. Mean Liveweights Post weanint to 12 Months of Age of pigs by Age and Weight

The mean LWs of pigs at 12 months of age of 36.4± 8.8 kg, 36.2±7.6 kg, 35.7±11.0 kg recorded in Adungosi, Apokor, Ngelechom respectively were significantly the same and higher than those of pigs in Amaase 33.9± 8.1kg and Odioi 31.1±6.3kg ($p<0.05$). Overall all pigs gained weight in the early post weaning phase of life. This trend was carried on in the last phase of life except in Adungosi and Odioi where pigs lost weight.

Of the 179 pigs provided to the farmers 63 reached 12 months of age and the survival rate was 35.2%. Most deaths (27.9%) occurred during the first month postweaning. Survival rates by 12 months of age of the three age groups were 33.7%, 31.7% and 52% for pigs weaned at 1 month 1.5 months and 2 months of age respectively.

Discussion

The overall mean ADGs and liveweights achieved in these trials were below the expected levels of pig performance and efficiency to slaughter weights within 12 months of life. In Kenya, under good management pigs are expected to attained 50-84kg in 6 months (MoLD 2009). The average daily gain (ADG) for pigs upto 12 months of age (88.9 ±23g/day) was within the range of that reported by Mutual *et al.,* (2012) of 99 ±92 g, for pigs of ≥10 months old in the area. Like other Western Kenya pig farmers, those in Teso sub county specialize in producing piglets which are sold to other farmers at the age of two months to be raised for slaughter as fatteners or finishers, or for breeding purposes (FAO, 2012; Mutual *et al.,* 2012; Emongor *et al*.,2014).

Most of the pig farmers in this system aim to maximize revenues from their pigs rather than profits and therefore tend to sell their pigs to meet critical cash requirements, not necessarily when they reach a particular market weight (Ajala and Adesehinwa, 2007). The average liveweight achieved in this study of 34.6±8.2kg at 12 months falls within the demand market weight range of 22-45kg (Levy, 2014). Limitations in performance of pigs is influenced by genetic and the environmental parameters (Baptist 1987; Ilatsia *et al* 2008; FAO, 2012), however, growth rate in pigs is mainly driven by feed intake (Lemke et al. 2006). Feed shortages and the associated high cost are known to occur in the region and therefore the tendencies to only provide inadequate rations that cannot meet the daily protein demand of the pig (Kagira*et al,* 2010; Mutual *et al*, 2012; Levy 2014). The phenomenon was clearly demonstrated by the fact pigs ADGs were high in the early post weaning phase when feed demands were low but reduced to very low levels in the late post weaning phase prior to slaughter where the demands were vice versa (Figure 1).

The finding that male pigs significantly grew faster and were heavier than females in all phases of growth was consistent with the expression of the genetic traits as has been demonstrated in past studies (Lynch, 2006). The effects of feed types was clearly demonstrated by the fact that "farm feed" only pigs had statistically significant low mean ADG than those which were additionally provided "commercial by products" at all stages of age. Mutua *et al* (2012) described these pig feeding systems and their limitations.

Pig performance and efficiency of growth were affected by weight at weaning (Figure 1). Pigs with light pre weaned weights showed inferior growth performance up to the finisher period. The findings expressed in this limited feed intake system has also been found in well fed pig where although pigs compensated some of the inferior growth towards the time of slaughter, they never reached the weights of the heavy birth-weight animals (Lynch 2006). The effects of different management factors among the five sub-locations was significantly apparent where farmers in Adungosi, Apokor and Ngelechom raised heavier pigs than those in Amaase and Odioi. Thus the general poor feeding practices are varied and any future improvement programmes should put this into considerations. (Mutua, 2010; Dewey *et al*, 2011)

Survival of pigs is a major factor of the economic efficiency of pig production (Crump *et al.,* 1997b; Hermesch *et al.,* 2000a). The overall rate of 35.2% observed in this study was very low. The fact that pigs with high pre weaning live weights had higher survival rates of 52% is in agreement with the estimates by past research where mortality rate is high in piglets with low birth and pre weaned weights (Damgaard*et al.,* 2003; Mesa *et al.,* 2006). Although low growth rate is due to cumulative effect of a combination of factors, the poor growth rates observed in this study were attributed to low quality feeds and poor management practices.

Conclusion

Growth rates and performance of pigs were lower than the national median of 130 g/day in Kenya (Wabacha *et al.,* 2004). The low growth rate was due to limited feeds provided by the farmers and the associated management practices. Despite the fact that farmers are able to off take the slow growing and light liveweight pigs there is need to realise their potential and experience faster growth and heavier market weights. The observed inconsistence, probably a contribution of genetic and phenotypic traits should be included in future pig improvement programme interventions to raise livelihoods and standards of these

farmers. This would improve on the general performance and economic efficiency of pig production enterprises in Kenya.

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References

Baptist, R. 1987. Computer simulation of monitoring herd productivity under extensive conditions: sampling error of herd size and offtake. Agricultural systems 24: 199-210.

Crump R E, Harley C S, Thompson R & Mercer J, 1997a. Individual animal model estimates of genetic parameters for reproductive traits of Landrace Pigs performance tested in a commercial nucleus herd. Animal Science 65, 285-290.

Dewey F K, Arimi C E, Ogara S M, Githigia W O, Levy S M, Schelling M, E. 2011. Indigenous pig management practices in rural villages of Western Kenya.

Emongor R A, Ogali I, Njanja C J and Kundembule P,2014.Testing technologies for sustainable pig farming systems in Busia county, Kenya.6th All Africa Conference on Animal Agriculture, (AACAA).

FAO (Food and Agriculture Organization), 2012. Animal production and health. Livestock country reviews. Pig sector, Kenya.

Hermesch S, Luxford BG, &Graser HU, 2000a. Genetic parameters for lean meat yield, meat quality, reproductivend feed efficiency traits for Australian pigs. 3. Genetic parameters for reproductive traits and agenetic correlation with productive, carcass and meat quality traits. Livestock Production Science. 65, 261-270.

Ilatsia E D, Githinji M G, Muasya T K, Okeno T O and Kahi A K, 2008.Genetic parameter estimates for growth traits of Large White pigs in Kenya. South African Journal of Animal Science 38 (3), 166-173.

Kagira, J.M., Kanyari, P.W.N., NdichoMaingi, N., Githigia, S.M., Ng'ang'a, J.C., aruga, J.W., 2010. Characteristics of the smallholder free-range pig production system in western Kenya. Tropical Animal Health and Production, 42, 865–873.

KNBS (KenyaNational Bureau of Statistics) 2009. MOLD Department of Livestock Production Estimates, 2010.

Lemke, U., Kaufmann, B., Thuy, L.T., Emrich, K., Valle Zarate, A., 2006. Evaluation of small-holder pig production systems in North Vietnam: Pig production management and pig performances. Livestock Science, 105, 229–243.

MoLD (Ministry of Livestock Development), 2009. Pig production manual. AIC. Nairobi.

Mutua, F.K. 2010. A study of opportunities for improved rural pig farming in Western Kenya: Feeding, productivity, marketing and public health. PhD thesis. University of Nairobi.

Mutua F, Dewey C, Arimi S, Ogara W, Levy M, Schelling E, 2012. Improving pig production and health in western Kenya. URL:/http://hdl.handle.net/10568/604.

Njanja J C, Ogali I N, Emongor R A,,Kundembule P, 2015.Farmers' perception on pig cysticercosis and the epidemiological status of the disease in Teso, western Kenya. 49th Kenya veterinary association (KVA) annual scientific conference&15th world veterinary day celebrations. April 22nd – 25th, 2015, Hotel Itoya, Busia, Kenya.

Factors influencing Postpartum Cyclicity of Friesian Dairy cows

HokaA.I[1], Gicheru M[2]., Otieno S[2]. and Njonge, F[3].

[1] KARI-National Beef Research Centre, P.O. Box 3840, Nakuru. [2] Department of Zoology, Kenyatta University, P.O Box 43844 (00100), Nairobi. [3] Department of Animal Science, Jomo Kenyatta University of Agriculture and Technology, P.O Box Nairobi.

[1] Corresponding author: Hoka, A.I. Email <indetie2001@yahoo.com>

Abstract

It is well documented that the fertility of a dairy cow is decreasing globally. Energy required for heat exhibition competes for the same nutrients with the energy required for milk production. Energy required for milk production is higher due to negative energy balance that results after parturition. In view of all the above, the cow prefers to direct its limited energy to milk constitution and production thereby compromising reproduction. An early return to cyclicity is important in regard to early conception. The timing of the first postpartum ovulation determines and limits the number of estrous cycles occurring prior to the beginning of the insemination period. The objective of this study was therefore to determine factors affecting postpartum cyclicity of Friesian dairy cows. Twenty 7- months in- calf Friesian dairy cows were randomly enrolled for the study. Milk samples were collected from the cows once a week pre-partum then daily for 90 days post-partum. Individual cow record on gestation period, parturition weight, parity, date calved, amount of milk, body condition score of dam, weight of calf, sex of calf, and days to postpartum heat was kept. Weights of calves and dams were taken using weigh bands, weights of milk was taken using balances, body condition score was done as recommended by Price et al. Ten mls of milk samples were collected from evening milk and preserved using sodium azide. The milk was then spun at 3000rpm for 30 minutes to yield skimmed milk which was pippeted into 5 ml vials and the vials kept at -20^{0}C until analysis. Analysis was done using radioimmunoassay technique developed by IAEA/FAO. Data collected was analyzed using SAS and the means were separated using Keul test. Cow that calved during drought took too long to cycle unlike the ones that calved during wet season. There was significant variation ($P<0.05$) in milk production and composition with higher parity cows producing more milk. Across all parities, protein was elevated during the first weeks but dropped and rose again then stabilized and dropped gradually as the lactation progressed. Postpartum heat ranged from 44 - 120 with an average of 82 days There was variation in postpartum conception among the cows with BCS 3 with female calves having the highest percent conception to 1st artificial insemination postpartum than the rest. There was negative relationship between amount of milk produced and % conception. BCS, Parity, amount of Milk, Sex and weight of calf, type of feed and season influenced postpartum conception with BCS and feed having the highest influence on postpartum reproduction among Friesian dairy cows.

Key words: Estrus, postpartum, Friesian cow

Introduction

Following parturition cows must undergo numerous physical and hormonal changes in order for reproductive function to be restored. Uterine involution and resumption of uterine activities must be achieved for the resumption of reproductive functionality in dairy cows, this process can take up to 60 days (Senger, 2003), and the uterus must decrease in both size and volume. This requires a decrease in uterine vasculature, expulsion of tissues and fluids associated with pregnancies and repair of endometrial tissue. Unlike most other, animals dairy cows are not continually sucked decreasing oxytocin pulse frequency, thereby reducing uterine contraction and prolonging the time taken for discharge of remaining pregnancy tissues and fluids (Senger, 2003). Timely uterine involution is important in the dairy cow. Without a

complete return of the uterus to non-pregnant state, a subsequent pregnancy cannot develop and continuation of lactation is prevented.

The other most important facets leading to the resumption of reproductive functionality is the return of ovarian activity. Pregnancy is dominated by high levels of Progesterone (P4) which prevents follicular growth and ovulation. Just before parturition, P4 levels decline sharply which allows secretion of gonadotropin-releasing hormone (GnRH) from the anterior pituitary and leading to resumption of follicular activity (Senger , 2003). Follicle-Stimulating Hormone (FSH) increases shortly after parturition in transient waves in response to increasing GnRH levels. This promotes the commencement of the first postpartum follicular wave. From this follicular wave, several follicles are recruited and begin to grow and produce estradiol. Only one of the recruited follicles continues growing and becomes the dominant follicle (DF), and suppresses FSH levels (Roche and Diskin, 1999). Once high enough, estradiol levels trigger a surge in lutenizing hormone (LH) in the anterior pituitary. This LH surge causes the follicle to rupture, releasing the ovum; this follicular lysis is known as "ovulation." The first postpartum ovulation signals a return to cyclicity and luteal activity in the form of progesterone (P4) production (Senger, 2003).

Justification

Long calving intervals averaging 633 days with a range of 308 to 1256 days due to impaired fertility in cows (Odima *et al.,* 1994) have been reported on smallholder farms in Kenya. Possible causes of this infertility may be due to poor nutrition and an ineffective AI system (Topps, 1994). Pregnancy percentage at first insemination, the number of inseminations per conception and the number of days from calving to conception all influence the length of the calving interval (Stevenson, 2001). On a per herd-year basis, shorter calving intervals result in higher milk production and more calvings per year.

Material and Methods

i). Study Site

The research was conducted at KARI-Lanet, the farm is within Nakuru District, Kenya. KARI-Lanet is situated in 2 agro- ecological zones 3 and 4 (Pratt and Gwyne, 1977). The farm is 1,600 metres above sea level and has a bimodal rainfall pattern with an annual mean of 800mm ranging from 534 to 1049mm and 83% relative humidity. Average Maximum and Minimum temperatures are 26 and 10^{o}C, respectively. Agro-ecological zone 3 has relatively good pastures while zone 4 has natural harsh pastures characterized by Manyatta grass and acacia.

ii) Selection of Experimental Materials

Twenty ranched Friesian dairy cows, seven months in-calf were randomly selected using random digits and were enrolled for this study. Each cow was cow was supplemented with 2kg of Rhodes (*Chloris gayana*) /Desmodium) hay during milking. Water and mineral licks were given *ad-libitum*. Details of body condition score, milk produced, parity, season, sex and weight of calf were recorded. Five mls of milk were collected thrice a month postpartum. Radioimmunoassay technique using self coating procedure was used to analyze milk to determine the physiological status postpartum. The data collected was was analyzed using the GLM procedure of SAS and the means were separated using studentised Keul test.

Results and Discussions

Chemical Composition

The DM, CP, ADF, NDF and ADL of the feeds varied across seasons (Table 1). Feeds with high dry matter content increased milk fat and protein percentages. This could be due to variation in dry matter in the feeds as dictated by the season. January to March is the dry spell and therefore the feeds had high dry matter content which is the raw material for fat sythesis but April to June is long rain season.The milk fat

decreased In April-June period due to decreased dry matter content of the feeds. This finding agreed with that of Henno et.al (2008).

Table 1: Overall mean and variations of feeds used

Ingredient	range	mean	SD	CV
Dry Matter	11-34	24.5	2.09	12.29
CP	9-18	12.47	3.38	19.88
ADF	18-40.6	30.11	6.47	38.05
NDF	38.6-45.2	31.20	10.63	65.52
ADL	4.6-19.2	10.03	4.64	27.29

Milk Production and Composition

There was significant difference ($P<0.05$) in percent values of milk and milk composition. This was due to changes in amount of nutrients in feeds with season. This agreed with the finding of Wood (1972).who reported that seasonality of pasture affected milk curve and milk component. Average milk production was 17.5L/day whereas percent milk fat, protein, averaged 3.81, and 3.19 respectively (Table 2).

Table 2: Overall mean and standard errors of the traits studied

Milk and its components	Range (%)	Mean (%)	S.E
Amount of milk/day(lts)	14-25	17.5	1.31
Butter fat	2.3-5.6	3.81	0.14
Protein	3.1-4.9	3.19	0.05

SE = Standard error

There was a gradual drop in milk progesterone from 4 Nmol/L at birth to 0.5 Nmol/L on day 6 postpartum followed by a peak of 7 Nmol/L on day 7 postpartum. The changes in Milk progesterone levels were less marked and were characterized by a minimum level of 0.30 Nmol/L until day 42 postpartum and then rose thereafter, followed by a peak level of 4 Nmol/L on day 53. The earlier rise in milk progesterone level of 7 Nmol/L on day 7 postpartum suggested Pseudo estrus activity (Fig.1a).

Postpartum cyclicity varied within the experimental cows, it ranged from 42-120 days with an average of 82 days. 1st postpartum cyclicity was established on 42 day with majority of the postpartum cows cycling on day 90 (Fig.1b). During pregnancy and parturation there was tear and wear of the reproductive tract which needed time to be repaired and complete convolution of the uterus. The finding agreed with that of Senger (2003).

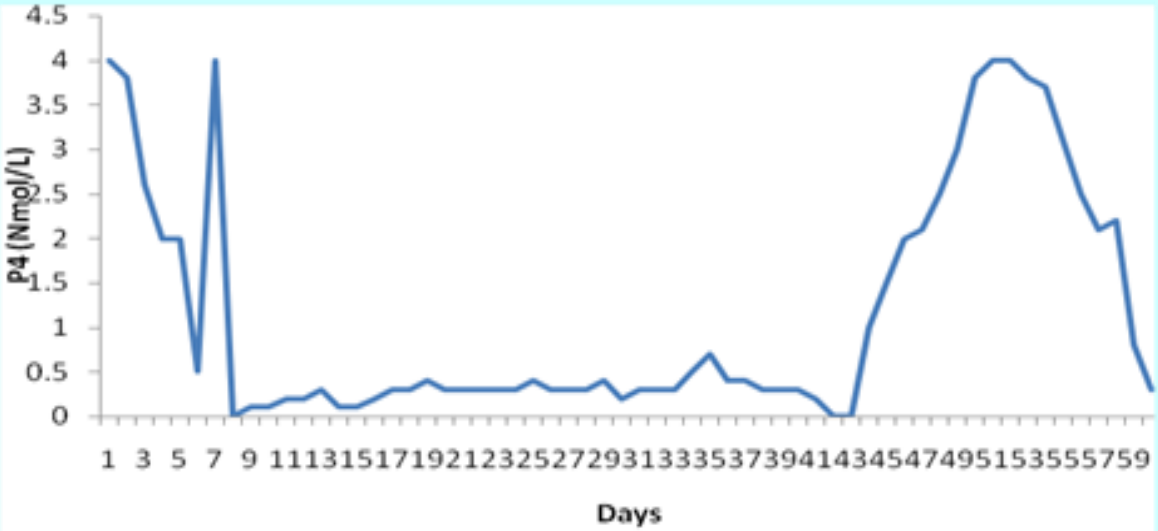

Fig 1a. Postpartum cyclicity of Friesian dairy cows

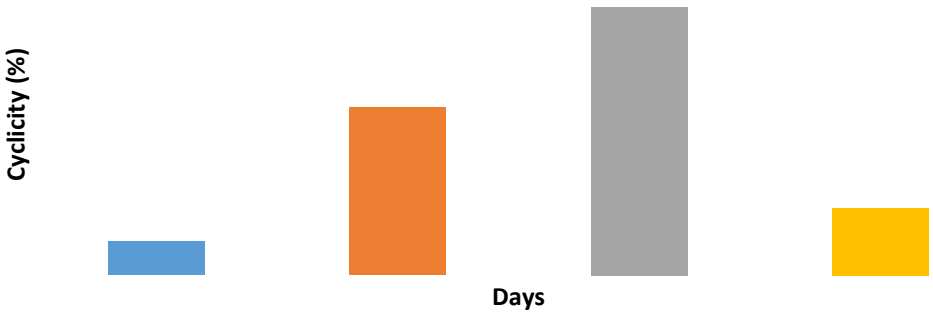

Fig. 1b. Days to postpartum cyclicity

The ratio of male to female calves born was 0.45 to 0.55. Calf weight ranged from 22-38 kg with an average of 29.3kg. Male calves were heavier than female calves at birth. This agreed with finding of Indetie *et al.,* (2010), who reported that male calves were more resistant to most endemic diseases due to their heavier weight as compared to the female calves at birth.

Calf sex and calf weight highly influenced ($P<0.05$) postpartum cycling. Dams with female calves cycled and conceived earlier that dams with male calves (Fig.2). This agreed with the finding of Gregory (1992) who reported that dams with male calves took long to cycle. The reason for this could be due to increased amount of milk produced by dams with male calves (Hoka, *et al.,* 2012) hence partitioning favoured milk production at the expense of reproduction. (Garcia et al; 2007).

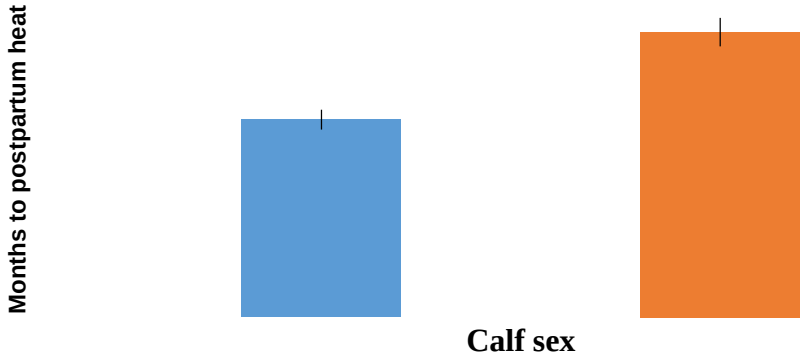

Figure 2: Effect of calf sex on postpartum cyclicity

There was great variation (P<0.05) in conception with cows taking 3 months to show heat getting higher percent conception than cows taking less or more months to be served (Fig.3). This finding agreed with finding of Senger *et al.,* 2003. The reason for this could be that in the earlier months the cow is still repairing its reproductive system and in the later months could be some reproductive deficiencies may have cropped in.

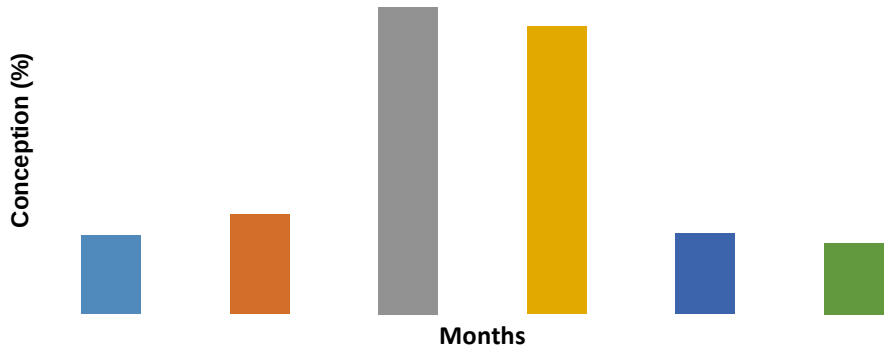

Figure 3: Months to postpartum Conception

Body condition score (BCS) highly influenced (P<0.05) postpartum cycling (Table 2) and conception with BCS 3 cycling earlier than other BCS. This finding agreed with the finding of Price *et al.,* (2001). Cows of body BCS 4 lost more weight at week 4 than cows of BCS 2 and 3. Parity highly influenced postpartum cyclicity and conception (Table 3) with parity 3 having cycled earlier than parity 2 and 4. This finding agreed with the finding of Hafez and Hafez (2000) who reported increase in conception with increased parity up to parity five. In early parities the cow is growing but at later parities the cow is fully grown and does not compete for food with lactogenesis. (Hafez and Hafez, 2000).

Table 3: Anova Table

Source	DF	Sum of Squares	F Ratio	Prob > F
BCS	2	1393.3095	5.3339	0.0088
Parity	2	9634.5340	36.8831	<.0001
Calf sex	1	415.53713	63.6868	<.0001

There was significant variation in body weight changes with BCS 2 lossing more weight than BCS 3 and 4. Mean body weight loss of the cows from parturition to cycling was 0.5Kg/day. This was because feed intake lagged behind production by 2-4 weeks (Early lactating cows did not eat as much as they did in the 2 and 3 months of lactation). Cyclicity started during the body weight gaining phase (Fig. 7). This finding agreed with finding of Senger *et al.,* (2003) who reported that the postpartum cow needed time to initiate ovarian function.

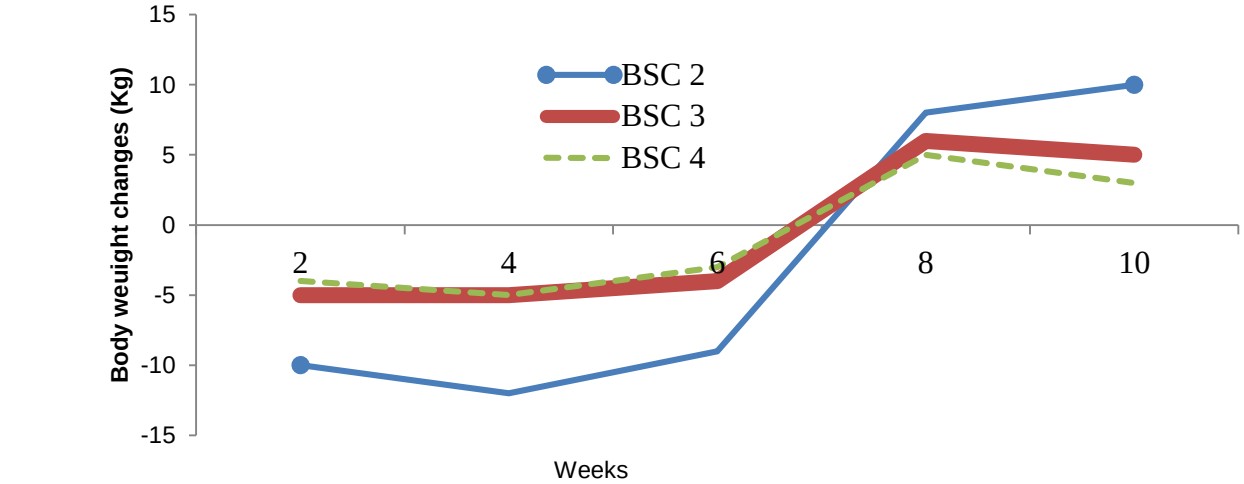

Figure 7: Effect of BSC on body weight changes postpartum

Conclusions

- Pseudo estrus on day 7 postpartum of 7Nmol/L
- Majority of cows cycled on day 90 postpartum
- 5th parity out performed others
- Male calves led to delayed cyclicity
- Low BCS cows lost a lot of weight during NEB
- Cows with female Calves were bred early

Recommendations

- Cows should be served at least 42 days postpartum
- Cows should be maintained in BCS 3 to minimize body weight change postpartum

References

Indetie, D., A. Indetie, J. Kinywa, E. Nambiro, T. Rewe (2010). Reproductive Characteristics and Herd Dynamics in Smallholder Dairy Farms of Nakuru, Kenya. In Sustainable Improvement of Animal Production and Health. Eds. N. E. Odongo, M. Garcia and G.J.Viljoen.Pp38-55.

García-Ispierto I, F., López-Gatius, P. Santolaria, J.L .Yániz, C .Nogareda, M. López-Béjar. (2007). Factors

affecting the fertility of high producing dairy herds in northeastern Spain. Theriogenology, 67:632- 638.

Hafez, E. S. E. and Hafez, B. (2000). Reproduction in Farm Animals. 7th Edition. Hafez and Hafez (eds) Lippincott Williams and Wilkins Pp55-172.

Gregory, K. E L. ,V. Cundiff, and R. M. Koch (1992). Effects of breed and retained heterosis on milk yield and 200-day weight in advanced generations of composite populations of beef cattle. J. Anim. Sci. 1992. 70:2366-2372.

Price, J. E., M.P. Coffey, and G. Simm, G. (2001). The relationship between body condition score and reproductive performance. American Dairy Science, 84:1508-1515.

Roche, J.F., and M. G. Diskins (1999). Resumption of reproductive activity in the early postpartum.period of cows. In: High –producing Dairy Cow.26:341-345.

Senger, P.L.(2003) Pathways to pregnancy and paturation., 2nd ed. Pullman: Current Conception, Inc.

Stevenson, J.S. (2001). Reproductive management of dairy cows in high milk-producing herds. J. Dairy Sci. 84(E. Suppl.):E128-E143.

Wood, P. D. P. (1972). A note on seasoanal fluctuation in milk production. Animal prod. 15: 89-92.

SNP Calling from Next Generation Sequence Data

Ngeno K.

Animal Breeding and Genomics Group, Department of Animal Sciences, Egerton University,
P. O. Box 536, 20115 Egerton, Kenya
Correspondence: K. Ngeno, Phone : +254708246317
Email: aarapngeno@gmail.com

Abstract

Next generation sequencing (NGS) is of great significance for genetic improvement. Some of the most common application of NGS is the identification of the genomic variants, genes and sequence mutations. Mining of genomic variants such as single nucleotide polymorphisms (SNPs) from raw sequences involves several steps and use of numerous bioinformatics tools in a systematic manner. This paper reviews the components of a pipeline that calls SNPs from NGS data. The SNP calling pipeline includes base calling, quality checks, reads trimming, alignment of the quality reads to the reference genome, quality score recalibration, visualization and SNP identification. The final step of the pipeline is making biological sense out of the SNPs data, which involves filtering and annotation of the candidates SNPs.

Introduction

Next generation sequencing (NGS) also referred to as high-throughput sequencing, involves whole genome, specific genomic region, whole-exome or RNA sequencing.The NGS generated a lot of data which has enabled scientists to examine genomic variants such as insertions, deletions (Xi *et al*., 2010), single nucleotide polymorphisms (SNPs)and sequence mutations that are likely to be the causal of phenotypic variations. Single nucleotide polymorphism is the most common genomic variant that provide abundant source of genomic variation.Some of the most common application of SNPs is the studying of heritable variations (Suh and Vijg, 2005),causal genesfor Mendelian diseases(Sohyun et al., 2015),mutations appropriate for diagnosis and therapy (Pabinger et al., 2014), population genetics such asphylogeography(Keim and Wagner, 2009), genome wide associations (Nelson et al., 2014) and genomic selection. SNP-based studies rely on accurate and consistent identification of SNPs. SNP calling process from raw NGS sequences encompasses several steps and use of numerous bioinformatics tools in a systematic manner. This paper reviews the general steps and bioinformatics tools used in the pipeline that calls SNPs from NGS data and making sense out of the identified SNPs.

Steps in the SNP Calling Pipeline

Base calling

The standard principal for NGS technologies is sequencing by synthesis. Synthesis procedure involves capturing of fluorescence images and converting into nucleotide bases to generate reads (Nielsen *et al*., 2011). In this process, the sequencing machines will generate errors (Altmann *et al*., 2012). Base calling involves estimation of sequence reads errors generated during sequencing(Nielsen *et al*., 2011).Estimation of the errors is usually performed by the sequencing platformusing their base calling softwares. Errors are expressed as phred-like quality score, which gives the expected error probability of each base call, based on the noise estimates arising from image analysis(Nielsen *et al*., 2011). Phred-like quality scoresare calculated using the formula;

$$Q_{phred} = -10 * \log_{10} P(error)$$

where *P* is the probability of an incorrect base call (Pavlopoulos *et al*., 2013).The phred scores range is 1 to 60, where a Phred score of 10, 20 and 30 represents accuracy of 90%, 99%and 99.9% respectively.

Quality control/trimming

Generally, all the NGS sequencing platforms do quality control checks using their base calling softwares and provide a summary on the data quality for the bases in the sequence reads. Although, the sequencing platforms provide quality scores, there can be quality issues in sequencing. Minimizing base call errors and subsequent improvement of the accuracy for the base quality score is essential in detection of polymorphism (Nielsen *et al*., 2011). Therefore, quality of the generated reads needs to be checked usingsoftwares such as prinseq(Schmieder and Edwards, 2011), shrimp2 (David *et al*., 2011), piqa(Martinez-Alcantara *etal*., 2009) orfastqc(http://www.bioinformatics.babraham.ac.uk/projects/fastqc/). Identified low quality read can be trimmed using sickle(Joshi and Fass, 2011), htqctoolkit(Xi *et al*., 2013), solexaqa(Cox *et al*., 2010)orbigpre(Zhang *et al*., 2011).

Read mapping or Alignment

After checking quality, high quality reads are aligned onto the reference sequences. Alignment is crucial in variant detection. Wrong alignment of the reads may result in artificial divergences from the reference sequences and consequently errors in variant calling (Altmann *et al*., 2012; Nielsen *et al*., 2011). In most cases, accuracy of alignment relies on the alignment tool used and their corresponding settings (Altmann *et al*., 2012). Most common alignment tools used are either hash-based algorithms such as MAQ (Li *et al*., 2008b) andStampy(Li *et al*., 2008a)) or data compression algorithms (Burrows–Wheeler transform) like Bowtie(Langmead *et al*., 2009), SOAP2(Li *et al*., 2009c) and BWA(Li and Durbin, 2009). These aligners generate alignments in sequence alignment map (SAM) or BAM formats. The SAM and BAM formats are the quasi-standards for storing information for the alignedsequences. The SAM and BAM files are manipulated using tools such as SAMtools (Li *et al*., 2009a), Genome Analysis Tool Kit (GATK)(McKenna *et al*., 2010)or Picard (http://picard.sourceforge.net).After the alignment step, success rate and the quality of mapped reads are usually checked by computing mapping statistics such as mean quality, quality score distribution and fraction of reads mapped successfully. Statistics are generated using softwares like SAMtools and Picard. The next step is the visual inspection of the alignments.Visualization reveals the success of sequencing. Visualization is done using software tools such as GenomeView(Abeel *et al*., 2012), Integrative Genomics Viewer (IGV)(Robinson *et al*., 2011) and savant(Fiume *et al*., 2010).

Processing of aligned reads

Alignment post processing step in the SNP calling pipeline involve removal ofartifacts and duplicate reads using SAMtools or Picard. Presences of artifacts and duplicates will bias the SNP calling. Indels (insertions and deletions) are also identified and realigned the reads using GATK or SMRA(Homer and Nelson, 2010). Presence of indels may be mistaken as SNP (false SNP) in the subsequent analysis (Altmann *et al*., 2012).

Recalibration of per-base quality scores

Sequencing error rates predicted by the sequencing platforms using base-calling algorithms may not truly reflect the true base-calling errors, resulting in potential wrong SNP calls (Li etal., 2009b). Phred score values have been found to have intrinsic errors resulting in deviation from the real sequencing errors(Nielsen et al., 2011). Therefore, there is a necessity to recalibrate the initial quality scores to improve the accuracy of the called variants (DePristo *et al*., 2011; Zook *et al*., 2012).Software used in base quality scores recalibration include SOAPsnp(Li *et al*., 2009b) and GATK.

SNP calling

Single nucleotide polymorphism calling also called variant calling implies finding SNPs in the NGS data using SNP calling softwares. Algorithms for identifying SNPs vary in their approach. Some algorithms find SNPs based on the number of high confidence base calls that are not in agreement with the reference sequence(Olson et al., 2015). Other variant callersuse likelihood ratio tests, Bayesian methodor machine learning statistical methods that considerallele frequencies, base and quality scoresto call SNPs (Nielsen et

al., 2011; Pabinger et al., 2014). The most commonly used SNP callers are SAMtools, GATK, Freebayes, VarScan, cortex_var, VCFtools(Danecek*et al*., 2011) and Ion Proton Variant Caller.The end result of SNP calling isthe collection of SNPs in a standard file called Variant Call Format (VCF) which is generated by SNP callers.

Filtering and annotation of SNP candidates

In the SNP identification step, the posterior probabilities calculated from each site may deviate from the true value due to errors (Nielsen *et al*., 2011). Therefore, additional filtering is applied to improve SNP calls by removing false positive SNPs and SNP calling artifacts. Filtering can be based on the posterior probabilities, read depth, quality scores differences between major and minor alleles, linkage disequilibrium patterns, strand biasness and deviation from Hardy–Weinberg equilibrium(Altmann *et al*., 2012; Nielsen *et al*., 2011). VCFtools, GATK and SAMtools are tools commonly used in filtering SNPs.The final step of the pipeline is making biological sense out of the called SNPs, which involves carrying out annotation to predict their potential effects or functions.Annotation of SNPs involves extraction of biological information base on nucleic acid and protein sequence. Commonly used annotation tools are SNPeff, VEP, ANNOVAR, PolyPhen-2, SIFT and FAST-SNP.

Conclusion

This paper provide useful guidelines for reliable SNP calling from NGS data to the annotation of the identified SNPs. SNP calling is a multistep process involving several bioinformatics tools.As such, SNP calling have to be carried out using steps, methods and tools that have been tested and benchmarked.

References

Abeel, T., P. T. Van, Y. Saeys, J. Galagan, and d. P. Y. Van. 2012. GenomeView: a next-generation genome browser. Nucleic Acids Res 40: 12.

Altmann, A., P. Bader, D. Preuß, M. Binder, E. B. Müller-Myhsok. 2012. A beginners guide to SNP calling from high-throughput DNA-sequencing data. Human genetics 131: 1541-1554.

Cox, M., D. Peterson, and P. Biggs. 2010. SolexaQA: At-a-glance quality assessment of Illumina second-generation sequencing data. BMC Bioinformatics 11: 485.

David, M., M. Dzamba, D. Lister, L. Ilie, and M. Brudno. 2011. SHRiMP2: sensitive yet practical SHort Read Mapping. Bioinformatics 27: 1011-1012.

DePristo, M. A., E.Banks, P. Ryan, G. Kiran, M. Jared, H. Christopher, P. Anthony, D. Angel, G. Rivas, Manuel and H. Matt. 2011. A framework for variation discovery and genotyping using next-generation DNA sequencing data. Nature genetics 43: 491-498.

Fiume, M., V. Williams, A. Brook, and M. Brudno. 2010. Savant: genome browser for high-throughput sequencing data. Bioinformatics 26: 1938-1944.

Homer, N., and S. Nelson. 2010. Improved variant discovery through local re-alignment of short-read next-generation sequencing data using SRMA. Genome Biol 11: 99.

Joshi, N., and J. Fass. 2011. Sickle: A sliding-window, adaptive, quality-based trimming tool for FastQ files (Version 1.33) [Software].

Keim, P. S., and D. M. Wagner. 2009. Humans and evolutionary and ecological forces shaped the phylogeography of recently emerged diseases. Nat.Rev. Microbiol. 7: 813-821.

Langmead, B., C. Trapnell, M. Pop, and S. Salzberg. 2009. Ultrafast and memory-efficient alignment of short DNA sequences to the human genome. Genome Biol 10: 25.

Li, H., and R. Durbin. 2009. Fast and accurate short read alignment with Burrows-Wheeler transform. Bioinformatics 25: 1754-1760.

Li, H.,B. Handsaker, A. Wysoker, T. Fennell, J. Ruan, N. Homer, G. Marth, G. Abecasis. 2009a. The sequence

alignment/map format and SAMtools. Bioinformatics 25: 2078-2079.

Li, H., J. Ruan, and R. Durbin. 2008b. Mapping short DNA sequencing reads and calling variants using mapping quality scores. Genome Research 18: 1851-1858.

Li, R., B. Handsaker, A. Wysoker, T. Fennell, J. Ruan, N. Homer, G. Marth, G. Abecasis, R. Durbin. 2009b. SNP detection for massively parallel whole-genome resequencing. Genome Res 19: 1124-1132.

Li, R.,Y. Chang, L. Yingrui Lam, T. Yiu, S. Kristiansen and K. Wang. 2009b. SNP detection for massively parallel whole-genome resequencing. Genome Research 19: 1124-1132.

Li, R.,Y. Chang, L. YingruiLam, T. Yiu, S. Kristiansen and K. Wang. 2009c. SOAP2: an improved ultrafast tool for short read alignment. Bioinformatics 25: 1966-1967.

Martinez-Alcantara, A.,E. Ballesteros, C. Feng, M. Rojas, H. Koshinsky, V.Y. Fofanov, P. Havlak and Y. Fofanov. 2009. PIQA: pipeline for Illumina G1 genome analyzer data quality assessment. Bioinformatics 25: 2438-2439.

McKenna, A.,M. Hanna, E. Banks, A. Sivachenko, K. Cibulskis, A. Kernytsky, K. Garimella, D. Altshuler, S. Gabriel, M. Daly and M.A. DePristo. 2010. The Genome Analysis Toolkit: a MapReduce framework for analyzing next-generation DNA sequencing data. Genome Res 20: 1297-1303.

Nelson, C. L., K.Pelak, M.V. Podgoreanu, S.H. Ahn, W.K. Scott and A.S. Allen. 2014. A genome-wide association study of variants associated with acquisition of Staphylococcus aureus bacteremiaina healthcare setting. BMC Infect.Dis 18: 83.

Nielsen, R., J. S. Paul, A. Albrechtsen, and Y. S. Song. 2011. Genotype and SNP calling from next-generation sequencing data. Nature Reviews Genetics 12: 443-451.

Olson, N. D., P. Steven L., R. E. Colman, J. T. Foster,J. W. Sahl,, J. M. Schupp, P. Keim, J. B. Morrow, M. L. Salit andJ. M. Zook. 2015. Best practices for evaluating single nucleotide variant calling methods for microbial genomics. Frontiers in genetics 6:235.

Pabinger, S.,S. Anzar, X. Liu, Q. Su and D. Puiu. 2014. A survey of tools for variant analysis of next-generation genome sequencing data. Briefings in bioinformatics 15: 256-278.

Pavlopoulos, G., A. Oulas, E. Iacucci, A. Sifrim, Y. Moreau, R. Schneider. 2013. Unraveling genomic variation from next generation sequencing data. Bio Data Min 6: 13.

Robinson, J. H. Thorvaldsdottir, W. Winckler, M. Guttman, E.S. Lander, G. Getz, J.P. Mesirov. 2011. Integrative genomics viewer. Nat Biotechnol 29: 24-26.

Schmieder, R., and R. Edwards. 2011. Quality control and preprocessing of metagenomic datasets. Bioinformatics 27: 863-864.

Sohyun, H., K. Eiru, L. Insuk, and M. M. Edward. 2015. Systematic comparison of variant calling pipelines using gold standard personal exome variants. Nature 5: 17875.

Suh, Y., and J. Vijg. 2005. SNP discovery in associating genetic variation with human disease phenotypes. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis 573: 41-53.

Xi, R., T. Kim, and P. Park. 2010. Detecting structural variations in the human genome using next generation sequencing. Brief Funct Genomics 9: 405-415.

Xi, Y., D. Liu, F. Liu, J. Wu, J. Zou, X. Xiao, F. Zhao and B. Zhu. 2013. HTQC: a fast quality control toolkit for Illumina sequencing data. BMC Bioinformatics 14: 33.

Zhang, S., Y. Luo, K. Liu, L. Pan, B. Zhang, J. Yu, and S. Hu. 2011. BIGpre: a quality assessment package for next-generation sequencing data. Genomics Proteomics Bioinformatics 9: 238-244.

Zook, J. M., D. Samarov, J. McDaniel, S. K. Sen, and M. Salit. 2012. Synthetic spike-in standards improve run-specific systematic error analysis for DNA and RNA sequencing. PloS one 7: e41356.

Random regression analyses using B-spline functions to model the growth of Large White pigs

Ilatsia E.D.[1]* and Ouko V.O [2]

[1]Kenya Agricultural and Livestock Research Organization (KALRO), P. O. Box 25, 20117 Naivasha, Kenya
[2]Department of Animal Science, University of Eldoret, P.O. Box 1125-30100, Eldoret, Kenya
Email address: evansilatsia@yahoo.com

Abstract

Genetic parameters were estimated using B-spline functions in random regression models for weight of Large White pigs measured between the 3rd and 36th week of age. The model accounted for contemporary groups, parity and sex as fixed effects while random effects modelled were; animal genetic effect, permanent environmental effect and maternal genetic effect along with heterogeneous residual variances. Heritability estimates decreased with age from 0.37 at 3 weeks to 0.27 at 36 weeks. Weight during the studied period showed initial positive genetic and phenotypic correlations, which decreased with increase in age gap. The results from this study shows that body weight in Large White pigs is moderately heritable, especially prior to weaning, suggesting the potential for genetic gain from selection. The genetic correlations suggests that considerable genetic gain can be obtained by considering pre-weaning weight only, though the genetic correlation less than unity indicates that more genetic gain would be realized by including all the estimates of heritability throughout the growth period. In all cases, the estimates generated by this study were consistent with the limited number of studies that exists in the reported literature. This study suggests that random regression methods using B-spline, are appropriate for estimating genetic parameters in Large White pigs; and genetic gain for weight is promising.

Key words: Body Weight, B-spline, Genetic Parameters, Large White Pigs, Random Regression

Introduction

Random regression models based on Legendre polynomials have been used to study several farm animals in Kenya: Boran cattle (Wasike *et al*., 2007) Dorper sheep (Kariuki *et al*., 2010) and Holstein–Friesian cattle (Muasya *et al*., 2014). Additionally, many countries have now incorporated the models in their breeding programs (Meyer, 2005a; Shirali *et al*., 2015). These models have had the advantage of using all performance records from an animal, thereby excluding the need to adjust for standard ages. Moreover, more accurate estimates are realized in comparison to the conventional multi-trait models (Wolc *et al*., 2013). B-splines have been recommended and adopted as an advanced alternative to Legender polynomials with increased accuracy in estimation of genetic parameters (Meyer, 2005; Misztal, 2006). This was to address undesirable properties associated with Legendre polynomials such as need to use high degrees of polynomials when small data sets are used and errors at the extremes of the curves due to oscillations therein (Meyer, 2005b; Köhn *et al*., 2007). Even though there is limited information on estimation of pig genetic parameters using random regression models, spline functions were used to describe genetic variations using weights from 50 to 225 days by Huisman *et al*. (2002) and carcass weight by Zumbach *et al*. (2008).

The pig industry in Kenya has had many challenges including inadequate breeding strategies and unavailability of structured breeding schemes, thereby hindering its full exploitation (Mbuthia *et al*., 2014; 2015). This resulted in deliberate efforts for improvement by establishment of nucleus breeding flocks by government and private farms to enable selection and supply of quality piglets to farmers; a move that was not sustained (FAO, 2012). Most of the government owned farms suspended or stopped pig breeding by the year 2007, leaving private commercial farm as the major breeders of pigs in the country.

The objective of this study was to estimate covariance functions for direct and maternal additive genetic effects, animal permanent environmental effects and successively, obtain genetic parameters for growth

traits in Large White pigs, from 3rd to 36th weeks, using random regression models on B-splines of animal age.

Materials and Methods

Data

Data used in this study were obtained from the Non-ruminant Research Centre of Kenya Agricultural and Livestock Research Organization (KALRO) Naivasha, where pig genetic evaluation program ran from 1982 to 1996. The animals were weighed weekly from birth to 36 weeks when they were sold, while weaning was done at the 8th week. There were several instances where weighing was not done or was not possible, thereby presenting an unbalanced number of records from different animals as presented in Table 1.

Table 1: Data characteristics and pedigree structure

Category	Measure/Size
Total number of records analysed	10,428
Number of animals with records:	1,398
≤5 records	307
=6 records	83
>7-10 records	1,008
Number of animals in the analysis[a]	1,476
!Number of animals without records	78
Number of sires[b]	16
Number of dams[b]	86
Mean weight of animals analysed (kg)	33.03 (24.98)†

[a] Including parents without records, [b] with progeny in the data

† Standard deviation shown in parenthesis.

The contemporary groups were divided into two (1982-1990 and 1990-1996) based on feeding regimes and feed quantities supplied per animal as described by Ilatsia *et al*. (2008). Weight at birth was not included to avoid implausible variance values at that age as reported by Köhn *et al*. (2007), while animals with less than three records were also excluded. The data set analyzed consisted of 10,428 records from 1,398 pigs (Table 1).

Analysis

The data set was used to fit the average growth trajectory using cubic B-spline after initial analysis indicated that linear and quadratic B-spline could not adequately model the data. The coefficients of the cubic B-spline were generated from the k interval defined by the points T_k and T_{k+1} with $T_k \leq T_{k+1}$, as described by Meyer (2005), Misztal (2006) and Scalez et al. (2014). The partitions into m intervals requires the specification of m – l internal knots and two external knots (T_0 and T_m). This approach produces m +1 knots and m + p non-null functions $\phi_{k;p}$ (Scalez et al., 2014).

The general random regression model with cubic B-spline is as follows: (1)

$$y_{ijm} = F_i + \sum_{m=0}^{K_{A+3}} \beta_{k(ix)} \emptyset_{m,3}(t_{ij})_{ix} + \sum_{m=0}^{K_{B+3}} \alpha_{im} \emptyset_{m,3}(t_{ij}) + \sum_{m=0}^{K_{C+3}} \gamma_{im} \emptyset_{m,3}(t_{ij}) + \sum_{m=0}^{K_{D+3}} \delta_{im} \emptyset_{m,3}(t_{ij}) + \varepsilon_{ij}$$

where y_{ijm} is the j[th] weight record taken at week t_{ij} from the *m[th]* pig, F_i is the i[th] random regression coefficient for the fixed effects (contemporary groups, parity and sex) and $\emptyset_{m,3}(t_{ij})$ represents the *m[th]* cubic B-spline covariate at week *t* which was nested in fixed effect level *i*; $\beta_{k(ix)}$ is the *k[th]* coefficient of fixed regression nested in fixed effect *i*; α_{im} is the *i[th]* random regression coefficient for the additive genetic effect

of pig *m*; γ_{im} is the random regression coefficient for the permanent environmental effect of pig *m*; δ_{im} is the random regression coefficient for the maternal genetic effect of pig *m*; while $K_{A+3}, K_{B+3}, K_{C+3}$ and K_{D+3} represents numbers of regular intervals in modelling the fixed average growth trajectories, random additive genetic, permanent environment and random maternal genetic effects, respectively.

In matrix form, the equation is represented by;

$$Y = X\beta + Z_1\alpha + Z_2\gamma + Z_3\delta + e, \quad (2)$$

where Y is vector with weight records; β is the vector with fixed effects; α, γ and δ are the vectors with random regression coefficients for direct additive genetic, permanent environment and maternal genetic effects respectively; X, Z_1, Z_2 and Z_3 are the corresponding incidence matrices; and e is a vector of random errors.

The residual variance was modelled considering eight age classes (3 to 8, 9 to 12, 13 to 16, 17 to 20, 21 to 24, 25 to 28, 29 to 32 and 33 to 36). The covariance components and genetic parameters were estimated by the Restricted Maximum Likelihood method using the Wombat Software (Meyer, 2007), while the criteria AIC and BIC were used to compare the models.

Results and Discussion

The importance of improving pig breeding strategies in third world countries is gaining momentum with the increasing desire for food security in these regions (Mbuthia *et al*., 2015b). Prediction of genetic information required therein by use of versatile models is limited and this study provides such, for utilization in the pig industry. Additionally, this data set is unstructured with some animals having less than three records in the entire growth period; a common situation with performance recording in developing countries. This kind of data may provide major limitations in analysis using conventional multi-trait models, with increased inaccuracy due to data interpolation and adjustments. Random regression models have the capacity to provide accurate estimates despite the limited structure of the presented data set. This study showed significant genetic variation for body weight at the end of the growth trajectory, indicating the possibility of increasing genetic gain by selection.

After examining the estimated variances, variance proportions together with the information criterion (AIC and BIC) from the fitted models, the best fitting model was the one of k = 7 for both direct additive and animal permanent environment and k = 4 for maternal genetic effects. Therefore, only results from this model are presented.

Covariance Functions

Additive genetic variance increased from birth up to the 12th week when there was a decline then an increase to a maximum in the 36th week (Figure 1). Variance due permanent environment increased steadily throughout the trajectory unlike maternal variance which only increased from birth to the 16th week then declined to naught at the 36th week. Phenotypic variance was relatively constant at 158.11 to 165.43 kg^2 up to the 24th week, but increased to 376.91 kg^2 towards the 36th week, which corresponds to ages when pigs get to sexual maturity and thereby deposit more fat. Similary, permanent environmental variance increased sharply at the 24th week and is attributed to preferential treatment obtained due to dominance hierarchy, with pigs ranking higher getting more feed and thereby getting bigger. A similar trend in phenotypic and permanent environment variance was recorded by Köhn *et al*. (2007) in Goettingen minipigs, Ilatsia *et al*. (2008) in Large white pigs and Wetten *et al*. (2012) in Duroc and Landrace pigs.

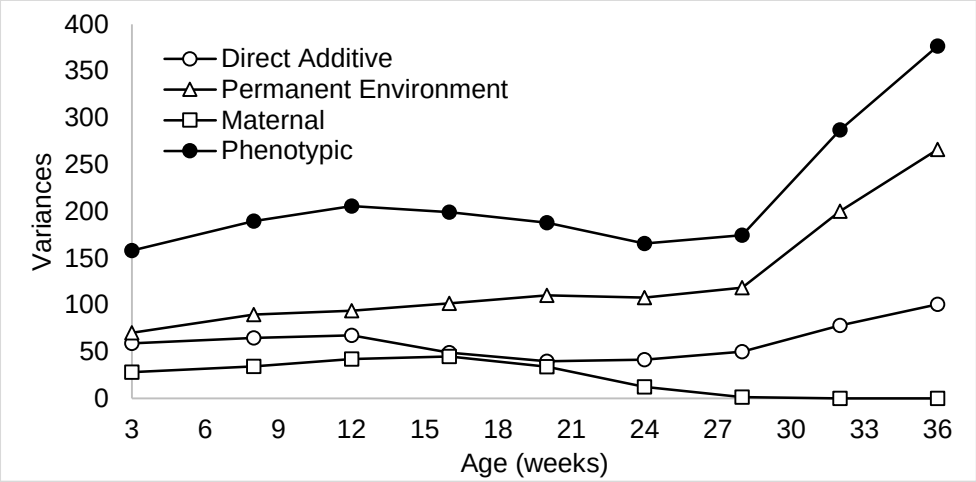

Figure 1: Estimates of direct additive genetic, animal permanent environment and maternal genetic phenotypic variance (Kg^2) obtained from model 774.

Heritability

Heritability decreased from the 3rd week to the 36th week while the proportion of animal permanent environmental variance increased gradually to a maximum of 0.71 in the studied period. On the other hand, the proportion of maternal genetic variance reduced steadily to naught at the end of the trajectory (Figure 2). Generally, direct additive and maternal heritability were low while the proportions of animal permanent environmental variance to phenotypic variance ranged from average to high.

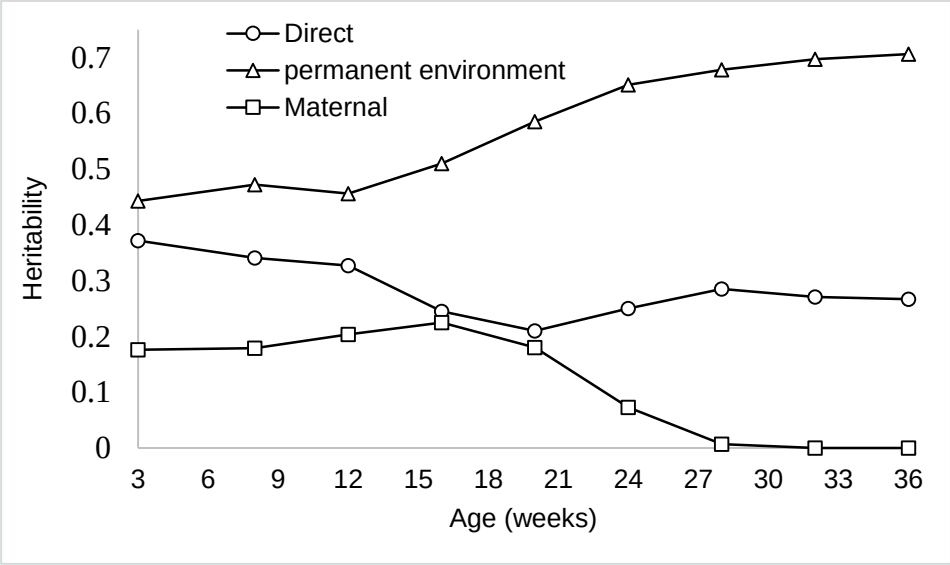

Figure 2: Estimates of direct and maternal heritability and estimates of animal permanent environmental variance as a proportion of phenotypic variance obtained from model 774.

The estimated heritability decreased with age from 0.37 to 0.27, along with increasing phenotypic variance signifying an increase in genetic variation. This designates that weight is averagely heritable early in the pig's life and is influenced by permanent environment and maternal genetic effects. A similar trend of heritability in pig weight was described by Huisman *et al*. (2002), Köhn *et al*. (2007) in Goettingen minipigs and Ilatsia *et al*. (2008) in Large White pigs, though with lower estimates than the ones presented by this study. Wetten *et al*. (2012) reported an increasing trend in heritability in Duroc and a decreasing one in Landrace between 80 and 160 days of growth. Norwegian Landrace sows had heritability estimates similar to this study, with the highest value observed at the 3rd week (Lundgren *et al*., 2014).

Maternal heritability, though minimal, was significant and declined from the 20th week to naught at the end of the growth period. This suggests that variations in weight observed up to the 20th week were partly determined by the condition of the rearing dam; including uterine nutrition and milk production capacity. Contrariwise, the diminishing trend, implies that selection for increased maternal ability is limited and genetic gains could only be realized before piglets get to 20 weeks old. Where weaning is done in three to four weeks, maternal genetic effect can be neglected due to its minimal influence (Köhn *et al*., 2007). It was however important to include maternal genetic effect in this study since weaning was done at the 8th week; the same should apply to studies involving cattle, goats and sheep. Using the same data set, Ilatsia *et al*. (2008) reported a similar trend, though with higher estimates.

Phenotypic and genetic correlations

As expected, phenotypic and genetic correlations between body weights reduced with increase in distance between age classes and ranged from moderate to high (Table 2). The low correlation between weight early in life and later in life indicates that they are different traits or affected by different genes altogether. Genetic correlations were slightly higher than phenotypic correlations, signifying that individual pig performance is partly determined by their ability to tolerate stressful conditions imposed by the production environment (e.g crowding, confinement, ear tagging and heat stress among others). High correlation between ages were recorded by Ilatsia *et al*. (2008) and Darfour-Oduro *et al*. (2009), though these authors used a multiple trait model unlike in this study. Similar estimates using random regression were reported by Huisman *et al*. (2002) and Haraldsen *et al*. (2009).

Table 2: Estimates of phenotypic (above diagonal) and genetic (below diagonal) correlations between weights from week 3 to 36 obtained for model 774**.**

Age (weeks)	3	8	16	24	36
3		0.91	0.75	0.60	0.25
8	0.89		0.92	0.75	0.34
16	0.74	0.91		0.87	0.40
24	0.44	0.51	0.79		0.514
36	0.20	0.33	0.53	0.67	

The estimates of the first three eigenfunctions were positive in all cases, accounting for 87.65% of the genetic variations. This, similarly to the correlations, implies that selection at any point within the growth period will lead to a positive change at other ages as similarly described by Köhn *et al*. (2007).

Conclusion

Random regression models employing cubic B-spline were effective to model the genetic variation for body weight among the Large White pigs. The estimates of heritability were moderate and can help in ranking and selection for increased genetic gain, in the current market that rewards for heavy pigs. The correlation estimates between the ages at recording were moderate to high, indicating that genetic selection at any point will lead to an indirect positive gain at all other ages. This study is of great value to pig breeding in Kenya, in light with the current absence of a national breeding scheme. It provides the required genetic information necessary for ranking and selection for weight gain at different ages to suit varying breeding objectives. It can be concluded that random regression models using B-splines, could be used to regularly monitor Large White pig growth, though it is recommended that more performance records should be used in future for increased accuracy.

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References

Darfour-Oduro, K. A., Naazie, A., Ahunu, B. K., & Aboagye, G. S. 2009. Genetic parameter estimates of growth traits of indigenous pigs in Northern Nigeria. Livestock Science, 125: 187-191.

FAO 2012. Pig Sector Kenya. Rome: FAO Animal Production and Health Livestock Country Reviews. No. 3.

Haraldsen, M., Odegard, J., Olsen, D., Vangen, O., Ranberg, I. M., & Meuwissen, T. H. 2009. Prediction of genetic growth curves in pigs. Animal, 3: 475–481.

Huisman, A. E., Veerkamp, R. F., & Van Arendonk, J. A. 2002. Genetic parameters for various random regression models to describe the weight data of pigs. Journal of Animal Science, 80: 575-582.

Ilatsia, E. D., Githinji, M. G., Muasya, T. K., Okeno, T. O., & Kahi, A. K. 2008. Genetic parameter estimates for growth traits of large white pigs in Kenya. South African Journal of Animal Science, 38: 166-173.

Kariuki, C. M., Ilatsia, E. D., Wasike C, B., Kosgey, I. S., & Kahi, A. K. 2010b. Genetic evaluation of growth of Dorper sheep in semi-arid Kenya using random regression models. Small Ruminant Research, 93: 126-134.

Köhn, F., Sharifi, A. R., Malovrh, S., & Simianer, H. 2007. Estimation of genetic parameters for body weight of the Goettingen minipig with random regression models. Journal of Animal Science, 85: 2423–2428.

Mbuthia, J. M., Rewe, T. O., & Kahi, A. K. 2014. Breeding objectives for pigs in Kenya. I: Bio-economic model development and application to smallholder production systems. Tropical Animal Health Production, 47:, 299-309.

Mbuthia, J. M., Rewe, T. O., & Kahi, A. K. 2015b. Analysis of pig breeding management and trait preferences in smallholder production systems in Kenya. Animal Genetic Resources. doi:1017/S207863361400054X

Meyer, K. 2005a. Advances in methodology for random regression analyses. Australian Journal of Experimental Agriculture, 45: 487-585.

Meyer, K. 2005b. Random regression analyses using B-splines to model growth of Australian Angus cattle. Genetic Selection and Evolution, 37: 473–500.

Meyer, K. 2007. WOMBAT-a tool for mixed model analyses in quantitative genetics by Restricted Maximuum Likelihood (REML). Journal of Zhejiang University, 815-821.

Misztal, I. 2006. Properties of random regression models using linear splines. Journal of Animal Breeding and Genetics, 123: 74-80.

Muasya, T. K., Peters, K. J., Magothe, T. M., & Kahi, A. K. 2014. Random regression test-day parameters for first lactation milk yield in selection and production environments in Kenya. Livestock Science, 169: 27-34.

Scalez, D. C., Fragomeni, B. O., Passafaro, T. L., Pereira, I. G., & Toral, F. L. 2014. Polynomials to model the growth of young bulls in performance tests. The Animal Consortium, 8: 370-378.

Shirali, M., Nielsen, V. H., Møller, S. H., & Jensen, J. 2015. Longitudinal analysis of residual feed intake and BW in mink using random regression with heterogeneous residual variance. The Animal Consortium, 1-8. doi:10.1017/S1751731115000956.

Wasike, C. B., Indetie, D., Pithford, W. S., Ojango, J. M., & Kahi, A. K. 2007. Genetic evaluation of growth of Kenya boran cattle using random regression models. Tropical Animal Health Production, 39: 493-505.

Wolc, A., Arango, J., Settar, P., Fulton, J. E., O'Sullivan, N. P., Preisinger, R., . . . Dekkers, J. C. 2013. Analysis of egg production in layer chickens using a random regression model with genomic relationships. Poultry Science, 92: 1486-1491.

Zumbach, B., Misztal, I., Tsuruta, S., Sanchez, J. P., Azain, M., Herring, W., . . . Culbertson, M. 2008. Genetic components of heat stress in finishing pigs: Parameter estimation. Journal of Animal Science, 86: 2076–2081.

Morphological characteristics of two strains of helmeted guinea fowl (*Numida meleagris*) in Bugoma CountyAnthony W., Lusweti, F.N., Rachuonyo F.N., and Musee, H.A.

Factors affecting super-ovulation in donor cows during synchronization

Ongubo, M. N.*[1, 2], Kios, D. K.[2], Rachuonyo, H. A.[2] Lusweti, F. N[1]., Musee, K.[3], Kitilit, J. K.[2], Oliech, G. O.[2] and Tonui, W. K[3]

[1]Kenya Agricultural and Livestock Research Organization, P.O. Box 450-30200, Kitale
[2]University of Eldoret, P.O. Box 1125-30100, Eldoret
[3]Agricultural Development Corporation, P.O. Box 917-30200, Kitale
Author for correspondence: ongubomary@yahoo.com +3540710 50 05 67

Abstract

Livestock sub-sector is the fastest growing in the world with the demand for improved livestock breeds and animal products outstripping the supply. Attempts to bridge this gap with newer biotechnologies including multiple ovulation and embryo transfer (MOET) have had variable success rates. This has led to higher cost of production thus discouraging the adoption of such high value technologies. A study was done to analyze factors affecting superovulation in donor cows. Donor cows (n=44) in three different lactation stages and three different Body Condition Score (BCS) were synchronized and superovulated. The super ovulations resulted in variable embryo production with a range of 0 to 11 transferable embryos. Results indicated that the significant factors that influence the ovulation were the Breed Type ($p \leq 0.05$) and Lactation Stage ($p \leq 0.01$). A significantly higher number of viable embryos were obtained from Ayrshire cows when compared to other breeds (Jersey, Guernsey and Friesian). Results indicated that careful selection of cows based on stage of lactation preferably >102 days post-calving can improve superovulation. The BCS ($p \leq 0.10$) has a significant effect on the number of embryos obtained. A higher number of embryos were obtained from animals at BCS 4 compared to those animals in BCS 3. Lack of an appropriate MOET protocol, poor choice of donors, poor technique and lack of finance were among the factors that have contributed to the observed variations of embryo production. Reproductive efficiency of the top producing cows through MOET may provide a solution to the high demand for elite cows. Observations from this study do suggest that for an adequate response in a breeding programme, cows must be suitably nourished and maintained in good body condition.

Key words: Donor Cows, Multiple Ovulation and Embryo Transfer, Superovulation

Introduction

Developing countries have nearly two thirds of the world livestock population but produce only about a quarter to a third of the world's meat and fifth the milk. Low output in the developing regions is due to both low off take rates and low yields per animal as reported by Rege, (2009). Kenya being among the developing countries is faced with the challenge to rapidly increase agricultural productivity to help feed its growing population without depleting the natural resources base. By the year 2020 World population is expected to grow to about 8 billion (Cunningham, 1990). This will have immense consequences on the volumes and composition of global food demand especially in the developing world. To improve food security, it is essential to double food production especially livestock production in Kenya with the demand being 114% and 133% for meat and milk respectively (Okeyo *et al.,* 2009).

Modern biotechnology approach is regarded as a means to meet the objectives through addressing the production constraints of small scale or resource-poor farmers who contribute more than 70% of the food produced in the country (Rege, 2009). One high quality cow could produce up to 32 embryos per year compared to the conventional method where the farmer has to wait for nine months for a calf that could be either male or female (Muchemi, 2011). The use of assisted reproductive techniques has propelled many countries to achieve sustainable production of milk and replacement heifers. Like AI has done to the bull, Multiple Ovulation and Embryo Transfer (MOET) is a technique that can greatly increase the number of

offspring that a genetically superior cow can produce (Glenn, 2004). It hastens the genetic improvement by virtue of its capacity to reduce the generation interval. MOET is the process which involves super-ovulation of the animals to release multiple eggs at a single estrus, insemination, flushing of embryos and transfer of the embryos from the donors to recipients whose estrus cycle has been synchronized with that of donors.

Factors such as species, treatment protocols, breed, age, health, nutrition, season and ovarian status, have been shown to affect superovulation and the quantity and quality of embryos produced (Baruselli *et al.,* 2004; Mapletoft, 2012). Other factors include; lactation status of donors and recipients and the time of embryo recovery after insemination. The success of MOET programs has been shown to be influenced by the superovulatory responses and fertilization rates of the donors and the survival rates of transferred embryos (Baruselli *et al.,* 2004).

Most dairy cattle breeders do not have adequate high quality replacement heifers due to low reproductive capacity and inadequate number of high quality breeding stock. The objective of the study was to determine the factors affecting superovulation of donor cows in Kenya.

Materials and methods

A study was carried out using primary and secondary data on multiple ovulation and embryo transfer from an Agricultural Development Corporation (ADC) farm in Trans-Nzoia County in the North Rift part of Kenya. Data on the number of donor cows super-ovulated, response to superovulation, lactation status of the donors, the number of embryos harvested, the quality and stage of the embryos was used. This study examined data collected over a period of three years at the Agricultural Development Corporation (ADC), Namandala Complex. ADC being the custodian of the national cattle stud herds has been the leaders in adoption of new technologies and MOET in particular. Over 70% of the country's MOET programs have been done at ADC. Donor cows (n=44) selected from 4 different breeds (Friesian, Ayrshire, Guernsey and Jersey) in three different lactation stages (1-70d, 71-90d and 91-210d) and three different Body Condition Score (3, 3.5 and 4) were synchronized and superovulated.

Super-ovulation, synchronization and embryo recovery procedure

The procedure for superovulation and synchronization is given in Table 1

Table 2:Super-ovulation and synchronization protocol

Day	Time	Donor program	Recipient program
1	AM	Inject 2ml PG+Mult V	Inject 20ml Mult V
7	AM		Insert CIDR+2ml ciderol
8	AM	InsertCIDR+2mlciderol+20mi mult V	
12	PM	Inject 4ml LH/FSH follitropin	Inject estrumate
13	AM	Inject 3ml follitropin	
	PM	Inject 3ml follitropin	
14	AM	Inject 2.5ml follitropin	Inject estrumate
	PM	Inject 2.5ml follitropin	
15	AM	Inject 2ml follitropin+2ml estrumate	Remove CIDR
16	AM	Remove CIDR 1.5ml follitropin	Observe heat
17	AM	Observe heat	
	PM	Inseminate	
18	AM	Inseminate	
	PM	Inseminate	
21	AM	Flush	Transfer

Embryo recovery

Embryo recovery was performed 7 days after the last insemination using standard nonsurgical method (Elsden., *et al.,* 1976). To collect the embryos non-surgically, a small synthetic rubber catheter (silicone catheter) was inserted through the cervix and a flushing medium was flushed into and out of the uterus to harvest the embryos. Each uterine horn was filled and emptied 5 to 10 times using an embryo filter with a pore size of 60-70 microns.

Embryo Evaluation

The flushed fluid was examined under a microscope to locate embryos. The embryos collected were classified according to the rules of the international Embryos Transfer Society (IETS) (Robertson and Nelson, 1998).The embryos were classified into:

Table 2:Standardized classification of bovine embryos based on stage of development. International Embryo Transfer Society (IETS) (Robertson and Nelson, 1998)

Name	IETS Stage	Description
Ovum	1	Unfertilized.
Morula	2	Cells have coalesced to form a compact mass.
Early Blastocyst	3	Embryo has formed a small blastocoele up to a blastocoele that half-fills the embryonic mass.
Blastocyst	4	Blastocoele is highly prominent but not enough to fill the zona pellucida and begin stretching the zona.
Expanded Blastocyst	5	Overall diameter of embryo increases, with a thinning of the zona pellucida.
Hatched Blastocyst	6	Undergoing the process of hatching or may have completely shed the zona pellucida.

The quality of the embryo is a subjective measure of developmental abnormalities intended to identify those embryos that are less likely to result in pregnancy. Only 2, 3, 4 and 5 were considered as transferable (viable).

Data type

Information was collected on the following parameters;

- Breed of the donor (Holstein Friesian, Guernsey, Jersey, Ayrshire).
- Body Condition Score (3, 3.5, 4).
- Lactation stage in days (1-70, 71-90, 91-210).
- Number of embryos flushed

Data analysis

The data were analyzed using logit regression analyses. Simple descriptive statistics was also used. In each parameter the variables were tested for the significant relations. The regression model was used to analyze the factors affecting superovulation. The model was specified as;

$$Y=\beta_0+\beta_1 X_{1i}+\beta_2 X_{2i}+\beta_3 X_{3i}+\varepsilon$$

Where Y was the number of embryos; X_i were the independent variable (X_{1i}=Breed Type, X_{2i}= Body Condition Score, X_{3i}=Lactation Stage) and ε=error term.

Table 3: Number of transferable embryos per donor cow

Number of Embryo	Frequency n=43	%PG
0	14	32.6
1	8	18.6
2	7	16.3
3	2	4.7
4	2	4.7
5	1	2.3
6	2	4.7
7	4	9.3
8	2	4.7
11	1	2.3
Chi-square	36.767***	

Results

Though there were no particular trends, the superovulations resulted in variable embryo production ranging from 0 to 11 transferable embryos as seen on Table 3. The average number of embryo per donor was 2.51±2.14. Out of a total of 43 donors those that did not ovulate were 14 (33%) while the highest donor gave 11 embryos (2%).

Results show a higher number of embryos were obtained from animals at BCS 4 compared to those animals in BCS3. Lactation stage of the donors which ranged between 60 and 210 had significant effect on the number of viable embryos harvested (Flushed).

Table 4: Ordinary Regression model on factors influencing number of embryos flushed (dependent variable=number of embryos)

	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
	β	S E	β		
Constant	-1.651	2.776		-0.595	0.555
BT1	-0.755	0.339	-0.271	-2.227	0.032
BC	0.541	0.707	0.093	0.765	0.449
LS	0.042	0.008	0.617	5.076	0.000
R-squ.	43%				
F-value	9.754***				
N	43				

Key ***; **; * significant at 1%, 5% and 10% respectively

Animals that were ninety days and above postpartum ovulated better than those that were in the early stage of lactation especially sixty-five and below as shown in Figure 1.

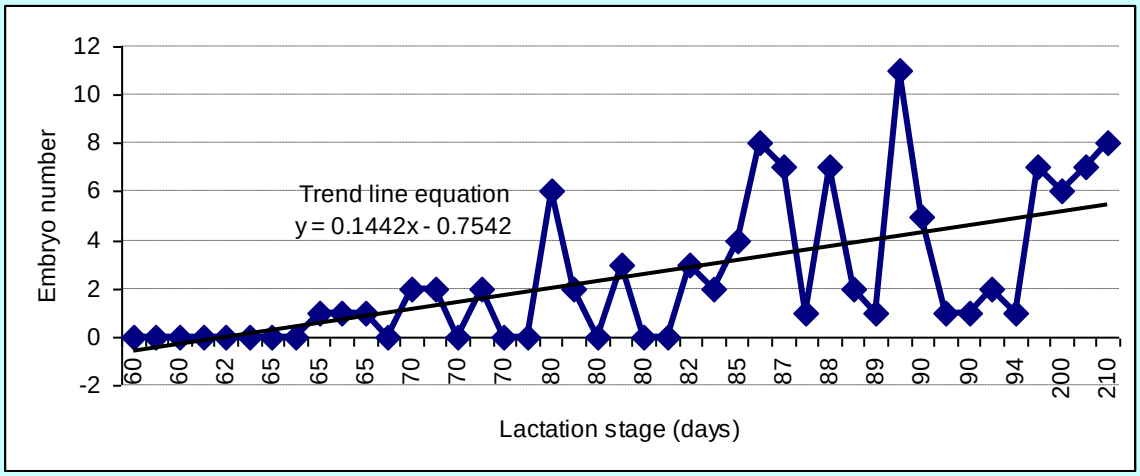


Figure 1: Number of embryos per donor cow over lactation period

Discussions

Factors influencing super-ovulation of Donors

The regression results indicated that the significant factors that influenced the ovulation were the Breed Type at ($p \leq 0.05$) as shown on (Table 4). A significantly higher number of viable embryos were obtained from Ayrshire cows when compared to other breeds (Jersey, Guernsey and Friesian). Other Authors obtained different results from different breeds (Breuel *et al.,* 1991; Bo *et al.,* 2006). It is still unknown whether this could depend from physiological status influenced from management and production levels.

Lactation stage of the donor had significant effect {LAS ($p \leq 0.01$)} on the number of viable embryos harvested (Table 4). The number of viable embryos decreased with the decrease in lactation stage (days). This is in agreement with (Sartori *et al.,* 2002) who reported that in dairy cattle, the partition of nutrients toward milk synthesis affects reproduction partially because of reduced ovulation. Previous studies by (O'Callaghan *et al.,* 2000; Snijders *et al.,* 2001; Lopez *et al.,* 2004) reported that milk production has been associated with poor reproduction performance.

The Body Condition Score was found to significant effect ($p \leq 0.10$) on the number of embryos obtained. A study on genetic merit for milk production and reproductive success in dairy cows by (Snijders *et al.,* 2001) showed that BCS has a direct association with energy balance.

Conclusion and Recommendations

Some of the key influencing factors on the super-ovulation were Breed Type (BT) and Lactation Stage (LS). More research may be done to establish why some breeds are more superior in ovulation than others.

Lack of an appropriate MOET protocol, poor choice of donors, poor technique and lack of finance were among the factors that have contributed to the observed variations of embryo production.

On-farm transfer of fresh embryos has practical difficulties and requires trained personnel and equipment for evaluation and packaging of embryos at the farm site.

Embryos can be frozen and conserved in a bank for future use and farmers can also use their best animals as donors and the low yielders as recipients.

It is recommended that the donor cows selected for super-ovulation should be 102 days post-partum and in good body condition.

References

Baruselli, P.S., E. L.Reis, M.O.Marques, L.F. Nasser, and G.A. Bo. (2004). The use of hormonal treatments to improve reproductive performance of anoestrus beef cattle in tropical climates. Animal Reproduction Science, 82–83, 479–86.

Bo, G.A., P.S. Baruselli, P.M. Chesta and C.M. Martins, 2006. The timing of ovulation and insemination schedules in superstimulated cattle. Theriogenolgy, 65:89-101.

Breuel, K.F., R.D. Baker, R.L. Butcher, E.C. Townsend, E.K. Inskeep, R.A. Dailey and S.P. Lerner, 1991. Effects of breed, age of donor and dosage of follicle stimulating hormone on the superovulatory response of beef cows. Theriogenology, 36:241-255.

Cunningham, E.P. (1990). Animal Production. In: Persley G.J (ed), Agricultural Biotechnology: Opportunities for International Development. CAB (Commonwealth Agricultural Bureaux) International, Wallingford, UK. Pp. 169-175.

Elsden, R. P., J, F.Hasler and G.E.Seidel, Jr. 1976. Non-surgical recovery of bovine eggs. Theriogenology 6:523.

Glenn Seik, 2004. Embryo transfer in cattle. Oklahoma State University, Division of Agriculture.

Lopez, H., L. D. Satter, M. C. Wiltbank. (2004). Relationship between level of milk production and estrous behavior of lactating dairy cows. Animal Reproduction Science 81:209-233.

Mapletoft, R.J., Colazo, M., Martinez, M. and Kastelic, J.P. 2012. Application of fixed time AI in beef management programs in Canada. In: International Symposium for Animal Production, 6. 2012, Cordoba, Argentina. Proceedings. Cordoba. pp. 81-96.

Muchemi.J 21.2011. New embryo transfer technology to boost dairy farmers' fortune, Sunday Nation Aug. pg 26-27.

O'Callaghan, D. and M. P. Boland. (1999). Nutritional effects on ovulation, embryo development and the establishment of pregnancy in ruminants. Journal of Animal Science 68:299-314.

Okeyo, M., H. Mutembei, B. Syombua, E. Mutiga, & V. Tzuma. (2009). Improving cattle genetics with invitro embryo production technology. http://www.ilri.org/ilrinews.

Rege, J.E.O. 2009. Biotechnology options for improving livestock production in developing countries with special reference to Sub-Saharan Africa.

Robertson, I. and R.E. Nelson, 1998. Certification and Identification of the embryo (3rd Edn.), International Embryo Transfer. Society. Illinois, USA. pp: 106.

Sartori,R., R. Sartor-Bergfelt, S. A. Mertens, J. N. Guenther, J. J. Parrish, and M.C. Wiltbank. (2002). Fertilization and early embryonic development in heifers and lactating cows in summer and lactating and dry cows in winter. Journal of Dairy Science 85:2803-2812.

Snijders, S. E. M., P. G. Dillon, K. J. O'Farrell, M. Diskin, A. R. G. Wylie, D. O'Callaghan, M. Rath, M. P. Boland. (2001). Genetic merit for milk production and reproductive success in dairy cows. Animal Reproduction Science 65:17-31.

Xu, Z., M. F. McDonald, & S. N. McCutcheon (1989). The effects of nutritionally-induced live weight differences on follicular development, ovulation rate, oestrus activity and plasma follicle-stimulating hormone levels in the ewe. Animal Reproduction Science, Vol.19, pp 67-78, 0378-4320.

Alternative Feed Development

Recent Advances in Poultry Nutrition and Feeding

Nyachoti C. M[1] and Agyekum A. K.

[1]Department of Animal Science, University of Manitoba, Winnipeg, MB, R3T 2N2, Canada
*Corresponding author: Email: martin_nyachoti@umanitoba.ca

Introduction

The poultry industry has seen tremendous advancement over the past 50 years. This advancement has resulted in considerable increases in poultry meat and egg production. For instance, the live weight of broilers has increased from, on average, 1.68 to 2.77 kg, representing a 65% improvement in live weight, whereas feed conversion ratio has improved by 30%. Currently, it takes male broilers 33 to 35 days to reach the target market weight. Further, turkeys reach target market weight within 24 weeks, where as layers start laying when they are around 17 weeks old on less feed. Advances in genetic selection are responsible for majority of the improvements in the poultry industry. However, nutritional management has also contributed considerably to the advances in poultry production. In this context, refinement in nutritional strategies has been the reason for the "extra" improvement in poultry production. The refinement in poultry nutrition has been due primarily to understanding and defining nutrient requirements and nutrient composition and ingredient quality, better diet formulation strategies, and progress in biotechnology (feed additives) in poultry feeding (Ravindran, 2012). Feed processing techniques and application of phase feeding strategies are also some of the advances made in poultry nutrition and feeding. This review paper will highlight some of the advances that have been made in terms of defining nutrient requirements for energy, amino acids, and phosphorus because they are more costly to supply in poultry diets. Early nutrition and the role of selected feed additives used to modulate gut health outcomes in poultry are also discussed in this paper.

Basic principles in poultry nutrition and feeding

Feed cost represents more than 60% of the variable cost in poultry production. Much of this cost is associated with supplying adequate energy and protein to meet requirements. The focus in formulating poultry diets is to closely match nutrient supply with requirements to minimize nutrient excretion and the related environmental pollution and to control feed cost. Thus, a clear understanding of the nutrient requirements of poultry is necessary in order to adequately meet the energy and nutrient supply for poultry. In this regard, the focus has been on meeting the needs for limiting nutrients and energy of poultry by carefully matching supply with requirements using least formulation strategies. In addition, due to the increasing cost of cereal grains and soybean meal, substantial amounts of alternative feed resources are used globally to formulate poultry diets. Although the use of alternative feed resources can be cost saving, this does present unique nutritional problems to poultry that can only be adequately addressed by fully understanding the nutritive value of such resources (Ravindran, 2012). Equally important is to factor into feeding programs the effects of such factors as genetics, sex, stage of production, stress, disease or pathogen load, and thermal environment, which are known to influence nutrient requirements and utilization in poultry.

To date, a significant advancement in poultry nutrition and feeding has been the refinement in nutritional requirements of meat chicken in varying stages of growth and for laying hen of birds and such information is documented in scientific and industry publications.

Energy

Energy is the most expensive component of the feed and therefore using appropriate energy systems to define the energy value of poultry feeds, especially when using alternative feedstuffs, becomes critical to maintaining optimal bird performance. Furthermore, the energy content in poultry feed is a major factor influencing feed intake because birds eat mainly to meet their energy needs, when the diet is nutritionally adequate (Leeson and Summers, 2010).The energy requirements of poultry are influenced by factors such

as age, production level, sex, environment and health status. The energy requirements of poultry are influenced by factors such as age, production level, sex, environment and health status. The energy requirements of poultry are influenced by factors such as age, production level, sex, environment and health status. Further, the energy requirements of poultry are influenced by factors such as age, production level, sex, environment and health status.

Dietary energy in poultry nutrition is typically described using the metabolizable energy (ME) system, which accounts for urinary energy losses. Correcting ME values for nitrogen retention gives AME_n values, which vary depending on the nature of the diet and age of the bird. In this context, a bird that is retaining nitrogen (i.e., growing chick) will excrete less nitrogen compared with a bird that is not (e.g., laying hen). When AMEn values are corrected for endogenous energy losses, true metabolizable energy values are (TME) values are generated. These values are typically derived using intact or caecectomized adult roosters and are believed to accurately reflect the ME value of a feed or ingredient for poultry. However, because of various concerns, including bird welfare (due to force-feeding) and the fact that roosters are physiologically mature and therefore the data may not be applicable to young growing birds, TME values are not widely used.

Currently, there is great interest in the applicability of the net energy (NE) system, which is believed to be the most accurate measure of the energy value of feed (Velayudhan *et al.*, 2015). This is largely motivated by the increased use of a wide array of low quality and often high fibre ingredients in formulating poultry diets and the benefits of being able to more accurately predict bird performance when using the NE system. However, because it is more difficult to determine NE values, prediction equations are normally used to estimate the NE value of poultry feeds. Nonetheless, it is expected that going forward there will be increased attempt to evaluate poultry feed and feed ingredients on a NE basis to allow for effective use of low-cost alternative feed resources in feed formulation for poultry.

Exogenous enzymes and feed processing techniques such as dehulling and particle size reduction can be used to improve the energy value of poultry feeds rich anti-nutritional factors such as fiber. Indeed, results of several studies have shown increased dietary energy content because of enzyme addition to poultry diets.

Protein and amino acids

Poultry do not have a requirement for protein *per se* and the function of dietary protein is to supply amino acids (AA) for maintenance, muscle growth, and egg protein synthesis. Of the 20 AA required to synthesize muscle and egg protein, only 10 are essential to poultry because they cannot be synthesized or are synthesized in limited amounts to meet metabolic demands and thus, have to be supplied in the diet (usually in crystalline form). Further, of the 10 essential AA, methionine, lysine, tryptophan, and threonine are the most critical because they are the most limiting in most practical poultry diets. Amino acids must be supplied in the diet in adequate amounts and in a balanced proportion to meet the requirements of poultry. In this context, the dietary AA supply in poultry diets is based on the ideal protein concept to increase the precision in dietary AA supply. Changes in AA requirements do not alter the relative proportion of different AA when based on the ideal protein concept. The ideal protein concept employs lysine as the reference AA and the other essential AA are expressed as a percentage of lysine (Table 1). When the dietary AA supply is based on the ideal protein concept, balance AA composition can be fed to poultry, over- and under feeding amino acids are avoided, AA excretion in urine is minimized, and protein synthesis is maximized.

Table 1: Ideal amino acid profiles for poultry feeds (in % of lysine; true digestible)

	Broilers chicken and turkey[1]	Layer
Lysine	100	100
Methionine + Cysteine	75	85
Threonine[2]	67	70

Valine	80	90
Isoleucine	67	80
Arginine	105	110
Tryptophan	17	24
Histidine	36	
Leucine	105	
Phenylalanine + Tyrosine	105	

[1]Values for turkey come from those for broiler chicken; some variations are possible.
[2]Threonine requirement increases with body weight and health conditionsof birds. (Source: Ajinomoto Animal Nutrition; http://ajinomoto-eurolysine.com/ideal-protein.html).

A portion of the AA present in poultry feeds is not biologically available hence formulating diets on a total AA basis is not appropriate. Instead, estimates of AA bioavailability are used to formulate poultry feeds with respect to AA supply. To this end, AA digestibility measurements are used as reasonable estimates of AA bioavailability. Much of the AA digestibility data (e.g. NRC, 1994) that have been used in formulating poultry diets were generated using the precision-fed rooster assay at the excreta level. However, for various reasons (e.g. age differences and effect of hind gut microbes) it is now known that digestible AA values determined using rooster assay may not be suitable for young birds. Instead, AA digestibility values determined at the end of the small intestine are considered to be better estimates of AA bioavailability for poultry.

Amino acid digestibility can be expressed on an apparent (AID), true (TID) or standardized (SID) ileal digestibility basis. The AID values do not account for AA of endogenous origin in digesta, whereas TID values are obtained when AID are corrected for diet ingredient specific endogenous AA losses. The greatest limitation of AID values is that they are not additive in a mixture of feed ingredients and they tend to underestimate AA digestibilities. On the contrary, TID values are additive in a mixture of feed ingredients and are independent of assay conditions. However, because TID values are difficult and expensive to measure, SID values are currently used to formulate poultry diets. The SID values, which are obtained by correcting AID values for basal (minimum) endogenous AA losses, are additive in mixed diets and appropriate for practical feed formulation with ingredients that do not induce additional AA losses, but not when feeding ingredients high in anti-nutritional factors such as phytic acid, fiber, and trypsin inhibitors. In Table 2 is a summary of the SID of essential AA of selected feedstuffs used to formulate poultry diets.

Table 2: Standardize ileal amino acid digestibility in selected feedstuffs[1]

Amino acid	Corn	Wheat	Sorghum	Barley	SBM	CSM	Pea	MBM	CM	SFM
Arginine	93	85	88	80	92	88	94	85	80	93
Histidine	95	87	84	81	89	81	90	74	84	88
Isoleucine	95	90	90	84	97	71	89	74	78	89
Leucine	94	91	88	85	88	73	90	78	76	88
Lysine	92	84	90	81	89	65	93	76	77	87
Methionine	94	91	89	88	90	72	90	74	86	92
Phenylalanine	94	94	89	91	89	81	92	78	76	90
Threonine	85	85	83	81	85	68	89	75	76	82
Valine	92	88	87	83	86	74	89	76	79	87

[1]SBM, soybean meal; CSM, cotton seed meal; MBM, meat and bone meal; CM, canola meal; SFM, sunflower meal.

Phosphorus

Phosphorus (P) is not only an essential nutrient for poultry but is also often the third most expensive nutrient in poultry diets. In addition to calcium, it is critical for skeletal development and egg shell formation. Typically, nearly 70% of the P in feedstuffs of plant origin used in poultry diet exists as phytate P, which is poorly utilized by poultry due to the lack of the enzyme phytase required to the hydrolyze the phytate molecule. The remaining one-third of the total P exists as non-phytate P, which is assumed to be biologically available to poultry. Thus, P requirements of poultry have been expressed as non-phytate P. However, current research suggest that it is not appropriate to express P requirement of poultry on the basis of non-phytate P but instead measurements of apparent ileal digestible (AID) P should be used (Adeola, 2014). Pre-cecal digestibility measurement is currently the preferred approach for P evaluation in poultry. This is because it avoids the confounding effect of urinary P and has been shown to be more additive in a mixture of feed ingredients. For these reasons, it is expected that there will more efforts to generate AID of P estimates in poultry feed ingredients going forward.

Because the P requirement of poultry is closely associated with Ca needs, it is critical that the dietary Ca-to-P ratios are carefully maintained. For instance, excess P reduces egg shell quality due to an associated Ca deficiency, whereas excess Ca precipitates P in the small intestine and prevents its absorption. The Ca-to-P ratio is also critical for minimizing incidences of skeletal problems (Leeson et al., 1995). It should be noted that birds can adapt to a wide range of dietary P levels provided that the relationship with Ca levels is maintained (Leeson and Summers, 2001).

Dietary P utilization in poultry can be improved considerably by the use of exogenous phytase. Indeed, results from several studies suggest that addition of phytase to poultry diets increases P digestibility and utilization and thereby reducing P excretion into the environment.

Early nutrition in poultry

Chicks are precocial and upon hatching, will forage for feed to grow. However, in the past, chicks were denied access to feed and water for an extended period of time post-hatch and the yolk served as the main energy source for the newly hatched chick. However, it has been shown that denying chicks access to feed results in weight loss until at least 24 hours after birds are fed (Moran 1990; Noy and Sklan, 1998). Therefore, birds will lose potential growth if feed is not made available immediately after hatch. Indeed, studies have reported that providing chicks at hatching with either solid or semi-solid feed resulted in increased body weight at day 4 post-hatch compared with chicks held without feed (in the review by Sklan, 2003). The observed improvement in body weight has been suggested to be due to some mechanical stimulation of the gastrointestinal tract close to hatching (Noy and Sklan, 1998). Providing newly hatch chicks water alone has also been reported to increase body weight, although this effect was marginal compared with that of

feed and was no longer apparent after day 8 post-hatch (Sklan, 2003). Further, studies have shown that newly hatched chicks that had access to nutrition were 7 to 10% heavier compared with those without access to feed or provided with only water (Noy and Sklan, 1998). Similar findings have been observed in poults. For instance, early nutrition resulted in a 10% improvement in body weight in poults (Noy and Sklan, 1998). Also, the proportion of breast muscle at marketing was 4 to 10% higher in birds with access to early nutrition than those held without access to early nutrition (Noy and Sklan, 1998). Therefore, chicks should have access to early nutrients/feed immediately post-hatch to enhance their initial body weight and thus, overall performance.

Feed additives

Feed additives are non-nutritive compounds that are added to poultry diets to provide responses independent of the bird's energy and nutrient requirements. The use of feed additives in poultry diets dates back to the 1940s, when sub-therapeutic doses of antibiotics were discovered to elicit beneficial effects on production efficiency (Moore et al., 1946; Castanon, 2007). Indeed, results of several studies evaluating the growth promoting effects of sub-therapeutic doses of antibiotics suggest considerable improvements in growth rate and feed efficiency (Niewold, 2007). The exact mode of action of antimicrobial growth promoters (AGP) is not clear, although their growth promoting effects have been associated with their interactions with intestinal microbial population such that incidences of enteric diseases are minimized and nutrients are spared for productive purposes (Dibner and Richards, 2005; Niewold, 2007). However, AGP use has been banned in the European Union (Castanon, 2007) and other parts of the world have seen varying degrees of voluntary withdrawals of AGP in poultry diets (Ravindran, 2012). The pressure to eliminate AGP use has been due primarily to the fear of risking human health through possible transfer of antibiotic-resistant bacteria to humans. In this regard, several feed additives have been evaluated as potential alternatives to AGP and have been the subject of several recent reviews in poultry nutrition. The main focus has been on the ability of these AGP alternatives to promote growth, control enteric pathogens, improves gut health, poultry health and to release energy and nutrient for poultry use. However, whereas evidence exists to suggest that some of these feed additives can positively influence growth alone or in combination, it is also apparent that response to their application varies considerably (Nyachoti, 2014). This makes it rather critical to gain a better understanding of the conditions under which the beneficial effects of these feed additives can be maximized. Some feed additives currently incorporated into poultry diets to mimic AGP to some extent include probiotics, prebiotics, organic acids, and feed enzymes.

Probiotics (direct-fed microbials, DFMs) are live microorganisms which, when added in adequate amounts to feed confers health benefits on the host by improving its intestinal microbial balance. Different types of bacteria, mainly Bacillus and lactic-acid producing bacteria, and yeast cultures are the main commercially available DFMs. The overriding objective of poultry studies involving DFMs is to exclude colonization of pathogens in the gut of birds, although other beneficial effects such as stimulation of a healthy gut microbiota, improving digestive capacity and pH lowering, improving mucosal immunity, and enhancing gut tissue maturation and integrity have been proposed. A prebiotic is "a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microflora that confers health benefits" (Gibson *et al.*, 2004). Therefore, the non-digestible carbohydrates, many of which are short chain oligosaccharides, have been evaluated for their ability to enhance the growth of beneficial bacteria, particularly those belonging to the genera Bifidobacteria and Lactobacilli. In poultry, fructo-oligosaccharide andmanno-oligosaccharide are the commonly researched oligosaccharides as prebiotics(Griggs and Jacob, 2005).

Feed enzymes are the most researched and used feed additives in poultry feeds to degrade anti-nutritional factors such as phytic acid and fiber (non-starch polysaccharides, NSP) to allow birds access to entrapped nutrients. Exogenous phytase use in poultry diet is widespread and the economic and environmental ramifications are well documented. Exogenous carbohydrases and proteases have also shown beneficial effects on nutrient digestibility and poultry performance. However, results of several studies suggest that the scope of enzymes, in particular carbohydrases, can be expanded to include maintenance of gut health and function in poultry (Kiarie *et al.*, 2013). This beneficial effect of carbohydrase enzymes are based on the

premise that they can target the NSP to generate hydrolysis products within the gut, which may elicit prebiotic effect (Bedford and Cowieson, 2012). Organic acids have been evaluated in several studies as dietary tools to reduce pathogenic bacteria in poultry production. Some of these studies added organic acids to the drinking water, whereas others added them to the feed (Griggs and Jacob, 2005). Organic acids generally reduce gastric pH and create unfavourable conditions for pathogens and they also elicit antimicrobial effect, independent of gastric pH. Commercially available organic acids include formic, propionic, caproic, acetic, and sodium salt of butyric acid.

Summary and Conclusions

Advances in poultry nutrition and feeding have been brought about by approaches that allow rapid assessment of ingredient quality, ingredient characterization on the basis of nutrient availability, and the use of robust feed evaluation strategies. Feed processing techniques and application of phase feeding strategies have also contributed immensely towards advances in poultry feeding. It is now clear that DE system is not suitable for poultry, whereas the AME_n system is the standard method used to predict the energy value feeds and feedstuffs for poultry. The NE system provides true energy value of feeds and feedstuffs; however it is not well developed in poultry. Standardized ileal digestible AA values should be used when formulating poultry diets. The use of non-phytate P as an estimate of available P for poultry is not appropriate and that apparent ileal digestible values should be used. Also, the dietary P-to-Ca ratio should be maintained to ensure proper utilization of P. These aspects will become more critical when alternative ingredients are used to formulate poultry feeds and therefore characterizing the nutritive value of poultry feed ingredients will remain an important issue. There is adequate evidence to support the provision of feed to newly hatched chicks to enhance early chick development and carcass development. The area of nutrition and gut health interactions in poultry nutrition is attracting considerable interest globally and this is expected to continue as many jurisdictions consider banning the use of in-feed antibiotics in poultry production. This will create additional pressure in designing feeding programs for young birds, especially during the starter phase as their digestive and immune functions are yet to be developed.

References

Adeola, O. 2014. Nutrient bioavailability in feed ingredients for swineand poultry.Proc. Eastern Nutr. Conf., Guelph, ON, May 14-15, 2014.

Bedford, M.R. and A.J. Cowieson. 2012. Exogenous enzymes and their effects on intestinalmicrobiology. Animal Feed Science and Technology 173:76–85.

Castanon, J.I.R. 2007. History of the use of antibiotic as growth promoters in European poultry feeds. Poultry Science 86:2466–247.

Dibner, J.J. and J.D. Richards. 2005. Antibiotic growth promoters in agriculture: History and mode of action. Poultry Science 84:634–643.

Garcia, A.R., A.B.Batal, and N.M. Dale. A comparison of methods to determine amino acid digestibility of feed ingredients for chickens. Poultry Science 86:94–101.

Gibson, G.R., H.M. Probert, J. Van Loo, R.A. Rastall, and M.B. Roberfroid. 2004. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. Nutrition Research Reviews 17:259–275.

Griggs, P.J. and J.P. Jacob. 2005. Alternatives to antibiotics for organic poultry production. Journal of Applied Poultry Research 14:750–756.

Kiarie, E., L. Romero, and C.M. Nyachoti. 2013. The role of feed enzymes in promoting gut health in swine and poultry. Nutrition Research Reviews 26:71–88.

Leeson, S. and J.D. Summers. 2001. Scott's Nutrition of the Chicken. 4th Ed. University Books, Guelph, Ontario, Canada.

Meng, X., B.A. Slominski, C.M. Nyachoti, L.D. Campbell, and W. Guenter. 2005. Degradation of cell wall

polysaccharides by combinations of carbohydrase enzymes and their effect on nutrient utilization and broiler chicken performance. Poultry Science 84:37–47.

Meng, X. and B.A. Slominski. 2005. The nutritive value of corn, soybean meal, canola meal or peas for broiler chickens as affected by a multi-carbohydrase preparation of cell wall degrading enzymes.Poultry Science 84:1242–1251.

Moore, P.R., A. Evenson, T.D. Luckey, E. McCoy, E.A. Elvehjem, and E.B. Hart. 1946. Use sulphasuccidine, streptothricin, and streptomycin in nutrition studies with the chick. Journal of Biological Chemistry 165: 437–441.

Moran, E.T. 1990. Effects of egg weight, glucose administration at hatch, and delayed access to feed and water on poult at two weeks of age. Poultry Science 69:1718–1723.

Niewold, T.A. 2007. The nonantibiotic antiinflammatory effect of antimicrobial growth promoters, the real mode of action? A hypothesis. Poultry Science 86:605–609.

Noy, Y. and D. Sklan. 1998. Are metabolic responses affected by early nutrition? Journal of Applied Research 7:437–451.

National Resource Council (NRC). 1994. Nutrient Requirements of Poultry. 9th revised edition.National Academy Press, Washington, DC, USA.

Nyachoti, C.M. 2014. Nutritional concepts to improve gut health in swine and poultry. Proc. Eastern Nutr. Conf., Guelph, ON, May 14-15, 2014.

Ravindran, V. 2012. Advances and future directions in poultry nutrition: An overview. Korean Journal of Poultry Science 39:53–62.

Selle, P.H., V. Ravindran, and G.G. Partridge. 2009. Beneficial effects of xylanase and/or phytase inclusions on ileal amino acid digestibility, energy utilisation, mineral retention and growth performance in wheat-based broiler diets. Animal Feed Science and Technology 153:303–313.

Shang, Y., A. Rogiewicz, R. Patterson, B.A. Slominski, and W.K. Kim. 2015. The effect of phytase and fructooligosaccharide supplementation on growth performance, bone quality, and phosphorus utilization in broiler chickens. Poultry Science94:955–964.

Sklan, D. 2003. Early nutrition and its effects on lifelong productivity in poultry. Recent Advances in Animal Nutrition in Australia 4: 77–79.

Tang, D., S. Hao, G. Liu, F. Nian, and Y. Ru. 2014. Effects of maize source and complex enzymes on performance and nutrient utilization of broilers. Asian-Australasian Journal of Animal Science 27:1755–1762.

Velayudhan, D.E., I.H. Kim, and C.M. Nyachoti. 2015. Characterization of dietary energy in swine feed and feed ingredients: A review of recent research results. Asian-Australasian Journal of Animal Sciences28:1–13.

Woyengo, T.A., W. Guenter, J.S. Sands, C.M. Nyachoti, and M.A. Mirza. 2008. Nutrient utilisation and performance responses of broilers fed a wheat-based diet supplemented with phytase and xylanase alone or in combination. Animal Feed Science and Technology 146:113–123.

Woyengo. T.A., B.A. Slominski, and R.O. Jones. 2010. Growth performance and nutrient utilization of broiler chickens fed diets supplemented with phytase alone or in combination with citric acid and multicarbohydrase. Poultry Science 89:2221–2229.

Zou, J., P. Zheng, K. Zhang, X. Ding, and S. Bai. 2013. Effects of exogenous enzymes and dietary energy on performance and digestive physiology of broilers. Journal of Animal Science and Biotechnology 4:14.

Prevelence of Toxic Fungi and Aflatoxin in selected grainsused for food and feeds

*** Lusweti F.N [1], Onyango R. M A[1], Wanyama[1]J M, and Mukasa B. M[1]**

[1]Kenya Agricultural Research Institute, P.O. Box 450-30200 Kitale, Kenya
*Correspondent address:
Mobile 'phone: +254722633140
E-mail address: francescalusweti@yahoo.com; francescalusweti@gmail.com; Francesca.Lusweti@kalro.org

Abstract

Mycotoxin contamination of major food crops presents a serious problem in Kenya. Contamination can occur in the field stage, during harvesting and drying, or in storage. Several outbreaks of aflatoxin poisoning after consuming maize have been reported in Eastern Kenya since 1978. In the year 2010 popular press reported that 2.3 million bags of maize were contaminated with aflatoxin and declared unfit for human and livestock consumption. A survey on fungal and aflatoxin contamination in maize and maize products was conducted during the 2010 and 2011 growing seasons in Trans Nzoia, Uasin Gishu and, Nandi counties. Maize and partially processed feed samples were taken from farms. Fungi from whole maize grains were isolated by direct plating and from the semi-processed and processed maize products by serial dilution before plating. Aspergillus species were isolated on the fastidious Czapek and potato dextrose agar media and identified based on their cultural and morphological characteristics. Aflatoxin content was determined by the competitive ELISA method. The major fungal genera isolated from samples were; Fusarium, Aspergillus, Diplodia and Penicillia. In this study six species of Aspergillus; A.flavus, A. fumigatus, A. niger, A. nodulans, A. Parasiticus and and A. vasicolor were observed with the frequency of toxigenic strains remaining below 50%. All maize samples were contaminated with aflatoxin B_1. The highest concentration was 15.5 ppb. All the Counties reported the least concentration of 0.01 ppb but the mode was 0.05 ppb. The means for aflatoxin concentration in Trans Nzoia, Uasin Gishu and Nandi Counties was 1.738±0.966, 0.834±0.177 and 1.060±0.213 ppb respectively. On average, the aflatoxin content in the samples was below the national tolerance level of 10 ppb. However, there is need to sensitize farmers about the potential danger of aflatoxins. There is also need to establish the presence of other mycotoxins.

Key words: fungi, aflatoxin, maize

Introduction

The FAO has estimated that worldwide, about 25% of crops are affected annually with Mycotoxins (Jelinek, 1987). Reports reveal sufficiently high occurrences and concentrations of mycotoxins to suggest that mycotoxins are a constant concern. In the North Rift of Kenya; commonly referred to as "the grain basket of Kenya" mycotoxins are primarily a problem in mature maize and wheat that remains in the field or that is stored without adequate drying and on repeated occasions tons of grains are spoilt on farms due to humid weather conditions before and after harvesting of the crop. The spoilt grains are usually are compounded and used as livestock feed.

The major fungal genera producing mycotoxins include Aspergillus, *Fusarium* and *Penicillium*. The most common mycotoxins are aflatoxins, ochratoxin A, fumonisins, deoxynivalenol, T-2 toxin and zearalenone. Mycotoxins can form in commodities before harvest, during post-harvest handling and in storage. Commodities and products frequently contaminated with mycotoxins include maize, wheat, barley, rice, oats, nuts, milk, cheese, peanuts and cottonseed. Mycotoxins produce a wide range of adverse and toxic effects in animals in addition to being food-borne hazards to humans (CAST, 2003).

Many different fungi grow as moulds on stored grains. *Fusarium* and *Aspergillus* fungi are among the most common grain moulds. Concerns regarding humans and livestock affected by mycotoxin have been on the increase since the realization that strains of *Aspergillus* species may produce aflatoxin in hot humid weather

(Murphy, 2007). Aflatoxins are poisonous, carcinogenic, mutagenic secondary mould metabolites produced during the growth of several species of the genus *Aspergillus* as the fungi grow in feed grains, processed feed, and food products (Cassel, et al., 2001). However, pre-harvest aflatoxin contamination of maize can occur, and is associated with drought and high temperature during grain fill. Post-harvest aflatoxin contamination can develop when grain is improperly managed though the drying and storage process (Vince et al., 1984). The major hosts of *A. flavus* among food and feed commodities are peanuts, maize and cottonseed. Low levels may be found in a wide range of other foods (Pitt *et al.*, 1993, 1994; Pitt & Hocking, 1997).

The goal of this work was enhanced sustainable productivity and competitiveness of the dairy sub-sector. The purpose was to reduce mycotoxins in feeds and milk at farm level to below acceptable levels according to World Health Organization (WHO) standards. The objectives of the study were: 1) To establish baselines on the current levels of fungi and aflatoxins in feeds and milk in the North Rift and Eastern Kenya at farm level and 2) To identify factors contributing to mycotoxin contamination during post-harvest handling of cereals and cereal by-products.

Materials and methods

Data was collected from different agro-ecological zones of Trans Nzoia, Uasin Gishu, Nandi West Pokot and Bungoma Counties from farmers at random, using a structured questionnaire after training the enumerators and pretesting of the questionnaire. All interviews were conducted in both Kiswahili and vernacular languages across all the counties. Visual appraisals on the quality of stores, their capacity and cleanness of the surrounding area were made. Data collected included: respondent and site identification, household composition and characteristics, maize agronomic and post-harvest information for 2011 seasons, farmer attitudes, and perceptions on mycotoxins and marketing aspects that were perceived to influence occurrence of the mycotoxins. A minimum of 200gm samples of whole maize grain, semi-processed grain, maize flour and animal feeds were taken from each household interviewed. The samples were stored at 4^{o}C until they were analyzed. Global Positioning System (GPS) information was also collected to be used to map out the extent of mycotoxin contamination in the study areas.

Identification of fungi

The potato dextrose agar (PDA) was prepared in the laboratory by mixing 39g of agar powder with one litre of distilled water, then bringing the mixture to the boil to dissolve the powder completely. The mixture was then sterilized by autoclaving at 121^{o}C for 15 minutes and cooled to 50^{o}C. Antibiotics (tetracycline, streptomycin, penta-chloro-nitrobenzine and penicillin) were added to the media to prevent bacterial grown. The media were then poured into the sterile Petri dishes. The media were made selective for yeast and moulds by the addition of 10 ml of sterile 10% lactic acid solution. The grains were first surface-sterilize in 3% sodium hypochlorite solution, then about 100 kernels per sample were plated into the PDA medium. The plates were incubated for 14 days at 25^{o} C. The number of kernels showing growth of moulds in each Petri dish was then recorded.

Some of the surface-sterilized grains were ground to pass through a 1mm screen. The ground samples were serially diluted by mixing one gram of sample with nine ml sterile distilled water. This was dilution 10^{0}. One ml of the 10^{0}dilution was then placed into another tube containing 9 ml sterile distilled water to make 10^{-1}. The process was repeated until a dilution of 10^{-4} was achieved. One ml of diluted sample was plated in the PDA medium and incubated at 25^{0}C for 14 days. The number of moulds per plate were counted and the number of colony forming unit per gram (CFU/g) calculated by multiplying the number of colonies by dilution factor. Any moulds observed were sub-cultured on the Czapek agar for 7 to 14 days and identified at the species level using cultural and morphological characteristics like colour, conidiophores, phalids, presence and sizes of vesicles.

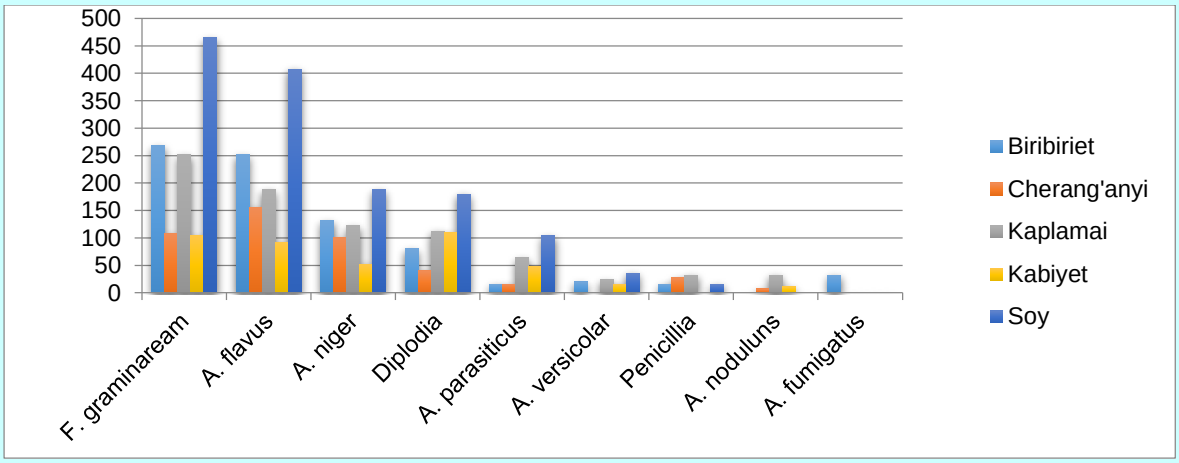
Analysis for aflatoxins

The enzyme linked immuno-sorbent assay (ELISA) was used to analyse for aflatoxin B1 in the samples. Whole grain and the semi-processed animal feeds samples were ground to pass through a 1 mm screen. Two grams of the ground samples was weighed into a screw cap glass vials and 10ml of methanol/distilled water (70/30 v/v) was added and mixed for 10 minutes at room temperature using a shaker. The extract was then filtered then 100 µl of the filtrate was diluted with 600 µl of distilled water and 50 µl of the diluted samples was used per well for quantitative analysis.

All reagents were brought to room temperature before use. Three micro-titre plate wells were inserted into the micro-well holder for all standards and samples to run in duplicates. Standard and sample positions were recorded. To each micro-well50 µl of the standard solution or prepared samples, then 50 µl of the enzyme conjugate and 50 micro-litres of the antibody solution added. The mixture was shaken gently and incubated at room temperature for 30 minutes in the dark. The liquid was then poured out of the micro-wells and any excess liquid dapped off using absorbent paper. The wells were washed three times with PBS washing buffer then 100 µl of substrate/chromogen was added to each well, mixed gently by shaking the plate manually. After incubating the wells at room temperature in the dark for 15 minutes, 100 µl of stop solution was added to each well, mixed gently by manual shaking and the absorbance measured at 450nm.

Results

Figure 1 below shows the regional distribution of the genera of fungi isolated from maize and maize products were Aspergillus, Diplodia, Fusarium and Penicillia. The species most frequently isolated were *A. flavus*, *A. parasiticus*, *A. niger*, *A. vasicolor*, *A. fumigatus* and *A nodulans*. The mean frequency of Aspergillus species isolated was 53.9%. The most frequently isolated Aspergillus species were *A.Flavus* (27.9%) and *A.Niger* (15.1 %)..*A. fumigates* was isolated from only 1 grain sample. *Fusarium graminarium* was encountered at a high frequency of 30.5%. .*A. flavus* was the most frequently isolated species from the semi-processed maize grain and the animal feeds. The number of fungal species isolated from the samples varied from 1 to 7.



The means of aflatoxin B1 in the samples collected was 1.738±0.966 ppb, 1.06±0.177 ppb and 0.834±0.213 ppb for Trans Nzoia, Uasin Gishu and Nandi counties respectively as indicated in Table 1. The highest levels were registered in Trans Nzoia (AEZ (UM) and the least was in Nandi county (AEZ LH). There was great variability in Trans Nzoia samples as seen from SD and CV compared to other counties.

Table 1: Descriptive statistic of Aflatoxin B1 levels in Rejected Maize samples.

County	N	Mean (ppb)	STD	CV	Range	
					Min	Max
Trans Nzoia	16	1.738±0.966	3.73	215.1	0.01	15.5
Uasin Gishu	16	1.060±0.213	0.684	64.60	0.01	2.61
Nandi	16	0.833±0.177	0.823	98.75	0.01	4.30

Discussion

The presence of *A. flavus* on maize and maize products as well as processed by-products indicates that Aspergillus inoculum is widespread in both the environment and in food in the study areas. However, the presence of *A. flavus* on maize does not imply an obvious occurrence of aflatoxin in maize. Circumstances that favour mould growth may also favour aflatoxin production but moulds may occur with little or no aflatoxin production. The level of toxin formation in the field is aggravated by host plant stress in the field, during harvesting, storage conditions and finished feeds and forages. The implication is that avoiding stressful conditions by irrigating during drought may reduce toxin formation.

High temperatures and high humidity favour the infection of maize kernels through the silks by the *Aspergillus* fungi. Below-normal soil moisture (drought stress) has also been found to increase the number of *Aspergillus* spores in the air. Therefore, when drought stress occurs during pollination, the increased inoculum load greatly increases the chances of infection. Furthermore, drought stress, nitrogen stress, and other stresses that affect plant growth during pollination can increase the level of aflatoxins produced by *Aspergillus* fungi. Often, *Aspergillus* will grow on the unfilled portions of the ear. Insect damage to ears provides wounds that allow *Aspergillus* to more readily infect the kernels. Insects also transport *Aspergillus* spores to the silks and the kernels. Therefore, insect damage, especially during pollination in drought-stressed maize, can increase the occurrence of *Aspergillus* and the levels of aflatoxins (Cassel, et al., 2001). To alleviate the problem, where possible, irrigation could be used around the time of pollination if a dry spell occurs at that time. Insect pest control in the field and in storage is crucial.

Time of harvest has also been shown to be important in influencing the occurrence and levels of aflatoxin because *Aspergillus* does not compete well with other moulds when maize is above the 20% moisture content. Harvesting maize when moisture content is above 20 percent followed by rapid drying to at least a moisture content of 14% within 24 to 48 hours of harvest keeps further *Aspergillus* growth and toxin production at a minimum (Cassel, et al., 2001). Investing in grain driers at national level would make this possible.

All the maize samples collected from farmers were contaminated with aflatoxin B1. This confirms the presence of aflatoxin in this region. Neyole (2009) reported that up to 30% of grain loss was due to moulding. Similarly, Bii (2013) showed that 100% of maize and oil cakes used for feeding livestock in the neighbouring South Rift was contaminated with aflatoxin B1. Though the aflatoxin content in the sampled grain and feeds was below the national tolerance limit, the highest amount observed was 15 ppb. This was observed in just one sample, indicating need for concern.

The highest level of Aflatoxin B1 was reported in Trans Nzoia County. This was probably due to difference in agro-ecological zones and other economic activities besides dairy farming. Nandi County's major farming activity is tea production while Trans Nzoia & Uasin Gishu Counties are cereal oriented hence the population of *Aspergillus spp.* fungi are likely to be lower in Nandi County. Kang'ethe (2009) revealed that 67% of dairy concentrates had Aflatoxin B1levels above 20 ppb. All the maize samples were positive of Aflatoxin B1but only 6.25 % of the samples exceeded the maximum limit set by European Union at 3 ppb for human consumption. Bii (2013) found 100% of oil seedcake was contaminated. Therefore using second grade maize and oil seed cakes would easily result in a feed with a concentration of aflatoxin B1 above maximum set by Kenya Bureau of Standards of 20 ppb. The findings of this research are consistent with

International Food Policy Research Institute (IFPRI) (2011) which revealed that maize from Western Kenya had aflatoxin B1ranging from 0 ppb to 1.4 ppb.

The principal toxins produced by *F. graminearium* which was isolated at a very high frequency (30.5%) are deoxynivalenol (DON; also known as vomitoxin), nivalenol and zearalenone (Maracas et al., 1984). DON causes vomiting and feed refusal in pigs at levels near 5 mg/kg of feed. Its toxicity to species other than pigs remains to be defined, and appears unlikely to be high.

The oestrogenic effects of zearalenone are genital problems in domestic animals, especially pigs. Symptoms include hyperemia and edematous swelling of the vulva in pre-pubertal gilts, or in more severe cases prolapse of the vagina and rectum. Reproductive disorders in sows include infertility, foetal resorption or mummification, abortions, reduced litter size and small piglets. Male pigs are also affected: atrophy of testes, decreased libido and hypertrophy of the mammary glands are all well documented (Maracas et al., 1984).

Conclusions and recommendations

The results of this study showed the presence of several fungal mould species, with the toxin producing strains being below 50%. The aflatoxin levels were also below the national tolerance limit of 10 ppb. But the large presence of Fusarium moulds is of concern. The current practices in maize handling after harvest, the change in weather patterns which has resulted in heavy rains around harvest time in recent years, and the practice of using rotten grain as a livestock feed in many parts in the region are all potentially hazardous situations that call for immediate action. Quality assurance bodies should be fully involved in periodically testing for mycotoxin content in manufactured food and feeds. More studies on presence of mycotoxins produced by Fusarium moulds need to be done.

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References

Bii,C.(2013,February 14).Poison on the table:We are eating ourselves to death,study reveals.The Standard Extra, p 1-4.Nairobi:Standard Group.

Cassel, E. Kim, Bill Campbell, Martin Draper and Bill Epperson. 2001. Aflatoxins: Hazards in grain/aflatoxicosis and livestock. Fact Sheet 907. South Dakota State University, Cooperative Extension Service / College of Agriculture & Biological Sciences / USDA.

Chu FS. Recent studies on immunoassays for mycotoxin.In: Beier RC, Stanker LH, eds. Immunoassays for ResidueAnalysis, American Chemical Society, Washington, DC,1996: 294–313.

Council for Agricultural Science and Technology (CAST). Mycotoxins: Risks in Plant, Animal and Human Systems. Task Force Report, No. 139, CAST, Ames, Iowa, 2003.

IARC (1995) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 62, Wood Dust and Formaldehyde, Lyon, IARCPress, pp. 217–362

IFPRI(2011). New study documents Spread of Aflatoxins in Kenya. Nairobi: Author. Link http//www.ifpri.org.

Kang'ethe, E.K, Lang'a, K.A. (2009).Aflatoxin B1 and M1 Contamination of animal feeds and milk from urban centres in Kenya. African Health Science 9(4) 218-226.

Maxwell, S.M. (1998) Investigations into the presence of aflatoxins in human body fluids and tissues in relation to child health in the tropics. Ann. Trop. Paediatr., 18 (Suppl.), 41–46.

Neyole, E.M and Maiyo, A (2008).Aflatoxin risks in maize production and its impact on food security in Rift valley Kenya. International Journal for Disaster Management & Risks reduction.Vol.1 No.2:13-19.

Pitt, J.I. & Hocking, A.D. (1997) Fungi and Food Spoilage, 2nd Ed, Gaithersburg, MD, Aspen Publishers.

Pitt, J.I., Hocking, A.D., Bhudhasamai, K., Miscamble, B.F., Wheeler, K.A. & Tanboon-Ek, P. (1993) The normal mycoflora of commodities from Thailand. 1. Nuts and oilseeds. Int. J. Food Microbiol., 20, 211–226

Pitt, J.I., Hocking, A.D., Bhudhasamai, K., Miscamble, B.F., Wheeler, K.A. & Tanboon-Ek, P. (1994) The normal mycoflora of commodities from Thailand. 2. Beans, rice, small grains and other commodities. Int. J. Food Microbiol., 23, 35–53

Trucksess MW, Koeltzow DE. Evaluation and applicationof immunochemical methods for mycotoxins in food.In: Nelson JO, Karu AE, Wong RB, eds. Immunoanalysisof Agrochemicals in Emerging Technologies, AmericanChemical Society, Washington, DC, 1995: 326–334.

Trucksess MW. Rapid analysis (thin layer chromatographicand immunochemical methods) for mycotoxinsin foods and feeds). In: de Koe WJ, Samson RA, vanEgmond HP, Gilbert J, Sabino M, eds. MycotoxinsandPhycotoxins in Perspective at the Turn of the Millennium,W.J. de Koe, Wageningen, The Netherlands, 2001:29–40.

Whitlow L W and Hagler W M, 2005. Mycotoxins in Dairy Cattle: Occurrence, Toxicity, Prevention and Treatment. Proc. Southwest Nutr. Conf.: 124-138.

Nutritional Composition of Donkey Milk: A Case Study of Limuru Sub-County, Kiambu County

Njau Wanjahi R.[1*] ,Osuga I,M. Isaac[1]

[1]Department of Agriculture Resource Management, Kenyatta University, P.O. Box 43844-00100, Nairobi. Kenya.

*Corresponding author e-mail: wanjahi.njau@gmail.com

Abstract

Milk is the most nutritious natural liquid. Milk components contribute significantly to meeting nutrient requirements of young animals while minimising incidences of diseases. Very young children (infants) and the elderly may be intolerant to cow's milk, its protein and cholesterol. Thus viable substitutes are needed to complement cow's milk in such cases. This case study was carried out in Limuru sub County Kiambu County. Donkey milk exemplifies a geographical shift from diet conscious consumers to change to nutritious as well as diets with health benefits. This article describes significant research findings on nutritional benefits and composition of donkey milk in comparison with cow milk. It determines nutritional components of donkey milk. It describes variations in milk components between cow and donkey milk by comparing both and analysing their differences. The study was intended to promote donkey welfare as a dairy animal and improve food security for the most vulnerable groups especially for the young infants in dry areas. Despite the limited data on donkey dairy production perspectives should fuel more research for commercial investments. Effective education and data dissemination are among requirements to develop an unbiased science of cow and donkey milk nutritional and functional value and its contribution to optimal human health

Key words: Donkey milk, Nutritional components

Introduction

Donkey milk has nutritional properties that are more similar to human milk than any other mammalian animal. Therefore it can be used to feed young children and for general human consumption. The aim of this project was to identify the nutritional composition of donkey milk and compare it with that of cow milk. It is believed that donkey does no harm to people with cow milk protein allergy and can be used as an alternate to cow's milk.

Social cultural restraints among several communities in Kenya have resulted to the low uptake of donkey milk. Many people in rural areas have a negative attitude towards donkeys and their contribution to people's livelihoods remain unacknowledged and unsupported. Donkey milk is rarely consumed and to do so is considered a taboo. However, it is used by the Maasai women to treat children with pneumonia or severe cough (Mutharia, 1995). Recently donkey milk has been used for sale to Indians and foreigners from Europe mainly Italians for human consumption. Among the local communities it has been used for to nourish vulnerable groups such as young children and the elderly

Donkey milk has been used successfully as an alternative food for infants with food allergies for example cow's milk protein allergy (Salimei and Fantuz, 2012). The flavour and appearance of donkey milk has been found to be attractive to children. One of the challenges with donkey milk is the seasonal supply during the year. Fertility of a donkey female is strictly connected with the photoperiod and delivering is normally limited to a range of a few months in a year. Furthermore donkey breeding is so dispersive and milk yield is low.

Materials and methods

Description of site

The project research was carried out in Limuru Sub County in Kiambu County. It is located in the central part of the country between 1^0 06′ 00″ s latitude and a longitude of 36^0 37′ 00″ E

Data collection

Collection of milk samples

Samples were collected from 3 donkeys and 2 cows at 3 different times for each. Milk sample were collected from donkey keepers before the start of their daily routines. Those from cows were collected before delivery into the cooperatives. The milk from both cows and donkeys were manually milked. They were collected in sterilized containers and taken to the laboratory and transported by use of an ice box. A total of 15 samples were collected for Physico-chemical analysis. The samples were analyzed on the same day.

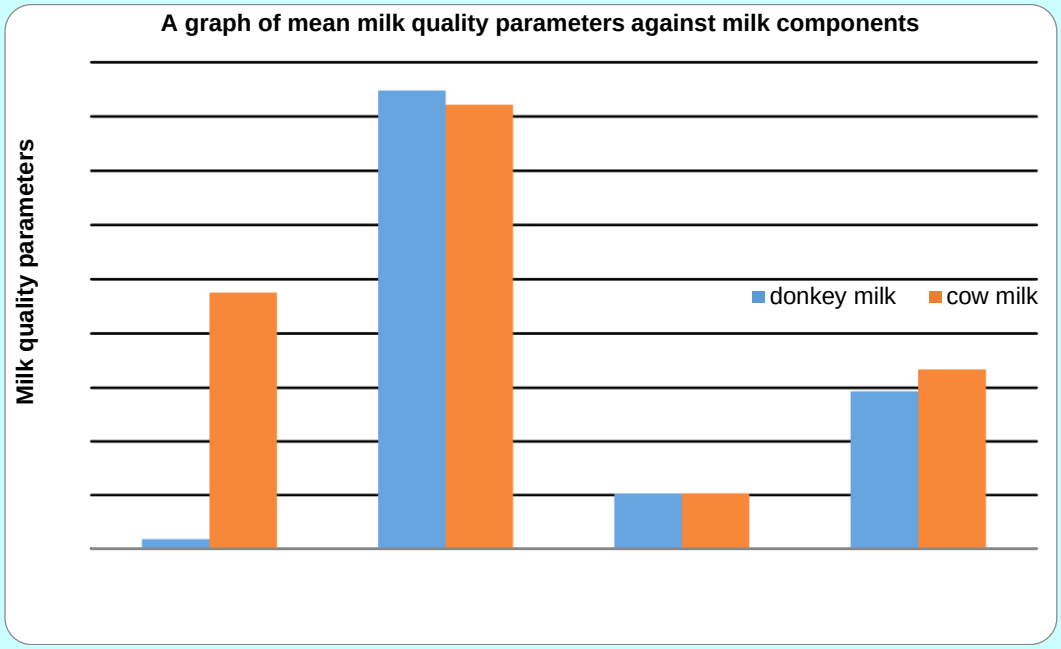
Examination of milk samples

Physico-chemical characteristics of the milk samples were determined using milk analyzer (LACTICHECK) to determine milk constituents (fat, solid non fat, protein and % of water added) and physical characteristics (density in $g/^{cm3}$).

Statistical analysis

Data was analyzed by use of SAS (Statistical analysis system) for windows V8 version 2001. Analysis of variance (ANOVA) was used to determine the statistical differences of milk quality parameters. These were used to analyze the association between milk quality parameters and effect of different independent variables on the milk quality.

Results



Y axis: represents milk quality parameters (what are the units?)

X axis: represents milk components

Table 1: Physico-chemical quality of cow and donkey raw milk in the study area

Mean values of Physico-chemical quality parameters		
Milk quality parameters	Donkeys	Cows
Fat	0.1778[b]	4.7533[a]
SNF	8.47778[a]	8.21667[b]
Density	1.0311333[a]	1.032233[a]
Protein	2.93556[b]	3.338333[a]
% water	-	-

Values in row with different letters have significant difference

Fat had a significant difference at p<.0001

SNF had a significant difference at p<.05

There was no significant difference in density

Protein had a significant difference at p<.05

Discussion

Significant difference in fat was due to species differences. Cows are able to efficiently synthesize fibre in the rumen to produce volatile fatty acids used by mammary glands to synthesize milk thus the high fat content. Donkeys also had a low fat content as it's a heavy worker which breaks down body fat to produce energy. The body condition of donkeys was poor compared to that of cattle. There was no significant difference in density. The solid non fats SNF means were higher on donkey milk than that of cow milk. Significant difference was due to the low fat content donkey milk has a higher SNF that contains of the following components whey proteins, lactose, caseins and minerals. The SNF content may have been lower in cows as they were in a late stage of lactation compared to donkeys which had recently foaled.

The significant difference between cow and donkey milk may be as a result of cows utilising protein efficiently than donkeys. Due to microbial digestion in rumen more proteins were used to synthesise milk. Although the donkeys were able to carry out microbial digestion in the large intestines they were less efficient in protein utilisation as most of it was used to regenerate tissues due to their work. Cows were also able to generate more proteins from non-protein nitrogen sources through microbial digestion compared to donkeys which are not able to derive proteins from NPN. The significant may have been caused by nutritional factors as donkeys were mainly fed on pastures from roadside verges which had more crude fibre than protein compared to cattle which were fed on fresh pastures and fodder with adequate protein. Cows were supplemented with high quality concentrates but donkeys were not.

The percentage of water added was not detected by the lacticheck machine showing that milk was not adulterated.

Acknowledgement

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References

Salimei, E and Fantuz, F. (2012). Equid Milk for Human consumption. International dairy journal vol 24 (pp. 130-142)

Mariani, P.L. (2011). Donkey milk nutraceutical characteristics: Biochemical evaluation of nutritious and clinical properties. XXIII Series. School of advanced studies. University of Camerino

Mutharia, L. (1995). A Participatory assessment of pastoral resources and their utilisation in selected areas

of Kajiado district. Study 1: Oloryiankalani Group Ranch. Study 2. Eselenkoi/Emutoroki Group Ranch. Intermediate technology Kenya, Nairobi. 71p and 69p

Nikkhah, A. (2011). Equidae milk provides substitutes for cow and human breast milk. Tubitak journal of animal science, 36(5): 470-475

Dry matter accumulation and nutrient composition of three early maturity forage sorghum varieties grown for feeding ruminants in semi-arid Kenya

Irungu R. [1, 2*] and Ashiono G.B [1, 3]

[1]Kenya Agricultural and Livestock Research Organization P.O. Box 3840 20100 Nakuru
[2]Kenya Agricultural and Livestock Research Organization P.O. BoxX 25 20117 Naivasha
[3]Kenya Agricultural and Livestock Research Organization P.O. Box 169 50100 Kakamega
***Corresponding author: robertirungu@gmail.com, Mobile +254 722 908 295**

Abstract

Sorghum (*Sorghum bicolour* (L.) Moench) is suitable fodder to alleviate feed shortage in semi-arid tropics as it is drought tolerant. Three early maturity varieties of forage sorghum were studied to determine their dry matter accumulation and nutrient composition at various ages when grown to feed ruminants in semi-arid Kenya. Varieties BJ 28, Cow candy and Hay grazer, planted in randomized complete block layout with three replicates, were sampled for dry matter yield and nutrient composition at 52 days (first thinning) and thereafter, every 21 days up to 156 days. The data was subjected to analysis of variance and means separated using least significant difference procedures. Dry matter accumulation increased with increased age in all the sorghum varieties. However, there was a plateau in dry matter accumulation in all sorghum varieties between 115 and 156 days. At 115 days Cow candy accumulated the highest (9311.3 kg DM/ha) DM and BJ 28 the lowest (4957.7 kg DM/ha) while Hay grazer recorded 7674.6 kg DM/ha. In all sorghum varieties DM, OM and ADL increased with age while CP decreased. However, NDF and ADF decreased with increased age in BJ 28 although these nutrients increased with increased age in Cow candy and Hay grazer. Generally, BJ 28 recorded the lowest NDF and ADF and Cow candy recorded the highest values in these nutrients. The values of DM, OM, ADL and CP at 115 days ranged between 266.9 to 316.1; 911.7 to 921.5; 44.0 to 48.3; 108.2 to 134.5 g/kg DM, respectively. The range in values of NDF and ADF were 476.8 to 607.4 and 294.3 to 377.4 at 115 days respectively. These DM and fibre values were lower than those recorded in the literature because the varieties in the current study were harvest at young age. The young sorghum produced highly nutritious feed for ruminants hence these sorghum varieties should be harvested not later than 115 days of age to optimize their dry matter accumulation and nutritive value.

Key words: Sorghum, accumulation, nutrient, age, days, variety

Introduction

A major challenge facing livestock production in Kenya, particularly in low rainfall areas, is the seasonal variation in terms of quality and quantity of available forages, particularly the natural pasture, as it is influenced by rainfall seasons. The growth and abundance of forage increases at the onset of the rains and trails off to little or no growth at the height of the dry season. Also, the quality of the forages decreases with age and rainfall. The deterioration in the quality of roughages in terms of protein and energy during the dry season means that it cannot sustain high livestock production performance. Protein in particular, is expensive in Kenya and is known to be a major limiting nutrient in all livestock production systems.

Technological innovations, particularly targeting increased feed availability could increase livestock production. This should aim at availing adequate quantity and quality feed year round to guarantee high and stable production continuously (Ashiono et al., 2005). This is particularly useful in areas where dairy production forms the main livestock activity. Sorghum (*Sorghum bicolour* (L.) Moench) is adapted to semi arid areas receiving 400 to 800mm of rainfall annually by virtue of its heat and drought tolerance. With improved varieties, appropriate water and soil management practices this amount of rainfall can support production of sorghum (Ouma et al., 2013). Sorghum varieties BJ 28, Cow candy and Hay grazer have been recommended and popularized for forage production in the dry highlands of Kenya (Ouma et al., 1995;

Ashiono et al., 2005). However, their dry matter accumulation and nutritive value from emergence to their optimum harvesting ages have not been elucidated under Kenya conditions.

The objective of the study was to determine dry matter accumulation and nutrient composition of three early maturity forage sorghum varieties in semi-arid Kenya

Materials and methods

The study was conducted at the Kenya Agricultural and Livestock Research Organization (KALRO) in Lanet located in the outskirts of Nakuru town, within Nakuru County, Kenya. The site is 0^0 18'S, 36^0 09'E and 1920 m above sea level. The area receives bimodal rainfall; with the long rains occurring late March to May and the short rains received in October and November (Jaetzold et al. 2006). The area receives on average 800 mm rainfall annually with a relative humidity of 83 %. The mean maximum and minimum temperatures are 26^0C and 10^0C, respectively. The study site falls within agro-ecological zone (AEZ) IV (Jaetzold et al. 2006) with soils classified as humic nitosols under FAO soil classification.

The experimental site was ploughed, harrowed and finally hand levelled to ensure a fine tilth. Experiments were laid out in a Randomized Complete Block Design (RCBD) with three replicates and plot sizes were 4.2 x 4.2 metres. Cold tolerant, early maturity sorghum varieties BJ 28, Cow candy and Hay grazer were used and sown at the onset of long rains. Furrows were made by manually dragging a stick along a string used to mark rows. Furadan 5G granules, used to control soil borne pests, were thinly applied in the rows and later thoroughly mixed with the soil. Phosphorous (P_2O_5) was thinly applied at 30 kg/ha in the furrows and mixed with the soil. Sorghum seeds of BJ 28, Cow candy and Hay grazer were sown in the rows at pacing of 60 cm x 10 cm, between rows and within rows, respectively, and thinly covered with soil. Nitrogen (CAN) was applied six weeks after sowing at 40 kg/ha. Plots were kept weed free by hand weeding and Actellic sprayed at one litre/ha to control foliage pests.

Three hills of sorghum plants were randomly selected from each of the middle three rows per plot, individually weighed, bulked, chopped and sampled. The samples were dried at 60^oC for 72h, ground and placed in airtight bottles awaiting analysis. Samples were analyzed for nutrient composition using AOAC (1998) procedures and Van Soest et al., (1991) methods of analysis. Analysis of variance was conducted on data using SAS (2003). Least significant difference (LSD) at the 5% level of probability was used to separate treatment means.

Results

Dry matter accumulation

The harvesting age affected ($P<0.01$) dry matter (DM) accumulation in the three early maturity sorghum varieties (Table 1). Generally dry matter accumulation increased ($P<0.05$) with increased age in all the sorghum varieties. All varieties accumulated similar ($P>0.05$) DM at 52 days but from 73 days onwards, Cow candy accumulated higher ($P<0.05$) DM than BJ 28 and Hay grazer. However, BJ 28 and Hay grazer recorded similar ($P>0.05$) DM at 73 days but thereafter, BJ 28 recorded the lowest ($P<0.05$) DM accumulation among all the cultivars up to the end of the study. Nonetheless, there was a plateau ($P>0.05$) in dry matter accumulation in BJ28 and Hay grazer and a decline in Cow candy production between 135 and 156 days. This decline in Cow candy production caused Hay grazer to rank the highest DM yielder between 135 and 156 days.

Table:1: Dry matter accumulation of three early maturity forage sorghum varieties (kg DM/ha)

Variety	Age in days							
	52	73	94	115	135	156	LSD	SED
	Dry matter yield, kg DM/ha							
BJ 28	513.5_1^a	1677.0_1^b	2944.2_1^c	4957.7_1^d	5307.9_1^{de}	5575.7_1^e	437.8	152.3
Cow candy	614.4_1^a	2775.8_2^b	4787.8_3^c	8917.8_3^e	8622.3_2^e	8038.6_2^d		
Hay grazer	453.7_1^a	1707.8_1^b	4148.4_2^c	7674.6_2^d	8944.7_3^e	8557.4_3^e		
LSD	309.6	SED	263.9					

^{abcde} Means within a low bearing different superscript are different (P<0.05)
^{1,2}Means within a column bearing different superscript are different (P<0.05)

Dry matter (DM), Organic matter (OM) and Crude protein (CP)

The harvesting age affected (P<0.01) DM, OM and CP in all sorghum varieties (Table 2). Generally DM increased (P<0.05) with increased age in all sorghum varieties. However, the lowest DM was recorded at 73 days in all cultivars and DM plateau occurred between 115 and 135 in Hay grazer and 135 and 156 days in Cow candy, respectively. All sorghum varieties contained similar (P>0.05) DM at 52 days but subsequently, BJ 28 recorded the highest DM. Nevertheless, Cow candy and Hay grazer recorded similar DM throughout the study. Generally OM increased (P<0.05) with increased age in all sorghum varieties between 52 and 94 days. However, OM recorded a plateau (P>0.05) beyond 94 days in BJ 28 and Cow candy. Such a plateau was recorded in Hay grazer from 115 days to the end of the study. Commonly, BJ 28 recorded the highest OM (P<0.05) and Cow candy recorded the lowest OM (P<0.05). However, between 115 and 156 days BJ 28 and Hay grazer recorded similar OM (P<0.05).

Crude protein decreased (P<0.05) with increased age in all sorghum varieties. Between 52 and 73 days, Hay grazer recorded the highest CP although BJ 28 recorded the highest CP between 94 and 156 days. Usually, Cow candy recorded the lowest CP during the study.

Table: 2. Nutrient composition of three early maturity forage sorghum varieties (g/kg DM)

Variety	Age in days							
	52	73	94	115	135	156	LSD	SED
	Dry matter, g/kg DM							
BJ 28	178.3_1^a	157.3_2^a	219.0_2^b	316.1_2^c	401.9_2^d	437.6_2^e	21.3	7.4
Cow candy	169.5_1^b	141.1_1^a	196.0_1^c	266.9_1^d	304.3_1^e	302.1_1^e		
Hay grazer	182.4_1^b	155.9_{12}^a	201.4_1^c	268.7_1^d	289.9_1^d	313.3_1^e		
LSD	15.0	SED	5.2					
	Organic matter, g/kg DM							
BJ 28	832.1_2^a	876.5_2^b	908.1_1^c	920.9_2^c	918.1_2^c	916.9_2^c	13.6	8.2
Cow candy	816.3_1^a	877.4_2^b	904.1_1^c	911.7_1^c	904.9_1^c	901.4_1^c		
Hay grazer	810.8_1^a	866.9_1^b	899.8_1^c	921.5_2^d	915.1_2^d	918.6_2^d		
LSD	9.6	SED	3.3					
	Crude protein, g/kg DM							
BJ 28	224.3_{12}^f	196.5_1^e	153.8_2^d	134.5_2^c	115.4_3^b	94.2_2^a	10.8	6.5
Cow candy	218.6_1^f	195.8_1^e	143.6_1^d	108.4_1^c	96.1_2^b	85.0_1^a		
Hay grazer	227.2_2^f	210.8_2^e	146.7_{12}^d	108.2_1^c	83.7_1^a	95.5_2^b		
LSD	7.6	SED	2.6					

^{abcdef} Means within a low bearing different superscript are different (P<0.05)
^{1,2}Means within a column bearing different superscript are different (P<0.05)

Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL)

The harvesting age affected (P<0.01) NDF, ADF and ADL in the three sorghum varieties (Table 3). Generally NDF decreased (P<0.05) with age in BJ 28 while NDF increased (P<0.05) in Cow candy and Hay grazer. Within Cow candy and Hay grazer, NDF was similar (P>0.05) between 52 and 94 days. Again NDF was similar (P>0.05) between 115 to 156 days in Cow candy and between 135 and 156 days in Hay grazer, respectively. However, within BJ 28 the NDF was similar (P>0.05) between 73 and 94 days and between115 and 135 days, respectively. All cultivars recorded similar (P>0.05) NDF between 52 and 94 days but BJ 28 recorded lower (P<0.05) NDF than Cow candy and Hay grazer between 115 and 156 days. Cow candy and Hay grazer recorded similar concentration (P>0.05) of NDF between 115 and 156 days.

Generally ADF decreased (P<0.05) with age in BJ 28 while ADF increased (P<0.05) in Cow candy and Hay grazer. Within Cow candy, ADF was similar (P>0.05) between 73 and 94 days and again between 135 and 156 days. However, Hay grazer recorded similar (P>0.05) ADF between 52 and 73 days and between 94 and 115 days. In BJ 28, ADF increase from 52 days to 94 days and subsequently recorded a lower (P<0.05) plateau between 115 and 156 days. All cultivars recorded similar ADF (P>0.05) at 52 days but subsequently Cow candy recorded higher (P<0.05) ADF compared to BJ 28 and Hay grazer up to the end of the study. However, BJ 28 and Hay grazer recorded similar (P>0.05) ADF between 52 and 94 days but BJ 28 recorded lower (P<0.05) ADF thereafter.

In general ADL increased (P<0.05) with increased age in all sorghum cultivars. However, between 73 and 94 days; 135 and 156 days within Cow candy ADL was similar (P>0.05) while within Hay grazer, between 73 and 94 days; 115 and 156 days ADL was also similar (P>0.05). Variety BJ 28 contained the highest (P<0.05) ADL compared to Cow candy and Hay grazer. However, Cow candy and Hay grazer recorded similar (P>0.05) ADL between 52 and 115 days after which age ADL increased (P<0.05) in Cow candy.

Table: 3. Fibre composition of three early maturity forage sorghum varieties (g/kg DM)

Variety	Age in days							
	52	73	94	115	135	156	LSD	SED
	Neutral detergent fibre, g/kg DM							
BJ 28	552.6_1^{d}	568.6_1^{c}	585.6_1^{c}	476.8_1^{b}	481.7_1^{b}	428.4_1^{a}	32.5	19.6
Cow candy	560.5_1^{a}	574.8_1^{a}	568.3_1^{a}	607.4_2^{b}	655.2_2^{c}	636.9_2^{bc}		
Hay grazer	550.3_1^{a}	562.5_1^{a}	579.9_1^{ab}	594.1_2^{b}	641.7_2^{c}	636.9_2^{c}		
LSD	22.9	SED	7.9					
	Acid detergent fibre, g/kg DM							
BJ 28	301.4_1^{a}	324.6_{12}^{b}	331.9_1^{b}	294.3_1^{a}	285.7_1^{a}	299.9_1^{a}	15.5	9.3
Cow candy	298.4_1^{a}	334.9_2^{b}	347.1_2^{b}	377.4_3^{c}	402.0_2^{d}	417.3_2^{d}		
Hay grazer	304.1_1^{a}	315.6_1^{a}	331.6_1^{b}	347.1_2^{b}	394.3_{12}^{d}	348.3_3^{c}		
LSD	10.9	SED	3.8					
	Acid detergent lignin, g/kg DM							
BJ 28	27.0_1^{a}	36.8_2^{b}	43.4_2^{c}	48.3_2^{d}	53.5_3^{e}	60.3_3^{f}	3.9	2.3
Cow candy	28.1_1^{a}	34.5_{12}^{b}	35.3_1^{b}	46.1_{12}^{c}	49.0_2^{cd}	52.2_2^{d}		
Hay grazer	27.1_1^{a}	33.5_1^{b}	34.8_1^{b}	44.0_1^{c}	45.7_1^{c}	45.8_1^{c}		
LSD	2.7	SED	0.95					

^{abcdef} Means within a low bearing different superscript are different (P<0.05)

^{1,2}Means within a column bearing different superscript are different (P<0.05)

Discussion

Dry matter accumulation

The increased dry matter accumulation with increased age in all the sorghum varieties recorded in this study is in accord with available literature (Gul et al., 2008; Pospisil et al., 2009; Torrecillas et al., 2011). Dry matter accumulation plateau indicated varietal maturity hence BJ28 and Cow candy matured between 115 and 135 days and Hay grazer matured slightly later between 135 and 156 days (Miron et al., 2006; Torrecillas et al., 2011). Before 135 days Cow candy accumulated the highest DM and BJ 28 recorded the lowest DM accumulation. After 135 days, Hay grazer accumulated the highest DM. Hence BJ28 and Cow candy can be harvested at 115 days and Hay grazer harvested at 135 days without significantly affecting yield. The Cow candy yields were within the range reported by the seed company (Fowler Seed Marketing). These values matched early cut and cumulated second and third cut in Cow candy and Cow candy II, respectively. The yield in Hay grazer was within the range reported by Pospisil et al. (2009) for Hybrid grazer harvested at height range of 100 to 150 cm. Yield data on BJ 28 is scarce in the literature.

Dry matter, Crude protein and Organic matter content

The general increase in DM content with increased age in sorghum is in agreement with available literature on forages (Firdous and Gilani, 2001; Relling et al., 2001; Gul et al., 2008). The plateau in DM between 115 and 135 in Hay grazer and 135 and 156 days in Cow candy was an indication of crop maturity (Torrecillas et al., 2011). The similarity in DM content recorded in Cow candy and Hay grazer pointed to their genetic similarity and their difference from BJ 28 (Bahrani and Deghani 2004; Kumar and Devender, 2010; Sher et al., 2012). The DM values obtained in this study were generally lower than those reported by other workers (Irungu et al., 2002; Ouda et al., 2004; Ashiono et al., 2005). These workers studied sorghum silage that was harvested at later age compared to forage sorghum in the current study. The low DM is disadvantageous as ruminants offered these forage varieties will ingest less DM compared to sorghum containing higher DM. Feeds that contained low DM were reported to depress intake, increased rumen passage rate and decreased digestibility in ruminants (Robinson et al. 1990; Pasha et al. 1994; Relling et al., 2001). Furthermore, the ruminant may be unable to ingest adequate DM in a day to meet its' energy requirement.

The trend in OM is agreement with previous observations by Snijders et al., (1992) and Kinyua (2013) who showed that as ash content in forages decreased with age, OM typically increased. The plateau in OM within all varieties between 73 and 115 days may imply redistribution of nutrients among various plant parts causing a nutrient dilution. This period may indicate sorghum booting, flowering and initial grain formation (Durr and Rangel, 2000; Bahrani and Deghani 2004; Torrecillas et al., 2011). This trend in OM content was similar to that observed on DM and is in agreement with reports by Preston and Leng (1987), which showed that the DM content in a feed is positively correlated with its OM. Generally, the OM of the test varieties was in the range reported in the literature (Irungu et al., 2002; Ouda et al., 2004; Ashiono et al., 2005). Organic matter content has been shown to be positively correlated to organic matter digestibility (OMD) (Kamalak et al., 2004; Karabulut et al., 2007) and OM is the main source of energy for ruminants fed forages (Aregheore, 2001). The high OM values in the test cultivars, therefore, make them valuable sources of energy in ruminants (Kariuki et al., 1998; Smit, 2014). However, BJ 28 was likely to contain the highest energy and Cow candy the lowest.

The varietal CP content differed as harvest age increased causing a decline in CP in all sorghum varieties (Posposil et al., 2009; Torrecillas et al., 2011; Sarfraz et al., 2012). Leaves are known to contain high CP hence Hay grazer may have contained the most leaves between 52 and 73 days but deteriorated thereafter (Firdous and Gilani, 2001). Variety BJ 28 may have contained most leaves between 94 and 156 days as it recorded the highest CP. Cow candy may have contained the least leaves as it recorded the lowest CP during this study. The study showed that harvesting age was more important than the cultivar in affecting the CP in forage sorghum. This was particularly so among the varieties younger than 115 days. The CP values obtained in this study are higher those reported in the literature because the sorghum was harvested at an earlier age (Irungu et al., 2002; Ouda et al., 2004; Ashiono et al., 2005). The CP values were more than the 80 g CP/kg DM below which forage is classified as low quality (Semenye et al. 1989; Snijders et al. 1992;

Kariuki et al. 1998). The three sorghum varieties are suitable feeds when fed to ruminants to improve their performance (Semenye et al. 1989; Kariuki et al. 1998; Smit 2014).

Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL)

The increased NDF and ADF with increased harvesting age in Cow candy and Hay grazer agreed with available literature on forages (Firdous and Gilani, 2001; Posposil et al., 2009; Torrecillas et al., 2011). The decreased NDF and ADF with age recorded in BJ 28 may have been due to grain formation and its high proportion in whole plant DM as grains contain low NDF and ADF (Torrecillas et al., 2011; Ouma et al., 2013). The similarity in NDF and ADF within the three varieties at various ages may imply that nutrients were partitioned favourably to other crop functions such as plant growth, head initiation and grain filling (Durr and Rangel, 2000; Bahrani and Deghani 2004). The similarity in NDF and ADF among the three varieties at various ages may indicate an optimum structural fibre requirement in sorghum plants (Firdous and Gilani, 2001; Gul et al., 2008). The NDF and ADF values obtained in this study are lower than those reported in the literature because the sorghum was harvested at an earlier age (Irungu et al., 1999; Ouda et al., 2004; Ashiono et al., 2005). Fibre is essential in ruminants for rumination, saliva flow, rumen buffering and health of the rumen (Minson, 1990; Strasia and Gill, 1990). The relatively low NDF in these varieties was consistent with the general observation that young forages contain lower NDF (Minson, 1990; Relling et al., 2001). Nonetheless, these cultivars had NDF higher than 150 g/kg DM the level recommended by Strasia and Gill (1990) as being suitable for growing ruminants. These varieties, however, generally contained NDF below 600 g kg/kg DM beyond which a feed is classified as poor quality (Meissner et al., 1991). High NDF has been shown to be negatively correlated to organic matter digestibility (OMD) (Relling et al., 2001; Kamalak et al., 2004; Karabulut et al., 2007). Hence the low NDF in the studied sorghum varieties make them valuable feeds to ruminants (Semenye et al. 1989; Kariuki et al., 1998; Smit, 2014).

The general increase in the ADL observed with increased age is in agreement with reported literature (Firdous and Gilani, 2001; Posposil et al., 2009; Torrecillas et al., 2011) who reported decreased forage quality due to senescence and decreased leaf. This led to increased proportion of stem to leaf with prolonged harvesting interval. Plant stems are known to contain more fibre than young leaves (Durr and Rangel, 2000; Relling et al., 2001). The similarity in ADL within Cow candy and Hay grazer at various ages may imply that nutrients were partitioned favourably to other crop functions such as plant growth (Durr and Rangel, 2000; Bahrani and Deghani 2004). The similarity in ADL in Cow candy and Hay grazer between 52 and 115 days may indicate that they were at similar physiological stage in growth (Firdous and Gilani, 2001; Torrecillas et al., 2011). The high ADL recorded in BJ 28 may have indicated that it was genetically different from Cow candy and Hay grazer (Firdous and Gilani, 2001). The ADF and ADL values observed in the present study were lower than those reported in the literature (Irungu et al., 1999; Ouda et al., 2004; Ashiono et al., 2005). Generally, low ADL is beneficial as it does not hinder diet digestibility in ruminants.

Conclusions and recommendations

Dry matter accumulation increased with increased age in all the sorghum varieties. However, there was a plateau in dry matter accumulation in all sorghum varieties between 115 and 156 days. At 115 days Cow candy accumulated the highest (9311.3 kg DM/ha) DM and BJ 28 the lowest (4957.7 kg DM/ha) during the study.

In all sorghum varieties DM, OM and ADL increased with age while CP decreased. However, NDF and ADF decreased with increased age in BJ 28 although these nutrients increased with increased age in Cow candy and Hay grazer. Generally, BJ 28 recorded the lowest NDF and ADF and Cow candy recorded the highest values in these nutrients. The DM and fibre values were lower than those recorded in the literature because the varieties in the current study were harvest at young age. The young sorghum produced highly nutritious feed for ruminants hence these sorghum varieties should be harvested not later than 115 days of age to optimize their dry matter accumulation and nutritive value.

References

AOAC, (Association of Official Analytical Chemists) (1998). Official Methods of Analysis. 16th Edition, 4th Revision, 1998. Gaithersburg, Maryland 20877-2417 USA.

Aregheore, E.M. (2001). Nutritive value and utilization of three grass species by croobred Aglo-Nubian goats in Samoa. Asian-Australian Journal of Animal Science 14:1389-1393.

Ashiono, G.B., J.K. Kitilit, K.R.G. Irungu, T.K. Akuja and K. Changwony (2005). Nutrient characteristics of six cold tolerant sorghum genotypes across different ecozones. Journal of Agronomy 4:276-276.

Bahrani, M.J. and A.G. Deghani (2004). Summer forage sorghum yield, protein and prussic acid contents as affected by plant density and nitrogen topdressing. Journal of Agriculture Science and Technology 6: 73-83.

Durr, P.A., and J. Rangel (2000). The response of Panicum maximum to a simulated subcanopy environment. 1. Soil X shade interaction. Tropical Grassland 34:110-117.

Firdous, R. And A.H. Gilani (2001). Changes in chemical composition of sorghum as influenced by growth stage and cultivar. Asian-Australian Journal of Animal Science 14:935-940.

Fowler Seed Marketing (undated). Cow candy BMR and Cow candy II BMR. FSM Technical Bulletin. www.fowlerseed.com/downloads/FSM-cowcandy-Tech.pdf. Accessed on 20th November, 2015.

Gul, I., R. Demirel, N. Kilicalp, M. Sumerli and H. Kilic (2008). Effect of crop maturity stages on yield, silage chemical composition and in vivo digestibility of the maize, sorghum-sudangrass hybrids grown in semi-arid conditions. Journal of Animal and Veterinary Advances 7:1021-1028.

Irungu, K.R.G., R.K. Keingatti and A.N. Abate (1999). Performance of beef steers fed on brewers' grain ensiled with hay or sorghum. Proceedings of the 6th Biennial KARI Scientific Conference, 9th-13th November, 1998, Nairobi, Kenya. pp 432-439.

Irungu, K.R.G., R.K. Keingatti and J.K. Kitilit (2002). Nutrient intake and growth of beef cattle fed on forage sorghum silage and sweet potato vines. Proceedings of the 7th Biennial KARI Scientific Conference, 13th-17th November, 2000, Nairobi, Kenya. pp 343-348.

Jaetzold R., H. Schmidt, B. Hornetz and C. Shisanya (2006). The Farm Management Handbook of Kenya. Central Kenya. Volume II, 2rd Edition. Ministry of Agriculture, Kenya.

Kamalak, A., O. Canbolat, Y. Gurbuz, O. Ozay, C. O. Ozkan and M. Sakarya (2004). Chemical composition and *in vitro* gas production characteristics of several tannin containing tree leaves. Livestock Research for Rural Development, 16(6).

Karabulut, A., O. Canbolat, H. Kalkan, F. Gurbuzol, E. Sucu and I. Filya (2007). Comparison of in vitro gas production, metabolizable energy, organic matter digestibility and microbial protein production of some legume hays. Asian-Australasian Journal of Animal Science, 20:517-522.

Kariuki, J.N., G.K. Gitau, C.K. Gachuiri, S. Tamminga, Van Bruchem, J.M.K. Muia and

K.R.G. Irungu (1998). Effect of feeding Napier grass, lucerne and sweet potato vines as sole diets to dairy heifers on nutrient intake, weight gain and rumen degradation. Livestock Production Science, 55:13-20.

Kinyua, J.M. (2013). Assessing the potential of sweet potato cultivars as protein supplement and energy feed in milk plant areas. MSc Thesis, Egerton University, Njoro. Kenya.

Kumar, C.V. and V. Devender (2010).Effect of plant age at harvest and season on the hydrocyanic acid potential of some sorghum cultivars. Indian Journal of Animal Nutrition 27:142-146.

Meissner, H.H., H.H. Koster, S.H. Nieuwuodt and R.J. Coertze (1991). Effect of energy supplementation on intake and digestion of early and mid-season rye grass and panicum/smuts finger hay. South African Journal Animal Science, 21:33-42.

Minson, D.J. (1990). Forage in Ruminant Nutrition. Academic Press, London.

Miron, J.R., G. Solomon, G. Adin, U. Nir, M. Nikbachat, E. Yosef, A. Carmi, Z.G.

Weinberg, T. Kipnis, E. Zuckerman and D. Ben-Ghedalia (2006). Effects of harvest stage, re-growth and ensilage on the yield composition and in vitro digestibility of new forage sorghum varieties. Journal of the Science of Food and Agriculture 86:140-147.

Ouda, J.O., G.B. Ashiono, K.R.G. Irungu, F.O. Ondabu and S.W. Gatwiku (2004). Sustaining milk production by use of sorghum silage and sweet potato vines. Proceedings of the 8th Biennial KARI Scientific Conference, 11th -15th November, 2002, Nairobi, Kenya. pp 389-392.

Ouma J. P. and T. E. Akuja (2013). Agronomic and morphological performance of sorghum for the dry highlands of Kenya. Journal of Applied Biosciences 63: 4720-4726.

Ouma, J.P., K.R.G. Irungu, M.N. Gaithuma and P.M. Maina (1995). Highland forage sorghum in Kenya: What Prospects? In: S.Z. Mukuru and S.B. King (Eds.) Proc. Eighth EARSAM Regional Workshop on Sorghum and Millets, 30 Oct-5 Nov 1992 Wad Medani, Sudan. pp. 192 - 195.

Pasha, T.N., E.C. Prigge, R.W. Russell and W.B. Bryan (1994). Influence of moisture content of forage diets on intake and digestibility by sheep. Journal of Animal Science 72:2455-2463.

Pospisil, A., M. Pospsil, D. Macesic and Z. Svecnjak (2009). Yield and quality of forage sorghum and different amaranth species (Amaranthus spp) biomass. Agriculturae Conspectus Scientificus 74:85-89.

Preston, T.R. and R.A. Leng, (1987). Matching Ruminant Production Systems with Available Resources in the Tropics and Sub-tropics. Penambul Books, Armidale.

Relling, E.A., W.A. van Niekerk, R.J. Coertze and N.F.G. Rethman (2001). An evaluation of Panicum maximum cv Gatton: 3. The partial digestion by sheep of organic matter, nitrogen and neutral detergent fibre of herbage at three stages of maturity during summer, autumn or winter. South African Journal of Animal Science 31:93-99.

Robinson, P.H., P.L. Burgess and R.E. McQueen (1990). Influence of moisture content of mixed ratons on feed intake and milk production of dairy cows. Journal of Dairy Science, 73: 2916-2923.

Sarfraz, M., N. Ahmad, U. Farook and A. Ali (2012). Evaluation of sorghum varieties/lines for hydrocyanic acid and crude protein contents. Journal of Agriculture Research 50:39-47.

SAS, (2003). Users Guide, release 6.03 Edition. Cary, NC, USA. N.

Semenye, P.P., J.F.M. Onim, W.T. Conelly and H.A. Fitzhugh (1989). On-farm evaluation of Dual- Purpose goat production systems in Kenya. Journal of Animal Science, 67:3098- 3102.

Sher, A., M. Ansar, F.U. Hassan, G. Shabbir and M.A. Malik (2012). Hydrocyanic acid content among sorghum cultivars grown with varying seed rates and nitrogen levels. International Journal of Agriculture and Biology 14: 720-726.

Smit, C.J., (2014). Effects of sweet potato forage meal on protein and energy supply, beta carotene and blood glucose content in dairy cattle milk. MSc Thesis. University of South Africa.

Snijders, P.J.M., Muia, J. and J.N. Kariuki (1992). Yield and quality of sweet potato vines harvested at different stages, Research Report, Naivasha, Kenya.

Strasia, C.A and D.R. Gill (1990). Formulating feedlot diets. Great Plains Beef Cattle Handbook. Animal science Research Report. Agricultural Experimental Station, Oklahoma State University. Fact Sheet. 1600-1625.

Torrecillas, M., M.A. Cantamutto and L.M. Bertoia (2011). Head and stover contribution to digestible dry matter yield on grain and dual-purpose sorghum crop. Australian Journal of Crop Science 5:116-122.

Van Soest, P.J., J.B. Robertson and B.A. Lewis (1991). Methods for dietary fibre, neutral detergent fibre, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74:3583-3597.

Influence of Moisture Regime and Soil Fertility on Growth and Development of Alternative Fodder Grasses to Napier in Western Kenya

Munyasi, J.W.[1], Auma, E.O.[2], Ngode, L.[2] and Muyekho, F.N.[3]

[1]Kenya Agricultural and Livestock Research Organization, Kakamega, P.O Box 169-50100, Kakamega Kenya
[2]University of Eldoret, P.O Box 1125-30100, Eldoret
[3]Masinde Muliro University of Science and Technology, P.O Box 190-50100 Kakamega
*Corresponding author: Email Address: jwmunyasi@gmail.com Mobile No. +254 720 860 938

Abstract

The description of morphological characteristics of plants is based on the canopy diameter, plant height, number of tillers, leaf length, stool diameter, leaf width and leaf numbers. A study was conducted at the university of Eldoret in the green house to investigate the influence of moisture regime and fertilizer level on morphological characteristics of two alternative fodder grasses (*Panicum maximum* Jacq and *Tripsacum laxum)* Scrib and Merr*)* and a Napier grass *cv Ouma*. A randomized complete block design replicated three times using factorial arrangement in relation to three moisture regimes (two, four and six days watering) and two fertilizer levels (recommended rate of 100kg/ha of DAP and control). Root split forage species were planted in pots filled with parental loam soil. The morphological parameters were measured on weekly basis for a period of 15 weeks after planting and coloration analysis computed to establish relationship between parameters. The ANOVA results showed significant differences between species ($p<0.05$), moisture regimes ($p<0.05$) and fertilizer levels ($p<0.05$) on parameters height, canopy diameter, number of tillers, leaf length and leaf width. Napier was the tallest (91cm) and the widest in canopy diameter (63 cm). *Panicum maximum* developed largest number of tillers (19) followed by Napier (16) while *Tripsacum laxum* had the least tillers (12). There was a positive correlation between the plant height, canopy diameter, leaf numbers, and length with shoot yield. It is concluded that irrigation of fodder at intervals of two and four days alongside fertilizer application morphologically performed better than at six days interval regardless of fertilizer application. These plant morphological responses to moisture regimes and fertilizer levels indicate the importance of soil moisture and fertilizer to plant growth and development for plant productivity. Therefore farmers in western Kenya should apply fertilizer at recommended rate alongside irrigation interval of either two or four days in order to attain optimum fodder growth.

Key words: Morphological characteristics, Irrigation interval, Pasture improvement

Introduction

Water and soil nutrients are major abiotic factors that commonly effect plants for higher yield and development (Lambers 1998). Inadequate water at critical stages of plant affects the morphological structures of the plant and productivity (Bahmani 1999). However, plants may vary in acquisition and efficient use of water depending on the rooting system, leaf numbers, positioning of the stomata and environmental conditions (Lambers 1998). While reviewing the influence of soil moisture in plant growth and seed yield, Muyekho (1993) observed that plant morphogenesis such as leaf area development, branching, root growth and physiological processes affects reproductive growth. Van Loo (1992) measured leaf area expansion of perennial ryegrass and observed reduced leaf appearance due to water stress. The total leaf area of a plant however, does not remain constant after all the leaves have matured but some leaves drop due to senescence or physiological adaptation to drought (Lamber 1998).

Physiological relationship exists between plant tolerance to moisture stress and secondary shoot formation (Lambers 1998). In an experiment comparing corn (*Zea mays*) and Sorghum (*sorghum bicolar*), Lambers (1991) showed that Sorghum continued to grow and flower after main shoot had fully matured because of secondary shoots. This was unlikely for corn which hardly develops secondary shoots. Water deficiency in

stressed plants tends to occur during day time when evapo-transpiration rate is high but rehydrated at night stimulating substantial leaf growth (Taiz and Zeiger 2002). However, because of changes in sensibility and yield threshold, the growth rate is still lower than that of unstressed plants at the same turgor.

Water stress limits not only the size of individual leaves, but also the number of leaves on a plant, because it decreases both the number and the growth rate of the branches (Lambers *et al*.1998). The growth of stems is also affected by the same forces that limit leaf growth during the same stress. In addition, water stress deficit affects the development of root system as the root-shoot relations appear to be governed by a functional balance between water uptake by the root and photosynthesis by the shoot (Lambers *et al*. 1998). When water uptake is curtailed, leaf expansion is affected very early, but photosynthesis activity is much less affected. Inhibition of leaf expansion reduces the consumption of carbon-dioxide and energy and a greater part of the plant assimilates are distributed to the root system where they can support further growth (Lambers*et al*.1998).

Effects of water stress on fodder grass yield are less well understood (but presumably are related to complex structural changes in the cell wall Lambers *et al*.1998). Pasture improvement levels require detail information on agronomic management practices that are tailored to practical system for the farm and which meets the economic goals of the farmer. The most practical and effective method to increase dry matter yield and quality production in pasture farming is with the use of appropriate and adequate fertilizers (Frame, 1992). Fertilization can increase dry matter yield up to two or three folds in areas with poor soil nutrients and annual rainfall of over 400 mm (Elliot and Abbott, 2003). Nitrogen and Phosphorus are usually the main limiting nutrients to fodder productivity, with potassium being an occasional constraint (Mafongoya *et al.* 2000). The selection and management of fodder crops for dairy production requires a quantitative and qualitative knowledge of the morphological characteristics of the fodder in relation to biomass yield. Important factors that influence morphological characteristics of the plant are the biotic and abiotic factors (Assuero and Tognettiet 2010) which should be adequately understood. The objective of the study was to establish the influence of moisture regime and fertilizer level on morphological characteristics of selected alternative fodder grasses (*Panicum maximum* and *Tripsacum laxum*) and Napier *cv Ouma.*

Materials and methods

The experiment was carried out at the school of Agriculture, University of Eldoret in a greenhouse under natural daylight from March to June 2013. The temperature was partially regulated and measured within two minimum and maximum thermometers, which showed the mean maximum temperature of 28^0C and the mean minimum temperature of 23^0C. The pH of the soil at the start of the experiment was 5.1% indicating that the soil was moderately acidic. The carbon content of the soil was 3.4% (Table 1) which indicated that the soil was moderately fertile for crop production. This soil was sourced from KALRO Kakamega site.

Table 3 Nutrient analysis of the parental soil

Soil Attributes	Mean
Soil pH (1:2.5 soil: water)	5.1
Organic carbon%	3.4
Nitrogen%	0.2
Olsen P (mg kg^{-1})	7.0
Sand%	72
Clay %	18
Silt%	10
Textural Class	Sandy-loam

Experimental Treatments

The treatment consisted of three irrigation frequencies, three species and two fertilizer levels. These three irrigation frequencies were 2-days interval of irrigation, 4-days interval of irrigation and 6-days interval of irrigation that were randomly distributed within the blocks. The species which were tested included *Panicum maximum*, *Tripsacum laxum* and Napier *cv Ouma*, which were randomly distributed within the blocks. The level of fertilizers tested were no application of fertilizer and application of fertilizer distributed randomly within the blocks. There were 18 treatments replicated three times

Design and plot layout for greenhouse experiment

A Randomized Complete Bock Design (RCBD) with three replicates of factorial arrangement of treatments (irrigation interval, fertilizer and species) was used. Three moisture levels were imposed by adding water to the soil after two days, four days and six days at field capacities. The two fertilizer levels were F1 = no fertilizer and F2 recommended fertilizer level of 100kg/ha of DAP was applied. The species were *Panicum maximum* grass, *Tripsacum laxum* and Napier grass *cv Ouma*.

Establishment of greenhouse experiment

The sample parental sandy loam soil of the three fodder grasses were prepared by digging at the depth of 15 cm deep, targeting the top layer. The soil was handy screened to remove weeds before transported to the green house at the University of Eldoret. However, prior to filling the soil in 15-litre plastic pots, it was dried on the sun for a period of three days and sieved through a 0.5 cm screen to further remove weeds and other impurities. The soil mineral analysis was carried out to determine mineral composition of the soils (Table 1). One root- split sample of each fodder grasses and Napier *cv Ouma* was uprooted at 15 cm deep **(**Donkor *et al*. 2003) from the parent field at KALRO Kakamega. The root-split sample of each fodder grass was placed carefully into a 30 cm-diameter and 15 cm deep plastic pot with little disturbance as possible. To prevent channeling of water along the outer edge of the soil core after watering, the small space between the edge of the soil and walls of the tin was carefully filled with soils collected from the edges of the holes left by digging the fodder grass. To avoid water logging in the pots, five tiny holes were opened at the bottom of the pots to allow free drainage. The moisture level treatment was applied by a means of gravimetric method described by (Donkor*et et al*. 2003). The moisture content of the soil at field capacity was determined on three replicate samples. The pots were brought to field capacity by standing their bases in water until the waterfront reached the top of the pot. The pots were removed and left to stand on an elevated wire grid to allow draining of water freely through the basal holes. At this water content, the pots were weighed. The figure obtained was the value of moisture content at field capacity that was maintained to provide a required water regime. The green house was maintained at an air temperature ranging between 23^0C to 28^0C with 18 hour photoperiod (Donkor *et al*. 2003). Morphological and phenological observations were made on weekly period for the two grasses and Napier *cv Ouma* on their response to treatments. Morphological characteristics of the plants were taken as follows: plant height, tillers number and leaf-length leaf-width and canopy diameter. Total root DM in the fodder grasses was measured at the end of the experiment. Below ground material was separated from soil by soaking each core in water for one hour. These samples were hand washed over a set of three sieves of sizes 1.18mm, and separated into roots and shoot. Samples were oven dried at 60^0C for 72 hour and weighed. The root: shoot ratios was computed for each fodder species as the total below-ground DM over the total accumulated shoot DM (live and dead material).

Parameters measured

These included weight of dry matter (Above and below ground biomass), canopy diameter, plant height, number of tillers, leaf length, stool diameter, leaf width and leaf numbers as already described in section

Statistical analysis

Statistical analysis was done using the Statistical Analysis System (SAS). Differences among the treatments were tested by analysis of variance (ANOVA) and compared using Standard Error Means (SEM) at the 5%

level of significance (Gomez and Gomez 1984). Correlation analysis was carried out to determine the association of the treatment effects and the morphological characteristics and biomass yield observed.

Results and discussions

Changes in plant height over time for various fodders species

Panicum maximum, Napier *cv Ouma* and *Tripsacum laxum* differed significantly ($p \leq 0.05$) in plant height regardless of fertilzer application and irrigation intervals (Figure 1a). The plant heights of the forage species increased steadily irrespective of moisture levels and fertilizer applications. This is not surprising since all the plants had just been planted and were still utilizing the parental fertile soil. However, after three weeks of date of planting, Napier *cv Ouma* started to out-compete other species in height throughout the growth period. This result is in agreement with Orodho (2006) who found Napier grass as a heavier feeder than several other fodder species suggesting that it utilizes more efficiently nutrients absorbed from the soil for growth than alternative grasses. Napier *cv Ouma* and *Tripsacum laxum* peaked about 17 WAP to plant height 91 cm and 75.4 cm respectively while *Panicum maximum* peaked about 14 WAP at plant height 71.1 cm. The growth height responses of the three fodder species were determined by the moisture levels in the soil as well as the available soil nutrients to the growing plants. In addition, different grasses respond differently to water use efficiency and nutrient absorption (Lambers *et al.* 1998). The Napier *cv Ouma* maintained superior heights over other species followed by *Panicum maximum* and least was *Tripsacum laxum* when fertilizer was added and irrigated at 2-days intervals. The influence of 2-days irrigation interval and fertilization on the height of Napier *cv Ouma* could be explained by better utilization of growth resources by Napier *cv Ouma* than *Tripsacum laxum* and *Panicum maximum*. A similar trend was observed in the canopy diameter and tillering ability for Napier *cv Ouma*, which is associated with the manner in which plants absorb and utilize nutrients in the soil.

Changes in leaf numbers over time for various fodders species

The leafing ability between *panicum maximum*, Napier *cv Ouma* and *Tripsacum laxum* differed significantly ($p \leq 0.05$) in the fertilizer applied and irrigation intervals received (Figure 1c) The number of leaves per tiller on forage species was steady in the first two weeks after planting but started fluctuating and dropped sharply at the fourteenth week. It however emerged that Napier *cv Ouma* mantained the highest number of leaves throughout the growth period, followed by *Tripsacum laxum* and *Panicum maximum* was the least. This was reflected in the biomass yield as shown in the field experiment where Napier cv Ouma out-yielded other species.

Changes in leaf length over time for various fodders species

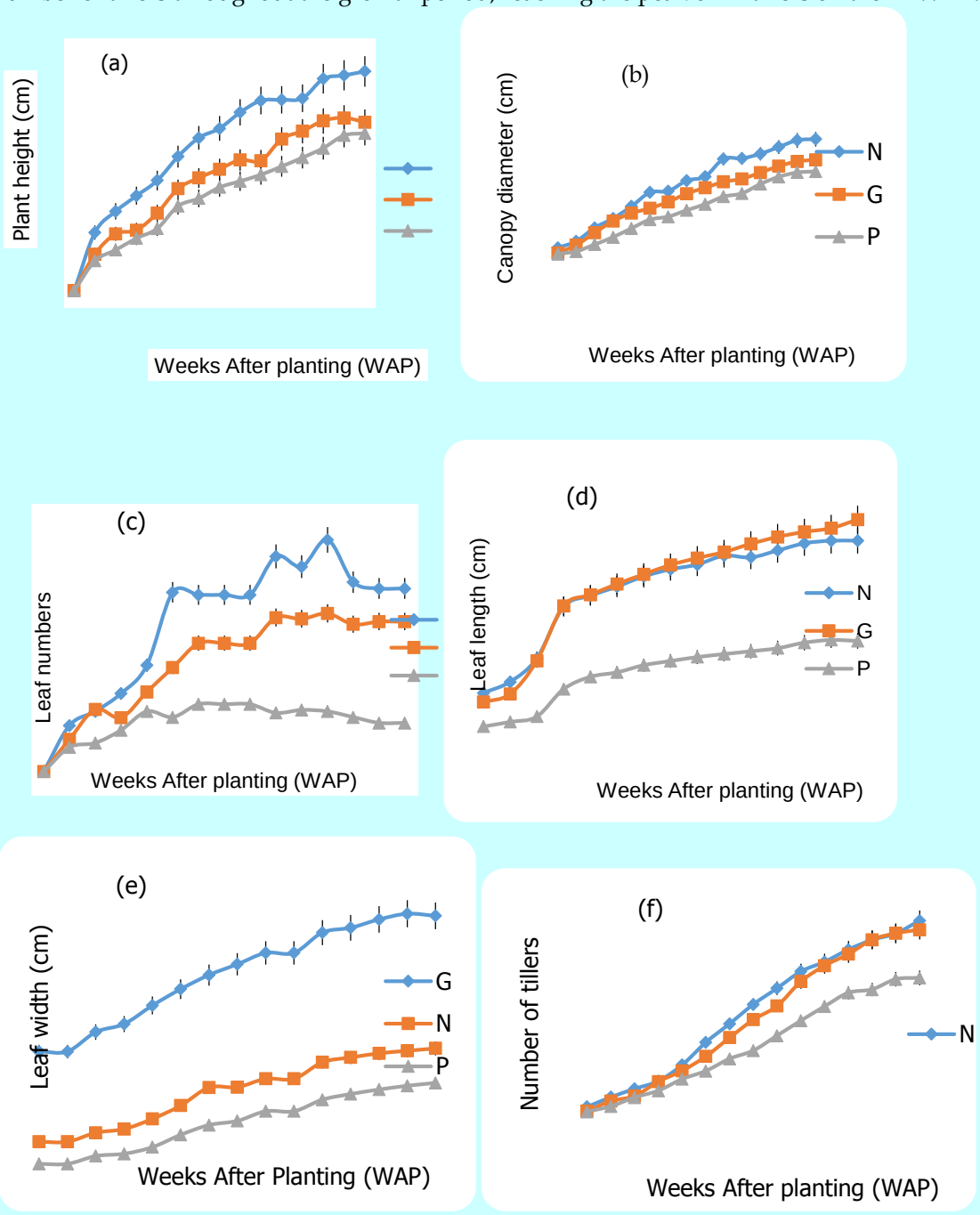
Napier *cv Ouma* and *Tripsacum laxum* were significantly different ($p \leq 0.05$) from the *Panicum maximum* in leaf length (Figure 1e). The length of leaf for Napier *cv Ouma* and *Tripsacum laxum* increased sharply up to 4 WAP to 48 cm. This trend was later mantained up to 15 WAP. *Panicum maximum* had the shortest leaf length throughout the growth period, reaching the peak of 38 cm on the 15 WAP. Naturally morphological leaf length of *Tripsacum laxum* and Napier *cv Ouma* are superior than *Panicum maximum* which was also expressed in the current study.

Changes in leaf width over time for various fodders species

Tripsacum laxum, Napier *cv Ouma* and *Panicum maximum* differed significantly in leaf width (Figure 1f). *Tripsacum laxum* showed significantly the widest leaf width throughout the growth period followed by Napier *cv Ouma* and the shortest was *Panicum mximum*. The leaf width for *Tripsacum laxum* increased steadily from 2.5 cm at week one after planting and peaked at 15 WAP with the width of 4.8 cm. *Panicum maximum* mantained the shortest leaf width throughout the growth period, reaching the peak of 1.8 cm on the 15 WAP.

Changes in number of tillers per stool over time for various fodders species

The tillering ability of Napier *cv Ouma* and *Panicum maximum* differed significantly (p≤0.05) with *Tripsacum laxum* throughout the growing period (Figure 1d). The number of tillers for Napier *cv Ouma* and *Panicum maximum* increased steadily, peaking equally on the 19 WAP to 18 tillers. *Tripsacum laxum* had the lowest number of tillers throughout the growth period, reaching the peak of 12 tillers on the 17 WAP.



Note: N= Napier grass, G= Guatemala grass and P=Panicum

Bars represent the SEM, p≤0.05

Figure 1:Growth trends of forage species in relation to plant height (a) Canopy diameter (b) Leaf numbers (c) Number of tillers (d) leaf width (e) and leaf numbers (f) number of tillers regardless of moisture regime and fertilizer application

Effect of Irrigation intervals on growth and development of selected alternative grasses to Napier in western Kenya

Plant height per tiller

There was significant difference (P≤0.05) between the irrigation intervals after two days, four days and six days on plant heights (Figure 2a). Irrigation of forage species after two days influenced plant height and peaked at 16 WAP to plant height of 95.8 cm while forage species irrigated at four days interval peaked at 16 WAP and plant height of 78.8cm. Watering at an interval of six days showed the lowest plant heights throughout the experimental period compared to watering at two and four intervals, suggesting that frequent irrigation denied the forage plant growth stress and therefore expressed optimal growth heights. However, infrequent watering similar to 6-days interval contributed to plant wilting and consequently dormancy in growth because the presence of moisture plays important roles in physiological functioning of the plant.

Leaf numbers per tiller

Irrigation of the plants at the interval of two, four and six days showed significant difference (p≤0.05) in leaf numbers (Figure 2c). Watering at an interval of two and four days stimulated the formation of more leaves than six days, which peaked at 10 WAP with both levels having seven leaves. However, watering at an interval of six days stimulated the lowest number of leaf formation throughout the growing period, attaining the peak at 10 WAP with six leaves. Number of leaves correlates with biomass production and active growth of the plant. Frequent watering influenced leaf formation which contributed to greater biomass yield.

Leaf length per tiller

Forages irrigated at an interval of two, four and six days significantly differed (p≤0.05) in leaf length throughout the growth period (Figure 2d). Irrigation after every two and four days showed the longest leaf (7.5 cm) at 10 WAP, followed by a decline due to senescence of some old leaves, which appeared to have been the longest. However, watering after every six days caused stunted growth of leaf length. This could be attributed to the influence of moisture stress on stomata opening and closing in the plant. Thus, during moisture stress, stomata close to conserve water. This also closes the pathway for exchange of water, carbon-dioxide and oxygen resulting in decrease in photosynthesis, which eventually affect leaf elongation and growth as shown in this study. Less frequently watered forage experienced the same effect of short leaf length and width which translated into reduced leaf area. This is a modification strategy to avoid evapo-transpiration loss (Anonymous 2010) and increase water use efficiency which helped to tolerate water stress. Low leaf surface area would reduce transpiration rate also by lowering stomata activity (Riaz *et al.* 2008).

Leaf width per tiller

Watering of the plants after every 4 days did not differed significantly (p≤0.05) with irrigation intervals of 2-days but differed significantly with and 6 days throughout the growth periods (Fig e). Watering after every 2 and 4 days stimulated the widest leaf growth throughout the experimental period regardless of fertilizer application and fodder species. This is in agreement with the findings of Riaz *et al.* (2008) that water stressed plants similar to the 6-days frequency of watering in the current study reduced the volumes of aerial parts as an adaptation mechanism to survive during water stressed period. In addition, they further established that water stressed plants expands their root system to draw water from the depth soils. Forge species under 6-days interval of irrigation showed signs of wilting, folding, and discoloration but regained leaf structure when watered, which re-absorbed water to compensate deficiency experienced over a long period of stress.

Number of tillers per stool

There was significant difference between the three irrigation intervals (P≤0.05) with respect to numbers of tillers (Figure 2f). Plants irrigated at an interval of two and four days influenced formation of more tillers

than those irrigated at six days intervals. However, significant difference was observed between irrigation interval of four and two days from the 13 WAP with the 4 weeks irrigation interval out-tillering the two days irrigation interval. Irrigation interval of six days had the lowest number of tillers throughout the growing period attaining the peak at 17 WAP with 13 tillers. Tillering ability is influenced by growth factors such as moist and fertile soils. Jonassen (1992) found that imposing delaying watering of ryegrass for three weeks had severe effect on tillering.

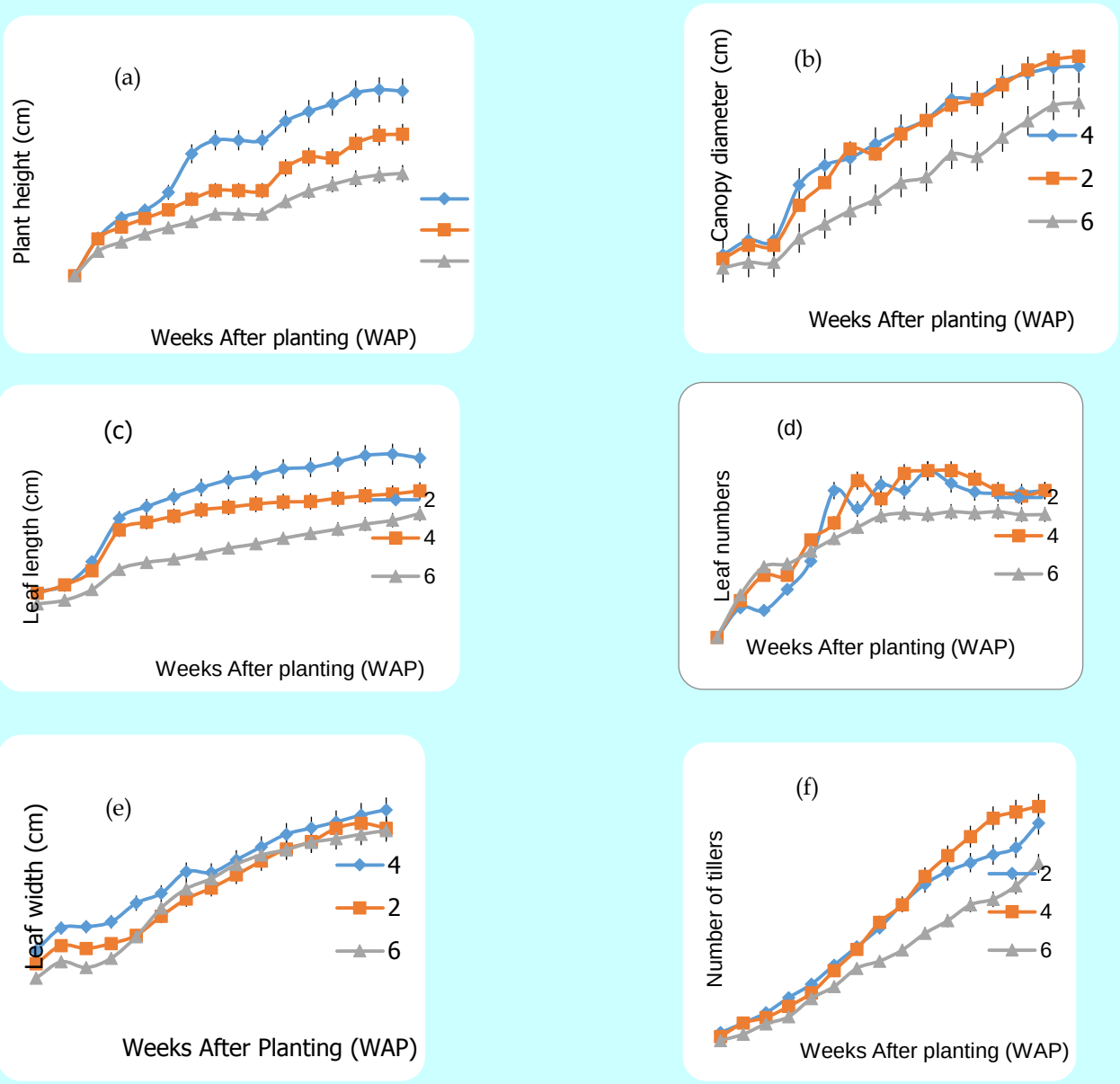


Figure 2: Effect of moisture regimes on growth of plant height (a) canopy diameter (b) leaf number (c)leaf length (d) leaf width (e) and number of tillers (f) regardless of species and fertilizer application

Effect of fertilizer level on growth and development of selected grasses in western Kenya

Plant height

Application of fertilizer at the rate of 18kg/ha of N increased plant height steadily and were above those which were not fertilized throughout the samplings (Figure 3a). Plant height of forages which were fertilized peaked at 14 WAP, at the height of 82 cm while those not fertilized peaked at 13 WAP at 72 cm height. Similar results were observed by Gasim (2001) and were associated with input of nitrogen fertilizer which promotes plant growth, increases the number of internodes and length of the internodes which results in progressive increase in plant height. These findings are in full agreement with Akintoye (1996) that increase plant height with application of fertilizer and is probably due to the increase in number of leaves (Figure 3c) under nitrogen treatments, producing more and heavy leaves. However, the increase in plant height for the non-fertilized plants at relatively similar pace could be attributed to the parent soil which was rich in organic compound sourced from the previous land use.

Leaf numbers per tiller

The number of leaves per tiller differed significantly ($p \leq 0.05$) between those which received fertilizer and those not fertilized regardless of frequency of irrigation (Figure 3c). Plants which received fertilizer increased leaves steadily above those which were not fertilized throughout the growth period. The fertilized plants peaked at 10 WAP, with 8 leaves while those which were not fertilized peaked at 10 WAP with 7 leaves. After 10 weeks of planting, the number of leaves dropped steadily regardless of either the fodder species, fertilized and irrigated. While studying the effect of Nitrogen on fodder maize, Amin (2011) found that increase in the number of leaves per plant could possibly be described to the fact that nitrogen often increases plant growth and plant height. This resulted in more nodes and internodes and subsequently more production of leaves. This explanation could be attributed to the current study since plants which were fertilized were taller and had more leaves.

Leaf length per tiller

There was a significant difference ($p \leq 0.05$) between fertilized plants and those not fertilized in leaf length per tiller (Figure 3d). Both treatments increased their leaf length sharply from the first WAP until the fourth WAP with fertilized plants attaining longer leaves than those not fertilized. However, those attained increase remained relatively constant until after the fourth WAP, when the fertilized plants attained longer leaf size than those not fertilized. The fertilized plants peaked at 15 WAP, with 62 cm while those not fertilized peaked at 15 WAP with 48 cm. This result may have occurred due to the increase in leaf elongation provided by the greater availability of nitrogen in the soil and tiller height that contributed to the longer leaf blade length (Roma *et al*. 2012, Skinner and Nelson, 1995).

Leaf width per tiller

There was a significant difference ($p \leq 0.05$) in leaf width between plants applied with fertilizer at recommended rate and those which were not applied with fertilizer (Figure 3e). Plants applied with fertilizer at the recommended rate of 18kg/ha of N increased leaf width steadily above those which were not applied with fertilizer. The fertilized plants peaked at 15 WAP, with 3.3 cm while non-fertilized peaked at 15 WAP with 2.8 cm (Figure 3d). The relatively wide width of the non-fertilized plants could be attributed to the rich parental soil which sustained the growth of the plants but at a lower width compared to the fertilized plants.

Number of tillers per stool

There was a significant difference ($p \leq 0.05$) between plants applied with fertilizer and those which were not fertilized in tillering ability regardless of frequency of irrigation (Figure 3f). Fertilized fodders increased the number of tillers steadily and were above those which were not applied with fertilizer throughout the sampling period. The fertilized plants peaked at 15 WAP, with 18 tillers while non-fertilized peaked at 15 WAP with 14 tillers. In agreement with the current study, Kizima *et al*.(2014) reported that application of fertilize significantly affected the appearance of new tillers and increased the dynamics of tiller population

of the pasture. These findings are further supported by Mushtaque *et al.* (2010) who reported that fertilizer application triggers the activation of dormant buds and enhances the vegetation sward filling through the highest rate of tiller replacement, which supports a higher proportion of very active healthier young tillers for each plant. This results in higher tiller density and consequently increases seed and biomass production.

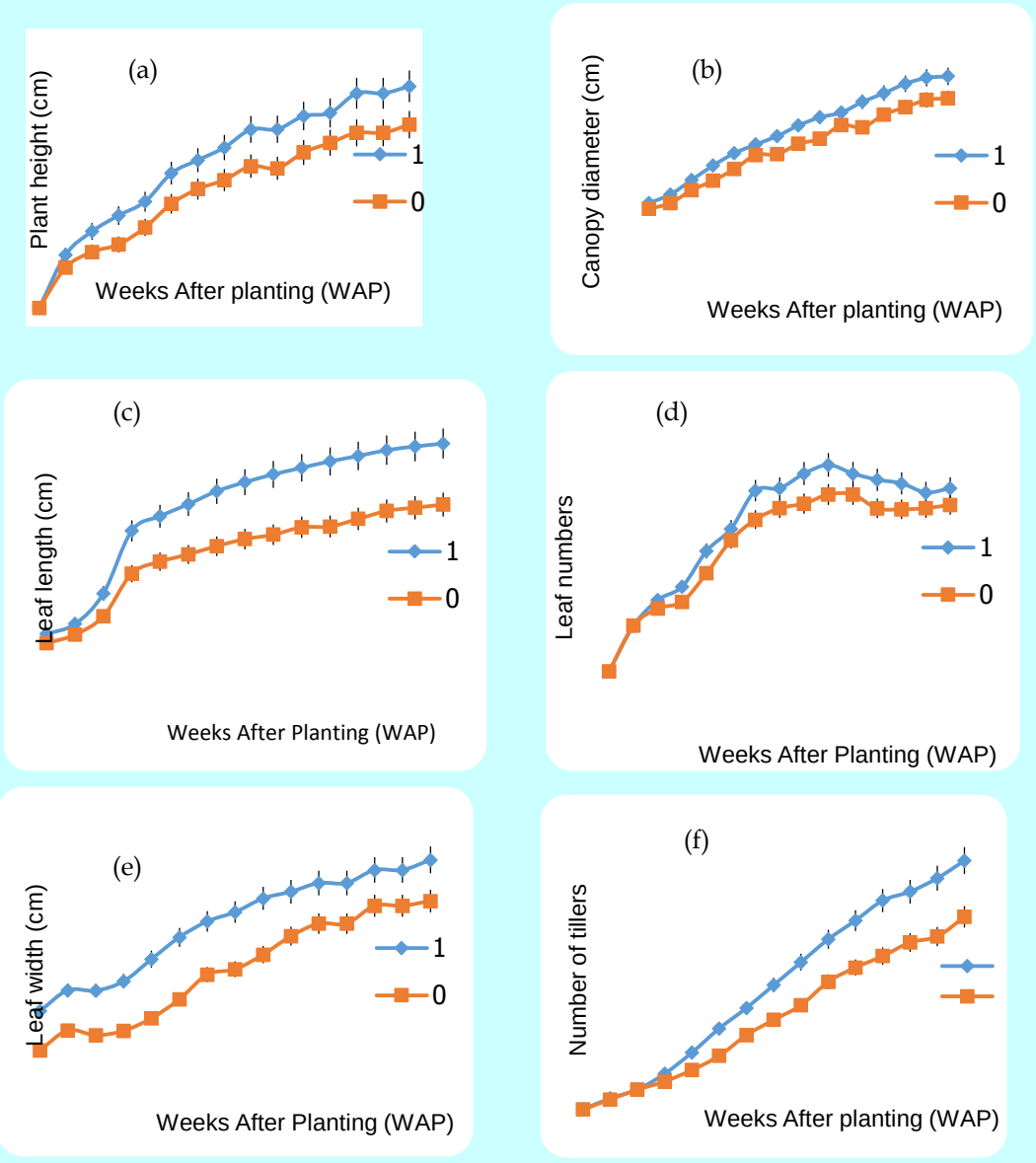


Figure 3: Effect of fertilizer application on plant height (a) canopy diameter (b) leaf numbers (c) number of tillers (d) leaf width (e) and numbers of tillers (f) regardless of species and moisture regimes.

Correlation matrix for morphological characteristics and biomass yield

There was a significantly correlation between plant height and canopy diameter ($r=0.67$, $p\leq0.05$), root biomass ($r=0.63$, $p\leq0.05$) and shoot biomass (0.64, $p\leq0.05$). There was also significant correlation (0.60, $p\leq0.05$) between numbers of tillers and canopy diameter.

The length of leaves was significantly and positively correlated with percentage root dry matter (0.84, $p\leq0.05$) and shoot biomass (0.76, $p\leq0.05$). This could be associated with increase in leaf formation, stem elongation and tillering ability which increase the biomass production which was also reported by Assuero and Tognettiet (2010). There was a significant positive correlation ($r=0.60$, $p\leq0.05$) between the leaf numbers

and tillering ability. This may be attributed to the close link between leaf development and tiller formation (Assuero and Tognettiet (2010). Nascimento Junior (2002) reported the number of leaves in a tiller as an important reference to the tillering potential because each axillary, can potentially generate a new tiller, and therefore can change the structural characteristics of forage. In their findings, Assuero and Tognettiet (2010) described tiller production as a function of leaf appearance rate, which may double the appearance of new leaf on the main stem. Napier *cv Ouma* recorded the highest number of leaves which later decline at the peak of 10 leaves due to natural senescence. Few leaves in *Panicum maximum* grass may be attributed to the formation of inflorescence and stem elongation over the synthesis of new leaves as demonstrated by Wentao *et al.* (2013) and my personal observation during the experimental period.

Table 4:Correlation matrix for mophological characteristics and biomass yield

Plant attributes	Plant height	Canopy diameter	Leaf numbers	Leaf length	Leaf width	Number of tillers	%DM root	%DM shoot
Plant height		0.67*	0.26*	0.52*	0.21	0.42*	0.63*	0.64*
Canopy diameter			-0.05	0.06	-0.31*	0.60*	0.25*	0.32*
Leaf numbers				0.63	0.33*	0.60*	0.25*	0.32*
Leaf length					0.60*	-0.17	0.84*	0.76*
Leaf width						-0.40	0.36*	0.15
Number of tillers							0.02	0.14
% DM root								0.94
% DM shoot								

*****Significant at α = 0.05

Conclusion

There were significant difference in plant heights, canopy diameter, number of tillers, leaf-length and leaf width between species, where Napier *cv Ouma* was taller and wider in canopy diameter than *Panicum maximum* and *Guatemala laxum* regardless of interval of irrigation and fertilizer level.

Panicum maximum outnumbered Napier *cv Ouma* and *Guatemala laxum* in tillers *regardless of interval of irrigation and fertilizer level*.

There was a positive correlation between the plant height, canopy diameter, leaf numbers, and length with shoot yield. These plant morphological responses to moisture regimes and fertilizer levels indicate the importance of soil moisture and fertilizer to plant growth and development for plant productivity.

Acknowledgment

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Reference

Assuero S and Tongnetti J.A (2010). Tillering regulation by endogenous and environmental factors and its agricultural management. The American Journal of Plant Science and Biotechnology 4 (special issue 1): 35-48.

Anonymous (2010). Drought tolerance in ornamental grasses. ttp://www.bluestem.ca/drought- (accessed December 2014).

Amin MEH(2011). Effect of different nitrogen sources on growth, yield and quality of fodder Maize (Zea mays L.). Journal of Saudi Society of Agricultural Science, 10: 17–23.

Bahmani I, (1999). Tiller dynamics and leaf growth process of the perennial ryegrass cultivars 'Ellett' and 'grassland ruanui' as influenced by environmental factors. PhD Thesis. Institution of Natural Resources, College of Sciences, Massy University, Palmertson North, New Zealand.

Donkor NT, Bork EW and Hudson RJ (2003). Defoliation Regime Effects on Accumulated Season-long Herbage Yield and Quality in Boreal Grassland. Journal of Agronomy and Crop Science, 189: 39—46.

Elliott DE and Abbott RJ (2003).Nitrogen fertilizer use on rain-fed pasture in the mount Lofty Ranges. Pasture mass, composition and nutritive characteristics. Australian Journal of Experimental Agriculture, 43: 553-577.

Frame J (1992). Improved Grassland Management. Farming Pres Books, Ipswich.

Gomez KA and Gomez AA (1984). Statistical procedures for agricultural research. An international rice research institute Book. A willey publication.

Gasim SH (2001). Effect of nitrogen, phosphorus and seed rate on growth, yield and quality of forage maize (Zea mays L.) MSc. Thesis, Faculty of Agriculture, University of Khartoum.

Jonassen GH (1992). Effects of experimental drought periods, irrigation and nitrogen fertilization in meadow fescue (Festuca pratensis Huds) seed meadows. (Norwegian). Norsk Landbruksforsking 6: 245–260.

Akintoye (1996). Thesis Abstract, International Institute of Tropical Agricultural Research: 25–27.

Kizima JB, Mtengeti EJ and Nchimbi-MsollaS (2014). Seed yield and vegetation characteristics of CenchrusCiliaris as influenced by fertilizer levels, row spacing, cutting height and season.Livestock research for Rural development, 26 (8).

Lambers H, Chaplain III FS, Pons TL (1998). Plant physiological ecology.

Mafongoya PL, Barakk P and Leed JD (2000). Carbon, Nitrogen, and Phosphorus mineralization of tree leaves and manure. Biology and Fertility of Soils 30: 298-305.

Mushtaque M, Ishaque M, Haji M AA and Bakhsh A (2010). Influence of maturity on morphological characters and biomass of buffel grass. Pakistan Journal of Science, 62 (2).

Muyekho FJN (1993). Environmental and agronomic factors affecting seed production in annual medics. PHD Thesis submitted University of Adelaide.

Nascimento Junior D, Barbosa RA and Andrade CMS (2002). Fundamentals of Pasture Management: Evolutionand Current Status. Proceedings of 1st Symphosium on Strategic Pasture Management: 149-196.

Orodho AB (2006). The role and importance of Napier grass in the smallholder dairy industry in Kenya

Riaz A, Younis A, Hameed M and Kiran S (2008). Morphological and biochemical responses of Turf grasses to water deficit conditions. Pakistan Journal of Botany 42(5): 3441-3448.

Skinner, RH and Nelson CJ (1995). Elongation of the grass leaf and its relationship to the phyllochon. Crop Science, 35:4-10.

Taiz L and Zeiger E (2002). Plant physiology (3rdd Edition).Publisher Sinauer Associate inc. Sunderland USA.

Van Loo EN (1992). Tillering, leaf expansion and growth of plants of two genetic lines of perennial ryegrass grown using hydroponics at two water potentials. Annals of Botany 70: 511-518.

Wentao L, Xyewang YJX, Mai-He L, Bai E, Han X, Zhuwen X (2013). Patterns of plant biomass allocation in temperate grassland across a 250km transect in Northern China.DOI:10:137/Journal.Pone.0071749.

Processed *Accea tortilis* pods and local grass as dry season feed supplements for lactating goats in rangelands of northern Kenya

Lengarite M. L., and Walaga H. K.

Kenya Agricultural and Livestock Research Organization, Sheep and Goat Research Institute,
P.O Box 147, Marsabit, Kenya

Abstract

This research brief report the findings of an on-farm feeding trial conducted at Olturot area in northern Kenya. We used 20 lactating Small East African goats owned by one pastoral producer. In the trial we set out to understand the nutritional value of processed and none processed *Acacia tortilis* pods and local grass and the influence of these supplements on milk yield of goats and growth rate of kids during the dry season. Whole pods of *Acacia tortilis* with their seeds were ground to form a course mill using a portable manual grinder while local mixed grass hay were chopped and these formed the set of processed feeds. The other feeds (none processed) were whole *Acacia tortilis* pods and long mixed standing grass. A benefit cost ratio (BCR) of the feed supplements was also carried out. The data collected on the chemical composition of feeds and animal performance was analyzed using the Genstat statistical program. We concluded that processing by milling of *Acacia tortilis pods* improved digestibility, while chopping of grass hay increased intake. All supplementation provided net economic benefits, but processing only paid off for *Acacia* pods. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods can alleviate nutritional constraints in the dry season, increase milk yield and sustain the body condition of pastoral goats in the arid rangelands.

Challenges of feeding home based milking goats in the dry season

In the pastoral systems found in some parts of Asia, Middle East and Sub-Saharan Africa goats are important component of animal agriculture. In the arid and semi-arid areas of northern Kenya, goats rank second to camels in terms of drought resilience, ability to survive in hot and dry environments, and year round production of high quality animal protein. The bulk of pastoral households who live in small rural towns in northern Kenya maintain a small herd of lactating goats mainly for milk supply during the dry season. However, the major nutritional challenges faced in the management of the milking goats in the dry spell are inadequate supply of natural forage and lack of affordable quality supplementary feeds. In these periods pasture supply falls and the available forage is low in dry matter intake and digestible nutrients. The low forage productivity is farther aggravated by high grazing pressure around the rural towns and the changing climatic patterns leading to reduced goat productivity and risk on pastoral livelihoods.

Feed supplementation as a coping strategy to alleviate feed shortages

In the pastoral areas of northern Kenya, emergency feed supplementation is increasingly being recognized as a strategy to correct nutrient deficiencies, maintain the body condition and milk productions of lactating goats. The Acacia riverine and mountainous zones of northern Kenya support local plant species that are suitable for supplementary feeding of livestock. In Olturot area which is a riverine area we collected local supplementary feeds of *Acacia tortilis* pods and local grasses and supplemented sixteen home based lactating goats owned by one pastoral producer.

Whole Acacia tortilis pods packaged in polythene bags and stored in raised wooden beds

Heap of whole Acacia tortilis pods

Ground course mill of *Acacia tortilis* pods packaged in sealed plastic bags

Mixed grass hay stored in raised store

A pastoral man using a manual grinding machine for milling pods

Pastoral woman chopping grass hay and the cuttings collected on clean polythene sheet

The ripe pods of *Acacia tortilis* were collected (January-February 2013) in the communal grazing and some of the pods were packaged in polythene bags, while others were milled using a portable manual grinder. The bags containing milled and whole pods were stored in a cool and dry storage shed. Local grasses, mainly *Bracharia leersiodes*, *Dactyloctenium aegyptium, Tetrapogon cenchriformis, Cenchrus ciliaris* and *Aristida mutabilis* were harvested and baled. Dry standing grass produced in previous seasons was collected and stored in a separate storage shed with hay grass. We divided the lactating goats into five groups of four animals each and supplemented daily (August-September 2013) with known quantities of one of the treatment diets; chopped mixed grass hay, long mixed standing grass, milled *Acacia tortilis*, whole *Acacia tortilis* pods and control (no supplement). The chemical composition and digestibility of diets were determined. The milk yield of the lactating goats and body weight of their suckling kids were recorded weekly and at the end of the experiment we assessed the body condition of animals and computed the benefit cost ratio of the diets.

Tethered lactating goats feeding on whole pods

Lactating goat feeding on chopped grass hay

Goat feeding on milled Acacia tortilis pods in mobile plastic trough

Goat feeding on long standing grass

Dietary intake and quality of supplementary diets

Our results showed that daily intake of chopped grass hay (309.5 g) and whole Acacia tortilis pods (413.1g) were higher than long standing grass (165.4 g) and milled Acacia tortilis pods (186.4 g). Of the supplement diets, whole *Acacia tortilis* was the most consumed (87.7%) followed by milled ATP (67.3%) and chopped grass (51%). Whole pods contributed over half (1.52%) of total dry matter intake of lactating goats (2.8% BW) (NRC, 2007). Supplementation using whole *Acacia tortilis* pods may decrease intake of the basal forage diet (Bii *et al*. 2010). The lower intake of ground *Acacia tortilis* pods may be attributed to the meal form and slight dustiness of the diet. In the case of grass, the higher intake of chopped mixed grass hay could be due to the short length and good quality grass, while the low consumption of long mixed long grass (40.4%) can be ascribed to the long length, high fibre and low crude protein contents. The chemical analysis report supports the observed variation in diet intake by goats. The milled Acacia tortilis pods, whole pods and mixed grass hay in that order were richer in crude protein (7.4-12.5%), macro and micro-minerals but lower in crude fibre contents (18.3-35.5%) while mixed standing grass was relatively poor in these nutrients but higher in crude fibre content (43.1%). The digestibility studies followed similar trends and were related to the quality of the diet. The *Acacia tortilis* based diets were highly degraded in the rumen, followed by chopped mixed grass which was moderate and least was the long standing grass. However, at early incubation period in the rumen, milled *Acacia tortilis* pods due to its small particle size was degraded faster (52%) compared other diets (33.7-45.8%).

Performance of lactating goats offered supplementary feeds and their suckling kids

We found out that supplementation increased milk production in the range of 6.3-45.3%. The daily milk yield was highest in goats receiving milled *Acacia tortilis* pods (348.6 g/day) followed by chopped grass hay (307.8 g/day), third whole *Acacia tortilis* pods (300.5 g/day), fourth mixed long standing grass (255.2 g/day) and least was control (240 g/day) with no supplement. The results are in agreement with previous studies in northern Kenya than indicated that milk yield of Small East African goats was a function of nutrient status than stage of lactation. Thus, supplementation modified the nutrition status and therefore milk production of goats. The body condition score of goats ranged between poor to fair. The animals receiving good quality supplements of *Acacia tortilis* pods and mixed hay grass had fair body condition, while those offered long standing grass or not supplemented showed poor body status. To meet the energy requirement during peak lactation, animals on poor quality diets mobilize their body reserves and thereby leading to poor body condition. Conversely, improving the nutrition status of goats during lactation by using good quality supplements can sustain the body condition of animals. During the two months of the feeding trial, the suckling kids showed similar daily weight gain (71.7-86.8 g/day). It appears that at early and mid-lactation, the milk output of supplemented and none supplemented Small East African goats was sufficient to support the observed kid growth rates. The traditional management system of allowing kids to stay with their mother during the night in early lactation and feeding kids with browse leaves in the second month could be some of the confounding factors in the weight gain assessment.

Benefit cost ratio of the supplementary feeds

The total cost of feed was highest for chopped grass hay and whole *Acacia tortilis* pods and least for long standing grass and milled *Acacia tortilis* pods. Processing of *Acacia tortilis* pods increased feed density leading to the reduction of feed consumed, while chopping of grass hay increased consumption. The total value of milk (KES 100 per litre) was higher for *Acacia tortilis* pods base supplements followed by mixed hay grass and the least was dry standing grass. The benefit-cost ratio reveals the net impact of feed intake, nutrition, cost, and milk yield. For example, the total amount of milled pods consumed (50.7 kg) was markedly lower than whole pods (112.4 kg), plus there are additional costs of milling *Acacia tortilis* pods (KES 30 per kg). However, when accounting for increased milk yield, the benefit-cost ratio for milled pods was 50% greater than for whole pods; therefore, milling provided a net benefit. The benefit: cost ratio was highest for milled *Acacia tortilis* pods (2.7) and long dry grass (2.6) and least for whole *acacia tortilis* pods (1.8) and chopped mixed grass (1.5). Thus, milling of whole *acacia tortilis* pods was a net benefit while processing of grass hay was not.

Practical implications

Our observation confirmed that processing by milling of *Acacia tortilis pods* improved digestibility, while chopping of grass hay (mixed) increased intake. Milled *Acacia tortilis* pod with low crude fibre content and small particle size was better utilized than whole *Acacia tortilis* pods. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods increased milk yield of goats. However, at early ages, supplementation had no benefit on kid growth. In summary, all supplementation provided more benefit than costs, whether processed or not. Processing pods increased benefits, while processing hay cost more than it was worth in increased milk yields. Thus, processing of feed supplements such as *Acacia tortilis* pods which are locally available would enhance the productivity of goats during the dry season in northern Kenya. The traditional emergency feeding strategies can be strengthened by adoption of improved technologies on feed processing demonstrated in this study. Feed processing methods such as coarse grinding of *Acacia tortilis* pods would reduce wastage of nutrients lost through undigested seeds, increase feed density and reduce the amount consumed by animals. In northern Kenya, opportunity exists for collecting ripe *Acacia tortilis* pods, milling the pods using commercial cereal milling machines available in most small rural towns and storing them as strategic protein concentrate feed.

References

Aganga A.A., Tsopito, C.M and Adogla-Bessa, T. (1998). Feed potential of Acacia species to ruminants in Botswana. Arch.Zootec.47: 659:668.

Bii, J.C., Abdulrazak, S.A., Mukisira E.A and Shakala, E.K. (2010). Performance of the East African Zebu weaner cattle supplemented with Acacia tortilis pods. In: Proceedings of 12th KARI biennial conference, Nairobi, Kenya.

NRC. (2007). Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids. The National Academies Press.

Status of Camel Milk Production, Utilization and Marketing in Isiolo County, Kenya

Adongo A.O.[1], S.G. Kuria[1], J.T. Njoka[2], P.N Kamande [2], O. Koech [2], and S. Mureithi [2]

[1]Kenya Agricultural and Livestock Research Organization, Marsabit Research Centre, P.O. Box 147 60500, Marsabit. Email: adongoam@yahoo.co.uk or amos.adongo@kalro.org
[2]African Drylands Institute for Sustainability (ADIS) formerly Centre for Sustainable Dryland Ecosystems and Societies (CSDES), University of Nairobi
P.O. Box 29053-00623, Nairobi

Abstract

Camels play a significant role in livelihood sustenance among pastoral households in Northern Kenya especially in Isiolo County. Given its ability to supply milk in all seasons, camels play a central role in meeting the ever increasing demand for camel milk in emerging urban centres in northern Kenya and Nairobi. The objective of this study was to generate baseline information on current status of camel milk production, utilisation and marketing of same in Isiolo County. The study showed most households had a mean of 9.7±1.27 lactating camels each produced an average of 4.01±0.30 L ($p<0.001$) of milk per day. The mean quantities of milk sold to target markets was 20.97 L with a litre costing a mean price of KES 63.38±3.61 ($p<0.001$). The study also showed majority ($\chi^2 = 31.387$; df =4; $p<0.001$) of households sold milk to individual consumers in nearby urban centres (43.5%) followed by traders/hawkers (25.8%) and individual consumers in the village (19.4%). The main form of value addition was through imparting fumigants in milk container and direct boiling of milk. In conclusion, Milk yield among Somali camel in Isiolo was still below target contributing to low supply to the market. Value addition of camel milk was minimal. There is still need for capacity building for pastoralists to increase milk yield and product improvement for better income. This may stimulate increased production at producer level.

Key words: Camel milk, production, utilisation, marketing

Introduction

Kenya produces 340 million litres of camel milk annually, 8% of the national production – MoLD 2012) worth KES. 8 billion based on a farm gate price of KES. 20 per litre (Kenya Dairy Board 2011, Kuria et al. 2010). Only about 12% finds way to the urban markets where the price is about KES. 80 per litre. About 88% of milk produced in pastoral areas is either wasted in the process of marketing or just left for the calves due to lack of marketing infrastructure to support milk collection systems. This trend has further been aggravated by movement of camels to far flung grazing such as Marsabit, Samburu in the area occasioned by climate change.

The demand for camel milk by consumers residing in the upcoming town centres within the pastoral areas is on the rise owing to increasing awareness about high quality of the products. However, supply gap cannot be met due to a number of factors. Low milk supply from producers due to low incentives. Unhygienic milk handling, lack of cooling facilities and other transport related constraints have been major hindrances to the marketing of camel milk. Increasing adoption of Somali breed among non-Somali communities in Isiolo can help in bridging the supply gap and by doing so, enhance income flow to the pastoralists. Promoting strategies for hygienic milk handling coupled with cooling facilities and efficient transport system has great potential to not only increase the volume of marked milk but also help in meeting the rising demand for camel milk in urban centres and improve human health. In 2014, University of Nairobi in collaboration with Kenya Agricultural and Livestock Research Organisation, PACIDA, a local NGO in Marsabit and the Department of Livestock production in Marsabit and Isiolo, received financial support from the Intergovernmental Authority on Drought (IGAD) to pilot research and development project in Marsabit and Isiolo counties. The broad objective of the project was to enhance resilience of pastoral household through capacity building and up scaling of research led knowledge, information and

technologies (KITs). The aim of this study therefore was to evaluate current practices with regard to pasture management, livestock husbandry and milk hygiene and marketing. This paper presents baseline information on current camel milk production, handling, utilisation and marketing.

Materials and Methods

The study was a cross sectional survey and was undertaken in the Counties of Isiolo in northern Kenya where a total of 91 randomly selected respondents were individually interviewed in Isiolo. A semi-structured questionnaire was used to gather data from respondents drawn from three purposively selected divisions in Isiolo namely; Ol Donyiro, Isiolo Central, Kina. In each division, a myriad of purposively selected villages with high concentration of Somali camels were sampled and respondents picked at random. The sampling frame was all the pastoralists owning Somali camels in each village that was selected. The selection of villages was carefully done to ensure representation. In total, 14 villages were sampled in Isiolo. The interviews were conducted by carefully selected and trained enumerators under close supervision by the research team. In addition to the individual interviews, three Focus Group Discussions (FGDs) involving 10 knowledgeable men and women in matters of Somali camel rearing, milk handling, marketing and rangeland environment were conducted to corroborate some of the data gathered through individual interviews.

Data Analysis

Pre coded data was analysed using Statistical Package for Social Scientist (SPSS) Version 20 (IBM Corporation, SPSS Statistics Release 20.0.0; USA) for analysis. Characteristics of the households were described using descriptive statistics (frequencies, means, totals, percentages and measures of dispersion). Continuous and categorical variables were reported as mean±standard errors and percent, respectively. Separation of means for continuous data was achieved using Tee Test whereas differences in categorical variables were analysed using chi-square. Variables with multiple responses were converted and given as frequencies and percent.

Results and Discussion

Household milk production, consumption and marketing

Table 1 gives figures of milking practices, quantities of milk produced and how amounts produced are utilised by the households. The study showed that most households were milking an average of 9.7 lactating camels, twice daily. Most households had a mean±SE of 9.7±1.27 lactating camels each produced an average of 4.01±0.30 L of milk per day. Most household potential supply ranged from 0.5 to 60 litres of milk per day with mean supply of 6.3litres. The study show most households were consuming what they produced, however, the quantities of milk sold to market by same households were very high. The mean quantities of milk sold to target markets was 20.97litres with a litre costing a mean price of KES 63.38. The disparities in household's production in relation to amounts consumed at household or given to friends may be attributed to a number of factors. Given high illiteracy levels, most households did not keep any records of either production or sales of milk produced hence it was not easy to verify data given by producers. Secondly, most producers said they did not milk all the animals in the *fora* where milk was not accessible. Most women could not tell how much such animals produced as most of the milk was consumed by herders. Most of the households engaged in both production and marketing of milk said that they source most of the milk sold from other producers hence were selling more than they produced from own herds. This shows that increase in demand for camel milk was a developing trend among the camel keepers in Isiolo and did have to rely on their own production alone. The study showed majority (χ^2 =31.387; df =4; $p<0.001$) of households sold milk to individual consumers in nearby urban centres (43.5%) followed by traders/hawkers (25.8%), individual consumers in the village (19.4%). Others also targeted hotels and institutions (3.2%) in Isiolo town (table 3). The mean ±SE distance covered with fresh milk was 23.5±8.00 Km to target markets. This ranged from a minimum of 1.0Km for households selling milk within their villages to 300Km for households selling milk in the urban centres and Nairobi. The target centres included

Kulamawe centre, Isiolo town, Maua and Nairobi. Attempts were made to sell milk to vital camel milk factory in Nanyuki, but this had not stabilised due to challenges with pricing and lack of compliance with stringent factory quality standards.

Table 1: Household production and utilisation of milk

Production characteristics	Minimum	Maximum	Mean	SE	Sig. 2 tailed
No. of lactating animals (n=89)	1	50	9.7	1.27	<0.001
Daily Milking frequency (n=90)	1.0	4.0	2.10	0.08	<0.001
Daily Average milk yield per animal(n=89)	0.5	20.0	4.01	0.30	<0.001
Average amount of milk per milking(n=89)	0.5	60.0	6.29	1.29	<0.001
Amount consumed at home per day(n=90)	0.5	70.0	6.39	1.18	<0.001
Amount given to friends and relatives(n=66)	0.5	20.0	3.09	0.51	<0.001
Amount of milk sold per day(n=65)	1.0	123.0	20.97	3.42	<0.001
Price per litre sold per day(64)	20.0	120.0	63.38	3.61	<0.001

Table 2 : Target market for Isiolo camel milk producers and traders

Target market	Percent
Individual consumers in the village (n=12)	19.4
Individual consumers in the urban centre (n=27)	43.5
Traders(brokers and hawkers)(n=16)	25.8
Hotels(n=2)	3.2
Processor (women groups,)(n=5)	8.1
Total(N=62)	100.0

Sig. χ^2 =31.387; df =4; p<0.001

Milk hygiene practices among camel keeping pastoral households

The section looked at the community perception and experiences with regard to diseases contributing to poor milk hygiene at udder level. It also focused on how pastoralists handle cases such as mastitis based on existing or acquired knowledge. Type of containers and general procedures used to sanitize milk containers as hygiene practices. According to the findings, 84.8%, n=78 ($\chi2$ = 44.522; df = 1; p < 0.001) compared to 15.2% (n = 14) of respondents said they were aware of mastitis. Figure 1 shows the samburu community in Oldonyiro (Kipsing) were more aware of the condition mastitis than Borana counterparts in Kulamawe/Barambate in Kina and Somali community in Isiolo central. Level of knowledge on this important disease was largely confined to the clinical aspects rather than the subclinical stages.

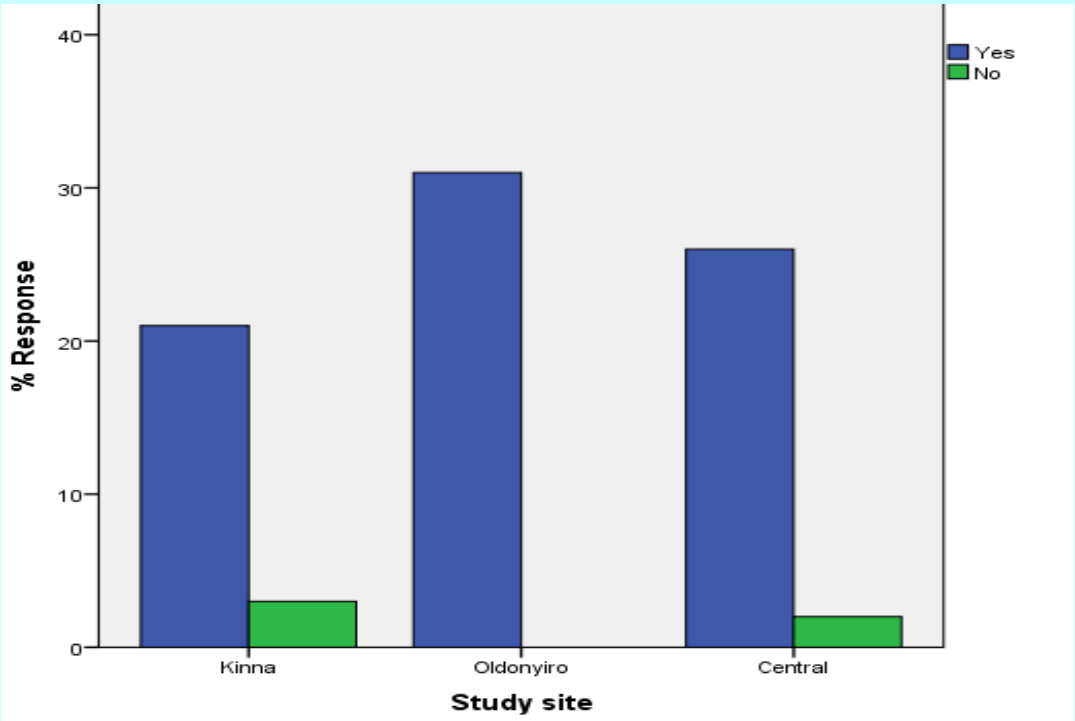

Figure 1 : Knowledge of Mastitis among the pastoralist of Isiolo

In Focus Group Discussions (FGD) held in Barambate which included participants from Kulamawe, Kipsing and Isiolo central, most farmers described mastitis thus:, Udder inflation (udder is hot on touch), milk change colour from white to brown and sometimes presents with blood clot in the milk, reduction in milk production and Painful udder. Some participants even attributed the condition camel teats/quarters becoming blind. This compares well with general sign and symptoms of clinical stage of mastitis. However, there was total lack of knowledge of the subclinical aspects of the diseases which globally poses a big challenge to milk hygiene and marketing. To manage the condition, most farmers (85.9%) use indigenous methods for checking presence of mastitis in lactating camels (table 4). Table 4 presents methods used by pastoralist to check for mastitis in lactating camels. Presence of swollen udder (38.5%; n=30), clots in milk during milking (35.9%; n=28) and boiling to see if milk separates are some of the practices used by most households to screen for milk with mastitis. However owing to previous capacity building on milk hygienic and processing by other development agencies in Isiolo, some households indicated knowledge and use of modern methods for screening for mastitis. Few producers (11.5%; n=9) used strip cup which only assisted in checking for clinical stage of the condition. Use of California mastitis test (CMT) was also identified as a method used by minority ((2.6% n=2) segment of the population ($\chi 2$ =31.696; $p<0.001$). The study showed majority (85.7 n=66) of respondents poured milk with mastitis away, 9.1% n=7 give to other domestic animalssuch as dogs whereas 5.2%, (n=4) still consume raw milk contaminated with mastitis. This latter practice may have been encouraged by pastoralist traditional belief that camel milk is more nutritious when taken raw. This not only posed a danger to consumers of such product but also contributed to low volumes of milk traded as most of milk could be lost due to spoilage. Mastitis is known locally as *Budha* in Boran/Gabra language. It is described as a disease caused by a person with bad eyes bewitching lactating camel or cows. Traditionally, this condition is treated by herbalists who are called when a swollen udder is noticed in a herd. The herbalist uses a concoction of herbs which he sprays through the mouth to the swollen sections of the udder. It was believed that such practices healed the animals from the condition. Other preventive measures involved calling witch doctor to heal the animal just by talking to it. In the mix of these traditional believes some FGD participants in Kulamawe informed their colleagues that *budha*

could still be treated with conventional antibiotics. This latter approach is what conventional veterinary practices recommend.

Value addition and marketing of camel milk

Fig 2 gives sources of milk traded in target markets in Isiolo. According to this study, pastoral households in Isiolo rely more on milk produced from their own herds compared to other sources such producers and traders (bulkers) ($\chi^2 = 65.786$; df = 2; $p<0.001$).

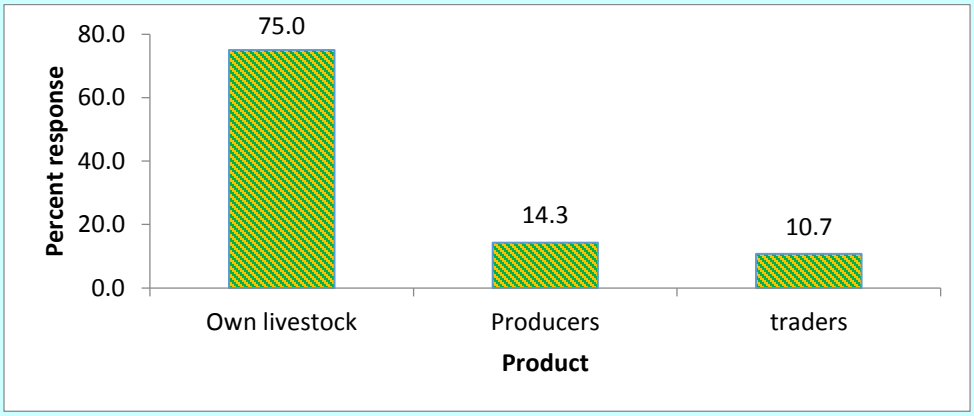

Figure 2. Source of milk sold by households

Value addition of camel milk is key to ensuring product diversification and efficiency in marketing of milk. As a strategy to combat income shocks occasioned by climate change, it is imperative to support efforts aimed at enhancing resilience of pastoralists through commercialisation of value added products. Currently, 70.7% of respondents said they did not engage in any value addition of milk products for sale. Only 29.3% were adding value to milk (Sig $\chi^2=15.696$; $p<0.001$). Table 3 gives the various value addition methods/products by respondents in Isiolo. Majority (58.8%) of respondent boil fresh milk as a way of improving keeping quality before taken to the market. This was followed by sale of naturally fermented milk (*susa*) at 19.6%. Camel milk yields very low quantities of butter if traditional methods were used but yields quantities enough to sell or process into other products if cream separator was used. This study therefore did not find production of butter and its derivatives among camel keepers. However, butter and ghee can still be promoted as an additional product.

Table 3: Value addition methods used by pastoral households in Isiolo

Product type	Valid Percent	Sig
Boiled milk (n=30)	58.8	χ=73.118; df=5;p<0.001
Naturally fermented milk(n=10)	19.6	
Butter cattle (n=2)	3.9	
Ghee cattle (n=1)	2.0	
Fresh Raw Milk(n=1)	2.0	
Fresh Smoked Raw milk(n=7)	13.7	
Total	100.0	

Table 4shows the common value added products in Isiolo market, units of sale and quantities produced and price per unit. In Isiolo, the most dominant unit of measurement for dispensing milk was a 350 ml cup popularly known as *jaleg (borana)*. However given the relatively developed marketing system within the county other larger units of sale for camel milk did exist. The common units used by large scale traders

was the 5-litre Jerican and the 3-litre-jerican. The study also indicates that price per litre of fresh boiled camel milk was selling between KES 20.00 to about KES 60.00 at production level but increased depending on the target market. The fresh milk was selling at about KES 100.00 per litre within Isiolo town and about KES180.00 per litre in Nairobi. The mean volumes of fresh boiled milk traded per household was 206 litres compared to 107.5 litres for naturally fermented milk (table 4). The price of naturally fermented milk was slightly lower than that of fresh milk. Hence price per litre ranged between KES 40.00 in Isiolo town to KES100.00. Using key Informant (KI) mainly a representative of Anolei cooperative, the cooperative currently supplies 7500 litres of fresh camel milk to Nairobi but increase to 10,000 in wet season.

Table 4: Mean daily quantities and price (in KES) per unit of products sold

Product sold	Price per unit of sold	Quantity of units sold / day
Boiled milk (5litre Jerican)	533.93	206.88
Naturally fermented milk(5litre Jerican)	333.33	107.50
Fresh Raw Milk(350 ml)	50.00	20.00
Fresh raw smoked milk (350 ml)	50.00	44.17

Conclusion and Recommendations

From the Focus Group Discussions, camel production is mainly dominated by adult males hence decision making may heavily depend on males for male headed households**.** However, decision on who to target in terms of any interventions may be informed by the roles played by various members of the household. Husbandry practices which incorporate aspects of animal health will require the input of male members of the households. Value addition of milk products may have to focus on female members of the households. Even though men have started getting involved in milk marketing, the practice still remains the domain of pastoral women in Isiolo.

Given the low education standards in the area affecting adult males and females equally, training package should as much as possible involve adult learning techniques. Some of the techniques to be adopted should embrace practical demonstration for most capacity building modules. When reinforced with exchange tours, the project may realise quick wins in the milk hygiene and marketing efforts. Involving the youth in the intervention activities will help improve record keeping and accelerate up take of technologies geared towards enhancing milk hygiene and marketing. This study did not find any youth based efforts in value addition and marketing of camel milk, yet a number of them could be seen with motorbikes which could be incorporated in the marketing approach.

The study also reveals that most producers travel long distance with milk against high temperatures and poor containers sanitised mainly through fumigation. It is therefore recommended that technologies that may enhance keeping quality of milk be promoted. This may include refrigeration through use of solar powered chillers, use of intermediate chillers such charcoal evaporative coolers. However, in areas with fuelwood problems, other media of evaporation could be adopted. Use of soaked hemp wrapped metal cans could help reduce rate of microbial build up during transportation of milk.

Value addition of livestock products remains a challenge in the area. Most farmers indicated having not been trained in hygienic handling and processing of milk. Currently, traditional practices still remained. There is need to train chain actors on principles of milk hygiene through demonstrations. Such training should target all actors along the chain. However, with poor organisation at community level, efforts should put in place to encourage cooperative approach to marketing. Although, this may heavily be guided by the business models that will be promoted by other actors. Individuals willing to invest in milk collection and processing may still be encouraged since the investing will still spill over to a greater number of milk producing households. For this efforts to work, proper capacity building bolstered by linkage with other input suppliers and other value chain platform players will be necessary.

Livestock and livestock product remains a major source of cash income to pastoral households hence support towards improving income from sale of livestock products is still needed. This can only be

achieved if pastoralists were encouraged to commercialise production of system. Currently more than half of milk produced is either left to calves to suckle, or just given to relatives.

Isiolo was the only area that recorded cooperative group involved in milk marketing. The Anolei cooperative has received a lot of support in terms of milk hygiene and marketing. They have also received support in form of milk cooler, however, the group still faces challenges at production level. Most milk supplied to the cooperative is meeting hygiene challenges. Therefore effort aimed at supporting hygiene related interventions at producer level will help improve quality at these bulking centres mainly centre in Isiolo town.

Acknowledgement

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Reference

Kuria, S.G., Omore, A., Thendiu, I. N., Mwangi, D. M., Ng'ang'a and Kaitibie, S. (2011). Constraints on camel meat and milk marketing and strategies for its improvement in Northern Kenya. Journal of Agricultural Science and Technology A1, 703-712.

MoLD (2012). Ministry of Livestock Development, Annual report 2011, Nairobi, Kenya.

Moving in and out of poverty: A case of the Somali and Turkana of northern Kenya

Watete, W.P.[1,2], Kogi-Makau, W.[1], Njoka, J.T.[1], MacOpiyo, L.[1], Mureithi, S. M.[1]

[1]University of Nairobi, College of Agriculture and Veterinary Sciences, Kabete
[2]Ministry of Agriculture, Livestock and Fisheries, Kenya
Corresponding author email address; pwatete@gmail.com, 0720 854 369

Abstract

There has been a tendency of pastoral households of northern Kenya to fall into and remain permanently trapped in poverty, while a few households have managed to escape poverty under certain circumstances. This study looks at how poverty levels among households in pastoral Counties of Turkana and Mandera have changed over the last twenty years. A combination of multi-stage and purposeful sampling techniques were used to identify three hundred and three hundred and sixty two households in Mandera and Turkana Counties respectively. The household questionnaire was used to collect data on household assets, income and expenditure. A participatory wealth ranking method was used to categorize the sample households into various wealth strata. Through FGDs and household interviews households' change in wealth status and the reasons for the change between 1993 and 2013 were established. The study found out that 71% and 58% of the households in Turkana and Mandera respectively could be classified as poor in 2013. Loss of livestock through drought, diseases and raids werethe major reasonsgiven for increased pastoral poverty. Pastoral households escaped poverty through diversification, receipt of remittances and employment. Drought management is key to preventing pastoral households from falling into poverty whereas diversification and education are the most important strategies that could help pull outthese pastoral households out of poverty. What is your recommendation?

Key words: poverty, stages of progress method, pastoral, agro-pastoral, northern Kenya Key words are normally five.

Introduction

Poverty is a complex phenomenon, without a single definition or standard methods of reducing it (Escobar, 1995; Maxwell, 1999; Sen, 1981). For this reason, designing appropriate methods of determining poverty levels becomes a great challenge (Baulch and Masset, 2003; Thorbecke, 2007). Perception of poverty varies across institutions, cultures and individuals. The leading United Nations (UN) agencies such as the International Monetary Fund (IMF) and United Nations Development Programme (UNDP) have over the years used 'the income approach' to define poverty. Although the current perception of UN has been broadened to include aspects of development and attainment of human rights (UNICEF, 2000; UNDP, 1998), poverty reduction approaches are still based on income - poverty conception, measured in terms of the number of people subsisting on less than one dollar per day.

Many pastoral communities view poverty as lack of animal ownership (Illife, 1987). Livestock perform both economic and social functions among pastoral groups. It has however been observed that lack of animals alone may not adequately explain pastoral poverty as other underlying factors such as political and economic forces are also crucial in shaping the daily pastoral livelihoods (Mohamed Salih, 1985). Pastoralism depends on extensive grazing of native and natural pastures (Gefu and Gilles, 1990; Salzman, 2004) whose availability is usually achieved through mobility (McCabe, 2004; Naimir-Fuller 1999) as pastoral areas are subject to fluctuations of grazing resources over time and space.

Studies using the 'stages of progress' method (Krishna 2010; Krishna, 2004; Krishna *et al*., 2006; 2004a; Johnson *et al*., 2009) have been done in several non-pastoral areas. These studies were able to identify factors that led to increased poverty and strategies that households used to escape poverty. However, given that

pastoral livelihoods are different from those of high rainfall areas, drivers of poverty may not be the same in the two localities; meaning that poverty reduction strategies applied in high rainfall areas may not be successfully replicated in pastoral areas.

Knowledge on how pastoral households have fallen into poverty or escaped poverty will be crucial for designing relevant poverty reduction policies and interventions. This study therefore aimed to establish how households in Turkana and Mandera had either fallen into poverty or escaped poverty between 1993 and 2013. Where are your objectives or research questions?

(These are the methods used and it fits in the methodology).

Methods and materials

Study site

The study was done in Mandera and Turkana Counties of northern Kenya.

Mandera County has a human population of 1,025,756 (Republic of Kenya, 2010) and had a poverty level of 87.8% according to the 2009 human census report. Turkana county had a population of 855,399 people in 2009, translating into average population density of 13 persons per square kilometre with a poverty rate was 94.3% (Republic of Kenya, 2010).

Data colection methods

Data were collected in two stages; the first stage involved the administration of a semi structured questionnaires to thesampled households, the second stage was use of FGDs. The process of identifying sample households started by identifying sub Counties by their predominant livelihoods; whether pastoral, agro-pastoral or off farm. In the selected sub Counties, two or three villages were randomly selected.In each of the selected villages, 30 households were systematically sampled from a village list obtained from local chiefs. For instance if a village had 150 households, every 5th household in the list was selected to arrive at a sample of 30 households in the village (manyatta). FGDs were used to establish household poverty dynamics over the last two decades using 'the stages of progress' method and also to determine the reasons associated with ascent from poverty or descent into poverty (Krishna 2010). From this exercise, it was possible to categorize sample households as either resilient or non resilient.

The stages of progress' is a participatory method that relies on community focus group meetings to delineate locally applicable 'stages of progress' that poor households are assumed to follow as they make their way out of poverty (Krishna 2010). This is a rapid method that captures data that would otherwise require a longer time and more resources. These stages are then used to create 'yardsticks' by which households' welfare was measured at different points in time.

During the FGDs, the local chiefs assisted in identifying between eight and ten individuals who had been residents of the village for at least the previous twenty years and who knew the sampled households well. The focus group comprised a mixture of resourceful men and women and one literate young man who assisted in translation and recording the discussion.

Twelve and ten FGDs were conducted in Turkana and Mandera Counties respectively.To ensure that the participating community members gave correct information, the objectives of the exercise were stated and it was emphasized that their participation was voluntary with no material advantages. Participants were guided to define collectively what it meant for a household to be poor. The participants were then guided to develop a 'stages of progress' ladder that was used as a scale of categorizing households into wealth strata (Table 1). These stages of progress were general, and a progressing household did not necessarily have to go through all of the stages as given. Participants were asked to identify well known signifying events that had occurred ten years and twenty years earlier (2003 and 1993). In 1993 the Turkana and Mandera community members remembered a famine (referred to as Red Cross famine), and the ouster of President Siad Barre of Somalia, respectively. Participants in both Counties associated 2003 with the NARC

victory when Mwai Kibaki was elected President of Kenya for the first time. These were then used as reference points during categorization of households.

The FGD members were then asked to identify the status of sampled households in 2013, 2003 and 1993. Sampled households were placed in four categories depending on how their wealth status changed between 1993 and 2003 and between 2003 and 2013. Households who were poor at the beginning and also at the end of the assessment period were placed in category A (remained poor), those who were poor at the beginning but had become rich at the end were placed in category B (escaped poverty), those that were rich at the beginning but had become poor at the end were placed into category C (became poor) and those that were rich at the beginning and were still rich at the end were placed in category D (remained non poor). Reasons for change (or stability) for the sampled households were ascertained from participants during the focus group discussion. Follow up household interviews for a random sample of households in each category were done to validate information obtained during focus group discussions.

Data analysis

The Kruskal Wallis test was used to evaluate whether population medians on a variable were equal across all levels of a factor. This test is very useful when the data are measurements in an ordinal scale. Whenever the Kruskal Wallis test indicated a significant difference between groups, the Mann Whitney test was used whereby pair wise comparisons were done to identify those groups that were significantly different. ANOVA was used to compare interval and ratio variables across households by livelihood strategies and County.

Results

Stages of progress among Turkana and Mandera pastoral communities

Both communities in Turkana and Mandera regarded livestock holding as the major determinant of wealth. For the Turkana, the levels of poverty were described as *Ekabaran* (rich), *Ekebotonit*(middle), *Ekalokan/Ekilokit/Ekadalan* (the poor) while the Somali of Mandera County used the term *qoole* to describe a poor person and *dures* to describe a rich person. The progression path that households normally followed to move from poverty to prosperity is indicated in Table 1.

Table 5: Stages of progress among Turkana and Mandera pastoral communities

Wealth category	Turkana	Mandera
Poor	1. Buys food 2. Buys clothes 3. Buys one goat 4. Increases goats up to 20 5. Marries a wife 6. Builds a shelter 7. Buys one donkey 8. Buys camel 9. Buys one cow	1. Afford one meal a day 2. Buy clothes for the family 3. Own few animals (some chicken, 3 goats or 3sheep) 4. Take children to primary school 5. Make your own makeshift house (*Herio)* *6.* Make an improved better house (*Harish)* 7. Buy a donkey or young cow
Middle	1. Increases sheep/goats up to 150 2. Increases number of camels up to 5 -10 3. Increases number of cows up to 6-8 4. Marries the first wife officially according to Turkana custom 5. Marries out the first daughter	1. Take children to secondary school 2. Buy a farming land along the river 3. Buy a plot in Mandera town 4. Take children to paid tertiary colleges
Rich	1. Increases number of sheep/goats up to 400 2. Increases number of camels up to 15 3. Increases number of cattle up to 15 4. Increases number of donkeys up to 10 5. Marries the second wife	1. Buy a second hand vehicle 2. Buy and transport livestock to other markets for sale 3. Make pilgrimage to Mecca 4. Buy modern high class vehicle

Table 6: Poverty levels between 1993 and 2003 in Turkana and Mandera

County	Household categorization				
	N	Remained poor (%)	Escaped poverty (%)	Became poverty (%)	Remained non poor (%)
Turkana	354	54	18	19	10
Mandera	310	42	13	17	27

Table 7: Poverty levels between 1993 and 2013 in Turkana and Mandera

County	Household categorization				
	N	Remained poor (%)	Escaped poverty (%)	Became poverty (%)	Remained non poor (%)
Turkana	354	46	14	25	14
Mandera	310	33	18	25	24

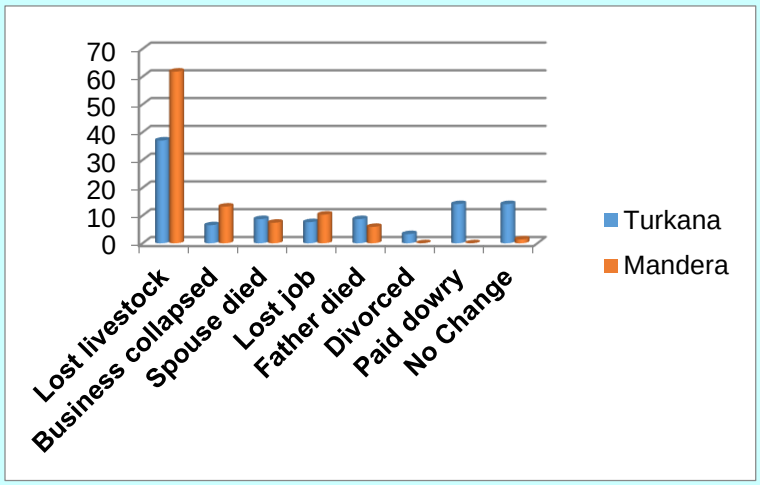

Figure 1 : Factors that pushed households into poverty

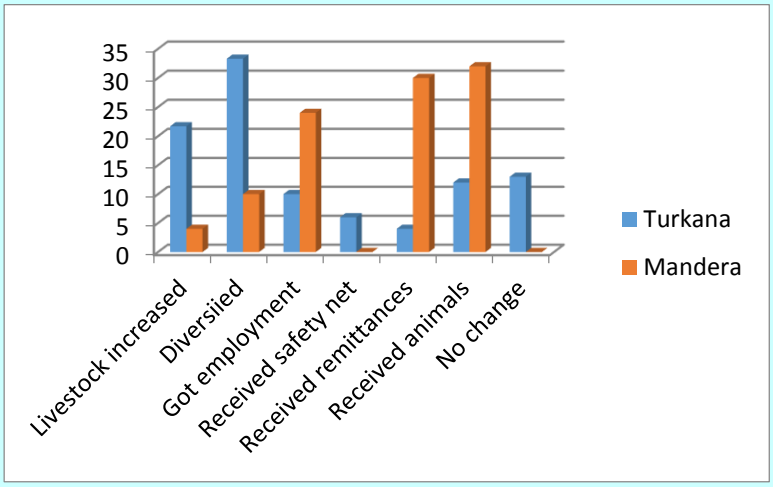

Figure 2: How households escaped poverty

Discussion

In both Turkana and Mandera, accumulation of livestock to create wealth became a priority only after the requirements for food and clothing were met. Poor households were depicted as those that could not afford the basic necessities of life. The overall poverty levels in 2013 were 73% and 59% for Turkana and Mandera Counties respectively, computed as the sum of households that remained poor and those that fell into poverty between 2003 and 2013. At the same time, 54% and 42% of households in Turkana and Mandera respectively had remained poor over the ten year period. On the other hand, 18% and 13% of households in Turkana and Mandera respectively had escaped poverty over the same period. Between 1993 and 2013, 25% of households in Turkana County fell into poverty while only 14% moved out of poverty, giving a net increase in poverty level of 11percentage points. In Mandera, 25% of households fell into poverty while only 18 percent moved out of poverty, giving a net increase in poverty level of 7 percentage points during the same period.

From focus group discussions and household interviews, it emerged that the main factors that led to pastoral poverty were loss of livestock, poor performance of businesses and loss of employment. Although some households lost livestock through diseases or raids, the highest portion of livestock lost was caused by the recurring droughts.

Turkana households escaped poverty mainly through increased herd (pride price) and diversification. Mandera households on the other hand escaped poverty through receipt of animals and remittances, and through employment.

The poverty rates obtained using the stages of progress method were way below those obtained through use of conventional poverty assessment methods such as income levels. KNBS (2013) reported that poverty in Turkana and Mandera stood at 87.5% and 86% respectively in 2013 (compared to 71% and 58% for Turkana and Mandera respectively when 'a stage of progress' method was used). Use of standard proxy indicators in pastoral areas has been shown to exaggerate pastoral poverty levels (Devereux, 2007; Tache and Sjaastad, 2010). In Kenyan context this may lead to inequitable allocation of resources since the poverty index of a County is used as the basis of determining amount of money to be allocated to devolved units (Counties).

Poverty assessment studies using the stages of progress method done in 35 villages of India revealed that the immediate priorities among households revolved around obtaining food, sending children to school, possessing clothes to wear outside the house and retiring debts (Krishna 2004). Apart from the issue of retiring debt, the other three priorities were similar to those in Mandera and Turkana.

The death of the male household head almost always signaled the beginning of a household's slide into poverty. This observation is supported by other studies that show that in Africa death of a male household head exposes the household to the risk of losing assets (Chapoto *et al*., 2008; Cooper 2008) and that female headed households are generally disadvantaged (Fafchamps and Quisumbing, 2005).

Getting a job, diversification and starting a small business were associated with households that managed to escape poverty in both India and western Kenya (Krishna, 2006; Krishna *et al*., 2006). These were the same factors that helped pastoral households to escape poverty in Turkana and Mandera. The same 'cargo net' interventions could therefore be used in all the three areas to alleviate poverty.

Conclusion

The use of 'the stages of progress' method to assess pastoral poverty gives lower poverty levels compared to the rates that could have been obtained if the conventional income-expenditure approaches were used. Poverty increases when households that drop into poverty outnumber those that climb out of poverty. Loss of livestock (especially due to drought) is the main factor that causes increased pastoral poverty. Diversification and education of pastoralists are the two important strategies that can help pastoral households to escape poverty. Although livestock holding is the main determinant of pastoral poverty, the

two pastoral communities follow different pathways to get out of poverty. Mandera pastoralists tend to diversify more out of livestock- based livelihoods than their Turkana counterparts.

Recommendations

Future poverty studies should combine both quantitative and qualitative approaches. Use of only quantitative methods tends to exaggerate pastoral poverty. At the same time, interventions among pastoralist should be community specific, instead of stereotyping pastoralists and replicating projects across different pastoral communities without taking cognizance of causes of poverty among particular communities and specific community aspirations.

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Note

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References

Barrett, C.B. (2005) 'Rural Poverty Dynamics: Development Policy Implications' Agricultural Economics (32): 46-60.

Baulch, B. and Masset, E. (2003). 'Do Monetary and Nonmonetary Indicators Tell the Same Story About Chronic Poverty? A study of Vietnam in the 1990s. World Development, 31(3)441-453.

Carter, M. R and Barrett, C. (2006) The economics of poverty traps and persistent poverty: an asset based approach. Journal of Development Studies, 42 (2). Pp 178-99.

Chapoto, Anthony, and Jayne, T. S (2008) 'The impact od AIDS-Related Mortality on Fram Househhold Wefare in Zambia. Economic Development and Cultural Change, 59(3), 511-547.

Cooper, E (2008) 'Inheritance practices and Intergenerational transmission of Poverty in Africa. Working Paper 116. Chronic Poverty Research Centre, University of Manchester, Manchester, UK. 34pp

Devereux, S (2007) 'Cashing in or cashing out: Pastoralist livelihoods in Somali region, Ethiopia' prepared for the 'Living on the Margins' conference, Stellenbosch, South Africa, 26 – 28 march 2007.

Escobar, A. (1995). Encountering Development. The making and unmaking of the Third World. Princeton: Princeton University Press.

Fafchamps, M., and Quisumbing, A. (2005) 'Assets at Marriage in Rural Ethiopia. Journal of Development Economics, 77(1), 1-25.

Gefu, J. and Gilles, J (1990). 'Pastoralists, Ranchers and the state in Nigeria and North America. A Comparative Analysis'. Nomadic Peoples, 25-27: 34-50.

Iliffe, J. (1987). The African Poor: a history. Cambridge. Cambridge Uaniversity Press.

Johnson N., Garcia J., Rubiano J. E., Quintero M., Estrada R. D., Mwangi E., Morena A., Peralta A. and Grandos S. (2009) Water and poverty in two Colombian watersheds. Water alternatives 2(1) 34-52

Kratli, S and W. Schareika (2010) Living off uncertainty: the intelligent animal production of dryland pastoralists. European Journal of Development Research 22: 605-622

KNBS (2013) Exploring Kenya's Inequality: Pulling apart or pooling together. Kenya National Bureau of Statistics, Kenya.

Krishna A (2004) Escaping Poverty and Becoming Poor: Who Gains, Who Loses, and Why? World Development 32(1): 12-20.

Krishna, A.,Kristajanson, P., Randeny, M. and Nindo, W. (2004) Escaping Poverty and Becoming Poor in 20

Kenyan villages. Journal of Human Development 5(2): 211 – 226.

Krishna A., Lumonya D., Markienez M., Mugunya F., Kafuko A., and Wegoye J. (2006) Escaping Poverty and Becoming Poor in 36 villages of Central and Western Uganda. Journal of Development Studies 42(2): 346-370.

Krishna, A (2006) 'Pathways out of and into Poverty in 36 Villages of Andhra Pradesh, India,' World Development, (34): 271-288

Krishna, A (2010). Who Became Poor, Who Escaped Poverty, And Why? Developing and Using a Retrospective Methodology in Five countries. Journal of Policy Analysis and Mangement 29(2), 351-372.

Kristjanson P., Krishna A., Radeny M., Nindo W. (2004) Pathways out of poverty in Western Kenya and role of livestock. FAO-Pro-Poor livestock Policy Intiative. PPLPI Working Paper No.14. Food and Agriculture Organization, Rome. 23pp.

Little, Peter D. and McPeak, John G. (2014) Pastoralism and Resilience in South of the Sahara, 2020 Conference Brief 9.

Maxwell, S. (1999).'The Meaning and Measurement of Poverty'. ODI Poverty Brief No.3

McCabe, J. T. (2004). Cattle Bring Us to Our Enemies: Turkana ecology, Politics, and Raiding in a Disequilibrium System. Ann Arbor: The University of Michigan Press.

Mohamed Salih, M. A (1985). Pastoralists in Town. Some Recent Trends in Pastoralism in the North west of Omdurman District. ODI. Pastoral Development Network Paper 20b.

Niamir-Fuller, M. and Turner, M. D. (1999) A review of recent literature on pastoralism and transhumance in Africa. In Niamir-Fuller (ed) Managing Mobility in African Rangelands. The Legitimization of Transhumance. London. Intermediate Technology Publications, pp 18-46.

Nori, M. (2007) Mobile livelihoods, patchy resources and shifting rights: approaching pastoral territories. Rome: International Land Coalition.

Republic of Kenya (2010). Kenya Population and Housing Census, 2009. Nairobi, Kenya Salzman, P. C. (2004). Pastoralists: Equality, hierarchy and the state. Boulder. Westview.

Sen, A. (1981). Poverty and Famine. An Essay on Entitlement and Deprivation. Oxford: Clarendon Press.

Tache, B. and Sjaastad, E (2010) 'Pastoralists Conceptions of Poverty, An Analysis of Traditional and Conventional Indicators from Borana, Ethiopia'. World Development 38(8), pp 1168-1178.

Thorbecke, E. (2007). 'Multidimensional Poverty: Conceptual and Measurement Issues' in N. Kakwami and J. Silber (eds) The Many Dimensions of Poverty. New York. Palgrave Macmillan pp 3-19.

UNDP (1998). Integrating Human Rights with Sustainable Development (http://www.undp.org/governance/docs/HR_Pub_policy5.htm)

UNICEF (2000). Poverty Reduction Begins with Children. New York. UNICEF

Impact model for upgrading the milk value chain in western Kenya: a policy perspective

Omondi, Simon P.W.

Kenya Agricultural and Livestock Research Organization
*Corresponding author: Email: spwomondi@yahoo.com. Tel: + 254 717 444 923

Abstract

This study examined an impact model for upgrading the milk value chain in the four counties of Busia, Bungoma, Kakamega and Vihiga in Western Kenya, a region with persistent milk insufficiency. Questionnaires, checklists and interview guides were used to collect both quantitative and qualitative data from 385 milk buyers (households, hotels and institutions), 400 dairy farms, 10 Cooperatives, seven service institutions and six focus groups discussions were held. The results showed that priority interventions for increasing milk production on smallholder farms in the region should consist of five key areas: integrated input supply (feeds, AI services, breeding stock); dairy farmer business clusters; new structured cooperatives operating as business entities; contract marketing and supportive County government policy. An impact model on smallholder farms using one-acre feed model is economically viable. The model appears feasible and could increase average milk yields to 10 litres per cow per day, increase annual income per cow from KES 62,000 to KES 126,500, reduce milk deficit by about 51%, with a benefit-cost of KES 14.14 for every KES 1 invested. The model has practical significance and could be adopted by the County Governments in Western Kenya to address the milk deficit problem. Urgent areas for policy interventions are a regional approach in: establishment of AI centre with liquid nitrogen plant; establishment of breeding stock multiplication centres and development of dairy strategic plan as a road map to guide dairy development.

Key words: Impact model; upgrading, milk value chain, Western Kenya; Policy intervention

Introduction

At KES 50-60 a litre, Western Kenya Counties of Busia, Bungoma, Kakamega and Vihiga have one of the highest raw milk prices in Kenya. Yet, despite several dairy development interventions initiated in the region, there has been little success towards a commercialization path and to solve the milk deficit problem since majority of farmers are still subsistence-driven (Otieno *et al*., 2005). Between 2004 and 2006, a consortium of Dutch companies wanted to invest in a milk processing plant in the region, but abandoned the initiative due to inadequate milk volumes (The Netherlands Embassy, personal communication). The region has an estimated 99,000 smallholder farmers (County Government of Kakamega, personnal communication) keeping an improved dairy cattle population of 192 300 (FAO, 2011). Total annual milk production from both grade and local cows is estimated at 215 million litres (KDB Kakamega annual report, 2011).

Low productivity of cows and milk insufficiency still persist (Mudavadi*et al*., 2001). Data from studies by Wambugu (2011) reported that Western Kenya had low production of about 500 litres per cow per year compared to the Central highlands with yields of 2,000 litres per cow per year. At the cooperative level, a study by Limo (2011) showed that between 1992-2008 there were 27 dairy cooperatives but many of these have since collapsed or operate with very low milk supply. The Kenya Dairy Board puts the number of active cooperatives in the region to be about 10 by 2013 with none of them involved in active processing of milk (KDB Kakamega, annual report). The KDB report identifies travelling traders from outside the region, milk bars, households, hotels and institutions as the other key actors in the value chain.

At the service provision level, Ongadi *et al* (2007), Otieno *et al* (2005) and Musalia *et al* (2010), all reported that institutional services especially AI, breeding stock, disease control, extension and marketing were weak. From the reported works, there are gaps which are still unknown and questions which need to be answered about the milk value chain in the region. They include: what structure is needed to improve the

performance of the value chain? What is the influence of variables identified by studies in the region such as use of feeds, A.I services, extension services, credit, dairy meal, access to markets and policy on milk production? And how should the value chain be upgraded? This study sought to find answers to these questions, particularly the feasibility of an impact model for upgrading the milk value chain in Western Kenya.

Methodology

The study was carried out in the four counties of Busia, Bungoma, Kakamega and Vihiga. The regionhas an estimated 99000 smallholder dairy farmers keeping about 192300 improved dairy cattle (FAO 2011). Data were collected from a total of 385 milk buyers (households, hotels and institutions), 400 dairy farms, 10 Cooperatives, seven service institutions and six focus groups and interviews. A purposive, proportional random sampling technique was employed using questionnaires, checklists and interview guides. Qualitative data was analysed using descriptive statistics and thematic grouping, while quantitative data used multiple linear regression (Nathans et al., 2012; Nimon et al., 2010) and product measure Pedhazur (1997; Pratt (1987).

Results nd Discussion

177 million litre deficit

The results obtained showed 53% of the milk marketed comes from outside the region with acute shortages of milk experienced for a period of three to four months between December and March. About 92% of consumers surveyed in the four counties reported experiencing low milk supply.With a population of 4.3 million people (GOK, 2009), using FAO recommendations for milk consumption of0.25 litres per person per day, the demand for milk in the region is about 392 million litres per annum against a production of 215 million litres/annum (Western Province livestock annual report, 2011). Therefore theregion's milk deficit is about 177 million litres per annum. From this study, 53% of milk comes from outside, which translates to 94 million litres

(Figure 1). This implies that the Counties of Busia, Bungoma, Vihiga and Kakamega are predominantly milk deficient.

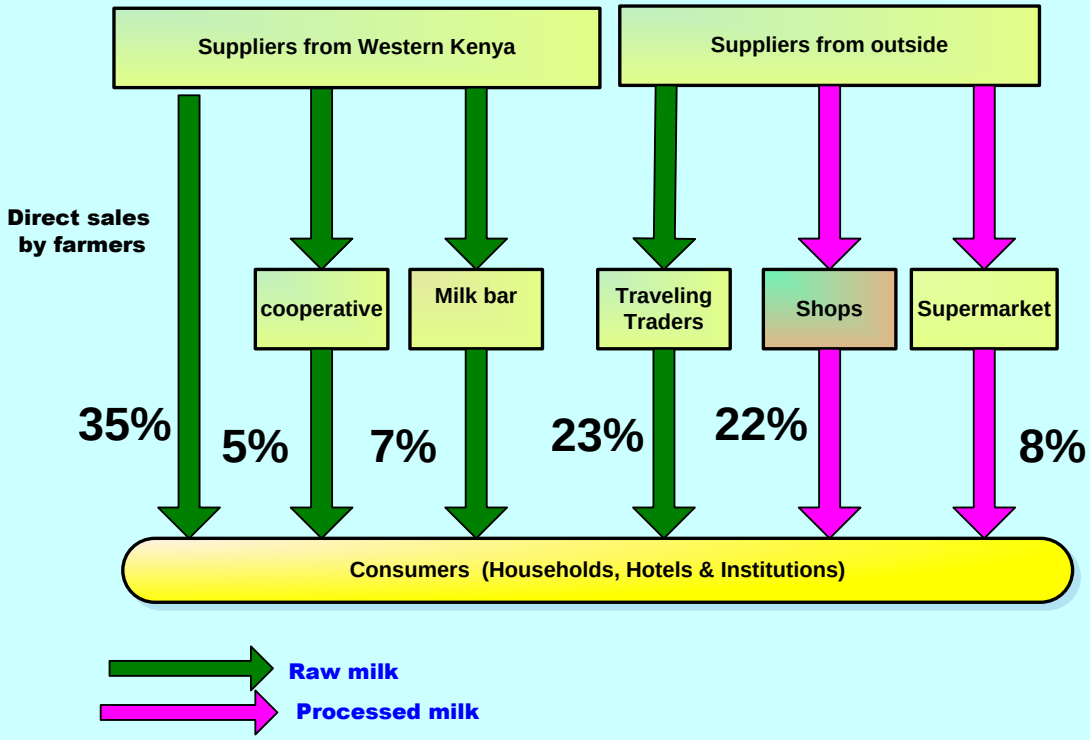

Figure 1: Sources of milk and marketing channels in Western Kenya

Idle coolers in cooperatives

Some parameters on the performance of selected cooperatives in the region are shown in Table1.Out of 11841 registered members, only 1,017 (8.6%) were active. The results also show that out of the region's total installed cooler capacity of 27,600litres;the average daily intake was 2,420 litres (8.8%).In addition, informal interviews established that coolers in all cooperatives surveyed were either grossly underutilized, broken down and had power supply disconnected due to inability to pay bills. Despite the huge idle capacity, more coolers were still being supplied in the region by development agencies. It is suggested that in a milk deficit region such as Western Kenya, the investment policy and priority is to target and focus on increasing volumes and capacity building of both farmers and cooperatives on management / agribusiness skills rather than the populist direction of provision of coolers. Prakash (2000), in a review of cooperatives in Japan, argues that cooperatives are neither social clubs nor charity organizations and should be managed in a business-like manner. To be efficient and remain relevant and competitive in the post liberalization era, cooperatives must upgrade from horizontal to vertical coordination through embracing modern functions (Bijman, 2007),

Table 1: Parameters on performance of dairy cooperative

Parameter	Busia		Bungoma		Kakamega				Vihiga		
	Nambale	Funyula	Kitinda	Naitiri	Kimilili	Butere	Kwitsero	Kakamega dairy	Hamisi	Bunyore	Overall
Registered suppliers	210	300	9000	1300	25	305	270	250	31	150	11841
Active suppliers	101	16	50	300	11	215	200	65	9	50	1017
Capacity of cooler(l)	2500	0	10000	5000	1000	1000	2500	2500	2500	600	27600
Intake /day (lit)	350	50	250	800	50	400	250	200	20	50	2420

6.5 litre/cow/day: average milk yield on smallholder farms

The mean milk yield per cow per day was 6.5 litres with a range of 1-20 litres (Table 2).About 89% of the farms produced less than 10 litres of milk per cow per day. The yields were relatively low when compared to the national average. A recent study by USAID (2012) showed that in the high potential areas of Central (Kabete) and Rift Valley (Kericho), the average yield had increased from 6.4 litres per cow per day to 16.75litres per cow per day and 12.61litres per cow per day respectively following implementation of Kenya Dairy Sector competitive programme.

Lactation period

The mean lactation period was 7.67 months (230 days) with a range of 5-12 months (150-210 days). The majority of farms (77.8%) had a lactation period of 5-7 months. This finding means that the cows are drying up too early before the desired normal lactation period of 305 days.

Table 2: Herd performance in Butula and Butere Sub Counties

Parameter	Butula	Butere	Overall			
			Mean	SD	Min	Max
Herd size	2.53	2.38	2.46	1.33	1	8
No. of milking cows	1.3	0.7	1	0.63	0	3
Av milk yield/cow/day* (litres)	6.47	6.47	6.47	3.88	1	20
Peak production*	12.4	11.18	11.79	6.54	2	40
lactation period* (months)	7.9	7.44	7.67	1.6	5	12
Av calving interval* (months)	14.4	15.3	14.77	3.9	12	36
Age at first calving* (months)	27.72	28.72	28.15	3.9	24	38

*No of farms: Butula =166 (73%)
Butere = 125 (72%)

Important variables influencing milk yields

Results of eight variables evaluated using different weighting measures are shown in Tables 3-5. There was agreement between the four approaches on the top two important variables: fodder and dairy meal, and the last two variables: economic returns and policy. However, a slightly different rank order was obtained for the remaining variables (Table 3). Indeed, quantitative methods are useful in establishing statistical significance and hence support validity, but statistical significance without theoretical or practical significance does not support validity. Because of the richness in data and insights obtained when using both quantitative and qualitative methods (Saunders et al., 2009), a combined weighting appears to be a better approach in selecting important variables since it capitalizes on the strengths of each to reflect the theoretical basis of the research issue. Using this ranking method, the most important variables influencing milk production on smallholder farms were found to be: fodder; dairy meal, credit, Artificial insemination, improved research technologies, group membership, policy and economic returns. Collectively, they explained 63.9% of the variance in milk yields in the area ($F_{8, 291}$= 65.089, $p<0.001$), (Table 4). Fodder and dairy meal combined explained 51% of variance in milk yields (Table 5).

Table 3: Prioritization of important variables using different measures

Variable	Ranking				average	**Overall**
	Farmers	Livestock department	Beta weights (b)	Product measure		
Fodder	1	1	1	1	1	1
Dairy meal	2	4	2	2	2.5	2
Research	5	9	3	5	5.5	5
Artificial insemination	3	5	5	6	4.75	4
Credit	4	6	4	4	4.5	3
Economic returns	9	10	8	8	8.75	8
Group membership	7	7	6	3	5.75	6
Policy	8	11	7	7	8.25	7

Table4: Collective effect of variables usingMultiple linear regression analysis

Variable	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1.765	.457		3.859	.000*
fodder dummy	1.903	.341	.245	5.578	.000*
Dairy meal dummy	1.643	.422	.210	3.888	.000*
AI dummy	1.303	.296	.167	4.406	.000*
Credit dummy	1.416	.353	.172	4.016	.000*
Policy dummy	.901	.339	.111	2.656	.008**
Research dummy	1.472	.289	.187	5.093	.000*
Returns dummy	-1.058	.394	-.098	-2.684	.008**
Group dummy	1.202	.454	.147	2.649	.009**
Adjusted R^2 = 0.639					
$F_{8, 291}$ = 65.089					
P < 0.001					
N= 291					
Constant=1.765					
Std error = 0. 457					

* P<0.001, ** P<0.01

Table 5: Variance explained by individual predictors on milk yield

Step	Variable	Multiple correlation coefficient (R)	Determination Coefficient R^2	Adjusted R^2	Variance explained (%)
1	Fodder Dummy	0.599	0.359	0.357	35.7
2	Dairy meal Dummy	0.656	0.430	0.510	15.3
3	Research technologies Dummy	0.740	0.548	0.543	3.3
4	Credit Dummy	0.762	0.580	0.574	3.1
5	Artificial insemination Dummy (AI)	0.781	0.610	0.604	3.0
6	Group membership Dummy	0.794	0.630	0.623	1.9
7	Policy Dummy	0.800	0.640	0.631	0.8
8	Returns Dummy	0.805	0.649	0.639	0.8

Business case : one acre feed models

Am impact model evaluated on one acre feed model showed that intercropping Napier grass with desmodium on ¾ acres while sweet potato vines was grown on ¼ acre could sustain 2 cows and 1 calf for 1 year, with a potential milk yield of 10 litres/cow/day even without use of dairy meal. With an estimated population of 698,888 dairy cows in milk in the region, based on this model, milk yield from

grade cows alone would be 176 million litres per year. Current production from Zebu and goats is 129 million litres/ year. Therefore expected total milk production in the region would be (grade cows + local cows + goats) 305 million litres. Since the regional demand is 392 million litres/year, the deficit would be reduced from 177 million litres to 86 million litres (51%).

Since smallholder farmers practice a mixed crop-livestock system, extra fodder from crop residues could even sustain a dry cow. Based on this model the carrying capacity on 1 acre of fodder is 3 animals (cow, heifer and calf). In terms of business, current production on small holder farms is 1240 litres/cow/year worth KES 62 000. In the new model, the yields could increase to 2530 litres per year with a revenue of KES 126,500.

Thus the findings of this study present an opportunity to pilot the proposed model in order to address the milk deficit problem in Western Kenya.

Economic viability

The costs and benefits for the proposed intervention are presented in Tables 6 and 7.

Net Present Value

Table 6 presents an estimation of the Net Present Value (NPV) of the proposed intervention. The NPV measures the net financial benefits of the program. The NPV was 34.30 meaning the intervention is feasible and should be considered.

Table 6: Anticipated Net Present Value of the intervention*

Year	1	2	3	4	5	Total
Benefits	3.8	11.1	11.1	15.28	15.28	56.56
Costs	4.0	0	0	0	0	4.0
B-C	-0.2	11.1	11.1	15.28	15.28	52.56
Discounted factor (12% SACCO rate)	1.12	1.25	1.40	1.57	1.76	7.1
Discounted annual cash flows	-0.92	8.88	7.93	9.73	8.68	34.30
SUM NPV= KES 34.30						

*Financial figures are in '00 000 000

Cost-Benefit Ratio and Internal Rate of Return

Table 7 compares the Benefit-Cost Ratio (BCR), Return on investment or Internal Rate of Return (IRR) and NPV. The calculated BCR is 14.14 meaning a return of KES 14.14 for very KES 1 invested. The IRR is 12.14 meaning the investment will generate a return that amounts to 1214% of the cost of investment. Hence the intervention should be considered.

Table 7: Comparing Benefit-Cost, Internal Rate of Return and Net Present Value

Benefits	Costs	Benefit - Cost Ratio (BCR)	Internal Rate of Return (IRR)	Net Present Value (NPV)
56.56	4.0	14.14	12.14	34.30

Policy implications

Based on empirical results, the study proposed vertical linkages in which cooperatives coordinate farm input supply to marketing. Key policy interventions proposed are:

- Fodder accessibility, availability and utilization on smallholder farms
- Use of high quality dairy meal and / or protein legumes
- Establishment of A.I and breeding services
- Policy: strategic plan to guide dairy development with emphasis on increasing milk production
- Access and availability of credit through interlocked transactions
- Formation of dairy farmer business clusters
- Commercialization and dissemination of improved dairy feed technologies
- Restructuring dairy cooperatives into business enterprises

Conclusion and Recommendations

This study examined an impact model for upgrading the milk value chain in Western Kenya.Based on the findings of this study, priority interventions for increasing milk production on smallholder farms in the region should consist of five key areas: integrated input supply (feeds, AI services, breeding stock); dairy farmer business clusters; new structured cooperatives operating as business entities; contract marketing and supportive county government policy. Urgent areas for policy interventions are a regional approach in: establishment of AI centre with liquid nitrogen plant; establishment of a breeding stock multiplication centres in Agricultural Training Centres and development of dairy strategic plan as a road map to guide development agencies. It is concluded that the priority for the Western region is a regional approach that focuses on increasing milk volumes on smallholder farms first and not installation of coolers or building a processing plant.

Acknowledgement

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References

Bijman, J. 2007. How can cooperatives meet the challenges ofagrifood supply chains? In: Ton, G, Bijman J. and Oorthuizen, J. (Eds): Producer organizations and marketchains. Wageningen: Academic Publishers.

FAO. 2011 . Dairy development in Kenya, by HG Muriuki. Rome: Food and Agriculture Organization of the United Nations.

Government of Kenya, 2009.Population and Housing census. Nairobi: Ministry of state for Planning, National development and Vision 2030.

Limo, K. S. and Popoi, M. 2011. Effects of liberalization on dairy cooperatives in Western Province, Kenya. International Journal of Current Research, 3(7): 222-228.

Mudavadi, P. O., Otieno, K., Wanambacha, J. W., Odenya, J. O., Odendo, and Njaro, O. K. 2001. Smallholder dairy production and marketing in western Kenya: A Review of Literature. The Smallholder Dairy (R&D) Project.

Musalia, L. M., Mukoya, M., Wangia, R., Shivairo, S and Vugutsa, V. 2010. Effects of policy change on the dairy production support services within the smallholder dairy farmers in Butere/Mumias and Kakamega sub Counties of Western Kenya. African Journal of Agricultural Research, 5 (8) : 661-667.

Nathans, L.L., Oswald, F.L., Nimon K. 2012.Interpreting Multiple Linear Regression: A Guidebook of Variable Importance. Practical Assessment Research & Evaluation, 17:9.

Nimon K., Gavrilova M, Roberts, J.K. 2010. Regression results in human resource development research: Are we reporting enough?" In C. Graham and K. Dirani (Eds.), Proceedings of the Human Resource Development 2010 International Conference (pp. 803-812), Knoxville, TN: AHRD.

Ongadi, P.M., Wakhungu, J.W., Wahome, R.G and Okitoi, L.O. 2007. Characterization of grade dairy cattle owning households in mixed small scale farming systems of Vihiga, Kenya. Livesock Research for Rural Development, Vol. 19: 3.

Otieno, D.C., Iruria D.M and Odhiambo, M.O. 2005. Input use efficiency in smallholder dairy farms in Western Kenya.African Crop Science Conference Proceedings, Uganda: ACSS, 7: 927-930. Web accessed, 25 Feb.2012.

Pedhazur, E.J. 1997. Multiple regression in behavioural research: Explanation and prediction(3rd ed.). Stamford, CT: Thompson Learning.

Prakash, D. 2000. Development of Agricultural Cooperatives-Relevance of Japanese . Experiences to Developing Countries. Paper presented at the 14th ICA-Japan International Training Course on"Strengthening Management of Agricultural Cooperatives in Asia"held at IDACA-Japan on April 18 2000.

Pratt, J.W. 1987. Dividing the indivisible: Using simple symmetry to partition variance explained. In Pukkila T, Puntanen, S, (Eds.), Proceedings of the second international Tampere conference in statistics (pp. 245-260). Tampere, Finland: University of Tampere. 2010 International Conference(pp. 803-812), Knoxville, TN: AHRD.

Saunders, M, Lewis, P and Thornhill, A. 2009. Research Methods for Business Students,5th Edition. Harlow, England: FT Prentice Hall-Pearson Education Limited.

Wambugu, S., Karimi, L. and Opiyo, J. 2011. Productivity trends and performance of dairy farming in Kenya. Tegemeo Institute of Agricultural Policy and Development. Egerton University.

Profitability of Economic Stimulus Program (ESP) Fish Farming Adopters in Kibwezi, Makueni County, Kenya

Wesonga P.W[1*] ,Wangia S.M[2]; Njoka J.T[4*]; and Maina J.G[3*].

[1]Department of Land Resource Management and Agricultural Technology, University of Nairobi
[2]Department of Agricultural Economics, University of Nairobi
[3]Department of Animal Production, University of Nairobi
[4]Center for Sustainable Drylands and Eco-Systems, University of Nairobi
Correspondence author: pswesonga@yahoo.com mobile +254 722 848 523

Abstract

Fish farming in Kibwezi is a recent livelihood alternative that was propelled by government funding under the Economic Stimulus Programme (ESP) between 2009 and 2012. A study was done to evaluate the profitability and sustainability of fish farming in Kibwezi, Makueni County. A sample size of 146 fish farmers was selected for the study. Profitability was measured by gross margins and net fish income. Net Present Value (NPV) and Internal Rate of Return (IRR) were not utilized since most of the ponds were constructed using a government grant. Overall, 8.9 percent of farmers had a positive net fish income while 26.7 percent had a positive gross margin. Farmers with a stocking density of 5 fish per m^2 and above serviced their total variable costs. Hatchery owners did better with 57.1 percent showing positive returns on both measures of gross margin and net fish income. Stocking density, feeds and labour affected the gross margins of 53.4 percent of farmers. Underweight fish was also a common problem among this group of farmers. Adopters with the highest gross margins paid employees or committed themselves to pond management activities. Secondly, most of them made their own feeds. It is recommended that farmers need to be trained to make their own feeds.

Key Words: Fish Farming, Profitability, Livelihood, Kibwezi, ESP, Adopters

Introduction

Aquaculture is the farming of aquatic organisms in inland and coastal areas, involving intervention in the rearing process to enhance production with individual or corporate ownership of the stock being cultivated (Food and Agriculture Organization (FAO), 2005). For the purpose of this paper, finfish specifically Nile Tilapia (*Oreochromis niloticus*) and African Catfish (*Clarias gariepinus*) respectively were studied.

Africa's fish production is about 5.7 percent of world total production of fish, that is, aquaculture, catches and landings combined. In Africa, tilapia and catfish are the most preferred for farming. Tilapia is the most cultivated species accounting for 70 to 80 percent of freshwater fish production except in Nigeria where catfish is higher with over 70 percent of farmed fish (Ponzoni*et al.*, 2008). The above mentioned countries both export and import fish in some form. However, most of the fish is not affordable to the majority of the local fish consumers. Thus there is high demand for affordable fish but the supply is limited. It is this scenario that has prompted most African nations to promote fish farming programs in their nations.

Statement of the Problem and Justification

Fish is one of the sources of protein nutrients for humans but Africa's average fish consumption has steadily declined between 1984 and 2000 from 7.9 to 6.8 Kg/ person per year (Ronnback*et al.,* 2002). Currently, Kenya has a per capita fish consumption 6.6Kg/person/year compared to 16.6Kg for the developed world and 17.7Kg for some Asian countries (FAO, 2010). Food insecurity continues to be a major problem in the developing world, specifically Africa. African fish production from aquaculture is well below the demand of the African consumers that rely on local catches to meet their needs. Kenya's low per capita fish consumption presents a nutritional and a livelihood challenge especially in Arid and Semi-arid lands (ASALs). The nutritional problem is more magnified given that ASALs local residents have merger resources and limited livelihood options

This study analyzed the profitability of fish farming in Kibwezi,Makueni County, Kenya. The study is important because fish farming has the potential to bridge the gap between current fish supply and fish demands of ever increasing Kenyan population. As the population grows there is need to secure more sources of quality protein foods. Fish meets these criteria of providing a high protein nutritional value, especially for vulnerable groups such as young children less than 2 years old, pre-school children, pregnant and nursing women. In Kenya, these vulnerable groups are predominantly rural and poor especially in the Arid and Semi- Arid Lands (ASALs). There is need to identify complimentary livelihood choices for pastoralists' communities and this profitability study will provide relevant information that takes advantage of good fish farming practices which increases aquaculture adoption. Good fish farming practices will lead to profitable operations and sustainable fish enterprises in ASALs. Adoption implies an enterprise is sustainable. Sustainability is evident if a farmer generates a profit (benefit). From these findings the researcher proposed recommendations that could be acted upon by various fish farming stakeholders.

Objective and Research Question

The objective of this paper was to determine the profitability of ESP fish farming in Arid and Semi-Arid Lands (ASALs) of Kibwezi, Makueni County, Kenya. While the research question to be addressed was: fish farming profitable in Kibwezi?

Materials and Methods

Study Area

The study was done in the larger Kibwezi that consists of Makindu and Kibwezi East Sub- Counties marked I and II of Makueni County (Figure 1). Kibwezi was taken as a representative sample of the fish farmers in the County. Makueni County is located in the lower eastern part of Kenya as shown in figure 1.

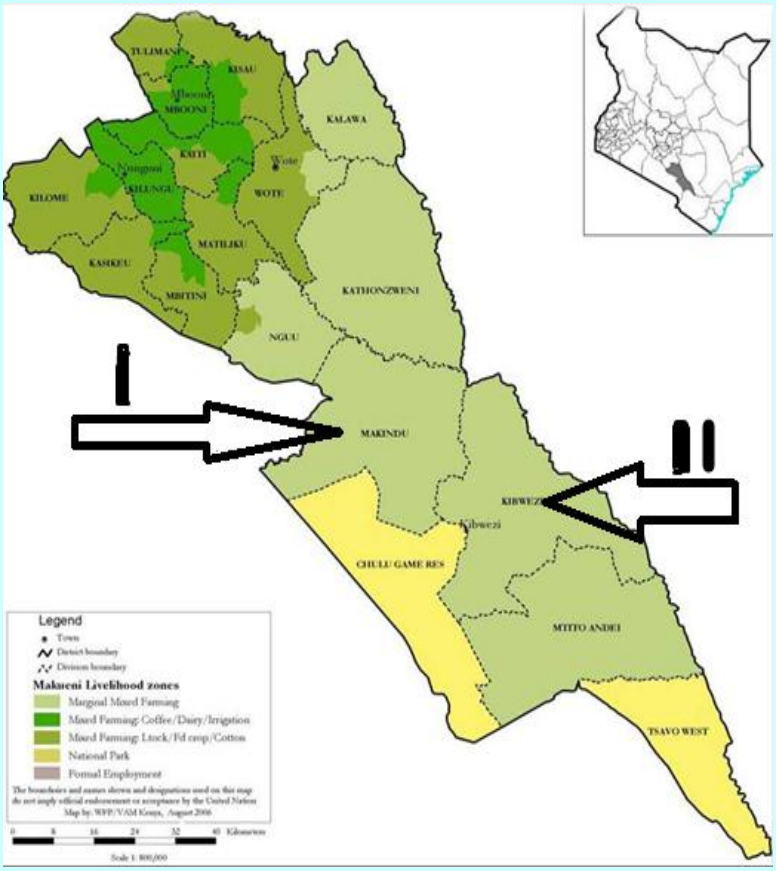

Figure 1: Makueni County showing the larger Kibwezi marked I and II (CDA, 2012)

Research Design Sampling Framework

The study used both primary and secondary data. To determine a representative sample size for active fish farmers, Cochran (1963) formula for cross sectional studies was used in selecting 80 active and 66 inactive farmers.

Data collection and analysis

Data was collected in February and March 2015 using questionnaires that were administered to the respondents. A total of 146 selected fish farmers were interviewed. The primary data collected included the cost of production and income generated from the sale of the fish. Regarding the amount of funds utilized by the government to support the projects, secondary data was acquired from the government officers. Data was entered into Excel and SPSS spreadsheets. The quantitative analysis used gross margins, net fish income, costs and returns. While descriptive analysis used frequencies and percentages

Gross margin (GM) for fish farming is the difference between the total revenue (TR) and the total variable cost (TVC) of fish farming (GM = TR – TVC)

Net Fish Income (NFI) is the difference between total revenue and total cost of the fish enterprise (NFI = TR – TC)

Results and Discussion

Stocking Density: Fingerlings.

Generally farmers had a stocking density of 3 fish/M^2 for tilapia while approximately 20 percent of farmers stocked at 10 fish/M^2 (Table 1a). The farmers with higher stocking density were based along river Kiboko 3 km north east of Kiboko market. Catfish stocking density was 5 fish per M^2 for farmers with earth ponds, while one farmer with concrete ponds were higher at 15fish per M^2 (Table 1 b). The fingerling cost ranged between 7.7 to 33.9 percent of TVC. This is inconsistent with Neira *et al.* (2009) that had a range of 21 to 31 percent.

Table 1a: Tilapia stocking density

Fish/M^2	Frequency	Percent
3	41	53.2
5	20	26.0
10	15	20.0
15	1	1.3

Table 1b: Catfish stocking density

Fish/M^2	Frequency	Percent
3^2	1	11,1
5	5	55.6
10	2	22.2
15	1	11.1

Feeds

Feed utilized accounted between 7.7 and 75. 9 percent of total variable cost (TVC) for the 146 sampled fish farmers, while their TVC values were between 35.9 to 61.9 percent. Sixty-six percent of farmers used commercial feeds bought from Nairobi at an average price of KES 67.50 per Kilogram. Fifty percent of the farmers ordered the required feeds to meet their fish food needs while 24 percent used a combination of commercial and farm made feeds. This study also revealed that farmers relied on homemade feeds when funds were limited.

Fish farmers who managed hatcheries relied more on locally made feeds using cereals such as wheat and sorghum as the primary energy sources while soya beans, sun flower and omena were used as protein sources. Eight percent of the farmers who relied on homemade feeds indicated that their feeds had a crude protein content of 26 to 36 percent and the average cost of raw materials was KES 32.00 per Kilogram. Studies by Neira *et al*. (2009) showed that the total variable cost (TVC) for tilapia production was between 28 to 71 percent. The feed cost ranged between 51-53 percent of TVC for farmers who used pellet feeds. The production cycle was 9 months due to improved growth rate that generated a higher profit. Farmers who had a TVC of 28-50 percent used rice bran or formulated feed and fish matured in 11 months. The feed cost percent of TVC was lowest at 19 percent in a polyculture type of production and highest at 51 to 53 percent in claris monoculture while tilapia monoculture farming practice had 31 percent feed cost (Table 2).

Table 2:Feeds Utilized

Types of feeds	Frequency	Percent
Commercial	53	66
Farm made	8	10
Combination	19	24

Labour

Fish farmers managed their fish farming activities using one or combination of the following: family labor, hired monthly labor, hired monthly security labor, and labor in fertilizer applications. About 63.3 percent of farmers hired monthly labor who were involved in daily activities of fish farming, 37% percent involved family members to do daily operations of fish rearing and only 1.7 percent of farmers hired fertilizing labour.

Eight farmers who had a positive net fish income had hired monthly labor with an average wage of KES 7,500 per month KES 6,000 being a minimum and a maximum of KES 25,000. Five farmers who used family members or self had a positive net fish income ranging from KES 18,250 to KEs 128,500. The labor cost which ranged from 12.7 to 51.6 percent was inconsistent with that of Neira *et al* (2009) of 28 to 31 percent.

Table 3: Type of Labour

Labor type used	Frequency	Percent
Family members	44	37.
Hired monthly	63	52.9
Monthly security	10	8.4
Fertilizer	2	1.7
No information	27	

Adoption

Adoption was referred to as those farmers who were still practicing fish farming for over five years continuously since the inception of the ESP in the year 2009 and the enterprise is sustainable. Sustainability is evident if a farmer generates a profit. Out of the 146 fish farmers surveyed, 63 farmers were classified as adopters with an adoption rate of 43.2 percent while 83 were found to be non-adopters (66 inactive and 17 active farmers). Among the 63 adopters nine farmers were classified as innovators, 24 early adopters and 30 late adopters.

Table 4: Adoption Rate

Adoption		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adopters	63	43.2	43.2	43.2
	non adopter	83	56.8	56.8	100.0
Total		**146**	**100.0**	**100.0**	

Gross Margins

Less than a third (26.7%) of the respondents had a positive gross margin, 53.4 percent had negative gross margins while 19.9 percent did not have enough information to calculate their gross margins (Table 5). Farmers' yield was 0.5-1.8 Kg/m^2 for tilapia production and 1.5- 8 Kg/m^2 for catfish production. These yields are within 0.5-1.5Kg/m^2 found by Neira *et al* (2009). Also farmers who operated four (4) or more ponds had a better gross margin than those who had one pond due to the economies of scale. This finding is in agreement with those of Okechi (2004) in the Lake Victoria Basin who noted economies of scale in operating twelve ponds instead of one pond.

Table 5: Gross margins of sampled fish farmers

Gross margins of fish farmers		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.7	.7	.7
	positive GM	33	22.6	22.6	23.3
	negative GM	78	53.4	53.4	76.7
	Not enough information to calculate GM	29	19.9	19.9	96.6
	positive GM hatcheries	5	3.4	3.4	100.0
Total		146	100.0	100.0	

Net Fish Income

Overall 8.9 percent of 146 fish farmers surveyed had a net fish income see Table 6. Four different hatchery owners had a positive net fish income out of seven independently owned hatcheries sampled. The remaining 3 hatcheries did not disclose their sales revenue and costs information.

Table 6: Net Fish Income

Net fish income for farmers		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	positive Net fish income farmer	9	6.2	6.2	6.2
	Loss	133	91.1	91.1	97.3
	positive net fish income hatchery	4	2.7	2.7	100.0
Total		**146**	**100.0**	**100.0**	

Is fish farming profitable in Kibwezi?

On the question whether adopters are profitable, the answer is yes as indicated by 52.4 percent of adopters who had a positive gross margin and yields of 0.5-1.8Kg/m^2. This is supported by Mbugua (2002) study that indicates a yield of .05-1.5 Kg/m^2 is what can sustain a profitable fish production that is reliant on cereal bran as primary feeds. The remaining 47.6 percent have potential if they can manage their variable costs. Security labor and feed cost being the main impediment to them The cost and returns of the adopters average were feed 56% fingerling 24.5 %, labor 19.1 % and gross margin (60.9%).These results differ with Boateng*et al*. (2013) on fingerling (12%), labor (13%), and gross margin (72%); however, there is collaboration on Feed cost at 56 percent.

Conclusion and Recommendations

The study established that fish farming is a viable enterprise for 8.9 percent of 146 interviewed fish farmers. Three factors that greatly contributed to improved gross margins and net fish income of fish farmers are as follow: First, ability to make their own feed meals. Secondly, use of regularly paid labor which translated into experience or better pond management practices. Finally, stocking density also improved profits with farmers stocking 5 per M^2 and above showing a positive net income.

From the above, it is recommended that farmers be trained appropriate methods of formulating fish feeds locally. The Government through Fishery Extension Offices could facilitate clusters of farmers to use one common locally made feed that can be analyzed at a government laboratory. Farmers or perspective investors need proper information relating to managerial skills and the commitment which is required in fish rearing.

References

Boateng V,F, Alhassan,E.H, Yaw S, Nensom E, and Abarike E.D. 2013 Profitability analysis of all male tilapia farming in Sekyere South and Bosomtwe Districts of Ashanti Region.

Agriculture and Biology Journal of North America: 2013 4(5) 568-575.

FAO (2005) Aquaculture production, 2004, year book of fishery statistics –Vol.9612.Food and Agriculture Organization of the United Nations,Rome,Italy.

FAO (2010) FAO Statistical Yearbook 2009 - Agricultural Production, available at: http://www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2009/b-agriculturalproduction/en/.

Ivano, Neira; Carole R. Engle; Charles Ngugi. 2009. Economic and Risk Analysis of Tilapia Production in Kenya. Journal of Applied Aquaculture 21: 1-23.

Mbugua, H.M. 2002. The role of Fisheries Department in aquaculture development in Kenya. Samaki 1 (1) 24-30.

Okechi J.K. (2004) Profitability Assessment: A case study of African Catfish farming in theLake Victoria Basin, Kenya. University of Iceland, Reykjavik.

Ponzoni, R.W. and N.H. Nguyen (Eds). 2008. Proceedings of a Workshop on the Developmentof a Genetic Improvement Program for African catfish Clariasgariepinus.World FishCenter Conference Proceedings Number 1889. The World Fish Center, Penang, Malaysia. 130 p.

Ronnback, P., Bryceson, I and Kautsky, N. (2002) Coastal Aquaculture Development in prospects and problems for food security and Local Economies. Royal Swedish Academy of Science 31: 7-8 2002.

Camel Deworming Practices: A Case Study of Pastoral Communities of Ngurunit and Ngare Mara in Marsabit and Isiolo County

[*]Kagunyu, A.W.[1], Njanja, J. C.[2], Wamae, K.D[2], Mũtahi[3] and Mũrĩira, J.[3]

[1]Kenya Agricultural and Livestock Research Organization- Sericulture Thika
[2]Kenya Agricultural and Livestock Research Organization, VSRI, Muguga
[3]Ministry of Agriculture, Livestock and Fisheries, Kenya
[*]Correspondence author: kagunyu2010@gmail.com mobile; +254 723 770 295

Abstract

Camels are very important and precious to pastoral communities of Northern Kenya since they fulfill many social and economic functions. They are reared in remote areas with poor infrastructure and this makes it difficult for them to have access to modern medicine. As a result of this researchers came up with this study which aimed at establishing the type of deworming practices applied by the camel keepers of Ngurunit and Ngare Mara. This study applied qualitative research methods namely, focus group discussions, direct observation and documentary information. The result of this study showed that camel keepers were familiar with different worms that affected their camels. The two communities also gave signs which they perceived as indicators of camels which had worms which included: Lacrimation-tears in the eyes, loss of appetite and loss of hair, low milk production, rough hair coat, and worms detected in the camel faeces and from the nasal cavity. The study also indicated that in the two localities, indigenous and conventional methods were used to treat camels that were perceived to have worms. Camel keepers in the two regions revealed that they used salty water and herbal medicine occurring naturally to deworm their camels. They also used modern drugs such as Abandezole®, Nilzan®, and Ivermectin®. Worms are a big problem in the two sites and they affect camel production, hence affecting the food security of the camel keepers. Therefore there is need of educating the camel keepers on the appropriate methods of treating their camels. There is also need for the governments to improve health delivery systems in these areas.

Key words: Camel, worms, indigenous, modern, medicine

Introduction

Five countries in the horn of Africa -Somalia, Ethiopia, Kenya, Sudan and Djibouti - account for 84 % of the continent's dromedaries and 60 % of the world's dromedaries (Spore, 1997). Kenya hosts 6% of African camel population (Hulsebusch and Kaufmann, 2002). The population of camel in Kenya according to the latest census held in the year 2009 was 3 million (MSNP, 2009), an indication that the camel population in Kenya has continued to increase despite the effects of climate change (MoF&P, 2002). Camels are the best suited in the Arid and Semi Arid Lands (ASALs) due to their biological and physiological adaptations, which help them to cope with the existence of hot, arid environments (Field, 2005). They drink less water than other forms of livestock and have varied diet which includes shrubs. Their height allow them to browse where other livestock cannot reach and their ability to live many days without taking water. According to Mungere (2001) camels have diverse range of species of perennial shrubs/trees to eat from the riverine where the water table is near and implying that the vegetation will be evergreen. Camelids are important and precious to pastoral people who rely on them in a variety of ways. Ononoet *al.*, (2010) indicated that camels fulfils many functions among the pastoral communities which includes provision of milk, meat, blood, transport, barter trade, fulfilling cultural functions, hides and skins, provision of transport and barter trade. According to Farah *et al.*, (2004) camel production is a major source of livelihood for the pastoralists in the drier parts of Kenya.

Majority of these camels are raised under the traditional management systems that are not well understood by both researchers and policy makers partly because they are reared in remote areas with poor infrastructure. This makes it very difficult for pastoralists to obtain adequate veterinary extension services. Study by Raziq*et al.*, (2015) indicated that the veterinary officersare usually trained and deployed in urban areas and are inaccessible to the pastoral people. They also observed that medical

drugs used to treat camels and other livestock are expensive and not available in the ASALs, altogether this puts pressure on the pastoralists to rely on ethno-veterinary medicine. Herbal medicine is an important alternative treatment synonymous with veterinary anthropology indicating the complexity of ethno veterinary medicine (EVM) treatment to enhance the normal adaptive and defensive functions of the body.All this is done because the causal agent may be impossible to eliminate. There is a wide variety of ethno medicine treatment principles according to the cause of disease. This need led to the emergence of this study which aimed at obtaining information about the type of curative measures taken by camel keepers of Ngurunit andNgareMara to treat camels infected with worms.

Materials and methods

Study area

This study took place in Marsabit and Isiolo Counties of in Eastern part of Kenya. The sites were chosen purposively because they are traditional camel rearing areas. In MarsabitCounty the study took place in Ngurunit location occupied by Samburu, Ariaal and the Rendille while in Isiolo County the study was in Ngaremara location with mainly Turkana pastoralists.

Data collection methods

(1) Documentary data

This was acquired through literature search of published and non-published work in order to get background information of the project.

(2) Focus group discussions

Data was gathered through focus group discussion, with the help of a focus group guide. Four focus groups were held in the two sites two in Ngurunit, Marsabit County and two in NgareMara, Isiolo County with 54 focus group participants. Of the total number of participants, 24 were from Ngurunit and 30 from Ngare Mara. All the focus group participants were camel keepers who have had experience of camel rearing from the ancestors and since childhood.

Research finding

Focus group discussants in Ngurunit and NgareMara identified different worms which infected their camels. The worms in discussion were round worms (nematodes) tape worms (cestodes) and flat worms (trematodes). The discussions revealed that camel keepers have local names (vernacular) for the worms identified. Forinstance in Ngurunit they call all the worms using one name *Deyyah or Ntumai*. InNgareaarathe most common name used for worms was *ngamaiteny*. The participants were able to differentiate worms and where theywere located in the body of the live animal.The worms named were identified as round worms *(Angipelki,nkur),* tape worms (*Ngiratan*), liver flukes *(Ngendeke)* and nasal bot (*Ekurut*). Theliver flukes like worm (*Ngendeke*) found in the camel is the tape worms *Stilesia hepatica,* long and thread like.This was an indication that camel helminth is a common problem in the two regions.

In the two sites camel keepers gave the signs manifested by camels that had worms.The signs given included lacrimation –tears in the eyes, loss of appetite, loss of body condition, loss of hair, low milk production, rough hair coat, the stomach seem to collapse since they were not full. Worms were detected in the faeces of camels and from the nasal cavity when the animal sneezed

Forms of treatments

This study indicated that camel keepers in Ngurunit and Ngare Mara used two methods in treating camel worms. These were traditional and conventional treatments while some participants indicated they do not deworm their camels even when they realized that they had worms.

Traditional deworming

Pastoralist from Ngurunitindicated that they traditionally dewormed their camels by taking them to salty wells namely Kargi wells, Wiya inKasuit, Sermia near Lake Turkana and in any other region where

salty water could be accessed. The focus group discussants of Ngare Mara also stated that they used traditional methods to de-worm their camels. According to them they used locally available medicinal plants such as *Emekui, Ngiralieuphobia, Akaya and Lokapalka*. The participants also revealed that in addition they took camels to salty springs and wells which were found far from their locality.

On the efficacy of indigenous de-worming practices focus group discussant revealed that it was not very effective since sometimes it worked other times it did not. According to them a lot of time was spent travelling to the salty waters to treat their camels

Conventional deworming practices

The conventional modern drugs used were Abandezole®, Nilzan®, and Ivermectin®. The drugs are bought from the existing agro–vets and the cost of a broad spectrum is about KES 700-800. However, the participants had different views relating to application regimes of the de-wormers. There were those who de-wormed once per year, twice, or three time per year while others indicated that they de-wormed after noticing that a camel had problems. There was a general consensus among all the discussants that modern medicine were expensive therefore they used indigenous methods or gave under dose to their camels.

Discussions, conclusions and recommendations

This study indicated that worms were a big problem in the two research sites and the worms identified were round worms (nematodes) and tape worms (cestodes) including the tape worms *Stilesia hepatica,* long and thread like often mistaken for liver flukes and nasal bots *(Cephalopinatitillator).* Past research work carried out in these areas confirmed the presence of camel worms (Rutagwenda 1985; Njanja 2007). From the four groups it came out clearly that all the four groups treat worms and they use different modes of treatment both traditional and convection as they are aware that it affects the health of camel and production of milk which is the staple food. There was a general perception that salty water and medicinal plants are capable of treating worms in camels.

The groups were aware of convectional de-wormers. However it came out clearly from the Ngurunit groups that they had inadequate knowledge of the dosage, so when administering the drugs they either gave under dose or overdose. For those who stated that they gave under dose they attributed this to lack of proper information and also to the high cost of the drugs. The cost of the drugs also affected the frequency of de-worming and as well as the number of camels given the drugs. The practice of application of drugs is a major factor in determination of the effectiveness of treatment and there is need to educate the camel keepers on the same.

Worms are a big problem in the two sites and they affect camel production, hence affecting the food security of the camel keepers. Therefore there is need of educating the camel keepers on the appropriate methods of treating their camels. There is need for the governments to improve health delivery systems

References

Farah, K., D. Nyariki, R. Ngugi, I. Noor and A. Guliye 2004. The Somali and the Camel Ecology, management and Economics. Available at: http;//www.krepublishers.com/02-Journals. Reviewed on 2 March 2015.

Farm – Africa, (2002): Micro – enterprise Development. Best Practices from FARM-Africa, Nairobi.

Field, C. 2005.Where there is no Development Agency: A Manual for Pastoralists and their Promoters. Natural Resources International, Aylesford, Kent, UK.

Field, C.R., 1994. Production from pastoralist systems in Kenya. In Marketing of pastoralist Livestock Products. Proceedings of the Kenya Pastoralists Forum Meeting 7th July 1994. KARI/ODA, Nairobi

Hulsebusch C.G and B. Kauffmann 2002. Camel Breeds and breeding in Northern Kenya. In proceedings of a collaborative research project on camel breed differentiation and pastoral camel Breeding strategies within the KARI/EU Agriculture/livestock Research Support Programme for Kenya.(ARSP11; Project No.6 ACP KE 0161-KE 6003/001).

Kuria, S.G and M. Mbui2001. The camel and food security in Northern Districts of Kenya. In APSK proceedings held in the proceedings of APSK 2001 Annual Symposium held on 7- 8 March at Egerton

University, Njoro, Kenya.

MoF&P (Ministry of Finance and Planning) 2002. National Development Plan, 2002-2008. Government Press, Nairobi.

Njanja, J. 2007. Major factors associated with high morbidity, mortality and poor performance of camel calves, kids and lambs in the Rendille and Samburu pastoral herds in Marsabit District, Kenya. PhD Thesis, University of Nairobi, Nairobi, Kenya.

Onono, J., W.Okelo, and S.Okuthe 2010. Challenges of camel production in Samburu District, Kenya. Journal of Camelid Science 3 (2010) 01-05. Available athttp://www.isocard.org reviewed on 20 September 2014.

Raziq A, Kerstin de Verder and M. Younas 2004.Ethnovertinary treatments by dromedary camel herders in the SULEIMAN Mountains Regions in Pakistan an observation and questionnaire study. Journal of Ethnobiology and Ethnomedicine; doi; 10, 1186/1746-4269-6-16. http://www.ethnobiomed.com/content/6/1/16.

Rutagwenda, 1985. Camel diseases and productivity in arid lands of northern, Kenya: Integrated Project in Arid Lands (IPAL) Technical report Number E – 7.

Spore Magazine 1997. Camel's neglected potential; Bi-monthly bulletin of the Technical Centre for Agriculture and Rural Cooperation NO. 1-no 68, 1986 -1997.

Cost of Production, Marketing and Revenue Generation from Somali Camel Breed in Isiolo and Marsabit Counties of Northern Kenya

Kuria S.G [1]and Njoka J.T [2]

[1]Kenya Agricultural and Livestock Research Organization, Kiboko; P.O. Box 12-90138 MaKindu; Email: simon.kuria@kalro.org; kuriasg@gmail.com; Private mobile: +254 722 289 697/+254 20 802 1905

[2]University of Nairobi, College of Agriculture and Veterinary Sciences, African Drylands Institute for Sustainability.

Abstract

A study was carried out in Isiolo and Marsabit Counties of northern Kenya to understand marketing and estimate potential profitability of commercial Somali camel rearing in northern Kenya. The study took the form of a survey where a total of 91 and 120 randomly selected respondents were individually interviewed in Isiolo and Marsabit, respectively using a semi-structured questionnaire. The data was analyzed using the IBM SPSS where independent samples t-test was carried out on quantitative data while for the qualitative data, descriptive statistics were carried and test for significance done using chi-square. Market price for camels ranged from KES. 12,500 for male calves under one year to KES. 97,143 for mature females and were within the range reported earlier by other researchers. The prices were higher in Isiolo than Marsabit across all age categories although not significantly except for mature males which sold for KES. 55,971±3,637 in Isiolo and KES. 39,682±3,333 ($p<0.05$) in Marsabit. Ninety point six % (n=77) of respondents in Isiolo estimated market value of camels before taking the same to the market compared to 67.7% (n=65) in Marsabit, suggesting Isiolo pastoralists were keener to have an idea of the market value before taking camels to the market for sale than was the case in Marsabit. The commonly used method for estimating market value of camels was that of visual assessment of body size in combination with market information. Isiolo pastoralists were spending more money on all types of inputs than their Marsabit counterparts although the differences were not significant except for the acaricides ($p<0.05$). In terms of revenue generation, pastoralists were making KES. 10,292 and 4,888 every month in Isiolo and Marsabit, respectively from sale of live camels and the milk. The fast expanding commercial rearing of Somali camels in peri-urban Isiolo and Marsabit was profiting the pastoralists. There however appeared to be a variance between actual market value of camels and the price offered to farmers in the market suggesting some degree of exploitation of the farmers. Considering the KES. 10,000 pastoralists were making in Isiolo was based on traditional management of the camel, the potential profitability of commercial rearing of the camel is much higher and could be exploited through training on improved camel management technologies.

Key words: Camel rearing profitability, camel milk and meat, climate adaptationand resilience

Introduction

Camels have traditionally provided milk, meat, blood for subsistence and have had socio-cultural values among the pastoral communities of Kenya (Field 2005, Guliye et al. 2007; MoLD2007; Mehari et al. 2007a, b; Mahmoud, 2010). The unique physiological, morphological and anatomical featuresincluding less water requirements and ability to supply milk throughout the year with or without drought makes camel the livestock species of choice in climate adaptation and resilience (Field, 2005). In the recent past, camel rearing in Kenya is increasingly gaining commercial value especially under the emerging peri-urban production system (Matofari et al., 2007; Noor et al., 2012). In 2011, camel milk production in Kenya was estimated at 553 million litres (7% of the national total) worth about KES. 16 billion (Behnke and Muthami, 2011) and in the same year, camel meat worth KES. 54 billion was sold. The expanding market-oriented camel production presents opportunities for poorer households to enhance their food and income security (SRA, 2004).

Camels have continued to replace the cattle in Isiolo County as confirmed by a pastoralist Abdi Maalimin an article carried by the Mediamax People daily Kenya (2015). The camel farmer at Kachiulu area in Isiolo County said *"life has been good since I turned to camel rearing in 1988"* noting that *'camel copes*

well in the arid and semi-arid conditions unlike the cow that needs constant supply of water. The camel drinks less water and is able to survive for days without quenching its thirst. Besides, the camel feeds on shrubs available in the region as opposed to cattle that feed on grasses.

The Somali camel breedin particular produce more milk, is heavier and produces more meat, fetch higher price in the market and has higher load capacitycompared with other breeds of camel in Kenya. Considering that feed resources will become scarcer in future owing to climate change and human activities, it makes sense to keep few but more productive animals and the Somali camel fits this bill in the peri-urban arid areas of Kenya. This study sought to understand marketing and estimate potential profitability of Somali camel rearing in northern Kenyaif it was to be done as a business. The study was part of a bigger baseline study ahead of interventions aimed at promoting rearing of Somali camels for business and climate adaptation.

Methodology

The survey was undertaken in the Counties of Isiolo and Marsabit in northern Kenya where a total of 91 and 120 randomly selected respondents were individually interviewed in Isiolo and Marsabit, respectively. A semi-structured questionnaire was used to gather the data from respondents drawn from three purposively selected divisions in Isiolo namely; Ol Donyiro, Isiolo Central, Kina and three in Marsabit namely; Torbi, Maikona and Gadamoji. In each division, a myriad of purposively selected villages with high concentration of Somali camels were sampled and respondents picked at random. The sampling frame was all the pastoralists owning Somali camels in each village that was selected. The selection of villages was carefully done to ensure representation. In total, 14 villages were sampled in Isiolo and 7 in Marsabit. The interviews were conducted by carefully selected and trained enumerators under close supervision by the research team.

Data analysis

The data was entered, cleaned and analyzed using the IBM SPSS statistics version 20 (2011). Independent samples t-test was carried out on quantitative data while for the qualitative data, descriptive statistics were carried and test for significance done using chi-square where applicable.

Camel Market Prices

Details of marketing were as presented in Table 1.

Table 1: Market Prices of Camels in Isiolo and Marsabit in the year 2014

Categories of camels	Sex	Sites	Sale price (μ±SE)	Sig.(t)
Calves < 1 year	Male	Marsabit	12,500±2,500	0.326(ns*)
		Isiolo	14,775±846	
	Female	Marsabit	20,000±1,104	0.887(ns)
		Isiolo	22,856±1,531	
Weaners (2 – 3 years)	Male	Marsabit	17,714±1,936	0.139(ns)
		Isiolo	24,672±1,172	
	Female	Marsabit	30,000±5,385	0.701(ns)
		Isiolo	37,015±1,424	
Mature camels (>3 years)	Male	Marsabit	39,682±3,333	0.038(s**)
		Isiolo	55,971±3,637	
	Female	Marsabit	97,143±34,531	0.095(ns)
		Isiolo	77,657±13,600	

**ns – Not significant; **s - Significant*

Based on the data in Table 1, it is clear the prices of camels in Isiolo were relatively higher than in Marsabit except for mature females. The price of males in Isiolo was significantly higher ($p<0.05$) than in Marsabit. The high price of mature Somali female camels in Marsabit may suggest there was a rush for this category of camels (higher demand than supply) in line with the finding that camels are currently being promoted in Marsabit. The higher camel prices in Isiolo were expected as Isiolo is more accessible and has a higher number of camel meat consumers compared to Marsabit. The findings of this study regarding prices in both Isiolo and Marsabit agreed with an earlier report by Hussein Mahmoud (2013). Mahmoud observed that rising demand for camel meat in Arab countries had also pushed up prices of the animal in North Eastern Kenya and Nairobi markets noting that consumers in

Arab countries preferred camel meat from the horn of Africa, which they say is sweet compared to meat they source from other vast global market segments such as Europe, Australia, and USA. Further, camels were being sold at between KES.70, 000 and 80,000 in Garissa market, between KES.90, 000 and 100,000 in Moyale market, and KES.80, 000 in Nairobi market. The demand of camel meat in Arab region mainly in Saudi Arabia is high attracting importers to source for camel from horn of Africa through Ethiopia, Djibouti, and Northern Somalia and thattraders in these markets were sourcing for camel from northern Kenya, Mahmoud added.The prices reported in this study were however much higher than those reported earlier by Noor et al. (2013) for all classes of camels suggesting fast improving fortunes for camel pastoralists. Overall, these dynamics presents a golden opportunity for pastoralists in northern Kenya to not only address the challenges of climate change by adopting the large bodied Somali camel breed but also rear the camel as a business.

On whether the pastoralists estimated market value of camels before taking the same to the market, 90.6% (n=77) of those interviewed in Isiolo did, the commonly used method being that of visual assessment of body size in combination with market information (85.9%, n=55). In Marsabit, 67.7% (n=65) did estimate mainly using the same method used in Isiolo (54.4%, n=31). The rest of the pastoralists in both sites did not bother. The results suggest Isiolo pastoralists were keener to have an idea of the market value before taking camels to the market for sale than was the case in Marsabit. Possible explanation for this observation is the fact that in Isiolo where the level of commercialization of camel rearing is high, the decision to sell camels is possibly informed by the market demand while in Marsabit, household needs could still be a significant decisive factor in camel marketing (McPeak and Little, 2006). Failing to have an idea of market value pre-disposes pastoralists to exploitation by middlemen and brokers who are reported to constitute up to 50% of the participants in some markets (McPeak and Little, 2006). The method the pastoralists were using to estimate the market value was less accurate, a challenge that would need to be addressed through capacity building. Exposing and demonstrating to the pastoralists the already existing simple but more accurate methodologies of estimating market value of an animal would serve to enhance their bargaining power in the market.

Cost of Production and Revenue Generation

The findings for both sites are summarized in Table 2.

Table 2: Average Household Cost of Producing Camels and Revenue Generated in Isiolo and Marsabit in year 2014

Average Annual Production Costs					
Type of Input	Sites	Quantity (μ±SE)	Sig.(t)	Cost (KES) (μ±SE)	Sig.(t)
Antibiotics (Litres)	Isiolo	57±46	0.278	2,722±628	1.78(ns*)
	Marsabit	43±12		1,505±268	
De-wormers (Litres)	Isiolo	55±52	0.203	2,002±542	0.416(ns)
	Marsabit	41±30		1,693±510	
Acaricides (litres)	Isiolo	18±12	0.313	2,244±376	0.049(s**)
	Marsabit	14±5		2,218±365	
Mineral supplements (Kg)	Isiolo	169±23	0.162	3,784±584	3.145(ns)
	Marsabit	150±35		1,590±381	
Herding labor (Man days)	Isiolo	298±157	0.069	25,791±4,246	3.836(ns)
	Marsabit	270±122		7,647±2,085	
Water (litres	Isiolo	806±183	0.053	9,962±2,249	0.050(s)
	Marsabit	695±157		7,004±1,672	
Totals	Isiolo	-		46,555	
	Marsabit	-		14,653	
Average Annual Revenue Generated					
Live camel sales (Numbers)	Isiolo	5±1.0	0.09	86,355±8,582	1.343(ns)
	Marsabit	3±0.7		72,310±5,979	
Milk sales (Litres)	Isiolo	1,784±992	-	83,700±25,406	-
	Marsabit	-		-	
Totals	Isiolo	-		170,055	
	Marsabit	-		73,310	
Annual Surplus Revenue					
Indicative Profit Margins	Isiolo	-		123,500	
	Marsabit	-		58,657	

**ns – Not significant; **s - Significant*

The data presented in Table clearly 2 shows that in terms of inputs, the Isiolo pastoralists were spending more money on all the inputs than their Marsabit counterparts although the differences were not significant except for acaricides ($p<0.05$). This can be explained by the fact that the level of commercialization of camel milk production is much higher in Isiolo compared to Marsabit. Pastoralists in Isiolo could afford to spend more since they had the money. Moreover, expenditure on production inputs is dependent on herd sizes explaining the relatively higher figures for Isiolo. However, pastoralists in both sites were indeed spending money in buying inputs for production. This finding compares favorably with that of Hesse and MacGregor (2006) in Ethiopia where the author reported that 37% of the income generated through destocking during drought period was spent on livestock care.

The overall camel off take in Isiolo was about 15%, much higher than 4% reported earlier for general livestock among pastoral communities by (McPeak and Little, 2006; Were, 2009) but lower than figures reported by Noor et al. (2013) for steers and breeding males in the same County. Dividing the money raised by the number of camels sold gives about KES 24,000 in Marsabit and KES. 17,000 in Isiolo suggesting that the pastoralists were either selling the middle aged camels or were not getting the actual market value where mature camels were sold i.e. were possibly being exploited by brokers, based on prices in Table 1. The pastoralists certainly need more training on pricing and how they can work out realistic estimate of market value of camels before taking them to the market.

The proceeds from milk sales were as high as those from live camel sales especially in Isiolo. This finding was in agreement with McPeak and Little (2006) who earlier reported that, in North Kenya the total value of milk exceeds that of meat in the pastoral economy by more than double.Unfortunately data for milk sales was unavailable in Marsabit County.

Based on surplus revenue figures, pastoralists were getting KES. 10,292 and 4,888 every month in Isiolo and Marsabit, respectively, from sale of camels and the milk and there is potential to significantly

improve these figures through capacity building of the pastoralists on improved Somali camel management. This suggests there is indeed money in camel rearing in Isiolo and MarasbitCounties.

Conclusion

The study concluded that commercialization of camel rearing within the peri-urban Isiolo and Marsabit was indeed rewarding to the farmers who were able to sell live camels as well as milk. However, there seem to be a variance between the actual market value of camels and the price offered to farmers in the market suggesting the farmers were perhaps being exploited by other market players. This would need to be addressed in order to motivate pastoralists to fully commercialize their camel rearing activities. Given that pastoralists were managing the Somali camel using their indigenous knowledge and could still make KES. 10,000 per month in Isiolo, it means potential profitability of commercial rearing of the camel is much higher especially if pastoralists were trained on improved camel management technologies.

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References

Behnke R and D Muthami. 2011. The Contribution of Livestock to the Kenyan Economy (IGAD LPI Working Paper No. 03 – 11) 2011. IGAD Centre for Pastoral Areas and Livestock Development (ICPALD), Djibouti.

Field C R. 2005. Where there is no development agency: A manual for pastoralists and their promoters, NR International, Aylesford, Kent, and UK.

Guliye AY, Noor IM, Bebe BO and IS Koskey. 2007. Role of camels (Camelus dromedarius) in the traditional lifestyle of Somali pastoralists in northern Kenya. Outlook on Agriculture 2007, 36(1):29–34. 10.5367/000000007780223669.

Hesse C and J MacGregor. 2006. Pastoralism drylands' invisible asset? IIED issue paper No. 142 ICTSD (2007).

IBM Corporation 2011. IBM SPSS statistics 20 Core System User's Guide. California State University, Northridge.

Mahmoud A. 2013. Meat-prices-head-north-as-long-rains-begin. Newspaper article published Wednesday, April 3rd 2013 at 00:00 GMT +3http://www.standardmedia.co.ke/business/article.

Mahmoud HA. 2010: Camel marketing in the Northern Kenya/Southern Ethiopia Borderlands. FAC Research Update 003. Brighton: Future Agricultures Consortium, University of Sussex; 2010.

Matofari JW, Shitandi A, Shalo PL, Nanua NJ, M Younan. 2007: A survey of Salmonella enteric contamination of camel milk in Kenya. African Journal of Microbiology Research 2007, 1(4):46–50.

McPeak JG and PD Little. 2006. Pastoral Livestock Marketing in Eastern Africa - Research and Policy Challenges. Intermediate Technology Publications / ITDG, UK

Mediamaxnetwork.co.ke/people daily. 2015. Camel meat now new gold mine in Kenya. .http://www.jambonewspot.com/camel-meat-now-new-gold-mine-kenya.

Mehari Y, Mekuriaw Z, G Gebru.2007a.Camel and camel product marketing in Babilie and

Kebribeyahworedas of the Jijiga Zone, Somali Region, Ethiopia. Livestock Research for Rural Development 2007a, 19(49): Accessed 1 May 2007 http://lrrd.cipav.org.co/index.html.

Mehari Y, Mekuriaw Z, G Gebru.2007b.Potentials of camel production in Babilie and Kebribeyahworedas of the Jijiga Zone, Somali Region, Ethiopia. Livestock Research for Rural Development 2007b, 19(58): Accessed 1 May 2007.

MoLD: Ministry of Livestock Development (MoLD). 2007. Annual report 2007. Hill Plaza, Nairobi, Kenya

Noor IM, Bebe BO, AY Guliye.2012: Analysis of an emerging peri-urban camel production in Isiolo County, Northern Kenya. Journal of Camelid Science 2012, 2012(5):41–61.

Noor I M, GuliyeAY, Tariq M and O. Bebe. 2013. Assessment of camel and camel milk marketing practices in an emerging peri-urban production system in Isiolo County, Kenya. Pastoralism: Research, Policy and PracticePastoralism: Research, Policy and Practice20133:28.

Were T. 2009? Rewards from twisted roles: case study on revitalized livestock marketing in Samburu, Northern Kenya. SNV Netherlands Development Organization - Case Studies 2009.

Poultry And Dairy Production Systems

The effects of dietary probiotics on natural IgM antibody titres of Kenyan indigenous chicken

Khobondo, J.O[1], Ogore, P.B[1], Atela, J.A[2], Onjoro, P.S[2], Ondiek, J.O[2] and Kahi, A.K[1]

[1]Animal Breeding and Genomics Group, Department of Animal Sciences, Egerton University, PO Box 536 - 20115 Egerton, Kenya
[2]Animal Nutrition Group, Department of Animal Sciences, Egerton University, PO Box 536 - 20115 Egerton, Kenya
Correspondence: jkhobondo@gmail.com

Abstract

This study was conducted to investigate the effects of probiotic supplementation on serum natural IgM levels binding keyhole limpet hemocyanin (KLH) in indigenous chicken (IC). One hundred and fifty, two months old chicken raised under low input-output system were sourced from small scale indigenous chicken farmers from Nyakach and Emining sub Countries of Kisumu and Baringo Counties, Kenya respectively. The IC were of mixed sex, randomly divided into five treatment groups of 25 birds each. The treatments were 5ml of Molaplus dissolved into 250, 500, 1000, 1500 and 2000ml of drinking water. The birds were raised in group cages, and fed commercial growers' mash for two months during the study period. A window of 14 days was left for immune stabilization. Blood was then drawn from the web vein and serum separated immediately. Levels of IgM binding was assayed using an indirect ELISA technique. IgM binding KLH was found but dietary probiotic supplementations did not significantly affect levels of IgM binding KLH in the serum. Probiotic supplementation in diet did not further enhance KLH binding IgM in ICreared under village production system.

Keywords; indigenous chicken, Kenya, immunoglobulin M, Probiotics.

Introduction

The indigenous chicken (IC) industry has become an important economic activity in Kenya and many countries. In large-scale rearing facilities, where chicken are exposed to stressful conditions, problems related to diseases and deterioration of environmental conditions often occur and result in serious economic losses. Prevention and control of these diseases have led in recent decades to a substantial increase in the chemical usage. The usage of these chemicals as a preventive measure has been questioned; there exist extensive documentation of the evolution of pathogens resistant to chemicals. The possibility of alternative to drug usage may be the use of probiotics and/ or breeding for disease resistance (Khobondo et al 2015b). Probiotics are being considered to fill this gap and already some farmers are using them in preference to antibiotics (Nava et al 2005).

Probiotic, meaning 'for life' in Greek, are defined as 'a live microbial feed supplement, which beneficially affects the host animal by improving intestinal balance' (Fuller, 2001). The species currently being used in probiotic preparations are varied and many. These are mostly *Lactobacillus bulgaricus, Lactobacillus acidophilus, Lactobacillus casein, Lactobacillus helveticus, Lactobacillus lactis, Lactobacillus salivarius, Lactobacillus plantarum, Streptococcus thermophilus, Enterococcus faecium, Enterococcus faecalis, Bifidobacterium spp.* and *Escherichia coli* (Kabir, 2009).Some other probiotics are microscopic fungi such as strains of yeasts belonging to *Saccharomyces cerevisiae* species (Fuller 2001). Probiotics may be composed of one or a combination of many strains.

Probiotics are used to help maintain a healthy microbial balance within the intestine to promote gut integrity and prevent enteric disease (Cox and Dalloul, 2015). This is accomplished through three main mechanisms: competitive exclusion, bacterial antagonism, and stimulation of the immune system (Ohimain and Ofongo 2012). The manipulation of gut microbiota via the administration of probiotics influences the development of the immune response (McCracken and Gaskins 1999). It has been shown that probiotics stimulate different subsets of immune system cells to produce cytokines, which in turn modulate the immune response (Lammers et al 2003) and activate other cells. Amongst the subset of B cells, B-1 cells constitute the predominant subset of B cells in mammals (Islam et al 2004). While B-2 cells

produce the majority of circulating specific antigen induced antibodies possessing high binding affinities. The antibodies secreted by B-1 cells called natural antibodies. They typically have low binding affinities and broad specificities (Parmentier et al 2004). Natural antibodies are usually produced without prior exposure to antigens (Khobondo et al 2015a). Foreign antigens like lipopolysaccharides (LPS), lipoteichoic acid, keyhole limpet hemocyanin, and bovine serum albumin (BSA) (Higgins et al 2007) that bind natural antibodies in the sera of unimmunized chickens have been found. In higher organisms including chicken, natural antibodies may be of isotype IgM, IgG, or IgA, but IgM is the predominant isotype. In mammals, B-1 cells are responsible for production of the natural IgMantibodies in serum (Khobondo et al 2015a) but in chicken B1 cells have not been defined yet. Natural IgM antibodies possess a wide range of activities, including regulation of immune response, induction of specific IgG antibodies, and protection against bacterial and viral infections (Nava et al 2005).

Natural antibodies in the chicken bind to antigens in a specific manner and the affinity of these interactions increases with age, suggesting a role for external stimuli. These roles can be exploited for breeding of disease resistance. Due to consumer concern on the use of antibiotics as growth promoters and prophylaxis in poultry diets, investigations evaluating the potential of dietary probiotics as substitutes for antibiotics do receive high priority and IC should not be exemptions. This is because, the IC are predominantly raised under extensive production system (Khobondo et al 2014). This makes the IC prone to various environmental challenges and disease causing pathogens hence the rationale of this study. Earlier, it was shown that that probiotics stimulate natural antibodies in poultry (Haghigi et al 2006). This study was carried out to determine possible effects of dietary probiotics on serum natural IgM levels in IC birds. The findings could be used to prevent disease burden or compliment breeding for disease resistance.

Materials and Methods

Source of birds, feeding regime and management

A feeding trial was conducted using one hundred and fifty (150) indigenous chicken two months of age from free range small scale farmers. The farmers were from Nyakach and Emening of Kisumu and Baringo countries, respectively. The trial was done in a randomized complete block design with control-not complete. The birds were randomly allocated the 5 test diets with 25 replicates (25 birds/replicate) per treatment. Twenty five birds had no supplementation (control). The dietary treatments and water were offered *ad libitum*. The probiotic were added into drinking water by giving a specific concentration of 5ml of Molaplus microbes (Molaplus LTD, Kenya) in different volumes (250, 500, 1000, 1500, 2000 ml)of the respective water once a day at 0900 hours. The Molaplus is a complex solution of various beneficial micro-organisms which are found naturally and are used in feed manufacturing. When used in poultry production, they avail, chelated minerals, ant-oxidant, enzymes, vitamins, organic acids, lactic bacteria, yeast and phototropic bacteria (Molaplus.com). The experiment was done for a period of two months (60 days), thereafter IC were left for two weeks (14 days) for immunological stabilization, then a blood sample was taken for natural antibody assay.

Natural antibodies (IgM) measurement

Blood samples (~2 ml in EDTA) from 150IC were drawn from the wing vein of each bird and serum was separated immediately by centrifugation at 2000rpm for 10 minutes for measuring IgM antibodies binding KLH. Isotype specific IgM antibody titers to keyhole limpet hemocyanin (KLH) in serum from the IC was determined by indirect enzyme-linked immunosorbent assay (ELISA) as described by Khobondo et al (2015).

Statistical analysis

The data was analyzed using one way ANOVA using Proc GLM of SAS (SAS, 2002). The following model was used;

$Y_{ij} = \mu + PR_i + e_{ij}$

Where y is the IgM absorbance level (titre value), μ is the overall mean, $PR_i$is the fixed effect of treatment (i=2), e is the residual error.

Results

Presence of natural IgM antibodies binding KLH in Serum of IC and effects of dietary probiotics

Natural IgM antibodies binding KLH were detected in IC serum but, there was no significant difference between the ICfed probiotics and the birds not fed probiotics (control) ($P > 0.05$). Neither was there significant difference in the titres of KLH binding IgM at 17 days after treatments ($P > 0.05$) between the treatments (different inclusion levels of probiotic concentration) (Table 1).

Table1: The LSmeans and standard deviations (SD) of the dietary treatment of IgM titres binding KLH. The Control group showed higher IgM titres but not significant

Isotype	IgM		
Parameter	LSMeans	Std error	P value
Control	1.75	0.121	
Probiotic	1.73	0.065	0.873

LSmeans = least square means; S.D = standard deviation

Discussion

Most of Nab bind pathogen-associated molecular patterns (PAMP), e.g., lipopolysaccharide, lipoteichoic acid or peptidoglycan conserved along different genera and these serve as targets for identification of microbes by the innate immune system (Parmentier et al 2004). The levels of Nabs are likely dependent on several factors, amongst them the environment (Kachamakova et al 2006), genetic background (Ardia et al 2011) and age (Berghof et al 2010).Despite the plethora of data demonstrating the positive effects of probiotics on immune performance (Haghighi et al 2006), this study and some others have reported no significant enhancements due to probiotic supplementation (Rahimi et al 2011). It has to be kept in mind, however, that titres of IgM to KLH were measured 14 days after dietary treatment, so short term temporary effects could not be found. Also there was information on the IgG levels KLH.

It is clear from the present study and other published research that responses to probiotic supplementation are inconsistent. Numerous investigations were done on possible factors that could influence the responses to these additives. For example, in broilers possible causes of variations in response to probiotic supplementation could be differences between strains, hybrids, age, sex, plane of nutrition, nutrient composition of the diet, microbial population of gastrointestinal tract, levels of inclusion of probiotics in the diet, duration of supplementation or other environmental conditions (Midili et al 2008). In this study involving IC, administration of probiotics did not significantly enhance serum IgM antibodies reactive to KLH. In this case, probiotic treatment resulted in the reduction of the mean reactive IgM antibodies in serum of the IC.

These discrepancies could be due to a variety of factors including, but not limited to, strain(s) of bacteria utilized, composition and viability of the probiotic, preparation method, dosage, and application method, frequency of application, overall diet, drug interactions, and condition of the animal (Huang et al 2004). The experimental design, source of birds and early stage production system in this study could be the cause of discrepancies in result. It is worth noting that the IC used in this study was naturally hatched and brood, the rearing was free range as well. This management system from incubation, hatching to the time they were sourced (2 months old) might have exposed them to these commensal microbes from the feces and environment. The chicken could have received a complete gut flora from the mother's faeces and would infer immune response similar to probiotic microbes. The shell microbial contamination during incubation and hatching could play a role. The extensive system of IC production may have predominantly exposed the IC to plethora of microbes, infested the gut with several microflora and consequently influenced Nab levels. These results are in agreement with the results of other studies in which probiotics (Huang et al 2004) or prebiotics (Franklin et al 2002) or combinations of probiotics and prebiotics (Midili et al 2008) were used in different animal species.

Several studies reported the role of probiotic in augmenting immune response (Cox and Dalloul 2015). There are evidence that probiotics stimulate production of natural antibodies (Haghighi et al., 2006)

and different subsets of immune system cells to produce cytokines, which in turn play a role in the induction and regulation of the immune responses (Maasen et al 2000). It was found recently Nab levels in elite improved breeds reflect different physiological health status (in this case enhanced survival) as opposed to IC kept in confinement (in which Nab levels may signal a status of stress (Wondneneh et al., 2015). Thus enhancement or decrease of Nab in birds may mimic sensitivity to stress or changing (dietary) conditions, indirectly reflecting the animals, condition to respond. In IC, conditions due to husbandry may have been such that probiotics could not further enhance or decrease immune sensitivity.

The induction of immune response and the preimmune antibody repertoire is a subject of debate. It is possible that resident dendritic cells (DCs) in the lamina propria, which directly sample the intestinal lumen and engulf commensal bacteria, could play a role (Yaman et al., 2006). The DCs express a repertoire of Toll-like receptors (TLRs) (Kabir et al 2005), and binding of structural components of commensal bacteria or probiotics to TLRs expressed on the surface of DCs may lead to activation and maturation of these cells (Apata 2008). Upon activation, DCs process and present antigens to other cells thereby promoting the activation and differentiation of different subsets of immune system cells, leading to the production of Th2 cytokines, such as interleukin 4 (IL-4), IL-10, and transforming growth factor, that are important for antibody production and isotype switching (Apata 2008). The former may have the implications on the Nabs level witnessed in this study. Most microbes used in probiotic may have shared PAMPs with the microbes already ingested by the chicken in the free range production system.

Conclusion

This study provides no evidence that the administration of probiotics to IC diets caused any significant changes in systemic natural IgM antibody concentration. Although non-significant reduction results were observed for the examined parameter, further studies are needed to understand the effects of these additives and to clarify the effect on the immune status of IC. More comprehensive experimental designs examining performance and humoral immunities especially natural IgG and IgA and levels of adaptive IgA, IgG and IgM responses, age of exposure and production systems should be conducted.

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References

ApataD F 2008. Growth performance, nutrient digestibility and immune response of broiler chicks fed diets supplemented with a culture of Lactobacillus bulgaricus. Journal of Scienceand Food Agriculture.88, 1253-1258.

Ardia D R, Parmentier H K and Vogel L A2011. The role of constraints and limitation in driving individual variation in immune response. Functional Ecology, 25, 61-73.

Baccala R, Quang T V, Gilbert M, Ternynck T and Avrameas S 1989. Two murine natural polyreactive autoantibodies are encoded by nonmutated germ-line genes. Proceedings of the National Academy of Sciences, 86, 4624-4628.

Berghof T V L, De VriesReilingh G, Nieuwland M G B and Parmentier H K 2010 Effect of aging and repeated intratracheal challenge on levels of cryptic and overt natural antibodies in poultry. Poultry Science, 89, 227-235.

Casali P and Notkins A L 1989 CD5+ B lymphocytes, polyreactive antibodies and the human B-cell repertoire. Immunology Today, 10, 364-368.

Cox C M and Dalloul R A 2015. Immunomodulatory role of probiotics in poultry and potential *in-ovo*application. Benefcial Microbes 6, 45–52. 10.3920/BM2014.0062.

Ehrenstein M R and Notley C A 2010The importance of natural IgM: scavenger, protector and regulator.

Nature Review Immunology, 10, 778-786.

Franklin S T, Newman K E and Newman M C 2002 Evaluation of mannanoligosaccharide on the immune status of dairy cows and their calves. Journal of Animal Science. 80, 192.

Fuller R 2001 The chicken gut microflora and probiotic supplements. Journal of Poultry Science, 38, 189-196.

Haghighi R H, Gong J, Gyles L C, Hayes M S, Zhou H, Sanei B, James R, Chambers R J and Sharif S 2006 Probiotics stimulate production of natural antibodies in chickens. Clinical Vaccine Immunology. 13, 975–980.

Higgins J P, Higgins S E, Vicente J L, Wolfenden A D, Tellez G and Hargis B M2007 Temporal effects of lactic acid bacteria probiotic culture on Salmonella in neonatal broilers. Poultry Science.86, 1662-1666.

Huang M K, Choi Y J, Houde R, Lee J W, Lee B and Zhao X 2004 Effects of Lactobacilli and an acidophilic fungus on the production performance and immune responses in broiler chickens. Poultry Science, 83, 788–795.

Islam M W, Rahman M M, Kabir S M L, Kamruzzaman S M and Islam M N2004 Effects of probiotics supplementation on growth performance and certain haemato-biochemical parameters in broiler chickens. Bangladesh Journal of Veterinary Medicine, 2, 39-43.

Kabir S M 2009The Role of Probiotics in the Poultry Industry. International Journal of Molecular Science, 10(8), 3531–3546. Doi: 10.3390/ijms10083531.

Kabir S M L, Rahman M Mand Rahman MB 2005 Potentiation of probiotics in promoting meat quality of broilers. Journal of Bangladesh Social and Agricultural Science Technology, 2, 93-96.

Khobondo J O, Nieuwland M G B, Webb L E, Bokkers A M and Henk K Parmentier2015a Natural (auto) antibodies in calves are affected by age and diet. Veterinary Quarterly, DOI: 10.1080/01652176.2015.1009657.

Khobondo J O, Muasya T K, Miyumo S, Okeno T O, Wasike C B, Mwakubambanya R, King'ori A M and Kahi A K 2015b Genetic and nutrition development of indigenous chicken in Africa. Live. Res. Rural Develop. Volume 27, Article #159. Retrieved from http://www.lrrd.org/lrrd27/8/khob27159.html.

Khobondo J O, Okeno T O, Lihare G O, Wasike C B and Kahi A K 2014 The past, present and future genetic improvement of indigenous chicken of Kenya. Animal Genetic Resources, 125.

Lammers K M, Brigidi P, Vitali B, Gionchetti P, Rizzello F, Caramelli E, Matteuzzi D and Campieri M 2003Immunomodulatory effects of probiotic bacteria DNA: IL-1 and IL-10 response in human peripheral blood mononuclear cells. FEMS Immunology Medical Microbiology, 38, 165-172.

Maassen C B, Van Holten-Neelen C, Balk F, Den Bak-Glashouwer M J, Leer R J, Laman J D, Boersma W J and Claassen E 2000 Strain dependent induction of cytokine profiles in the gut by orally administered Lactobacillus strains. Vaccine, 18, 2613-2623.

Marianne B 2000 Role of natural and immune IgM antibodies in immune responses. Molecular Immunology, 37, 1141-1149.

McCracken V J and Gaskins H R 1999 Probiotics and the immune system. In Probiotics, a Critical Review; Tannock G W Ed, Horizon Scientific Press: Norfolk, UK pp. 85-112.

Midilli M, Alp M, Kocabağli N, Muğlalı Ö H, Turan N, Yılmaz H and Çakır S 2008 Effects of dietary probiotic and prebiotic supplementation on growth performance and serum IgG concentration of broilers. South African Journal of Animal Sciences, 38, 21-27.

Nava G M, Bielke L R, Callaway T R and Castañeda M P 2005 Probiotic alternatives to reduce gastrointestinal infections: The poultry experience. Animal Health Research Review, 6, 105-118.

OhimainE I and Ofongo R T 2012 The effect of probiotic and prebiotic feed supplementation on chicken health and gut microflora: a review. International Journal of Animal and Veterinary Advances, 4, 135-143.

Parmentier H, Lammers A, Hoekman J J, Reilingh G D V, Zaanen I T A and Savelkoul, H F J 2004 Different levels of natural antibodies in chickens divergently selected for specific antibody responses. Developmental & Comparative Immunology, 28, 39-49.

Quintana F J and Cohen I R2004 The natural autoantibody repertoire and autoimmune disease Biomedicine & Pharmacotherapy, 58, 276-281.

Rahimi S, Kathariou S, Grimes J L and Siletzky R M 2011 Effect of direct-fed microbials on performance and Clostridium perfringens colonization of turkey poults. Poultry Science, 90, 2656-2662.

Sun Y, Parmentier H K, Frankena K and Van Der Poel J J 2011 Natural antibody isotypes as predictors of survival in laying hens Poultry Science, 90, 2263-2274.

Van Knegsel A T M, De VriesReilingh G, Meulenberg S, Van Den Brand H, Dijkstra J, Kemp B and Parmentier H K 2007 Natural Antibodies Related to Energy Balance in Early Lactation Dairy Cows . Journal of Dairy Science, 90, 5490-5498.

Vani J, Elluru S, Negi V-S, Lacroix-Desmazes S, Kazatchkine M D, Bayary J and Kaveri, S V 2008 Role of natural antibodies in immune homeostasis: IVIg perspective. Autoimmunity Review, 7, 440-444.

Wondmeneh E, Van Arendonk J A M, Van der Waaij EH, Ducro B J and Parmentier H K 2015 High natural antibody titers of indigenous chickens are related with increased hazard in confinement. Poultry Science, 94, 1493-1498.

Yaman H, UlukanliZ, Elmali M and Unal Y 2006 The effect of a fermented probiotic, the kefir, on intestinal flora of poultry domesticated geese (Anseranser). Review Medical and Véterinary, 157, 379-386.

Effects of Rainfall and temperature variability on milk yield of Sahiwal Cattle at the Sahiwal Stud-KALRO Naivasha Kenya

Githinji M.G., Ilatsia E.D., Bebe B.O, Mbuthia J.M.

Kenya Agriculture and Livestock Research Organization, P.O. Box 25 – 20117 Naivasha
Egerton University, P.O. Box 536 – 20015 Egerton
Corresponding Author: Macdonald Githinji macgithinji@gmail.com

Abstract

The Sahiwal cattle breeds have been raised over the years under semi-arid ecosystem which is classified as hotspot of climate change where temperatures and precipitation changes are increasing in magnitude and have been experiencing fluctuating herd dynamics and performance. These have been attributed to among other factors, breeding strategies implemented in the past and changes in herd management regimes. In response, altering breeding and husbandry practices are prioritized to improve performance. However, interventions are planned without adequate understanding of the extent of sensitivity of the Sahiwal cattle breed to impacts of climate change. Sensitivity to temperatures and precipitation changes are likely to manifest in the herd dynamics and milk production performance because of associated changes in the productivity of forage and pastures and outbreaks of livestock diseases. The objectives of this study was to: characterize the variability in monthly rainfall and temperatures, determine whether variable rainfall and temperatures have any influence on herd dynamics and milk production of Sahiwal cattle herd. The PROBIT procedure was used to fit a logistic regression model to the probability of a positive response (survive) as a function of the variables month, temperature and rainfall. Considering the interaction between the rainfall and temperature on survival, there was significant month ($p < .0001$, $\chi^2 = 44.98$), rainfall ($p = 0.01$, $\chi^2 = 6.68$), and temperate by rainfall interaction ($p = 0.01$, $\chi^2 = 6.16$) but insignificant temperature effect, ($p = 0.79$, $\chi^2 = 0.07$). The prolonged drought that came around December all the way to Jan affected the survival of cattle through the constrained availability of feeds which led to starvation during this period. The month of May and October were also significant in the study because during this month there is plenty of lush pastures due to the long and short rains and this led to deaths due to bloat.

In general, the overall correlation coefficient for milk yield was -0.04 and 0.06 with temperature and rainfall respectively. The results show that with temperature, production of milk was high in January, May, June, and July. When temperatures are high the milk tends to decrease and when they are low, milk tend to increase. This shows the trend of milk yield versus rainfall and shows that milk yield mainly depends on precipitation. As precipitation increases, milk yield will increases. Although not seeming an important predictor of milk yield, precipitation was positively associated with high milk yield.

Introduction

Climate change and the associated risks are being experienced worldwide at unprecedented proportions but are greatest in the tropics where people are most reliant on natural resources, are more vulnerable to environmental disasters, and least equipped to adapt to the impacts (IPCC, 2007; IISD 2007; Thornton *et al*., 2009). In Kenya, the current understanding of climate change impact is that higher temperatures and more variable rainfall will likely be prevalent. Increased floods are more likely with more precipitation in shorter periods, while droughts are more likely with longer dry seasons. The impacts of high temperatures and variable precipitation manifests as change in security of water resources, in productivity of forage and pastures, and in outbreaks of livestock and crop diseases (Herrero *et al*., 2010; Rege *et al*., 2011). These climate related impacts ultimately depress animal numbers and milk production through reduced quantity and quality of pastures, forages and water resource, and increased severity of livestock diseases and parasites and loss of animal genetic resources.

Faced with a projected greater variable precipitation and higher temperatures, rain-fed livestock systems face threats of inadequate water and feed resources and exposure to increased disease

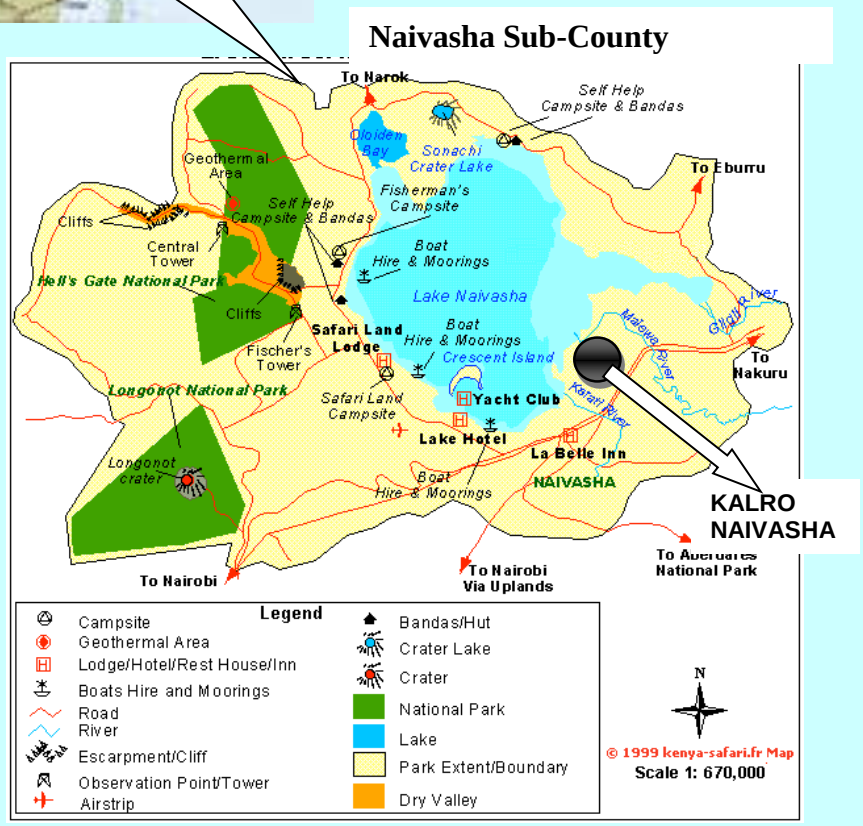
incidences. This has made search for adaptable cattle breeds more urgent to secure livestock assets in the face of posed threats from the changing and variable climate (Rege *et al*., 2011). Indigenous Zebu cattle breeds, though perceived to be genetically inferior in terms of productivity, are considerably resilient to the impacts of variable precipitation and higher temperatures in pastoral systems (Ilatsia *et al*., 2011). Sahiwal cattle breed is one of the popular breeds of choice used in up-grading programs of the local Zebu cattle especially in the southern rangelands of Kenya due to its relatively high milk production and growth potential as well as adaptability to impacts of variable precipitation and higher temperatures (Ilatsia *et al*., 2007; Ilatsia *et al*., 2011). Climate change can be expected to have several impacts on feed crops and grazing systems, including changes in herbage growth brought about by changes in atmospheric CO_2 concentrations and temperature, changes in the composition of pastures, such as changes in the ratio of grasses to legumes, changes in herbage quality, with changing concentrations of water-soluble carbohydrates and N at given dry matter (DM) yields, and greater incidences of drought, which may offset any DM yield increases (Hopkins and Del Prado, 2007).

The influence of adverse climatic factors such as intra and inter annual changes in rainfall and temperatures could interrupt breeding and husbandry interventions leading to fluctuations in herd dynamics and milk production performance in the Sahiwal herd. The Sahiwal cattle breed is used in upgrading local Zebu cattle and exotic cattle breeds. The National Sahiwal Stud (NSS) at Naivasha has comparable agro-climatic conditions to those found in the rangelands (Muhuyi *et al*., 1999). The NSS is a research facility for development of appropriate husbandry and breeding practices for the pastoralists in the southern rangelands of Kenya (Muhuyi, 1997). It has remained the major source of breeding cattle for the Maasai pastoralists and other leading Sahiwal ranches in the country. The performance of the Sahiwal cattle breed under the agro-ecosystem at Naivasha, where the breed has adapted over long period of breeding, can provide insights into sensitivity of the breed to impacts of variable precipitation and change in temperatures. To date, the NSS has concentrated on breeding and husbandry practices without emphasis on climatic related factors. The stud herd is managed under rain- fed pasture grazing systems in semi-arid ecosystem, characterized by large variability in rainfall (average annual rainfall of 620mm), daily minimum and maximum temperature ranging 8 to 26°C and humidity ranges from 60 to 75%. The breeding and husbandry interventions are planned and designed for implementation without adequate knowledge and evidence on the extent of sensitivity of the Sahiwal breed to impacts of variable and changing rainfall amounts and temperatures. This has therefore led to observed continuous decline in herd population levels and low milk production (Herrero *et al*., 2010; Rege *et al*., 2011).

Of all the factors influencing livestock production, climate and location are the most significant (Lamy et al. 2012). Climatological characteristics such as ambient temperature and rainfall patterns have great influence on pasture and food resource availability cycle throughout the year. During rainy season pastures are available in higher quantities with good nutritional quality whereas during the dry seasons, pastures are scarce and have poor nutritional quality with high fiber and low protein contents. In addition to affecting feed availability, climatic conditions affect the productive performance of livestock. In dairy cows, high temperatures during hot season have an effect on physiology, metabolism, production and reproduction of the animal. (Bertocchi *et al*., 2014).

Material and methods

Description of the study area



This study was done at the National Sahiwal Stud herd (NSS) situated at Kenya Agricultural and Livestock Research Organization (KALRO), Naivasha. The NSS is a research facility used for development of appropriate husbandry and breeding practices for cattle keepers mostly in the southern rangelands of Kenya. The stud rears purebred Sahiwal cattle and their F1 crosses with Friesian (Friesian-Sahiwal crosses). The Stud is the leading source of breeding stock for both pastoralists and other Sahiwal herds in Kenya and the Eastern African region. Compared to other nucleus herds, the NSS maintains good herd records that are used to enable selection and management decisions. The NSS has been, therefore, chosen because of the reliability of the data derived from the good herd records whose accuracy is crucial in evaluating the herd dynamics caused by rainfall and temperatures.

KALRO, Naivasha is located approximately 100km North West of Nairobi at an altitude of 1,829-2,330m above sea-level and situated in agro-ecological zone IV which is generally classified as semi-arid. The average rainfall is 680mm per annum whose distribution is bimodal with peaks in April and November. The temperatures ranges from 8°C to 26°C while the relative humidity varies from 60% to 75%. The vegetation consists mainly of Naivasha star grass (Cynodon plectostachyus) with scattered Acacia trees (Acacia xanthophloea) and shrubs.

General herd and breeding management

Calves are immediately removed from their dams at birth, weighed and ear tagged then receive colostrum in the first 4 days before bucket milk feeding with some concentrates introduced gradually up to weaning at about 9 weeks. Subsequent weighing is done weekly up to when they attain a body weight of about 55 kg and thereafter twice monthly until at an average weight of 125kg. Bulls and heifers are separated and managed in different herds. They are grazed on rain-fed pastures without supplementary feeding. Bulls are weighed monthly while heifers at about 27 months and 270kg body weight (expected service age and weight). Bulls are selected at two to three years of age either for progeny testing or for natural service in the pastoralist areas. All heifers and cows are weighed immediately after calving. Lactating cows are milked twice daily in mobile milking parlors. Water is provided to all groups *ad- libitum*. All animals are dipped at least once a week to control ecto parasites. Routine vaccination is done against Foot and Mouth, Rinderpest, Black-quarter, Anthrax, Rift Valley Fever and Brucellosis. Breeding is by artificial insemination and is done all year round with no pre-defined breeding seasons.

Data collection

Precipitation and temperature data

The KALRO, Naivasha maintains a weather station that collects data on basic weather variables such as rainfall, temperature, wind direction and speed and other parameters. Rainfall data is collected and recorded on daily basis and stored in hard book records. In this study rainfall data was extracted from the hard copies and entered into MS Excel data sheets. Temperature records including daily minimum and maximum temperatures were extracted from data relayed from KALRO, Naivasha to the Metrological Institute, Nairobi. The records included all daily rainfall data and daily minimum and maximum temperature from January 1979 to December 2012.

Milk production data

Data on milk production was collected from the milk record books which were entered on a daily basis since 1979 and recorded on excel spread sheets. The data was then summarized into monthly totals and analyzed.

Data analysis

Data on milk production

Data on basic weather variables such as daily rainfall and temperature were obtained from the KALRO Naivasha weather station. They were summarized into monthly rainfall and monthly minimum and maximum temperature data from January 1979 to 2012. A total of 153,181 animals' monthly milk production were entered into excel spreadsheets.

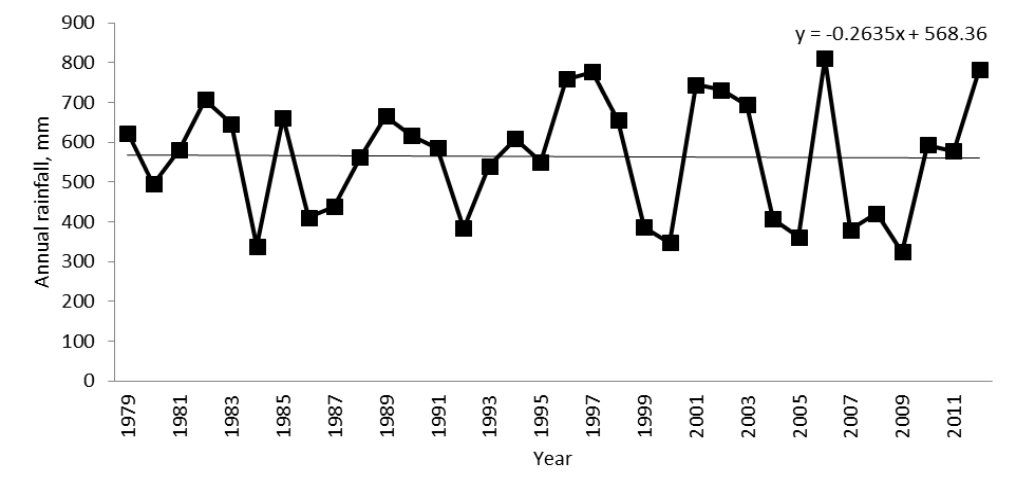
Correlation procedure of SAS (2003) was used to analyze this data and to get the effect of changes on milk production as a result of changes in monthly rainfall and temperatures.

Results

Characterizing trends in monthly rainfall and temperature variabilities

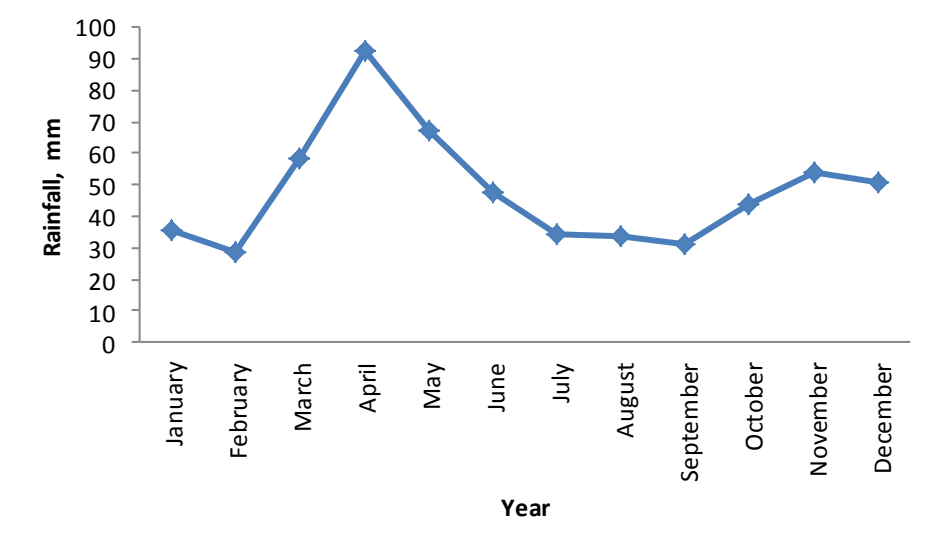
Table 1 shows mean Annual rainfall averages for the period (1979–2011) for the Naivasha station. The graph shows how rainfall has been distributed over the study period. There was a mean annual rainfall of 568.36 mm.

Annual Averages



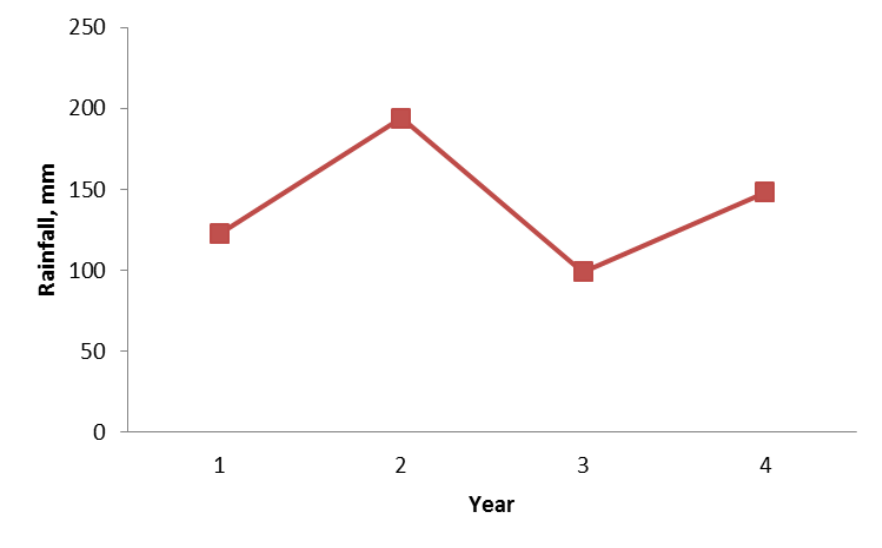
In 19 years out of 33 years the amount of rainfall was above the average of 538.36 mm of rain with the remaining 14 years receiving less than the average 538.36 mm of rain. Therefore, there is no evidence that rain has been declining over the years.

Monthly means



Cumulatively, the monthly means showed that the month of April had the highest amount of rainfall of about 90mm which falls under the long rain season and the month of November had a peak rainfall of above 50mm. The rainfall pattern has remained bimodal in which there are usually 2 rainfall seasons in a year.

Seasonal means



Seasons are periods in a year marked by specific weather conditions, temperatures and length of day. Most calendars around the world divide the year into 4 seasons. These are: spring, summer, fall (autumn) and winter. The main rainy seasons are from March to May and November to December but the amount of rainfall varies year to year. Kenya is generally hot and dry. There are two rainy seasons, the first is from March to the end of May and the second shorter season runs from October to the end of November. The sunniest time of year is December to March and the cloudiest time is from June to September.

Rainfall and temperature variability effects on survival

From the analysis of temperature effect, results indicate significant month effect ($p<0.0001$, $\chi^2 = 42.71$) and also significant temperature effect ($P<0.01 \chi^2 = 7.17$). Significant differences ($p<0.05$), were observed in the months of January, May, October and December.

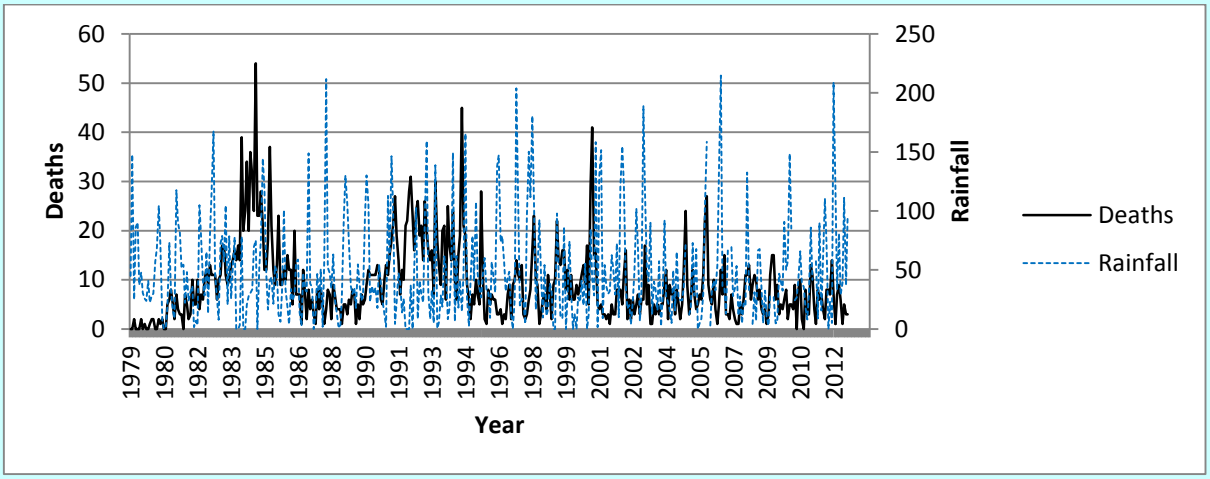
Results from the rainfall predictor indicate that survival was significantly affected by the month ($p<.0001$ $\chi^2=41.16$) but not significantly by the amount of rainfall p, 0.09 ($\chi^2=2.83$). Significant differences ($p<0.05$), were observed in the months of January, May, October and December

Considering the interaction between the rainfall and temperature on survival, there was significant month ($p <.0001$, $\chi^2 = 44.98$), rainfall ($p= 0.01$, $\chi^2 = 6.68$), and temperate by rainfall interaction ($p = 0.01$, $\chi^2= 6.16$) but insignificant temperature effect, ($p= 0.79$, $\chi^2= 0.07$). The regression coefficients and χ^2 estimates for the 33 years clustered by month are shown in the Table 1.

Table 1. The regression coefficients and $\chi 2$ estimates for the 33 years clustered by month.

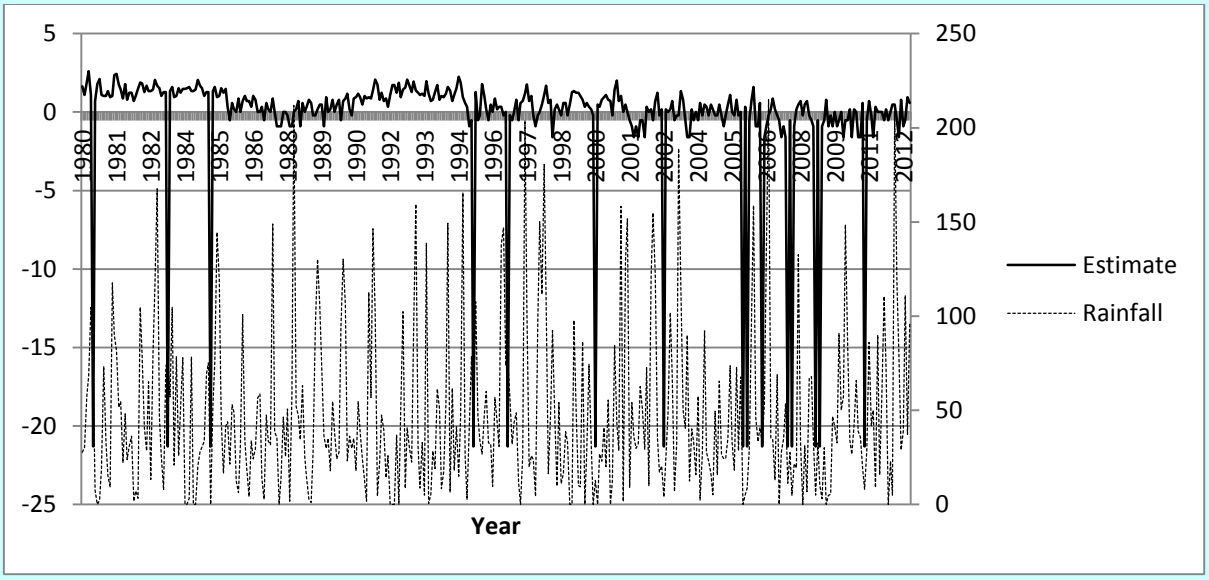
	Temperature		Rainfall		Temperature rainfall interaction	
Month	Regression coefficient	χ^2	Regression coefficient	χ^2	Regression coefficient	χ^2
January	-0.25	0.02	-0.30	0.01	-0.28	0.01
February	-0.12	0.25	-0.15	0.17	-0.14	0.19
March	-0.01	0.90	-0.07	0.49	-0.02	0.86
April	-0.02	0.88	-0.09	0.42	-0.08	0.45
May	-0.32	0.00	-0.35	0.00	-0.36	0.00
June	0.09	0.39	-0.08	0.47	-0.13	0.22
July	-0.05	0.64	-0.02	0.87	-0.04	0.71
August	-0.10	0.36	-0.05	0.60	-0.10	0.35
September						
October	-0.19	0.08	-0.20	0.06	-0.20	0.07
November	0.04	0.67	0.01	0.94	0.00	0.98
December	0.24	0.01	0.19	0.05	0.23	0.02

The regression coefficients for the variables, temperature, rainfall and the interaction for the 33 years followed a similar trend which is presented in Figure 1.



Death and rainfall trends for months within years

The graph in fig 1 shows that during the early years of the study, animals tended to survive more than in the later years when there were negative regression coefficients meaning that the survival rates had been low after the year 2001. This definitely shows a change in climate that was affecting the low survivability of animals but since 2000 there has been stiff competition on natural pastures by wild animals due to the increase in their numbers and fencing off by private farms around the research farm. Wild animals found solace on the research farm giving the cattle undue competition.



Trends in rainfall and regression coefficients for months within years

The dairy animal is a milk-producing factory which converts nutrients, derived from a variety of dietary constituents, into a complex, marketable and highly nutritious product. In order to do this it must first produce a calf, and then, like all factories, the efficiency of the processing of the raw material (the dietary roughages and concentrates) is of paramount importance. It is determined by the amount of feed eaten, the genotype of the animal and its ability to resist those elements in its environment that operate to reduce the intake of feed or the efficiency with which it is digested and metabolized. There are a number of elements in the environment which must be overcome if an animal it is to reproduce and be efficient and highly productive. Major environmental constraints to high productivity in the tropics are ambient temperature and humidity, annual and seasonal availability of feed resources, internal and external parasites and a variety of bacterial and viral infections. The effect of climate, parasites and diseases on

production can be minimized either through the use of resistant genotypes or through managerial interventions to the animals' environment. In most cases a combination of these two basic strategies is used.

The effect of climate and the environment on animals is complex. For example environments which have similar air temperature and humidity but differ in wind speed will have different effects on the animal in terms of its ability to maintain body temperature. Measurement of these variables and/ or the formulation of an index, tells nothing about the state of the animal. For this reason, the preferred strategy is to measure the state of the animal, its body temperature, respiration rate and production, and relate this to the conditions that prevail. Measurement of the environmental variables to predict what the likely effects might be on an animal, without prior knowledge of how a particular genotype responds to such environments, can be very misleading. The animal is the best integrator of all the climatic and environmental variables and it is through direct measurements on the animal that the effect of the environment can be most accurately judged.

Sahiwal survivals were greatly depressed during January, May and October while it was high in December. with the following years were reported to experience: Deaths in 2008, 2005-06, 2004, 1999-02, 1997-98, 1994-95, 1991-92, and1984 can be associated droughts.

Rainfall and temperature variability effects on milk yield

In general the overall correlation coefficient for milk yield with temperature and rainfall was -0.04 and 0.06 respectively. The results show that with temperature, production of milk was high in January, May, June, and July. When temperatures are high the milk tends to decrease and when they are low, milk tends to increase.

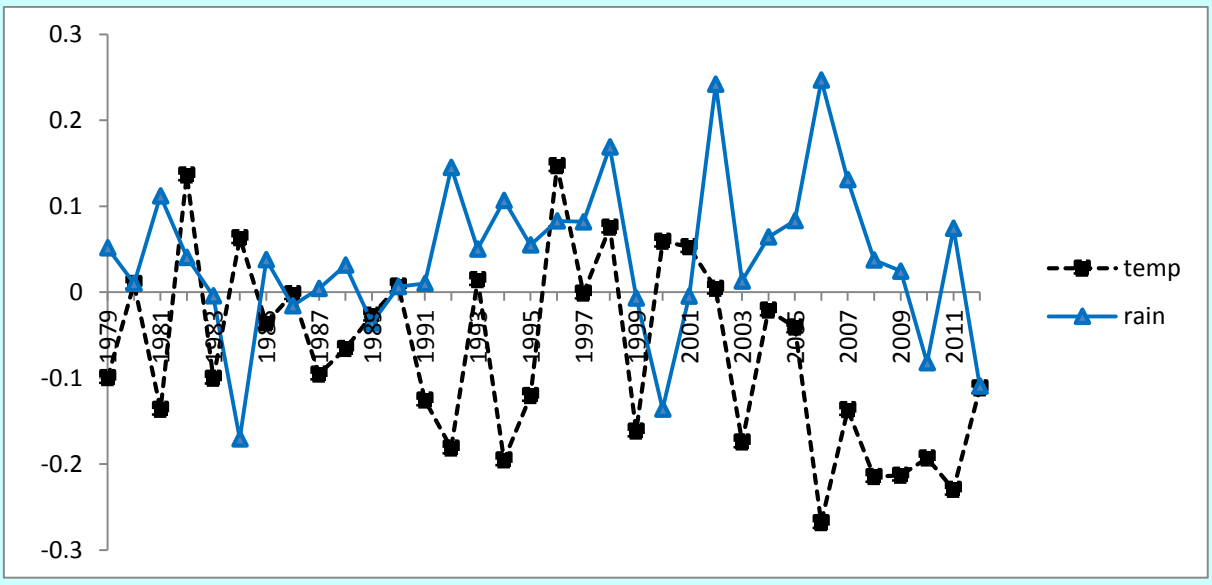
Table 1: Mean monthly milk yield and temperature and the correlation coefficient across months

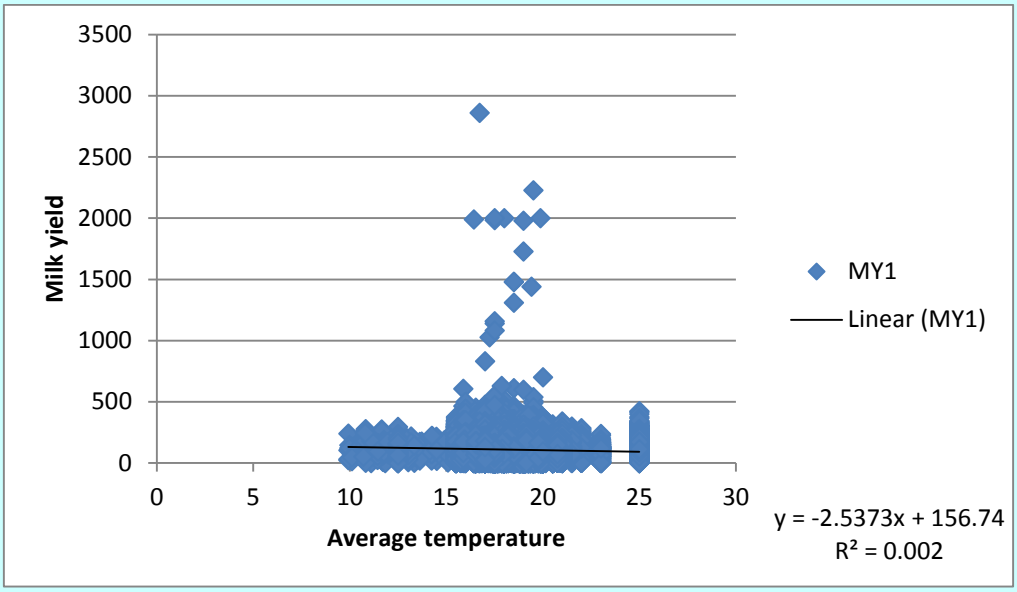
Month	MY (±SE)	Temperature	Correlation coefficient
January	111.52±73.42	19.36±1.96	0.04
February	92.22±61.49	18.70±1.00	-0.09
March	96.06±68.04	19.02±1.19	-0.01
April	106.33±74.18	18.59±00.87	-0.17
May	122.93±93	18.17±0.95	-0.08
June	119.89±87.59	17.65±1.38	-0.02
July	117.51±81	17.51±1.35	-0.01
August	113.08±76.89	17.46±1.15	-0.02
September	109.62±72.89	18.36±1.08	-0.03
October	107.38±1.01	18.39±1.01	0.08
November	112.16±73.53	18.53±1.21	-0.06
December	113.02±76.19	18.99±0.93	0.00

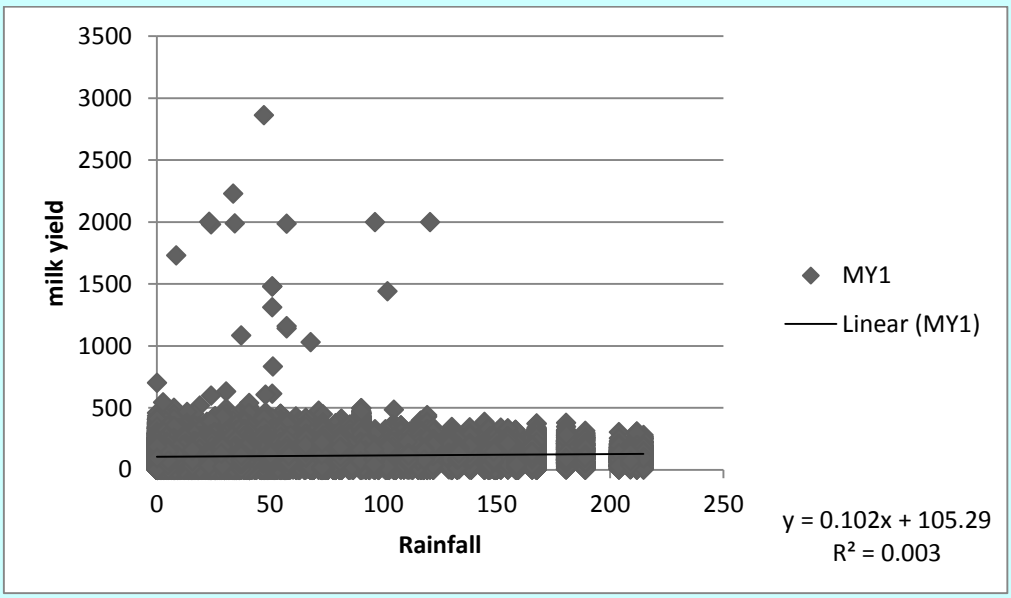
Table 2: Mean monthly milk yield and rainfall and the correlation coefficient across months

Month	MY	Rainfall	Correlation coefficient
January	111.52±73.42	32.13±44.26	0.06
February	92.22±61.49	25.60±30.62	0.10
March	96.06±68.04	56.26±46.38	0.06
April	106.33±74.18	91.12±51.82	0.04
May	122.93±93	65.50±45.59	0.14
June	119.89±87.59	48.71±37.11	0.08
July	117.51±81	35.23±28.22	-0.09
August	113.08±76.89	32.94±23.63	0.14
September	109.62±72.89	30.46±20.34	-0.08
October	107.38±1.01	41.30±24.00	-0.02
November	112.16±73.53	54.62±37.60	0.10
December	113.02±76.19	51.40±45.37	0.06

The month of January, May, June and July experienced high milk yields just as reported for temperatures. This emphasized that there is no significant difference between precipitation and temperatures that affected milk production. The graph below shows the trend of milk yield versus rainfall and shows that milk yield mainly depended on precipitation. As precipitation increase, milk yield increases, precipitation was positively associated with high milk yield. This was due to the re-growth of pastures which supported increased milk production.







Livestock systems in developing counties are highly dynamic. Various drivers of change can be identified: increasing population and incomes are combining to drive considerable growth in demand for livestock products, and this is projected to continue well into the future (Delgado et al., 1999), although at diminishing rates (Steinfeld et al., 2006). One implication of this is the intensification of land use in the production of livestock feed. A second feature of the growing demand for livestock products is the shift in location of livestock production: the rapid urbanization of (particularly monogastric) livestock production (the LLM systems), followed in time by ruralisation again, primarily in response to environmental drivers.

Rainfall and temperature variability on survival of Sahiwal herd

In addition to the physiological effects of higher temperatures on individual animals, the consequences of climate change are likely to include risk of the geographically restricted rare breed populations such as the Sahiwal breed stud in Naivasha will be badly affected by disturbances.

The results also show that the months of October, December, January and May were highly significant and that survival for cattle during these months were depressed due to various reasons. Temperatures were not significant to survival and this showed that high temperatures had no direct effects on the availability of feeds. The prolonged drought that came at around December to January affected the

survival of cattle through the constrained feed availability which led to starvation during this period. The month of October and May were also significant in the study because during these months, there was plenty of lush pastures coming from a period of drought in the preceding months and this led to deaths due to bloat. The graph shows that there has been more negative regression coefficient for survival compared with the positive ones and this could lead to various explanations. It has not been explained if the declines and increases in cattle numbers reflect planning, by slaughtering and selling more cattle in dry periods, or if the declines in cattle numbers in dry periods can be attributed to natural mortality due to lack of food and water. These are important aspects which should be further investigated and documented, since the response to long term (30 years) changes in the climate might be different from the responses to short term fluctuations (2–3 years). Wildlife numbers have continued to increase on the farm leading to competition of pastures and this led to low survival rates.

Alterations of temperature and precipitation regimes may result in spread of diseases and parasites into new regions or produce an increase in the incidences of diseases, which, in turn, would reduce animal productivity and possibly increase animal mortality (Singh et al., 2014).

Rainfall and temperature variability on Sahiwal milk yield at the national stud

The milk production performance of dairy animals is influenced by various environmental factors like year and season of calving, length of lactation and parity. The IPCC (2007) fourth assessment report demonstrated the relationship among heat stress, decline in physical activity and the associated direct and indirect decline in animal feed intake. High ambient temperature and reduced feed intake and put a limitation on milk yield, which can reduce a third to half of the potential yield of a dairy cow. Physiologically, the heat of external origin causes the rostral cooling center of the hypothalamus to stimulate the medial satiety center and inhibit the lateral appetite center (Brobeck, 1960). This results in decreased feed consumption and consequently lowered milk production and/or other production traits.

In addition, under high temperatures animals avoid grazing during the hot mid-day hours consequently reducing the grazing time and therefore overall productivity. Under these conditions the animals decrease their feed intake in order to reduce their digestive heat production.

Variations exist in individual animal production. As the Sahiwal breed is a dual-purpose tropical breed of cattle, this study aimed at investigating the effects of temperature and rainfall variability on milk yield in semi-arid environment. Among the Sahiwal breed this arise from the low genetic potential for milk production and short lactation lengths caused by environmental effects (Ilatsia et al., 2007). The decrease in milk yield as temperature increases can be explained by the resulting increase in energy requirements for maintenance whereas feed intake is consequently suppressed (Stull *et al*., 2008).

Discussion

Climate change and global warming are the major concerns that will define livestock production systems and livestock globally. This will have greater influence on selection of livestock types and breeds in the coming decades (Lamy *et al*., 2012). The cattle populations which are most sensitive to climate variability are located in arid regions. An interesting report is that East African countries are less sensitive to climate variability (Lunde and Lindtjørn 2013). This means there is no influence of cattle holdings by climate variability at national level. However, it has been reported that cattle populations in pastoral production systems have been strongly influenced by rainfall variability and trends in Ethiopia (Angassa and Oba, 2007). This follows the IPCC 2007 report that changes in range-fed livestock numbers in any African region will be directly proportional to changes in annual precipitation. Results presented in this study reinforce earlier findings that year to year and season to season rainfall variability is persistent in eastern Africa and this will continue to impact on vegetation and rain-fed defendant livelihoods. This research establishes that the October-December rains are more reliable as manifested in the amount of rainfall and the greenness of the vegetation compared to the March-May rainfall season. Effective dissemination of this information to stakeholders will go a long way to ameliorate the suffering of many households and enable government to plan ahead of a worse season. This would greatly reduce the vulnerability of livelihoods to climate related disasters by improving their management.

References

Angassa, A., Oba, G. (2007). Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia. Agricultural Systems, 94:715-725.

Bartocchi L., Vitali, A., Lacetera, N., Nardone, A., Varisco, G. and Bernabucci, U. (2014). Seasonal variations in the composition of Holstein cow's milk and temperature Bertocchi -humidity index (THI) relationship. Animal, 8, 667-674.

Herrero, M., Thornton, P.K. (2010). Livestock and Global Change Proceedings of the National Academy of Sciences.

Hopkins, A., Del Prado, A. (2007). Implications of climate change for grassland in Europe: impacts, adaptations and mitigation options: A review Grass and Forage Science 62: 2 118–126.

IISD (2007). International Institute for Sustainable Development. Summary for policy makers. In climate change : Mitigation, contribution of working group III to the fourth assesment report of the Inter Panel on Climate change.

Ilatsia, E. D. (2011). Breeding Strategies for Sahiwal Cattle Genetic resources in Kenya. PhD dissertation. University of Hohenheim, Stuttgart-Hohenheim, Germany.

Ilatsia, E.D., Roessler, R., Kahi, A.K., Piepho, H.P., Valle Zarate, A. (2012). Production objectives and breeding goals of sahiwal cattle keepers in Kenya and implications for a breeding programme. Tropical Animal Health and Production, 443:519-530.

IPCC (2007). Intergovernmental Panel on Climate Change. Climate Change Impacts, Adaptation and Vulnerability. Summary for policy makers.

Lamy, E., van Harten, S., Sales-Baptista, E., Guerra, M. M. M., and André de Almeida, M. (2012). Factors influencing livestock productivity.

Lunde TM, Lindtjørn B (2013) Cattle and climate in Africa: How climate variability has influenced national cattle holdings from 1961-2008 PeerJ, 1, e55

E. C. Kipkorir, "Analysis of rainfall climate on the Njemps Flats, Baringo District, Kenya," Journal of Arid Environments, vol. 50, no. 3, pp. 445–458, 2002.

Muhuyi, W.B. (1997). A comparative study of productivity of sahiwal cattle and its crossbred in large-scale dairy dual-purpose and beef production system. PhD Dissertation. University of Nairobi, Kenya.

Muhuyi, W.B., Lokwaleput, I., Sinkeet, S.N. (1999). Conservation and utilisation of the Sahiwal cattle in Kenya. Animal Genetics Research Information, 26:35-44.

Rege, J.E.O., Marshall, K., Notenbaert, A., Ojango, J.M.K., Okeyo, A.M., (2011). Pro-poor animal Improvement and breeding. What can science do? Livestock Science 136:1 15-28.

Sejian et al. (eds.), Environmental Stress and Amelioration in Livestock Production, DOI: 10.1007/978-3-642-29205-7_2, _ Springer-Verlag Berlin Heidelberg

Thornton P.E., Doney S.C., Lindsay K., Moore J.K., Mahowald N., Randerson J.T., Fung I., Lamarque J.F., Feddema J.J., Lee Y.H. (2009). Carbon-nitrogen interactions regulate climate-carbon cycle feedbacks: results from an atmosphere-ocean general circulation model. Biogeosciences, 6:2099-2120.

Dairy Goat Development in Kenya: The Case of Smallholder Dairy Commercialization Programme

Kembe, M.A. and Kibiego, M.B

Ministry of Agriculture, Livestock and Fisheries, State Department of Livestock
P. O. Box 34188 Nairobi, Kenya

Abstract

Dairy goats play important roles in the lives of the people who own them. They contribute to food and nutritional security, generate income, and are an important means of storing wealth and an insurance against emergencies. Despite the important roles of goats, many challenges still exist, especially under the smallholder production systems. These include: small flock sizes, high mortality rates, low husbandry practices, lack of systematic animal identification and recording systems, absence of consistent selection criteria and/or well designed breeding programmes, low levels of literacy among producers and lack of or poor organizational structures. The Smallholder Dairy Commercialization Programme selected beneficiaries of dairy goats among the resource poor farmers using the Participatory Analysis of Poverty and Livelihood Dynamics (PAPOLD). Additional beneficiaries included commercial dairy goat breeders. Following programme implementation, a sample of 377 beneficiaries was selected using the purposive sampling method and interviewed using a structured questionnaire. The results showed substantial growth in dairy goat population, milk production and income. The annual volume of dairy goat milk sold by the respondents before and after the programme increased from 5 to 4,150 litres respectively. Further programme interventions included a study to review, test and optimize implementation options of the goat milk production and marketing sub-programme, design of a breeding programme, hosting of a national dairy goat conference and development of a dairy goat manual. Recommendations include the need to upscale the outcomes of SDCP and strengthen the dairy goat breeder associations.

Key words: Dairy goat, development, resource poor, income

Introduction

Background Information

Dairy goats play important roles in the lives of the people who own them. They contribute to food and nutritional security, generate income, and are an important means of storing wealth and an insurance against emergencies (Rege et al., 2003; Peacock, 2005; Kosgey et al., 2005c). They fulfill a wide range of socio-cultural roles and their manure helps to maintain soil fertility (ILRI, 2004). Their role in reducing poverty is therefore enormous. Goats in particular, can help start the poor along a pathway out of poverty (Peacock, 2005). Kenya has a goat population of 13.6m, of which 98% and 2% are indigenous and dairy goats respectively.

Although goats are important, especially in sub-Saharan Africa, their planned development has seldom been emphasized by both governments and development agencies (Peacock. 2005). However, recent trends are encouraging, especially in the last decade, during which period, a number of non-governmental organizations (NGOs) have been implementing community-based goat improvement programmes, as opposed to hitherto solely government implemented projects. It is important that new initiatives in dairy goat development must involve the target beneficiary groups right from the very beginning. Majority of goats and small ruminants in general are kept by small-scale resource-limited livestock keepers (Peters, 1988).

Despite the important roles of goats, many and enormous challenges to the goat genetic improvement programmes exist, especially under the smallholder production systems. These include: small flock sizes, single-sire flocks, high mortality rates, low husbandry practices, lack of systematic animal identification and recording systems, absence of consistent selection criteria and/or well designed breeding programmes, low levels of literacy and lack of or poor organizational structures (Kiwuwa,

1992; Baker and Gray, 2004). In pastoral flocks, high mobility, shared pasture and watering facilities reduce independence, especially as regards breeding decisions (Kiwuwa, 1992; Kosgey, 2004). In general, the above constraints can be classified as: technical, institutional or organizational, managerial and socio-economic factors. The external factors are mainly economic and market forces. Setting up a sustainable intensive goat production system requires that these challenges be addressed wholesale.

Technical factors include the design and implementation of genetic improvement programmes, in particular whether or not they are sound and suit the farmers' conditions. Institutional factors relate to whether or not there exist effective farmers' institutions (e.g., breed societies, enabling and supportive policy frameworks, breeding and technical support services provision arrangement with governments, research institutions or universities, and the existence of recording schemes) to offer technical backstopping and ensure sustainability of breeding programmes. Managerial factors refer to the farmers' own knowledge and experience in livestock husbandry and production, e.g., ability to detect heat, feed the animals well and to protect them from diseases and parasites, including access to and affordability of veterinary and breeding services.

Past genetic improvement programmes in the Eastern Africa region, for both small and large ruminants, have been more research-linked and motivated (Okeyo 1997; Ahuya et al., 2005) and tended to be inflexible and research or multiplication station-based (Peters, 1991). The inability to have comprehensive and truly participatory development protocols right from the diagnosis and prescription to prognosis stages presents a common weakness. (FAO, 1995), while others had no prognosis at all (Carles et al., 1991). The first major goat research and development initiative in Kenya and indeed the eastern Africa region, was a United Nations Development Project (UNDP) funded and FAO executed Sheep and Goats project (SGP) from the early 1970's to late 1980's (Carles et al., 1986, Okeyo, 1997, Ahuya et al., 2004).

A review of past crossbreeding programmes indicates that most of them are never designed and implemented in a participatory manner and do not take into consideration the aspirations of the target farmers who in most cases are small-scale resource-limited livestock keepers (Kosgey et al., 2005a and b). Consequently, no notable positive impacts are apparent for many goat improvement programmes in the region. Due to the economic and institutional reform programmes in the eastern Africa region that started about a decade ago and the decline in government expenditures on public activities, governments can no longer offer subsidised services (e.g., animal health delivery and extension services) as was previously the case for many years. Unfortunately, there has been little effort to review and put in place the necessary policy and institutional support that is critical in ensuring sustainable livestock improvement programmes, as part of the government exit plans and the public-sector entry plans. Especially for goats, government policies to support their development have been lacking in most cases or where they exist rather weak and not focused. This kind of approach as resulted in more emphasis on research and development of cattle, mainly the dairy genotypes, lack of community participation and/or institutional support, weak extension services and poor understanding of the local needs.

One of the most successful community based goat project in the region, has been implemented through farmer group approach, which uses farmer groups as the entry point to the community. The group also forms the basic grassroots institution for community-based goat improvement initiatives. The group approach, as opposed to station or government's farms, is preferred because of the following advantages; cost effectiveness in the delivery of extension services, enhances sharing of knowledge and information, positive peer pressure to eradicate social vices, and increases networking and collaboration among community members. The group approach also augments marketing and bargaining power for the farmer groups, enhances the sharing and pooling of scarce resources and helps in diversification as farmers venture into other activities. It also increases self-esteem through participation in group activities, group member empowerment and opportunities for livestock improvement exposed and increases development of community leadership.

Experience has shown that a typical community based goat improvement project requires the following five sub-components; establishment and operations of breeder units and the maintenance of the purebred flock; establishment and operation of buck stations, production of three-quarter crosses, and eventual formation/development of the required genotype, establishment and operation of three-

quarter stations and breeder units for eventual stabilization of the local goats and formation of a community-based farmer-led breed association and registration with the Kenya Stud Book.

Challenges to dairy goat development

- High cost of breeding stock
- Inbreeding partly due to uncoordinated crossbreeding programmes.
- High veterinary costs, unaffordable by most of the small scale poor livestock farmers.
- Social cultural practices and beliefs against goat milk
- Inadequate technical staff coupled with inadequate technical skills in dairy goat management for the few available staff.
- Nutrition in the upgraded goats is limiting.
- Quality breeding bucks not available.
- Inspection of the breeding bucks very few or none in most cases.
- Gender issues-men are more involved in trainings while the goat is left under the custody and care of women
- Pass over of bucks to beneficiaries take them long to realize benefits
- Goat housing done poorly thus impacting negatively
- Inaccessibility to fodder seeds
- Inadequate breeding stock
- Prevalence of diseases especially worms and pneumonia
- High cost of veterinary services that is not affordable to farmers.

Methodology

The development of the dairy goats in the entire programme area shown in Figure1. In selecting the beneficiaries of dairy goats, the programme carried out the Participatory Analysis of Poverty and Livelihood Dynamics (PAPOLD). The SDCP endeavours to address the needs of the poor living in the Dairy Commercialization Areas (DCA) communities and who by nature of their condition might not be able to express their needs in public forums. The SDCP therefore recognizes members of the community falling in the following categories/characteristics as vulnerable and in need of special interventions:

- Hard-core poor (food poor and uncertain of the next meal)
- Orphans without adequate care and protection
- HIV/AIDS infected and affected without secure means of livelihood
- Poor female headed households
- Widows and widowers without secure means of livelihoods
- Child headed households
- The aged persons without secure means of livelihoods
- Teenage mothers
- Physically challenged persons

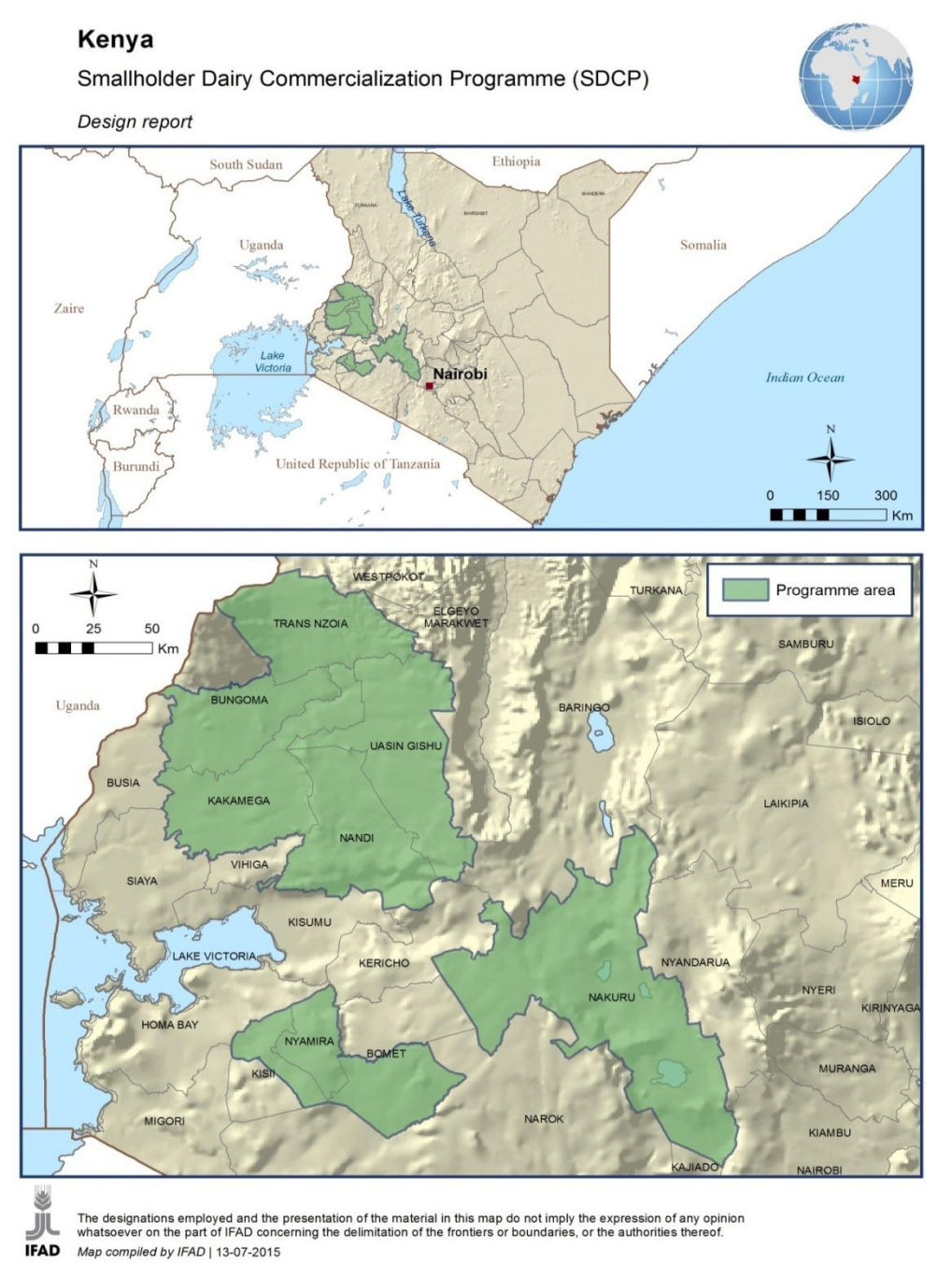


Figure 1: Programme area for dairy goat development

A farmer with a dairy cow cannot be considered poor or vulnerable. Such a farmer can access some income, food and afford a decent shelter. The implication is if Smallhoder Dairy Commercialization Programme (SDCP) has to restrict itself to Dairy Groups (DGs) then the poor and the vulnerable shall be excluded. Though we cannot underestimate the trickledown effect to the poor because of the increased dairy production of dairy farmers through creation of employment, there must be a deliberate move by the programme to identify the poor and the vulnerable to benefit from the grant on dairy goat sub-programme.

Identification of the poor and vulnerable is a key activity in the programme area. Using the Participatory Analysis of Poverty and Livelihoods Dynamics (PAPOLD) tool, the poor were also identified from the blocks and this formed a forum for engagement whereby this category of people were facilitated to

develop specific action plans based on their perceptions on their own situations. These action plans served three purposes as follows:

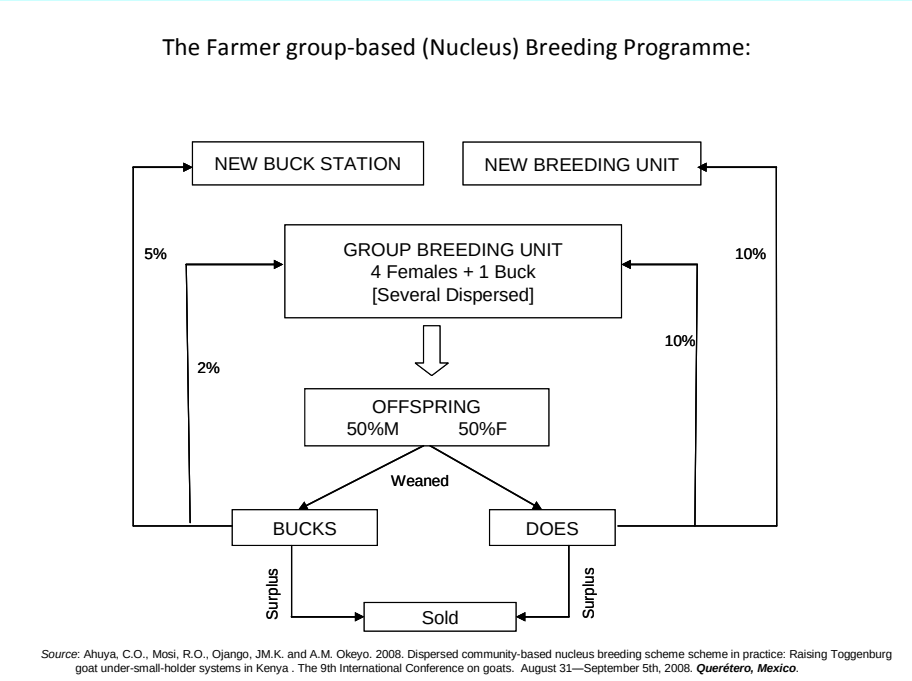
- Link farmers to appropriate persons/NGOs working in the respective Counties which have a mandate that is specific to a particular category of the poor and the vulnerable
- sensitise the poor and the vulnerable on specific areas of resource mobilization that can be appropriate to them which can be used to change their situation hence the resource mobilisation training was organised immediately after the PAPOLD exercise
- Budgeted for for specific project activities targeting the poor and the vulnerable.

Results

The results are sub-divided into various sections based on programme interventions.

Baseline survey

In 2009 the programme commissioned a study for reviewing, testing and optimizing implementation options of the goat milk production and marketing sub-programme. The study revealed that there are numerous dairy goat groups in the programme area although the majority of them have no goats and look to SDCP to provide them with goats. Available genotypes within the programme area include Toggenburgs and Kenya Alpines and their crosses, majority found in Nakuru, Bomet, Nandi North, Lugari, Bungoma and Trans Nzoia. The Saanen crosses are the majority in Nyamira and Bomet. Unfortunately, due to lack of a clear breeding programme on the ground, these crosses have either been bred or mated liberally, making it impractical to confidently identify what crossbred animals are being reared. This study developed the SDCP breeding and sustainability model shown in Figure 2.



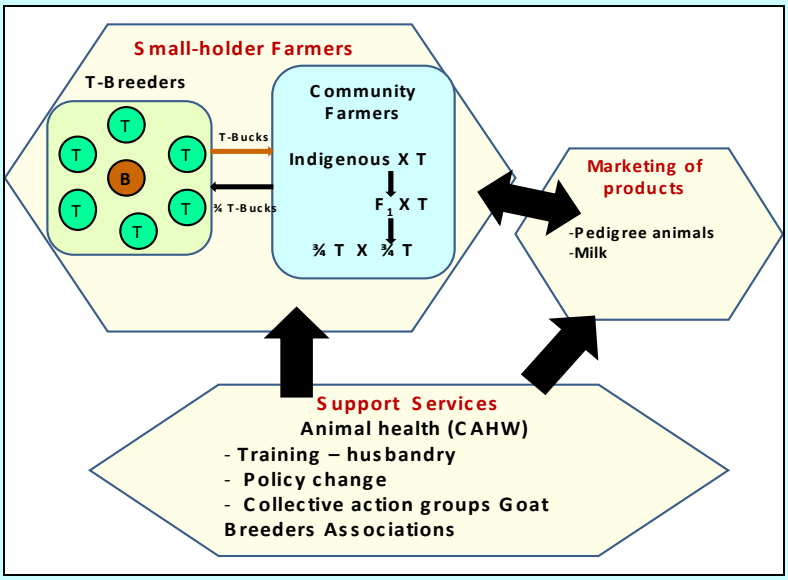


Figure 2: SDCP Breeding Model and its Sustainability

In addition, the study made the following recommendations:

a) Implement a systematic capacity building initiative for the primary stakeholders. Initial trainings should target extension staff as trainers who will then train farmers accordingly twice in a quarter targeting farmers at most.
b) SDCP should embrace the proposed Dairy Goat Model wholesale to ensure aspects of efficacy, impact and sustainability are realized.
c) The SDCP embraces zoning the programme area during breeding stock distributionwhich will ensure effective linkage with ongoing initiatives. For example where HPI is providing Alpines to farmer groups, the SDCP could add value by providing the same breed hence ease of genetic material access.
d) The SDCP explores all the factors of sustainability as per the proposed Goat Project Model and in response to the goat value chain framework developed.

Programme Interventions

Dairy goats targeted to the poor and the vulnerable and commercial dairy goat breeders

The use of PAPOLD led to the selection of resource poor women who benefited from a grant for 100% support in establishing dairy goat enterprises. In addition, the programme set up commercial dairy goat breeders on a cost-sharing basis. Market reports indicate a strong and growing demand for goat milk. Goat milk is considered to have both healing properties and is known to be easier to digest than bovine milk. The growth in demand and increasing acceptance and use of goat milk is reported among immuno-compromised consumers, the aged and children. Goats are reported to be better forage utilisers than cattle and their milk is widely reported to have more benefits. A goat milk production and marketing sub-programme for women groups and the vulnerable was therefore set up based on best practices from past and ongoing dairy goat programmes. The programme developed an innovative programme is commercial dairy goat breeders to solve the shortage of breeding stock and to commercialize the dairy goat sub-sector. The programme has procured and distributed over 2,000 dairy goats The birth rate was cumulatively 1.3 offspring against a death rate of 0.18 offspring. This low death rate is attributed to better management of dairy goats and better animal health conditions. It is recommended the good management is continued to reduce the death rate further.

Gender mainstreaming is very important in achieving the goals of SDCP. It is now an accepted fact that unless gender biases are tackled, there is a danger that the promotion of dairy goat production and marketing will lead to accumulation and business development by men, while women who lack access to finances and are constrained by gender divisions of labour and responsibility as well as social norms of appropriate behaviour, will be left out at the different levels of production, marketing and farmer groups engagement. Many SDCP activities are being implemented by women and much cannot be achieved without support from their spouses (Figure 3). When gender is mainstreamed, access to critical resources like finances, inheritance and land, which is crucial in the implementation of programme activities, will be enhanced.

Figure 3: A dairy goat beneficiary in Lugari County

Development of a dairy goat manual

The demand for dairy goats has expanded against the backdrop of inadequate extension materials and skills. The development of new technologies has necessitated increased training needs and reference materials for our service providers, farmers and other stakeholders. The manual therefore, will be handy in nurturing this young and rapidly evolving industry.

The subjects handled are comprehensive and simplified in a less technical language and practical illustrations making our readers able to grasp the ideas without having a background in agricultural training.. The manual is also fairly relevant to our secondary schools and tertiary institutions for easy reference. It covers dairy goat housing and waste management, dairy goat feeding systems, breeding and reproduction and clean milk production dairy goat's health management and husbandry, and agribusiness in dairy goats enterprise.

Assessment of the Livelihood Changes among the Resource Poor SDCP Beneficiaries

The programme carried out an assessment of the livelihood changes among the resource poor beneficiaries with a total of 377 respondents being interviewed in 2014 and out of the total, 71.1% received does from the programme, 19.9% received both does and bucks and 5.3% received bucks (Table 1); representing about 90% beneficiary respondents from the dairy goat sub-programme.

Table 1: Number of times the Goats have kidded

No. of Kiddings	Frequency	Percentage
0	99	26.3
1	109	28.9
2	91	24.1
3	52	13.8
4	20	5.3
5	4	1.1
6	1	.3
8	1	.3
Total	377	100.0

Source: SDCP Survey, 2014

Number of kids passed to other group members

Majority of the respondents did not pass the kids to other group members (61.0%) and only 39.0% of the respondents shared at least a kid with other group members as indicated in the Table 2. A total of 208 other group members had received goats from the initial beneficiaries. The rotation scheme through passing on the gift needs to be enhanced to increase the outreach of members benefitting from the dairy goat sub-programmme.

Table 2: Number of kids passed to other group members

Number of kids Passed On	Frequency	Percentage
0	232	61.5
1	103	27.3
2	31	8.2
3	4	1.1
4	4	1.1
5	3	.8
Total	377	100.0

Source: SDCP Survey, 2014

Goats owned before and after SDCP

Respondents were asked to state the number of goats they owned before SDCP interventions and the number they now have after SDCP interventions. This was done for comparison purposes in order to assess the change brought about by the programme.

Table 3: Goats owned before and after SDCP

		No. of dairy goats owned before the programme	No. of dairy goats owned now
N	Valid	377	377
Mean		.24	2.06
Median		.00	2.00
Std. Deviation		.82	1.63
Variance		.67	2.69
Minimum		0	.0
Maximum		6	11.0
Sum		91	776.0

It is evident from the table above that the number of goats owned has substantially increased from a sum of 91 goats to 776 goats (Table 3). Similarly the maximum number of goats owned has increased from 6 to 11 per farmer with majority having two animals at present and majority having none before SDCP intervention. The tables below shows the distribution of the animals owned before and after SDCP.

Average Milk Production

Respondents were asked to state the average milk production before SDCP interventions and the average milk production after SDCP interventions.

Table 4: Average dairy goat milk production

	Average milk production per goat per day (liters) before project	Average milk production per goat per day (liters) now
N	377	377
Mean	.05	1.01
Median	.00	1.00
Std. Deviation	.220	.926
Variance	.048	.857
Minimum	.00	.00
Maximum	2.00	4.00
Sum	18.45	380.65

Table 4 shows that the average milk production has substantially increased from 0.05 litres to 1.01 litres per day per goat. Similarly the maximum average milk production has increased from 2 to 4 litres per goat per day. This may be attributed to farmers adopting recommended technologies such as improved rations and feeding, improved breeds better animal health management.

Table 5 indicates that the average volume of milk sold per day has increased from. 0.13 litres to 11.01 among the respondents. This could be associated with market access improvement, greater farmer empowerment through programme intervention such as better goat breeds and training. The use of money from dairy goat milk sales is shown in Table 6.

Table 5: Volumes of milk sold per day before and after SDCP

	N	Mean	Std. Deviation	Minimum	Maximum	Sum
Volume of milk sold before project	377	.013	.103	.00	1.00	5.00
Volume of milk sold After project	377	11.01	46.06	0	450	4,150

Table 6: Use of income from sale of goat milk

	Frequency	Valid Percent	Cumulative Percent
Purchase of food	46	12.2	12.2
Household expenses	46	12.2	24.4
clothing	1	.3	24.7
Acquisition of household assets	5	1.3	26.0
Pay school fees	4	1.1	27.1
no response	275	72.9	100.0
Total	377	100.0	

Other benefits from dairy goat keeping

Respondents were asked whether there are any other benefits gained from dairy goat keeping and the majority said it saved them fertilizer cost due to availability of manure, improved goats breed from local one and establishment of kitchen garden for increased income and improved nutrition accounting for 54.6%, 30.8% and 5.8% respectively (Table 7). Only 8.8% had no other benefits recorded.

Table 7: Other benefits from dairy goat keeping

	Frequency	Valid Percent	Cumulative Percent
Upgrading of local goats	116	30.8	30.8
Savings on fertilizer due to availability of manure	206	54.6	85.4
Establishment of kitchen gardens for increased income and improved nutrition	22	5.8	91.2
None	33	8.8	100.0
Total	**377**	**100.0**	

National Dairy Goat Conference

The Smallholder Dairy Commercialization Programme hosted the 1st National Dairy Goat Conference in November 2014 in Kisumu City. It addressed the challenges and opportunities in dairy goat production and marketing. The identified challenges included narrow genetic pool, poor husbandry practices, lack of registration and identification and scattered low milk producers hence lack of bulking. The identified opportunities were diminishing land sizes better suited to dairy goats, high quality of milk, high demand for goat milk and low investment and maintenance costs of dairy goat enterprises. The following additional policy interventions were proposed:

1. Streamline dairy goats breeding associations and transform them into functioning breeding organizations
2. Characterize and standardize goat products
3. Develop standards for dairy goat feeds.
4. Promotion of artificial insemination for dairy goats

Conclusion and Recommendations

The Smallholder Dairy Commercialization Programme has contributed significantly towards the development of the dairy goat enterprise in Kenya. The programme has provided substantial capacity building for both resource poor farmers and commercial dairy goat breeders. Training of implementing staff and community resource persons has strengthened the community's ability to benefit from dairy goat milk production and marketing. There is also need to scale up the outcomes of SDCP and strengthen the dairy goat breeder associations.

Economic evaluation of alternative selection strategies for small-sized nucleus dairy cattle breeding programs

Kariuki C.M,[1]*† Brascamp E.W†, Komen H†, . Kahi A.K ‡ and van Arendonk J.A.M †

*Department of Animal Sciences, Chuka University, P.O. Box 109-60400, Chuka, Kenya
†Animal Breeding and Genomics Centre, Wageningen University, P.O. Box 338, 6700 AH Wageningen, The Netherlands
‡Animal Breeding and Genomics Group, Department of Animal Sciences, Egerton University, P.O. Box 536-20115, Egerton, Kenya
[1]Corresponding author: charles.kariuki@wur.nl

Abstract

In developing countries minimal and erratic performance and pedigree recording impede implementation of large-s breeding programs. Small-sized nucleus programs offer an alternative. Economic performance underpins the viability of such programs. We economically evaluated a small-sized dairy nucleus program implementing two selection criteria i.e., progeny testing (PT) and genomic selection (GS), over a 20 years investment period. The nucleus was made up of 453male and 360female animals distributed in 8 non-overlapping age classes. Each year 10 active sires and 100 elite dams were selected. Genetic expressions were in a population of 100,000 commercial cows. Commercial recorded cows (CRC) provided information for genetic evaluation of selection candidates in the nucleus. CRC were used to produce test daughters in PT and to create a reference population in GS. Revenues were defined as cumulative discounted expressions (CDE) of genetic superiorities. Net returns were the differences between discounted revenues and discounted costs. Genetic superiorities were deterministically simulated using a pseudo-BLUP criteria for a total merit trait. Alternative PT and GS schemes differed in the size of CRC population and how bulls were used. The maximum size of the CRC population was 9 961. Results show that equivalent GS schemes had higher cumulative genetic levels in the commercial cows and net returns compared to PT schemes. Implementation of small-sized breeding schemes is economically viable for developing countries. This can play a role in countering effects of unfavorable genotype by environment (GxE) interaction resulting from semen importation. In addition, it's likely to positively impact the overall success of the dairy industries through more participation of producers in breeding decisions making.

Keywords: Economic evaluation, small-sized breeding programs, progeny testing, genomic selection

Introduction

Dairy production makes an important contribution to poverty reduction and food security in developing countries. Different dairy production systems are present in developing countries reflecting the wide range in production and marketing conditions (Mburu et al., 2007; Mubiru et al., 2007). Genetic improvement offers an opportunity to improve the efficiency of dairy value chains. Genetic improvement can be realized by importation of exotic germplasm or by local breeding programs. Adoption of genetic improvement initiatives for developing dairy cattle industries provides a means to address unfavorable genotype by environment (**GxE**) interaction resulting from importation of exotic germplasm (Ojango and Pollot, 2002; Vargas and Arendonk, 2004; Okeno et al., 2010).

Minimal routine pedigree and performance recording impede the implementation of local breeding programs in many developing countries (Wasike et al., 2011). Breeding programs based on small-sized nucleuses may provide the means for improving local genetic resources in countries where infrastructure for pedigree registration and milk recording are lacking. Small-sized breeding programs can create genetic gain (Gizaw et al., 2009; Gizaw et al., 2014a; Gizaw et al., 2014b). Besides creating genetic gains, the successful implementation of such programs will be determined by their economic results. Adoption of genomic selection (**GS**) by dairy cattle breeding programs has genetic and monetary advantages compared to traditional progeny testing (**PT**) selection in developed countries (Schaeffer, 2006; Konig et al., 2009). Monetary advantages are mainly due to higher annual genetic gains

resulting from shorter generation intervals. However, these studies consider large, well developed breeding programs. Results can, therefore, not be directly translated to developing countries.Economic appraisal of breeding programs is therefore imperative, particularly for high-risk situation in developing countries (Marshall et al., 2011).Economic evaluation of alternative selection strategies underpins the decision on the choice of breeding strategy to adopt.

A dairy cattle genetic improvement program will result to (a) improved performance at the production level due to use of superior bulls and, (b) increased demand of superior semen. Revenues from genetic improvement are hence realized at two separate levels i.e. at the breeding firm selling semen and commercial producer's level where genetic superiority is expressed. Economic appraisal of breeding programs will therefore depend on the objective to be achieved (Brascamp, 1978). On one hand, the objective may be to maximize the profitability of the breeding firm through increasing the semen market share. For such situations, economic appraisal aims at determining the economic impact of changes in market share due to adoption of alternative schemes e.g. (Dekkers and Shook, 1990; Brascamp et al., 1993). On the other hand the objective may be to increase productivity and/or reduce production costs at the commercial producers' level. Such an approach considers a national breeding program where revenue is generated from sale of end products such as milk or meat (Brascamp et al., 1993); (Konig et al., 2009). National approach aims at maximizing efficiency in the dairy value chain and does not pay attention to the distribution of the profit to the different stakeholders in the chain. For small-sized nucleus schemes in developing countries economic appraisal from a national perspective seems more suitable as the aim of such schemes is to address challenges posed by importation of germplasm (Ojango and Pollot, 2002; Vargas and Arendonk, 2004); (Okeno et al., 2010).

The aim of the current study was therefore to economically appraise alternative selection strategies for small-sized dairy cattle breeding programs in developing countries from a national perspective.

Materials and Methods

Computation of Genetic Superiorities

Description of the Breeding Scheme.Economic performance of PT and GS selection strategies were for a small-sized nucleus breeding scheme. Revenues and costs were for running the same scheme under the two selection strategies. The basic structure of the breeding schemes is illustrated in Figure 1 and comprised of (a) a closed nucleus where all genetic improvement was generated and (b) a commercial cow population benefiting from selection in the nucleus. A randomly selected group of commercial cows (commercial recorded cows, **CRC**) was used to provide extra information for genetic evaluation of candidates in the nucleus. Commercial non-recorded dams formed the production population, and comprised of 100,000 cows.

The Nucleus. The nucleus was made up of 360 female and 485 male animals (including calves) distributed in 8 one yearlong age-classes (Table 1). Conception rates and sex ratio at birth in the nucleus were fixed at 0.80 and 0.50, respectively. This resulted in approximately 100 male and 100 female selection candidates been born annually. Cows dropped their first calf when 2 years old and had their first performance record by the end of their 3rd year. 100 elite dams and 10 active sires were selected annually. Annual culling was fixed at 0.15 and 0.25 for males and females, respectively.

Maintenance of bulls in the nucleus. Two methods of maintenance of male candidates were (a) as live animals for their entire life time (abbreviated as **NSS**) and (b) culled at 2 years of age and semen stored (abbreviated as **SS**). With NSS there was limited collection of semen from test bulls. Intense semen collection was done with active sires for use in the nucleus and the commercial population. With SS, intensive semen collection was done within the 2ndyear of age which was used during the evaluation process and in the commercial population after selection.

Breeding objective. For simplicity the breeding objective was to improve a single trait which reflects total merit. The heritability of total merit trait was fixed at 0.30. We did not find information on actual standard deviation of total merit trait for Kenya dairy sector in the literature. We, therefore, used the phenotypic standard deviation for milk production (i.e., 1,110 kg), as working value (Ojango and Pollot, 2002; Kahi and Nitter, 2004).

Description of the Selection Strategies. We investigated two strategies of using commercial recorded cows (CRC): PT and GS. In PT strategy, CRC were used to produce test daughters. With GS strategy CRC were used to create a reference population for genomic evaluation. In the PT schemes male candidates were evaluated on the performance of their 1st crop of daughters and pedigree. Female candidates were evaluated on their 1st lactation performance record and pedigree. For this strategy, active sires and elite dams were selected from 4 and 6 years of age, respectively. In the GS strategy, active sires and elite dams were selected based solely on their genomic breeding values at 2 years of age. The effect of the selection strategy on the distribution of selection candidates in the nucleus is shown in Table 1.

Evaluation information from commercial population. We considered two sizes of CRC population. First, each candidate bull was modeled to have 15 complete daughter records and second, each candidate had 30 records. We fixed the conception rate, sex ratio and involuntary culling in the commercial population at 0.80, 0.50 and 0.25, respectively. Therefore, to obtain 15 daughter performance records per candidate bull we required 4 980 CRC. For the PT scheme with 30 TD per bull the number of CRC was 9 961. We denoted PT schemes with 15 and 30 records as PT15 and PT30, respectively. Under GS schemes, CRC were used to create a reference population. Corresponding GS schemes were denoted as GS15 and GS30.

Deterministic Simulations of Genetic Superiorities. We considered genetic superiorities following a single generation of selection. Genetic superiorities for alternative selection strategies were determined through deterministic simulation based on selection index theory with overlapping generations as (Ducrocq and Quaas, 1988),

$$\Delta G = \sum_{j}^{c} i_j r_{IH} \sigma_{A,j} \frac{n_j}{n_{total}}$$

Where ΔG is genetic superiority, i is the intensity of selection, r_{IH} is the accuracy, σ_A is the genetic standard deviation, j refers to a particular age-class, n_j is the number of selection parents in the j^{th} age-class, n_{total} the total number of selected parents and c is the number of age-class cohorts.

Genetic superiorities for GS breeding programs were simulated by including an "extra" correlated trait with heritability equal to unity in the model as suggested by (Dekkers, 2007). Genetic and phenotypic correlations between the true and "extra" trait were calculated as $r_{g\hat{g}}$ and $hr_{g\hat{g}}$, respectively, where h is the square root of the heritability and $r_{g\hat{g}}$ the accuracy of genomic EBV which was calculated based on (Dekkers, 2007):

$$r_{g\hat{g}} = \sqrt{\frac{\lambda r^2}{\lambda r^2 + 1}}$$

where $\lambda = n_P/n_G$; n_G depends on the size of historic effective base population size (N_E) and the size of the genome (L) in Morgan and was computed as$n_G = 2N_E L$. N_E was equal to 156 (Muasya et al., 2013) and L was equal to 30.n_P was the size of the reference population andr^2 was equal to the heritability.

Simulations to determine genetic superiorities were done using a pseudo-BLUP selection index implemented in the program SelAction(Rutten et al., 2002). This program calculates the equilibrium genetic superiorities for sires and dams after correcting for changes in genetic variances due to selection (Bulmer, 1971).

Computation of Discounted Revenues

Weighting expressed genetic superiorities with the net value per unit of expression, generated superiorities can be expressed in monetary values (Brascamp, 1978). Revenues were cumulated for a period of 20 years and expressed in euros (1 Euro was taken to be equivalent to 100 Kenya Shillings). Revenues and costs were discounted to the year of birth of selection candidates.

Cumulative Discounted Expressions. The economic benefits for each selection strategy were determined by the selection superiorities, and the frequency and timing of the expression of these frequencies in the commercial cow population for a time horizon, T = 20 years. Revenues were computed as cumulative discounted expressions (**CDE**) (Brascamp, 1978). Gene flow method was used to model the passage of genetic superiorities from selected parents to offspring in subsequent age by sex classes through reproduction and ageing. An age-class was 1 year period. Gene frequencies per sex in an age-classat a particular year *t* was expressed by a vector$\boldsymbol{m}_t$. $\boldsymbol{m}_t$ was calculated as (Brascamp, 1978)

$$\mathbf{m}_t = \mathbf{R}\mathbf{n}_{t-1} + \mathbf{P}\mathbf{m}_{t-1}$$

where ***R*** is a matrix defining gene transmission through reproduction, ***P*** is a matrix defining gene transmission through reproduction and ageing, and

$$\mathbf{n}_t = \mathbf{Q}\mathbf{n}_{t-1}$$

where ***n*** is a vector with gene frequencies in the first age class and ***Q*** is a matrix defining ageing. CDE were calculated as(Brascamp, 1978),

$$E = \sum \mathbf{m}'(t)\mathbf{h}\left(\frac{1}{1=r}\right)^t$$

where *E* is the CDE, ***m*** is a vector with gene frequencies in defined age-classes in all tiers by sex subclasses originating from the selected parents, ***h*** is an incidence vector describing the relative frequency of expression of the trait, *r* is the discount rate. ***h*** was determined based on expected proportions of lactating cows in different age-classes and effects on age on milk production. All calculations were done using the program GFLOW (Brascamp, 1978). Revenues were calculated as:

$$\mathrm{Re}venue = E \times 0.32 \times 100000$$

where, *E* = CDE, 0.32 is the net value of 1 kg of raw milk in Kenya and 100 000 represents the number of expressions of the genetic superiority (size of the commercial population).

Gene Flow Pathways. Proportions of selected sires and dams from different age-classes were determined through truncation on estimated breeding values (Ducrocq and Quaas, 1988).Gene flow pathways were categorized as (a) flow of genes within the nucleus and (b) flow of genes from the nucleus to the commercial population. Within the nucleus, we accounted for flow of genes from sires and dams to male and female offspring. Flow of genetic superiority from the nucleus to commercial cows was through use of elite nucleus sires to breed commercial cows. For simplicity, the effect of use of young sires on the CRC was ignored (this population only corresponds to % of commercial cow population). There was no selection in the commercial herd.

Calculation of Costs

We also calculated the operation costs of the breeding program for the two selection strategies. Data on annual costs were collected through a group discussion with stakeholders in Kenya. The stakeholders included dairy farmers and representatives from government agencies involved in livestock genetic improvement. Agencies represented were the Livestock Recording Centre (involved with performance recording and genetic evaluations), Kenya Animal Genetic Resources Centre (maintains the bull station), Kenya Agricultural Research Institute and the Ministry of Agriculture.

The study assumed that the nucleus comprised of 25 individually owned commercial farms with consistent recording history and a government owned bull station. Female selection candidates and elites dams were maintained within the nucleus farms. Male candidates and active sires were maintained in the bull station. Only costs incurred directly in the running of the bull station were considered. The costs of the female nucleus herd was equal in both schemes (except for costs of genotyping).

Each year 250 superior dams in the nucleus were contracted by the bull station for production of selection candidates. Males' selection candidates were moved at the age of 1 month to the bull station where they were maintained until culling. Female selection candidates were retained in the participating farms. Maintenance costs for female candidates and selected dams was borne by the producers.

We considered costs for running the bull station for a single generation i.e., 8 years. Since we calculated superiorities for a stable situation (after accounting for Bulmer effect). In addition, we only considered costs that would differ between the selection strategies. Consequently, costs that related to hire of specialized personnel, purchase and maintenance of motor vehicles, purchase of equipment, and running of offices were not considered. The section below explains the specific costs of running the bull station considered and how they were computed.

Cost Items Considered in the Study

Labor costs. Labor costs were defined as costs for hire of personnel involved in the daily management of bulls in the station. The average labor requirement under the Kenya situation were determined to be 1 person for every 10 bulls. Distinction was not made for the age of bulls. The average monthly labor cost per individual was €136.

Health costs. Health costs were due to routine parasite and disease control. Costs were for purchase of dipping and oral anthelmintics. De-worming and dipping was every three month. The cost per 1 liter of anthelmintic was estimated at €30. A fixed costs of €2 per animal were charged as the veterinarian fee. Dipping costs were fixed at €40 per each dipping.

Feed costs. The main feed sources were hay, concentrates and mineral licks. The cost of a 15 kg hay bale, 70 kg sack of concentrates and 2 kg sack of mineral salts were €2.3, €22.7 and €3.6, respectively. Average feed requirements were approximated based on the number of animals and age distribution.

Housing costs. In the present study we included a fixed value of €1 per month per animal as the housing costs.

Bull-dam contracting and insemination costs. This included costs for contracting elite dams and insemination. Insemination of CRC with young bulls was accounted as a bull station cost. The number of inseminations per conception was fixed at 1.5. Cost were €455 for contracting a bull-dam and €45 per insemination.

Genetic evaluation costs. Genotyping costs comprised of costs for hair collection, DNA extraction and genotyping. Genotyped animals were bulls and cows in the nucleus and cows in the reference population. Genotyping of bulls and heifers was done annually for each new batch of calves born in the nucleus. Total genotyping cost per animal was €45.

Semen collection costs.Amount of semen collected and the timing of collection differed within and between PT and GS schemes. In PT schemes with NSS small amounts of semen was collected for producing test daughters from 2 year old bulls. Semen was later collected from active sires after selection to breed elite dams and commercial cows. In GS schemes with NSS semen was collected from active sires only. In PT and GS schemes with SS semen was collected from bulls in their 2nd year of age only. The amount of semen collected was determined by number of cows to be inseminated and the number of inseminations per conception, fixed at 1.5. Cost of semen collection was fixed at €5 per dose. Costs for storage and purchase of storage vacuum containers were ignored.

Results

Genetic Superiorities for Alternative PT and GS Schemes

Table 2 presents genetic superiorities ($\boldsymbol{R}$), accuracy of selection in sires in the 8th age-class ($\boldsymbol{r_{IH}}$), average generation intervals ($\bar{\boldsymbol{L}}$), and additive genetic variance ($\boldsymbol{\sigma_A^2}$) for alternative selection strategies following one generation of selection. R and r_{IH} were higher for all PT schemes compared to equivalent GS schemes. Most response for all strategies was realized from the sire pathway. Dams in the GS strategy had relatively higher responses. Accuracies in PT strategy were approximately double those in GS strategy. However, $\bar{L}$ was more than twice as long in PT than in GS for all schemes.

In addition, semen storage (SS) had higher impacton PT schemes compared to GS schemes. For instance, adopting SS in the PT15 schemes increased R by 15% compared to 2% in GS15 schemes. As expected, increase in the amount of information had a corresponding increase in$r_{IH}$and$R$ for all schemes.

Cumulative Genetic Levels for Alternative PT and GS Schemes

Table 3 presents the cumulative genetic levels in the commercial population for alternative PT and GS schemes in 20 years. The cumulative genetic level in a year was derived from the CDE over the investment period at 0% discounting. GS had higher levels compared to PT. The different selection paths had a different impact on the genetic level, selection in sires had a larger impact than selection in dams. Genetic levels in commercial population indicate the impact of a selection strategy on the flow of superiorities to the production population and ultimately on production. Our results indicate that long L for PT strategy not only negatively impacted on time required to generate response but also for the time required for superiorities to reach the commercial population. Consequently, despite higher responses in PT schemes only limited proportions of the response was actually expressed. On the other hand, with GS schemes which had much shorter L, generated superiorities reached the commercial population at a fast rate resulting in much higher impact on production.

Economic Performance for Alternative GS and PT Schemes

Figure 2 compares the net returns for alternative PT and GS schemes. Discount rates were 4 and 7%. Positive net returns were realized for all schemes. GS schemes out-performed PT schemes irrespective of the size of CRC population. However, both selection strategies were responsive to amount of evaluation information and discount rate.

Figure 3 presents the economic impact of alternative ways to use bulls in the station. With SS all bulls surviving to the 2nd year were "available" for selection in later years. SS therefore had higher selection intensities compared to NSS. In economic terms, SS had the much larger impact on PT strategy compared to GS.

Discussion

Our aim was to compare the economic performance of PT and GS selection strategies for a small-sized nucleus dairy cattle breeding program in a developing country. The emphasis was on how best to utilize participating cows from the commercial population to increase response to selection and profitability. Traditional PT requires participation of a proportion of commercial population (which we refer to as CRC in this study) to produce test daughters for evaluation of male candidates. In GS, CRC were used to create a reference population for genomic evaluation. We defined economic performance as the difference between discounted revenues and discounted costs.

Genetic Performance of Selection Strategies

Breeding programs are designed with the aim of maximizing responses to selection in the commercial cow population. How generated response is translated to market products is of economic importance. Calculated (changes) in genetic level of the commercial cow population resulting from alternative breeding programs therefore provides insight for designing a breeding program.CDE with zero discounting gives the actual genetic level following selection. Our results show that despite higher superiorities, PT schemes had much lower actual genetic levels in the commercial population within the considered time span (20 years). The impact of the selection strategies on commercial population was highly influenced by generation intervals, L.

Two effects of L on the industry as a whole can be distinguished. First is the rate at which superiorities are generated within the nucleus. The second is rate at which generated superiority flow to the production population. In our study we consider a single round of selection; from which PT yields more superiority than GS. We then modeled the flow of the superiorities in subsequent years through reproduction and aging. With GS, realized superiorities in the nucleus flowed at a higher rate and were expressed earlier in the commercial cows. Longer L in PT resulted in delays in both cases. As a result, despite the higher superiorities realized in PT schemes, GS had much higher cumulative gains over time.

Cumulative genetic level in the commercial population is paramount in the economic evaluation of a breeding scheme as it reflects the monetary impact of selection effort. Low cumulative levels in PT indicate that only very limited superiority was translated into products in the time horizon considered. GS on the other hand had much higher cumulative levels indicating much more expression of realized genetic superiorities. GS strategy is therefore attractive as it will (a) result in fast turnover of generated superiorities and (b) have higher cumulative effect over time.

Economic Performance of Selection Strategies

Time lag before genetic superiorities are expressed and the discount rate were two major factors that influenced the economic performance of selection strategies. Prolonged time lag, besides resulting in increase in time required to generate superiorities also leads to delays in expressions. This has a negative economic impact scheme since expressions achieved far in time will have less discounted value compared to expressions in the earlier years. Consequently, besides higher cumulative genetic level advantage, GS strategy stands to benefit the whole scheme in terms of less impact of discounting on the monetary value of revenues.

Discount rate reflect the cost of money in terms of interest payable for borrowing or accrued for lending money. Through discounting, revenues and costs can be comparable on the same basis as it accounts for the time lag between when investments are made and when revenues are generated (Brascamp, 1978). Choice of interest rates have huge impacts on the profitability of breeding programs (Smith, 1978). Three types of discount rates i.e., opportunity cost rates (**OCR**), social time preference rates (**SPR**), and synthetic rates (**SR**) have been distinguished based on the time projection and the social impact of an investment (Smith, 1978). (Smith, 1978) has convincingly shown that interest rates that reflect the rates of in terms of goods rather than money i.e., SPR, are more appropriate for long-term public investments. Such rates are generally much lower than OCR as they don't account for inflation.

In any business investment risk is an important aspect to consider. Various studies in animal breeding have incorporated risk (Kulak et al., 2003; Wahinya et al., 2015). Distinction need to be made when economically evaluating economic values of breeding goal traits and selection strategies. This emanates from the effect of the two decisions. Economic values directly impact on the profitability of a farm, and are geared towards improving the producers' income. Effects of changes in breeding goal traits are more short-term compared to selection strategies, and will therefore be influenced by monetary dynamics (interest rates and risks).In addition, they are not geared towards the public benefit but to benefit producers. Selection schemes on the other hand are largely long-term investments from which benefits are recouped for much longer period of time in the future. In addition, benefits of a breeding program are geared towards the public e.g., in terms of lower costs of products or better products. For such investments, inflation and risk play a less significant role when determining the economic impact of the investment (Smith, 1978). However, risk can be incorporated in the economic evaluation of a breeding scheme by increasing the interest rate (Brascamp, 1978). In this study we considered two interest rates, 4 and 7%.

General Discussion

While there exists a need for local breeding programs in developing tropical countries, such ventures require careful planning to be successful (Marshall et al., 2011). Besides genetic gains economic performance will influence the viability of such programs. Our aim was to determine the most economically rewarding selection criteria for local dairy cattle breeding programs in developing countries.

Conventionally, dairy cattle breeding has been based on progeny testing programs. GS has rapidly gained popularity especially as it greatly reduces generation intervals, resulting to higher annual genetic responses. Various studies have showed the economic implications of adopting GS for large scale dairy cattle breeding programs both from breeding firms' and national perspectives (Brascamp et al., 1993; Schaeffer, 2006; Konig et al., 2009). The first step towards implementation of a dairy cattle breeding programin developing countries should be an economic evaluation (Marshall et al., 2011).

When establishing a breeding program in developing countries in is imperative to have a more holistic view of the projected benefits. In developing countries livestock production plays multiple roles which

include provision of food, employment, financial security and insurance against emergencies for vulnerable persons in the society and is an important driver in the overall development. Therefore, increased productivity from the livestock sector is of national interest. Consequently, breeding programs in developing countries, especially for large stock such as cattle and small ruminants should be implemented as government funded projects. Such investments will hence take a social preference discount rate.

Our results show that implementation of small-sized nucleus breeding program for dairy cattle is economically feasible. This could play a major role in countering the effects of GxE resulting from semen importation. Implementation of a locally run breeding program also offers the local producers opportunity to be more active in the making of breeding decisions. A more inclusive decision making process is likely to positively impact other aspects of breeding such as definition of more acceptable of breeding objective (Dekkers and Gibson, 1998), and increased participation in pedigree and performance recording.

GS schemes out-performed PT schemes both in impact on the genetic level of commercial cows and economic performance. The higher impacts are explained by the short generation intervals that highly impacted the commercial population.This are particularly important when accounting for the effect of discounting. Besides, breeding programs could benefit from cost cutting measures. One such measure is to reduce costs associated with maintenance of bulls by early culling and storing semen. Our results show that adopting such an approach would have huge monetary benefits for PT schemes.

Conclusion

Adoption of a selection strategy will be determined by the ability to generate profit. The present study shows that GS will not only yield higher cumulative genetic gains but also net returns.PT strategy is also economically viable. Small sized nucleus dairy cattle schemes can be implemented for developing dairy industries. Future enlargement of such schemes is also economically viable.

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References

Brascamp, E. W. 1978. Methods on economic optimization of animal breeding plans. Rapport B-134. Zeist, the Netherlands.

Brascamp, E. W., J. A. M. van Arendonk, and A. F. Groen. 1993. Economic appraisal of the utilization of genetic markers in dairy cattle breeding. Journal of Dairy Science 76:1204-1213.

Bulmer, M. G. 1971. The effects of selection on genetic variability. American Naturalist 105:201-211.

Dekkers, J. C. M. 2007. Prediction of response to marker-assisted and genomic selection using selection index theory. Journal of Animal Breeding Genetics 124:331-341.

Dekkers, J. C. M. and J. P. Gibson. 1998. Applying breeding objectives to dairy cattle improvement. Journal of Dairy Science 81:19-35.

Dekkers, J. C. M. and G. E. Shook. 1990. Economic evaluation of alternative breeding programs for commercial artificial insemination firms. Journal of Dairy Science 73:1902-1919.

Ducrocq, V. and R. L. Quaas. 1988. Prediction of genetic response to truncation selection across generations. Journal of Dairy Science 71:2543-2553.

Gizaw, S., T. Getachew, S. Goshme, A. Valle-Zarate, J. A. M. van-Arendonk, S. Kemp, A. O. Mwai, and T. Dessie. 2014a. Efficiency of selection for body weight in a ooperative village breeding program of Menz sheep under smallholder famring system. Animal 8:1249-1254.

Gizaw, S., H. Komen, and J. A. M. van-Arendonk. 2009. Optimal village breeding schemes under smallholder sheep famring systems. Livestock Science 124:82-88.

Gizaw, S., B. Rischkowsky, A. Valle-Zarate, A. Haile, J. A. M. van-Arendonk, A. O. Mwai, and T. Dessie. 2014b. Breeding programs for smallholder sheep famring systems: I. Evaluation od alternative designs of breeding schemes. Journal of Animal Breeding and Genetics doi:10.1111/jbg.12101:1-9.

Kahi, A. K. and G. Nitter. 2004. Developing breeding schemes for pasture based dairy production systems in Kenya I. Derivation of economic values using profit functions. Livestock Production Science 88:161-177.

Konig, S., H. Simianer, and A. Willam. 2009. Economic evaluation of genomic breeding programs. Journal of Dairy Science 92:382-391.

Kulak, K., J. Wilton, G. Fox, and J. Dekkers. 2003. Comparisons of economic values with and without risk for livestock trait improvement. Livestock Production Science 79:183-191.

Marshall, K., C. Quiros-Campos, J. H. J. v. d. Werf, and B. Kinghorn. 2011. Marker-based selection within smallholder production systems in developing countries. Livestock Science 136:45-54.

Mburu, L. M., J. W. Wakhungu, and W. G. Kang'ethe. 2007. Characterization of smallholder dairy production systems for livestock improvement in Kenya highlands. Livestock Research for Rural Development 19:Article #110.

Muasya, T. K., K. J. Peters, and A. K. Kahi. 2013. Breeding structure and genetic variability of the Holstein Friesian dairy cattle population in Kenya. Animal Genetic Resources 52:127-137.

Mubiru, S. L., J. S. Tenywa, N. Halberg, D. Romney, W. Baltenweck, and S. Staal. 2007. Categorization of dairy production systems: A strategy for targeting meaningful development of the systems in Uganda. Livestock Research for Rural Development 19:Article #10.

Ojango, J. M. K. and G. E. Pollot. 2002. The relationship between Holstein bull breeding values for milk yield derived in both the UK and Kenya. Livestock Production Science 74:1-12.

Okeno, T. O., I. S. Kosgey, and A. K. Kahi. 2010. Economic evaluation of breeding strategies for improvement of dairy cattle in Kenya. Tropical Animal Health Production 42:1081-1086.

Rutten, M. J. M., P. Bijma, J. A. Woolliams, and J. A. M. v. Arendonk. 2002. SelAction: Software to predict selection response and rate of inbreeding in livestock breeding programs. Heredity 93:6.

Schaeffer, L. R. 2006. Strategy for applying genome-wide selection in dairy cattle. Journal of Animal Breeding Genetics 123:218-223.

Smith, C. 1978. The effect of inflation and form of investment on the estimated value of genetic improvement in famr livestock. Animal Production 26:101-110.

Vargas, B. and J. A. M. v. Arendonk. 2004. Genetic comparison of breeding schemes based on semen importation and local breeding schemes: Framework and application to Costa Rica. Journal of Dairy Science 87:1496-1505.

Wahinya, P. K., T. O. Okeno, I. S. Kosgey, and A. K. Kahi. 2015. Economic and biological values for pasture-based dairy cattle production systems and their application in genetic improvement in the tropics. J Anim Pro Adv 5:664-675.

Wasike, C. B., T. M. Magothe, A. K. Kahi, and K. J. Peters. 2011. Factors that influence the efficiency of beef and dairy cattle recording system in Kenya: A SWOT-AHP analysis. Tropical Animal Health and Production 43:141-152.

	[1]Selection strategies															
	PT								GS							
[2]Population information																
	NSS				SS				NSS				SS			
Total live males	453				185				453				185			
Total live females	360				360				360				360			
Active sires	10				10				10				10			
Active dams	100				100				100				100			
[3]Distribution of bulls across age-classes in a generation																
Age-classes (years)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
NSS - males	100	85	72	61	52	44	38	32	100	85	72	61	52	44	38	32
NSS/SS - females	100	75	56	42	32	24	18	13	100	75	56	42	32	24	18	13
[4]SS - males	100	85							100	85						

Table 8: Information on the structure of the nucleus and the effects of culling on the number of selection candidates. [1]PT = progeny testing; GS = genomic selection. [2]Refers to the total number of males and females maintained as live animals in a generation; they include selection candidates and active sires and dams: NSS = no semen storage, SS = semen storage. [3]Illustrates involuntary culling and the periods that bulls where maintained in the nucleus as live animals, numbers in bold indicate the ages at which candidates were available for selection. [4]With semen storage (SS), the number of male selection candidates from age-class 3 to 8 was equal to 85 i.e., we modeled a situation where sufficient amounts of semen were stored to allow evaluation of all 2 year old bulls in subsequent age-classes after voluntary culling. However, bull selection criteria was the same as with NSS.

	PT15		PT30		GS15		GS30	
	Sires	Dams	Sires	Dams	Sires	Dams	Sires	Dams
	NSS							
R	301.7	57.3	348.7	56.7	169.8	63.3	225.1	84.0
	SS							
	356.7	56.4	412.1	53.1	174.2	63.1	231.0	83.7
r_{IH}	0.56		0.72		0.29		0.40	
$\bar{L}$	5.9				2.5			
σ_A^2	1 232 113							

Table 9: Genetic superiorities (R), accuracy of selection for sires only (r_{IH}), average generation intervals ($\bar{L}$), and additive genetic variance (σ_A^2) for alternative schemes. NSS = no semen storage, SS = semen storage, h^2 = heritability, PT15 = progeny testing scheme with 4 980 cows in the commercial population to produce test daughters, PT30 = equivalent to PT15 but with 9 961 cows in the commercial population. GS15 = genomic selection scheme with 4 980 cows in the reference population, GS30 = equivalent to GS15 but with 9 961 cows in the reference population.

Scheme	**NSS**	**SS**
PT15	333.9	391.1
PT30	381.8	447.9
GS15	530.2	541.1
GS30	703.1	717.5

Table 10: Cumulative genetic level (i.e., CDE with 0% discounting) in the commercial cow population after 20 years (T=20). NSS = no semen storage, SS = semen storage, h^2 = heritability, PT15 = progeny testing scheme with 4 980 cows in the commercial population to produce test daughters, PT30 = equivalent to PT15 but with 9 961 cows in the commercial population. GS15 = genomic selection scheme with 4 980 cows in the reference population, GS30 = equivalent to GS15 but with 9 961 cows in the reference population.

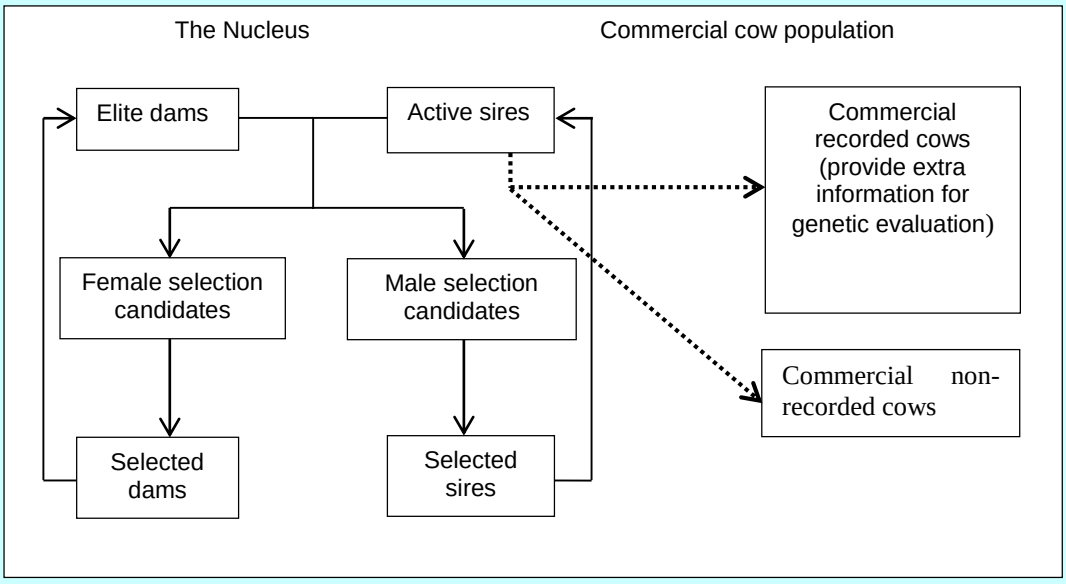

Figure 3: The general breeding structure considered

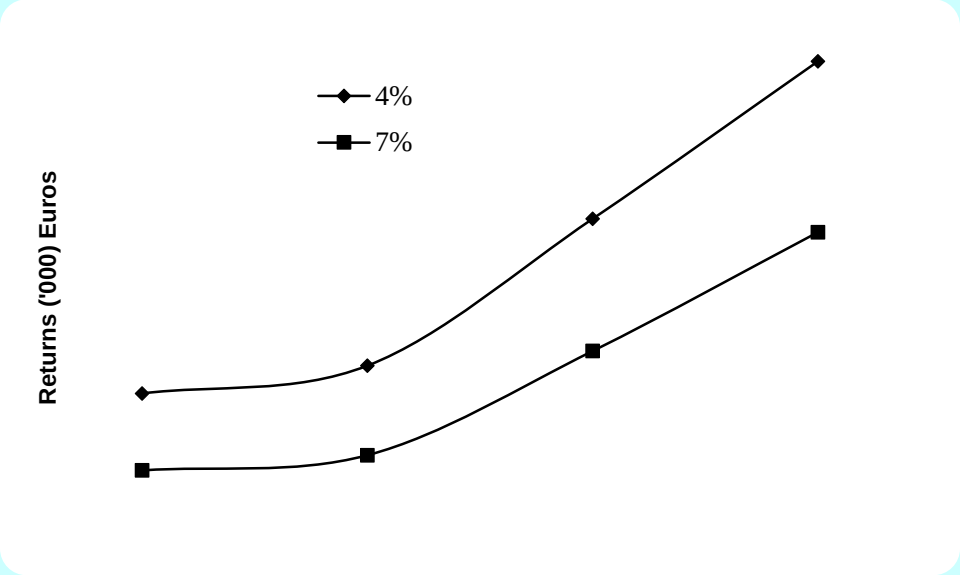

Figure 4: Cumulated net returns in '000 euros for alternative selection strategies at 4 (4%) and 7% (7%) discount rates for T = 20 years.PT15 = progeny testing scheme with 4 980 cows in the commercial population to produce test daughters, PT30 = equivalent to PT15 but with 9 961 cows in the commercial population. GS15 = genomic selection scheme with 4 980 cows in the reference population, GS30 = equivalent to GS15 but with 9 961 cows in the reference population

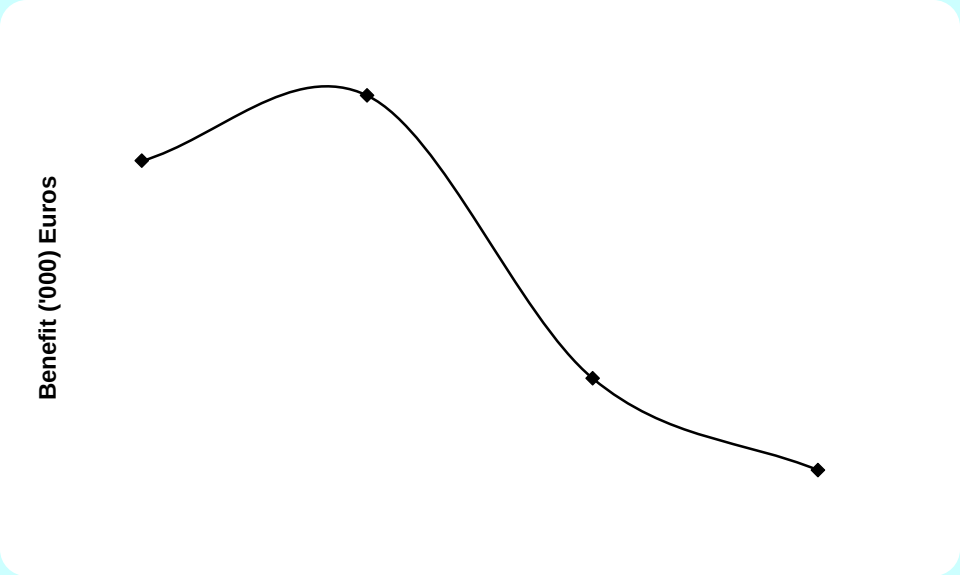

Figure 5: Change in net returns ('000 euros) resulting from adoption of semen storage for alternative strategies.PT15 = progeny testing scheme with 4 980 cows in the commercial population to produce test daughters, PT30 = equivalent to PT15 but with 9 961 cows in the commercial population. GS15 = genomic selection scheme with 4 980 cows in the reference population, GS30 = equivalent to GS15 but with 9 961 cows in the reference population

Current trends in dairy cattle nutrition research: a review

Francesca N. Lusweti

Kenya Agricultural and Livestock Research Organization, Food Crops Research Institute, Kitale,
P.O. Box 450-30200, Kitale
Corresponding Email: Francesca.Lusweti@kalro.org

Abstract

As the society changes its eating habits, farmers will have to respond and adapt to new market needs. The approach to research will also have to change to address farmers' needs. The implications on feeding of livestock are that nutrient composition of the final product has to be kept in mind. Already these changes in the researchers' outlook are seen in the current research publications. This review focuses on the effects of dairy cattle feeding on the fatty acid profile of milk, and on methane production. Particularly, feed additives that alter the fatty acid profile of the product have been investigated with the aim of reducing trans fatty acids, which have been associated with increased risk of coronary heart disease, the worldwide leading cause of death. The rumen fermentation and biohydrogenation process can affect the quantities of trans fatty acids. Furthermore, the type of feed must take in consideration the question of environmental resilience especially as regards greenhouse gas emission. Ruminants, and especially dairy cattle have been referred to as the 'big culprits' when it comes to greenhouse gas emission. The type of feeding regime preferred must therefore reduce the greenhouse gas emission as much as possible. This is seen in some of the papers reviewed here where several additives are being tested in their efficacy in reducing rumen methane. The major approach seems to be to reduce the populations of methanogenic bacteria in the rumen. Some promising additives identified include ionophores and other antimicrobial substances that target the ruminal bacterial population, increasing production efficiency, while reducing methane emissions.

Key note: feed additives, fatty acid profile, rumen methane

Introduction

Food production is one of the basic fundamentals of our society. With increasing awareness on health issues related to quality of food consumed, the Kenyan masses are becoming more and more concerned about the quality of food on their plates. The government has reflected this concern by introducing regulations on fortification of different foods. Researchers could also begin to focus on investigating feeds that have positive effects on, not just quantity, but the quality of the product, in this case milk. This paper discusses a few of current research findings that have an implication on product quality.

If society changes its eating habits, producers will have to respond and adapt to the new market needs. In the 21st century, healthy eating is gaining popularity. Gauging from available literature, animal feeding concerns in the 21st century are quality food produced and environmental resilience. As the population becomes more enlightened on their nutritional requirements, micro-nutrient composition in the food is going to gain importance in the research field. Food consumption trends have changed from reducing the amount of fat consumed to eating the right type of fatty acids. The implications on feeding of livestock are that nutrient composition of the final product has to be kept in mind. Furthermore, the type of feed must take in consideration the question of environmental resilience especially as regards greenhouse gas emission. Indeed, ruminants, and especially dairy cattle have been referred to as 'big culprits' when it comes to greenhouse gas emission. The type of feeding regime preferred must therefore reduce the greenhouse gas emission as much as possible. A review of resent research publications shows that many researchers are already headed in that direction, and there is no reason for Kenya to remain behind.

Feeding with product quality in mind

Trans fat has been associated with increased risk of coronary heart disease, the worldwide leading cause of death. The *trans* configuration results in a molecular chemistry that is not recognizable by the body, resulting in an immune response in the form of inflammation. In food production, liquid *cis*-unsaturated fats such as vegetable oils are partially hydrogenated to convert some of the *cis* double bonds into *trans* double bonds yielding a *trans*-fat.Consumption of *trans* fats raises the levels of the low density lipoprotein (LDL), the so-called "bad cholesterol", and lowers levels of the high density lipoprotein (HDL), sometimes referred to as "good cholesterol", increasing triglycerides in the bloodstream and promoting systemic inflammation (Food and nutrition board, 2005). Vaccenic acid and conjugated linoleic acid (CLA) containing *trans* fats occur naturally in trace amounts in meat and dairy products. Recent studies have looked at the effect of feed on the levels *cis* and *trans* fatty acid composition of the milk.

Feed additives have been used to improve the efficiency of rumen function. A number of recent studies have considered the effects of the additives on the fatty acid profile in dairy products. When evaluating the effects of different feed additives (cinnamaldehyde, monensin, and quebracho condensed tannin extract) on fermentation in continuous culture systems on the efficiency of rumen function and *trans* fatty acids formation. Ishlak, *et al.*, (2015) found that the feed additives, while reducing protein wastage, increased ($P < 0.05$) vaccenic acid production compared with the control diet. The formation of C18:0 in the effluent from continuous culture systems was reduced ($P < 0.01$) but only monensin and cinnamaldehyde increased ($P < 0.05$) vaccenic acid and other *trans* C18:1 fatty acid formation.This increase was greatest with the monensin diet. The concentration of *c*9*t*11conjugated linoleic acid increased ($P < 0.05$) only with the quebracho condensed tannin extract diet. The DNA abundance of *Butyrivibrioproteoclasticus,* a rumen bacterium species thathas been shown to play an important role in bio-hydrogenation decreased ($P < 0.05$) with the monensin and cinnamaldehyde diets, which could partly explain the increased vaccenic acid formation. Therefore the feed additives used in this study affected the fermentation and bio-hydrogenation process (Ishlak, et al., 2015).

Using ruminally fistulated multiparous Holstein cows, do Prado, et al., (2015) studied the interaction between sunflower oil and monensin supplementation on milk fatty acid profile. Sunflower oil supplementation decreased proportions of all short-chain and most medium-chain fatty acids. Cows supplemented with sunflower oil had higher proportions of total *trans* fatty acids and monensin addition had no effect on the fatty acid profile. These study results suggested that supplementing dairy cow diets containing a maize-based concentrate with a combination of monensin and sunflower oil does not improve milk fatty acid profile compared to supplementing sunflower oil alone (do Prado, et al., 2015).

One study (Razzaghi et al., 2016) compared the potential influence of three agro-industrial by-products:pomegranate seed pulp, pistachio hulls, and tomato pomace on ruminal fermentation, performance and milk fatty acid profile of dairy goats.Blood cholesterol concentration increased ($P < 0.01$) with pomegranate seed pulp and tomato pomace diets. The blood urea nitrogen concentration decreased ($P < 0.05$) when pistachio hulls diet was fed. Feeding tomato pomace diet decreased ($P < 0.01$) 16:0 and tended ($P < 0.10$) to increase *c*9-18:1 proportion in milk fat in comparison to the other diets. Inclusion of all by-products increased ($P < 0.01$) *t*11-18:1 (2-fold) and total conjugated linoleic acids (CLA, 5 to 6-fold) in milk fat compared to the control diet. In addition, concentrations of *c*9,*c*12,*c*15-18:3 and total polyunsaturated fatty acid in milk fat component were highest ($P < 0.01$) in the milk samples of animals fed onpomegranate seed pulp diet. All the 3 by-products showed no adverse effects on the dairy goats' performance and ruminal fermentation. Based on the positive changes in milk fatty acid profile, pomegranate seed pulp was superior to the pistachio hulls and tomato pomace by-products, since it promoted omega-3 fatty acid*c*9, *c12, and c15*-18:3 in milk (Razzaghi et al., 2016).

Analysis and Application

Cinnamaldehyde, monensin, and quebracho condensed tannin extract increased vaccenic acid and other *trans* C18:1 fatty acid formationby a mechanism thought to be reduced hydrogenation as a result of reduced

bacteria populations involved in bio-hydrogenation. Since the increase was greatest with the monensin diet (Ishlak, et al., 2015) it would appear that the positive effects of monensin in rumen function could be negated by the increase in *trans* fatty acid formation. Sunflower oil alone increased *trans* fatty acids in milk, but when monensin was added no further changes were observed, indicating a need for a more detailed study of this combination of supplements. Of the agro-industrial by-products considered here, all increased the *trans* 18:1 fatty acids, although the concentrations of *c*9,*c*12,*c*15-18:3 and total polyunsaturated fatty acid in milk fat component were highest in the milk samples of animals fed on pomegranate seed pulp diet (Razzaghi et al., 2016). Availability and cost of these products locally, coupled with further investigation in combination of local feed resources merit further consideration.

Reducing rumen emission of methane

Methane gas is a potent greenhouse gas produced in the rumen of cattle during the normal process of feed digestion and represents a significant loss of feed energy that increases feed costs. For example, a lactating dairy cow produces about 400 grams of methane each day. In one year, the amount of methane a dairy cow produces is equivalent to the greenhouse gas emissions from a medium sized vehicle driven 20,000 kilometres. Studies reveal that methane production increases with days in milk when measured in L/d, L/kg of dry matter intake and L/kg energy corrected milk, or when expressed as a percentage of gross energy intake (Alstrup et al., 2015). Agricultural methane emissions can be reduced through livestock feeding and management systems.

In one study using rumen protected fat there was a reduction in methane production when fat was added to the diet. The reduction persisted throughout the lactation, and supplementation with hydroxy-methionine-analog-isobutyrate tended to decrease methane production further (Alstrup et al., 2015). Similar reductions in methane were also seen when other fat sources, such as whole cottonseed, plant oils, and some ethanol by-products were added to the diet. Overall methane was lowered by 5 percentage units for each percentage of crude fat added to the dietary dry matter.

Adding more grain in the ration also reduced methane emissions, but the scope for increasing the amount of grain fed to ruminants is fairly limited as this ignores the importance of ruminants in converting fibrous feeds, unsuitable for direct human consumption, to the high quality protein sources milk and meat. Diets based on maize grain, compared with barley grain, reduce methane emissions, as does feeding high quality forages such as maize silage and lucerne. Ionophores, antimicrobials that target the ruminal bacterial population and increase production efficiency, also reduce methane emissions at least for a short time.

In vitro studies comparing condensed with hydrolysable tannins revealed that all the tannins decreased methane concentration either linearly or quadratically, but the magnitude of decrease was greater for the hydrolysable tannins than the condensed ones, and correlated with their protein precipitation capacity. However, hydrolysable tannins had a greater effect in reducing methane emission with less adverse effects on digestibility than condensed tannins (Jayanegaraet al., 2015). All the purified hydrolysable and condensed tannins decreased total methanogen population ($P \leq 0.05$) compared to that of control when added at 1.0 mg/ml; the decrease ranged from 22.3 to 36.7% from control. Additions of purified tannins at all levels generally decreased *Fibrobacter succinogenes* population ($P \leq 0.05$). Tannins of one particular source (sumach) decreased the population of *Ruminococcus flavefaciens* ($P \leq 0.05$), at a greater magnitude than those of other sources (Jayanegara et al., 2015).

The enzymatic inhibitor 3-Nitrooxypropanol (NOP) has consistently reduced methane emissions in sheep, dairy and beef cattle (up to 59% reduction on a long term basis). Like tannins, this enzyme also works by reducing methanogen populations. Using rumen simulation technic, Romero-Perez, et al., (2015) found that when they added 0, 5, 10 and 20 mg of NOP to sample diets, dry matter (DMD; $P = 0.79$) or organic matter disappearance (OMD; $P = 0.50$) were not affected, but methane production (mL g^{-1} DM) was reduced by up to 86.2% ($P < 0.01$). Results showed that NOP addition to diet is an effective means of reducing methane production *in vitro* (Romero-Perez, et al., 2015). There was a redirection of metabolic hydrogen, mainly to volatile fatty acid synthesis, when methane production was inhibited, which could be

beneficial for animal production when supplementing NOP (Romero-Perez, et al., 2015). A reduction in the molar proportion of metabolic hydrogen used for methane production was observed with concomitant increase of metabolic hydrogen used for volatile fatty acid ($P < 0.01$) and gaseous hydrogen ($P < 0.01$) synthesis (Romero-Perez, et al., 2015).

At the dosage levels assessed in one study (up to 75 mg/kg), eugenol could not be promoted as an effective dietary approach to mitigate enteric CH_4 emissions, decrease N excretion, and enhance feed efficiency in dairy cows (Benchaar et al., 2015). Methane production, N excretion, ruminal fermentation, nutrient digestibility, milk production, and milk fatty acid profile were not affected by addition of eugenol to the diet. (Benchaar et al., 2015).

Other researchers are also exploring innovative ways of eliminating the micro-organisms in the rumen that produce the methane, such as vaccines, among others (Agriculture and Agri Food Canada, 2012). For example the enzymatic inhibitor 3-Nitrooxypropanol (NOP) reduced ($P < 0.01$) the total copy number of 16S rRNA genes for methanogens in the solid phase but not the total protozoal cells (Romero-Perez, et al., 2015). In a study by Liu et al. (2015), addition of *Suaedaglauca* seed to diets for lambs at 0, 80, or 160 g/kg diet decreased methanogen ($P < 0.05$), protozoa ($P < 0.01$), and *Fibrobacter succinogenes* populations ($P < 0.05$). Methanogen and protozoa populations were also affected by an interaction between treatment and sampling day ($P < 0.01$) and the effect of *Suaedaglauca* seed on methanogen and protozoa populations decreased with time after feeding (Liu et al., 2015). Addition of *Suaedaglauca* seed did not change populations of fungi, *Ruminococcus flavefaciens*, and *Ruminococcus albus* (Liu et al., 2015). Addition of *Suaedaglauca* seed increased average daily gain ($P < 0.05$) and dry matter intake ($P < 0.05$) of lambs but reduced methane emissions ($P < 0.05$) (Liu et al., 2015).

Other feed additives that have been explored are plant extracts such as saponins and essential oils, and rumen modifiers such as yeast and bacterial direct fed microbials. In a recent study, they supplemented the cattle diet with commercial active dried yeast products including a new product selected on its ability to improve fibre digestion in the rumen. This combination was found to reduce methane by six percent and demonstrates the possibility of developing yeast products to improve cattle digestion.

So far, several feeding strategies show promise. For example, increasing the level of dietary fat by feeding a diet of crushed oilseeds (sunflower seed, canola seed or flaxseed) or dried maize distillers grain reduced the energy lost as methane by up to twenty percent. Because methane production increases as the animal eats more feed, improving feed conversion efficiency, the amount of feed consumed per kilogram of milk produced or weight gained, decreases methane output. Diets that are more highly digestible lower the amount of methane emitted per product produced. It may also be possible to breed more efficient cattle that produce less methane (Agriculture and Agri Food Canada, 2012).

Analysis and Application

Tannins reduce methane production in the rumen, but hydrolysable tannins reduce rumen methane with less adverse effects on digestibility than condensed tannins. The enzyme inhibitor, 3-Nitrooxypropanol (NOP) appears to hold great promise since it reduces methane emission with no effect on digestibility. Both tannins and NOP act by reducing the populations of methanogenic bacteria in the rumen. The redirection of metabolic hydrogen, mainly to volatile fatty acid synthesis, when methane production was inhibited, as observed by Romero-Perez, et al. (2015) could be beneficial for animal production. This could explain why *Suaedaglauca* seed supplementation, apart from reducing the methanogens and methane emission, also led to improved feed intake and growth rate in lambs (Liu *et al*., 2015).

The papers reviewed here show that additives which target improvement in rumen efficiency also reduce methane production. Methane emission represents a certain percentage of intake energy that is lost to the environment. Taking steps to reduce methane emission is thus not just an environmental concern, but also results in improved feed utilization efficiency.

Conclusion

This literature review shows that the research trends in dairy cattle nutrition are changing. The focus is on manipulating the rumen to take care of the changing consumer needs in the 21st century, ensure environmental resilience and optimize the performance of the cows. The target of the current ruminant nutrition research themes is to change the rumen microbial populations to reduce wasteful fermentation that results in losses through methane. In so doing efficiency of feed utilization is improved. Ruminal hydrogenation or partial hydrogenation of fatty acids is also controlled by reducing the populations of bacteria the effect hydrogenation. This is achieved by feeding the right type of feed or additive. There is need therefore for researchers in dairy cattle nutrition to change their perspective.

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References

Agriculture and Agri Food Canada. 2012 Archived content - Reducing methane emissions from livestock. Technical fact sheet.

AlstrupLene; Anne Louise Frydendahl Hellwing; Peter Lund; Martin Riis Weisbjerg. 2015. Effect of fat supplementation and stage of lactation on methane production in dairy cows. DOI: http://dx.doi.org/10.1016/j.anifeedsci.2015.05.017.

Benchaar, C., F. Hassanat and H. V. Petit.2015 Dose–response to eugenol supplementation to dairy cow diets: Methane production, N excretion, ruminal fermentation, nutrient digestibility, milk production, and milk fatty acid profile. DOI: http://dx.doi.org/10.1016/j.anifeedsci.2015.07.027.

Cohen-Zinder, M, Jayanegara, Anuraga, GunjanGoel, Harinder P. S. Makkar and Klaus Becker. 2015. Divergence between purified hydrolysable and condensed tannin effects on methane emission, rumen fermentation and microbial population in vitro. DOI: http://dx.doi.org/10.1016/j.anifeedsci.2015.08.002.

Food and nutrition board, institute of medicine of the national academies (2005).Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients). National Academies Press. p. 423.

Food and nutrition board, institute of medicine of the national academies (2005).Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients). National Academies Press. p. 504.

Liu H.W., B.H. Xiong, K. Li, D.W. Zhou, M.B. Lv and J.S. Zhao. 2015. Effects of Suaedaglauca crushed seed on rumen microbial populations, ruminal fermentation, methane emission, and growth performance in Ujumqin lambs. Animal Feed Science and TechnologyVolume 210, Pages 104–113. DOI: http://dx.doi.org/10.1016/j.anifeedsci.2015.10.007.

Razzaghi, A., A. A. Naseria, R. Valizadeh, S. H. Ebrahimi, B. Khorrami, M. Malekkhahi and R. Khiaosa-ard. 2015. Pomegranate seed pulp, pistachio hulls, and tomato pomace as replacement of wheat bran increased milk conjugated linoleic acid concentrations without adverse effects on ruminal fermentation and performance of Saanen dairy goats. Animal Feed Science and TechnologyVolume 210, Pages 46–55. DOI: http://dx.doi.org/10.1016/j.anifeedsci.2015.09.014.

Romero-Perez, A., E. K. Okine, L. L. Guan, S. M. Duval, M. Kindermann and K. A. Beauchemin. 2015. Effects of 3-nitrooxypropanol on methane production using the rumen simulation technique (Rusitec). DOI: http://dx.doi.org/10.1016/j.anifeedsci.2015.09.002.

Impact of Dairy Goats among Smallholder Farmers in Nakuru, Kenya

Ochieng, A.[1], D. Muiruri[2], B. Wasike[1] and C. Wambui[1*]

[1] School of Agriculture and Food Security, Department of Animal Science, Maseno University, P.O Box 333, Maseno, Kenya
[2] Technical Manager, Farming Systems Kenya. P.O. Box 2816, Nakuru, Kenya.
* Correspondence, wambuicc@gmail.com. Cell +254 708 384 835

Abstract

A study was conducted to determine the impact of dairy goats on smallholder farmers in Rongai Sub-county, Nakuru County. Data was collected on how the farmers have benefited from dairy goats provided by Farming Systems Kenya (FSK), a registered non-governmental organization (NGO) which offers agricultural and community development services to poor rural smallholder farming communities in Kenya. The study focused on the milk production per day, utilization avenues of income generated from sales of milk and live goats and the challenges that farmers face during management of goats. The objectives of the study were to determine (a) the benefits of dairy goats to the smallholder farmers (beneficiaries of FSK) in different areas in Nakuru County and (b) the challenges that farmers face in the management of the dairy goats. A total of 30 farmers were interviewed using a questionnaire in Ngata, Shalom, Kimangu and Solai areas of Rongai Sub-county. Goats provided enough milk for household consumption (90% consumed goat milk at household level) and the income received from sale of milk or of live off springs was mostly used by farm families to pay school fees (13%), purchase farm inputs (10%) and householdutility (7%).Diseases, repeated service, feeding and poor routine management were the main challenges encountered by the farmers.

Introduction

Smallholder dairy goat farming in Kenya is increasingly being promoted by development organizations and policy makers as an option to increase incomes of the farmers and to improve rural livelihoods (Kosgey et al., 2008). Pure exotic or crossbred dairy goats and associated technologies are preferred as a fast means of improving animal production of smallholder farmers and quicken their economic status and diet quality (Kosgey et al., 2006).

Goats are an important component of livestock industry having adaptability to harsh climates which makes them suitable for landless and marginal farmers. Goat milk contains higher amount of calcium, magnesium and phosphorus than cow and human milk. Goat milk is recommended for infants, old and convalescent people (Bhattarai, 2012). Goats can reduce bush encroachment in Africa which is important in the control of tsetse mosquito and equally, raising goats in confinement is environmentally friendly. The goat needs little heavy work, so can be done by women and men, young and old and even people who are suffering from HIV/AIDS (Ojango et al., 2010).

The Small Grants Program (Goat Project) was initiated by FSK with the aim of supporting smallholder farmers who lack the economic capacity and saving power to acquire a dairy cow or a dairy goat. The project therefore provides them credit "in kind" in form of a live goat. The households receive knowledge and skills on goat husbandry through training sessions conducted by FSK. This system has been attractive for families who have had inadequate resources hence repay their credit in kind by returning the first female (kid) which is then "passed on" to another group that is in need. The repayment in kind has been much easier for the community and ideal for FSK to reach and help the poorest in the community. Apart from alleviating poverty and contributing to household nutrition and food security, this project has raised breeding stock that is sold to middle class farmers interested in dairy goats, hence becoming a source of livelihood for these needy families. Group breeding bucks have been used to upgrade the local herd thus increasing the genetic potential of the goats. The case study was done on smallholder dairy goat farmers in

Rongai sub-county, supported by Farming Systems Kenya (FSK) with the aim of evaluating the benefits and challenges of rearing dairy goats.

Materials and Methods

Study area and sample size

The data for this study was collected in the period of June to August 2015 from 30 beneficiaries of Faming Systems Kenya dairy goat project in, Rongai sub-county in areas namely; Ngata, Shallom, Kimangu and Solai in Nakuru County. In Ngata, the study was conducted in Cannan and Kamung'ei self - help groups (SHG). In Shallom, the groups interviewed included Upendo, Amani Baraka and Giwa SHG. In Kimangu, the Kimangu Elders SHG was sampled and in Solai, Munyaka SHG groupwas interviewed. The target population of farmers in the selected areas had an approximate population of 300 farmers out of which a ten percent sample of 30 farmers was randomly selected for the study.

Data collection

Data was captured through personal interviews with the use of structured questionnaires. The information that was collected included: activities in groups, income, caretaker of goats, milk production per day, purpose of the milk, challenges faced during management of the dairy goats, results after buck service and farmers who have benefited from the dairy goats apart from milk. Data analysis was done using Statistical Package for Social Scientists (SPSS) software and the results presented in form of tables.

Results and Discussion

Milk production

Most goats, 39% produced between 1 to 1.5 litres of milk per day, 29% produced 2 to 3 litres per day while 32% produced less than a litre per day. Milk produced per day was barely enough for the household hence the little amount of milk didn't allow them to sell. A total of 90% of the interviewed farmers consumed the dairy goat milk produced at the farm level while only a paltry 10 % did not. Goat milk is a highly digestible dairy product. This is due in part to the composition and structure of the lipid (fat) portion of goat milk and in part to the way the protein in goat milk reacts in the stomach. It has often been found that infants that are not able to tolerate mother's milk or cow's milk are able to take goats milk (Farnworth, 2002). The higher proportion of short and medium- chain fatty acid compared with the milk of other livestock species allows goat's milk to be digested easily by infants and those with digestive problems (Peacock, 1996). Household consumption of goat milk is essential in supplementing protein intake and reduction of expenditure on purchase of cow's milk. It is worth noting however, that milk production is a function of many factors among them, breed, stage of lactation and level of management.

Income expenditure from sale of milk and live goats

A total of 83.3% of milk produced went to house consumption,10% of the farmers neither consumed nor sold milk while the remaining 6.7% consumed and also sold milk. The retail price of a cup of goat milk at the farm gate was 40 Ksh but most farmers were not selling as production was low. The income that the farmers obtained from sale of milk and live goats was used differently having a higher number of farmers using it to pay school fees for their children and also buying farm inputs as shown in (Table 1.)

Table 1.:How/ where the income from milk and sales of live goats is spent on

Income expenditure activity	Percentage %
School fees	13.3
Farm inputs	10.0
Household	6.7
Farm input and school fees	3.3
No income	66.7

Income from the sale of live goats to other farmers for improvement purposes seems to be of major impact contributing to a large percent on the school fees and farm input expenditures. A very high percentage (67%) indicated no income which was alarming considering the aim of the project is to improve livelihoods. A myriad of reasons could have alluded to this high figure of which sufficient data may not have been captured. Farmers are at different stages with regard to acquisition of goats as some groups have been in existence for a longer period than others, hence may be yet to experience the reproductive benefits of the goats. Adaptability, of the goats on farms, management levels and farmers interest could also have an impact on the goats' productivity.

Challenges in dairy goat management

he study revealed that the farmers experienced challenges in dairy goat management among them, cases of diseases that led to loss of kids. Most of them suffered from pneumonia and diarrhoea. Breeding was also a challenge in that does don't show heat signs delaying buck service and conception rates. Feeding was a constraint too since they (farmers) did not store feed that would be used to feed the dairy goats during the dry season. Table 2 shows the challenges faced by farmers in their daily management of the dairy goats.

Table 2: Challenges in dairy goat rearing

Challenge	Percent %
Diseases	36.7
Breeding	6.7
Feeding	6.7
Other challenges	10
Diseases and breeding	6.6
Diseases, breeding and feeding	6.7
Diseases, breeding and others	3.3
Breeding and feeding	3.3
Breeding and other	3.3
No challenges experienced	16.7

It appears that diseases and breeding were the main challenges hindering the realization of the productivity or benefits (67%) indicated in table 1. Heavy losses from kid mortality, due to diseases such as pneumonia and diarrhea reflect on the low management skills of the farmers in terms of housing, feeding and disease control measures. Loss of reproductive potential due to failure to detect heat meant that the farmers loosed on the milk and also live animals as a result of protracted kidding interval. This coupled with the fact that the group buck is far are some of the challenges that have compounded the low pass on rate among the groups. The results concur with Farzana (1999) who noted problems that are faced by goat industries and small farmers include poor nutrition, herd management and health programs. There is also a challenge regarding marketing of various products from dairy goats and sometimes lack of organized marketing channel interferes with the price control system (Farzana, 1999).

Conclusions and Recommendations

Dairy goat farming provides a promising opportunity for food security and income to smallholder farmers in Nakuru in light of the ever increasing population and the resultant land fragmentation. It has significant impact in increasing household protein intake and strengthening economic stability of the vulnerable groups especially women and the elderly who constitute the membership of the self- help groups interviewed. However, it was noted that record keeping was a challenge to most members and it is an area

that needs more investment. Farmers also need training of doe and buck management, heat sign detection, feed conservation and storage and disease control measures. There is also need to create awareness on breed improvement, that is, the farmers to be educated on the importance of upgrading their local breeds. This would also help the farmers waiting for pass-on to have milk instead of just depending on the female kid (goat) that would be born since most of the kids being born are males.

Despite the challenges, the farmers viewed the impact of the dairy goats as positive and most of them were hoping to increase and enlarge their flock. This would in turn increase the milk production per household and also allow sales of milk and live goats for improved household income.

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References

Bhattarai R R. (2012). Importance of Goat Milk. Journal of Food Science and Technology 7: 107-111.

Braker M J E., Udo H M J and Webb E C. (2002). Impact of invention objectives in goat production within subsistence farming in South Africa. Journal of Animal Science 32:185-191.

Farzana P. (1999).Goat farming in Sindh – Pakistan.www.goatworld.com/articles/goatslife/farming.shtml.

Kosgey I S., Rowlands G J., Van Arendonk J A M and Baker R L. (2006). Small ruminant production in smallholder and pastoral / extensive farming systems in Kenya. Small Ruminant Research 77:11-24.

Kosgey I S., Rowlands G J., Van Arendonk J A M and Baker R L. (2008). Successes and failures of small ruminant breeding programmes in the tropics. A review. Small Ruminant Research 61:13-28.

Ojango J M K., Ahuya C., Okeyo A M and Rege J E O. (2010) .FARM Africa – Dairy goat improvement project in Kenya.

Peacock CP. (1996). Improving Goat Production in the Tropics. A manual for development workers. FARM-Africa/Oxfam, Oxford.

Thirunavukkarasu M and Prabaharan R. (1996). Production capacity of goats in different ecozones in Tamil Nadu. Indian Veterinary Journal 73:857-860.

The Effects of Twelve Cultivars of Napier Grass on Dry Matter Intake and Digestibility by Sheep

Robert Irungu [1,2] and Naftali Ondabu[2]

[1]Kenya Agricultural and Livestock Research Organization, P.O. Box 25 20117, Naivasha, Kenya
[2]Kenya Agricultural and Livestock Research Organization, P.O. Box 3840 20100, Nakuru, Kenya
*Corresponding author, Email: robertirungu@gmail.com ; Mobile +254 722 908 295

Abstract

Napier grass (*Pennisetum purpureum,* Schumach) is popular among Kenyan smallholder dairy farmers due to its high dry matter yield. The objective of the current study was to evaluate the effects of twelve cultivars of Napier grass on dry matter intake and digestibility by Red Maasai sheep. The twelve Napier grass cultivar were Bana grass, Clone 13, Ex-Mariakani, French Cameroon, Kitui, L7, KK1, KK2, KK3, Machakos Hairless, Parkistan Hybreed, Songo Nandi L13 and Uganda L14 and were grown following recommended cultural practices. The grass was harvested at a mean height of 67.3 cm and fed to Red Maasai sheep in conventional intake and digestibility study. Analysis of variance for a completely random design (CRD) were done on cultivar height, dry matter (DM), dry matter intake (DMI), dry matter digestibility (DMD) and digestible dry matter intake (DDM). Means were separated using least significant difference procedures. The Napier grass cultivar affected its height, dry matter, dry matter intake and digestibility by Red Maasai sheep. The shortest and the tallest cultivars at harvest were Pakistan Hybreed and Songo Nandi L13 at 30 and 105.3 cm. Napier grass harvested between 63.3 and 65.6 cm was more nutritious than that harvested taller. The highest dry matter and dry matter digestibility was 211.6 and 678.0 g/kg DM in Bana grass and KK1 respectively. The highest dry matter intake and digestible dry matter intake in Red Maasai sheep was 108.9 and 70.5 g/kg $w^{0.75}$ in clone 13 respectively. The DMD in French Cameroon, Kitui L7, Songo Nandi L13 and Uganda L14, DMI in Bana grass and French Cameroon and DDMI in KK1 and KK2 were similar respectively. Ex-Mariakani, KK1, Machakos Hairless and Pakistan Hybreed; Clone 13 and KK1 and Bana grass, Clone 13, French Cameroon, KK3 and Songo Nandi L14 recorded different DMD, DMI and DDMI from all the remaining Napier grass cultivars studied. Napier grass should be harvested between 63.3 and 65.6 cm to provide nutritious diets to Red Maasai sheep. Compared to all cultivars, diets of high digestibility to sheep were provided by KK1, KK2 and KK3 with 678.0, 664.4 and 659.0 g/kg DM. However, Bana grass and Clone 13 which provided diets that achieved high dry matter intake and digestible dry matter intake were the most suitable to Red Maasai sheep.

Introduction

The Kenya dairy smallholders produce 80% of the annual national milk output. A significant proportion of these farmers practice zero or semi-zero grazing system (Anindo and Potter, 1994). Their dominant fodder is Napier grass (*Pennisetum purpureum,* Schumach) whose popularity is due to its higher dry matter yield compared to Rhodes grass (*Chroris gayana* Kunth), Setaria (*Setaria sphacelata,* Stapf) and Kikuyu grass (*Pennisetum clandestinum,* Hochst*)* (Wouters, 1987). The dry matter yield will, however, vary with ecological zone, soil fertility and cultivaral practices.

Napier grass is propagated vegetatively because its seeds have low viability and genetic stability (Humphreys 1994). Planting materials in Kenya have been obtained from a few bulking sites which dominantly distributed cuttings of Bana grass and French Cameroon. Cuttings of these two varieties have been widely grown on most smallholder farms without incorporating other Napier grass varieties. This has caused narrowing of the genetic diversity of Napier grass within Kenyan smallholder farms. The risk of reduced diversity has been shown by the outbreak of Napier grass smut caused by *Ustilago kamerunensis* which reduced Napier yield by over 50 percent (Farrel, 1999). The objective of the current study was to

evaluate the effects of twelve cultivars of Napier grass on dry matter content and dry matter intake and digestibility by Red Maasai sheep.

Materials and Methods

Experimental site

The study was conducted at the Kenya Agricultural and Livestock Research Organization (KALRO) in Lanet located in the outskirts of Nakuru town, within Nakuru County, Kenya. The site is 0^0 18'S, 36^0 09'E and 1920 m above sea level. The area receives bimodal rainfall; with the long rains occurring late March to May and the short rains received in October and November (Jaetzold et al. 2006). The area receives on average 800 mm rainfall annually with a relative humidity of 83 %. The mean maximum and minimum temperatures are 26^0C and 10^0C, respectively. The study site falls within agro-ecological zone (AEZ) IV (Jaetzold et al. 2006) with soils classified as humic nitosols under FAO soil classification.

Sheep and Experimental Design

Forty eight ten–month old and healthy Red Maasai sheep were obtained from a large flock. Their average live–weight was 36.0kg. The sheep were dewormed before being used in the study. A completely randomized design was adopted where four sheep were allocated to each treatment diet of the twelve Napier grass cultivars. The sheep were weighed at the start and again at the end of the study period.

Feeds, Feeding and dry matter digestibility

The twelve Napier grass cultivar: Bana grass, Clone 13, Ex- Mariakani, French Cameroon, Kitui L7, KK1, KK2, KK3, Machakos Hairless, Pakistan Hybreed, Songo Nandi L13 and Uganda L14 were grown following recommended cultural practices (Wouters, 1987, Kariuki,1998 and Muia, 2000). The grass was harvested at a mean height of 67.3 cm (majority ranging 63.3 to 66.7 cm), chopped to 2.5cm length and offered to sheep in individual troughs at 9.00 a.m daily (Schneider and Flatt, 1975). An allowance of 10% above previous day's intake was allowed to cater for any unexpected increased feed intake. Representative samples of each day's batch of Napier grass cultivars fed were collected and bulked for the whole experimental period. The refusals from the previous day's feeding were weighed, recorded and sampled. Water and mineral licks were offered *ad libitum*.The sheep were housed in individual metabolic cages during the 21 days digestibility study. Fourteen days adaptation period was followed by seven days total faecal collection for each sheep. Feaces were pooled for each sheep and sub sampled (Schneider and Flatt, 1975 and Irungu et al. 1999)

Chemical and Statistical Analysis

The representative samples of feed offered, feed refusal and feaces collected were dried at 70^oC for 24 hours, ground to pass through 1 mm sieve and stored in plastic containers to await chemical analyses. Dry matter was determined according to Association of Official Analytical Chemists (AOAC, 1990). Analyses of variance for a completely randomized design were done on nutrient intake and digestibility using general linear model of SAS (2000). Separation of means was done using least significant difference procedures.

Results

Plant height and Dry matter

The cultivar of Napier grass influenced ($P<0.05$) the plant height and dry matter (Table1). The tallest ($P<0.05$) and the shortest cultivars at harvest were Songo Nandi L13 and Pakistan Hybreed at 105.3 and 30.0 cm respectively. Kitui L7 was taller than ($P<0.05$) Uganda L14 at 95.0 and 78.3 cm respectively. Bana grass, Clone 13, Ex-Mariakani, French Cameroon, KK1, KK3 and Machakos Hairless recorded similar ($P>0.05$) height ranging between 63.3 to 66.7 cm which was lower than ($P<0.05$) the height of other Napier grass cultivars studied. The highest ($P<0.05$) dry matter (DM) was contained in Bana grass, KK1 and Uganda L14 and the lowest ($P<0.05$) DM was recorded in Kitui L7 (Table: 1). The highest ($P<0.05$) DM ranged between 209.0 and 211.6 g/kg DM and the lowest ($P<0.05$) was 193.7 g/kg DM. Although the DM

contained in Clone 13, KK3 and Uganda L14; Bana grass, KK1 and Uganda L14 respectively were similar (P<0.05), the DM contained in Clone 13 and KK3 was lower than (P<0.05) in Bana grass and KK1. The DM contained in Ex-Mariakani, French Cameroon KK2, Machakos Hairless and Songo Nandi L13 was similar (P>0.05). The DM contained in Kitui L7 did not differ (P>0.05) with the value in Songo Nandi L13.

Dry Matter digestibility, dry matter and digestible dry matter intake by sheep

The cultivar of Napier grass influenced the dry matter digestibility, dry matter and digestible dry matter intake (P<0.05) by red Maasai sheep (Table 2). The highest (P<0.05) dry matter digestibility (DMD) was in KK1 and lowest (P<0.05) DMD was recorded in Ex- Mariakani at 678.0 and 451.2 g/kg DM respectively (Table: 2). The DMD in Bana grass and Clone 13; French Cameroon, Kitui L7, Songo Nandi L13 and Uganda L14; KK2 and KK3 respectively were similar (P>0.05). Ex-Mariakani, KK1, Machakos Hairless and Pakistan Hybrid recorded different (P<0.05) DMD from all the remaining Napier grass cultivars studied. The highest (P<0.05) dry matter intake (DMI) by sheep was in Clone 13 and the lowest (P<0.05)

Table 1: The Effect of Napier Grass Cultivars on Plant Height and Dry Matter

Cultivars	Height (cm)	DM (g/kg DM)
Bana grass	63.3^{c}	211.6^{f}
Clone 13	63.3^{c}	206.0^{de}
Ex-Mariakani	66.7^{c}	199.8^{b}
French Cameroon	63.3^{c}	197.8^{b}
Kitui L7	95.0^{c}	193.7^{a}
KK1	63.3^{c}	211.6^{f}
KK2	48.3^{b}	200.6^{bc}
KK3	65.6^{c}	206.4^{e}
Machakos Hairless	65.0^{c}	198.8^{b}
Pakistan Hybrid	30.0^{a}	203.6^{cd}
Songo Nandi L13	105.3^{f}	197.1^{ab}
Uganda L14	78.3^{d}	209.0^{ef}
LSD	5.9	3.4
CV	5.2	0.8

^{abcdef}: Means in a column followed by a different superseded are different (P<0.05)
LSD: Least significant difference, CV: Coefficient of Variation

DMI was recorded in Ex-Mariakani, Machakos Hairless and Songo Nandi L13 at 108.9, 83.2 and 81.5 g DM/kg $W^{0.75}$ respectively (Table: 2). The DMI in Bana grass and French Cameroon; Kitui L7 and Uganda L14; KK1 KK3 and Pakistan Hybrid respectively were similar (P>0.05). Clone 13 and KK1 recorded different (P<0.05) DMI from all the remaining Napier grass cultivars studied. The highest (P<0.05) digestible dry matter intake (DDMI) by sheep was in Clone 13 and the lowest (P<0.05) DDMI was recorded in Ex-Mariakani at 70.5 and 37.6 g/DM/kg $W^{0.75}$ (Table: 2). Cultivars KK1 and KK2; Kitui L7 and Uganda L14; Machakos Hairless and Pakistan Hybrid respectively were similar (P>0.05). Bana grass, Clone 13, French Cameroon, KK3 and Songo Nandi L14 recorded different (P<0.05) DDMI from all the remaining Napier grass cultivars studied.

Table 2: The Effect of Napier Grass Cultivars on Nutrient Intake in Sheep

Cultivars	DM (g/kg DM)	DMI (g/kg $W^{0.75}$)	DDMI (g/kg $W^{0.75}$)
Bana grass	644.5^{e}	104.7^{e}	67.4^{h}
Clone 13	647.4^{e}	108.9^{f}	70.5^{i}
Ex Mariakani	451.2^{a}	83.6^{a}	37.6^{a}
French Cameroon	540.6^{b}	102.1^{e}	55.3^{e}
Kitui L7	544.2^{b}	87.0^{b}	47.5^{c}
KK1	678.0^{g}	92.8^{c}	63.0^{g}
KK2	664.4^{f}	96.6^{d}	63.8^{g}
KK3	659.0^{f}	91.0^{c}	60.0^{f}
Machakos Hairless	595.0^{d}	83.2^{a}	49.6^{d}
Pakistan Hybrid	555.0^{c}	92.0^{c}	51.2^{d}
Songo Nandi L13	538.1^{b}	81.5^{a}	44.2^{b}
Uganda L14	541.3^{b}	87.0^{b}	47.1^{c}
LSD	8.8	3.2	2.1
CV	0.9	1.6	1.7

DMD: Dry Matter Digestibility, DMI: Dry Matter Intake, DDMI: Digestible Dry Matter Intake
^{abcdefghi}: Means in a column followed by a different superseded are different ($P<0.05$)
LSD: Least significant difference, CV: Coefficient of Variation

Discussion

Plant height and Dry matter

The highest DM was contained in Bana grass, KK1 and Uganda L14 as they were short and vegetative. At such height, the ratio of leaves to stems in high and leaves are known to contain higher DM compared to the fleshy stem. This may also explain the low DM recorded in Kitui L7 and Songo Nandi L13 as they were taller and most likely with lower ratio of leaves to stems. Between the Napier grass height of 63.3 to 66.7 cm the Napier cultivars contained 197.8 to 206.4 g/kg DM and beyond this height range the DM decreased. Clone 13 and KK3; Ex-Mariakani, French Cameroon, KK2, Machakos Hairless and Songo Nandi L13; Kitui L7 and Songo Nandi L13 respectively contained similar DM as they were of similar height and were most likely at similar vegetative stage.

Dry matter digestibility, dry matter and digestible dry matter intake by sheep

Short and vegetative Napier grass has favourable ratio of leaves to stems and leaves are known to have higher digestibility compared to stems. Hence, with increased height in Kitui L7, Songo Nandi L13 and Uganda L14 the ratio of leaves to stem may have decreased causing reduction in digestibility. However, within the Napier grass height between 78.3 and 105.3 cm the digestibility did not change. In the current study, Napier grass harvested between 63.3 and 65.6 cm had high digestibility. Cultivars KK1, KK2 and KK3 were more digestible compared to all other Napier grass cultivars although KK1 had the highest digestibility. This superiority in digestibility is in accord with the findings of Kariuki (1998), Muia (2000) and Irungu et al., (2006) who showed that nutrient digestibility rose with increase in metabolizable energy content of forage. These cultivars may contain more energy compared to the remaining cultivars studied.

The trend in DMI and DDMI by sheep fed Napier grass was closely linked with the trend in DMD. However, Bana grass and Clone 13 seemed to have superseded KK1, KK2 and KK3 in DMI and DDMI. Increased intake of crude protein by sheep on Bana grass and Clone 13 may have caused high DMI (Onyango, 1986; Irungu et al., 2002; Irung et al., 2006). Bana grass and Clone 13 may have protein that was soluble and degradable in the rumen enabling microbial protein synthesis and multiplication (Preston and Leng, 1987) reducing rumen retention time. This agrees with the findings of Irungu et al., (2006) who

showed reduced crude protein digestibility in KK2 and KK3. Furthermore, the probable reduced content of neutral detergent fibre and lower lignifications in Bana grass and Clone 13 may explain their nutrient intake superiority (Minson, 1990; Irungu et al., 2006). These explain too, how Bana grass and Clone 13 nutritionally superseded cultivar KK1, KK2 and KK3 in DMI and DDMI. This is in agreement with Minson, 1990 who showed that the quality of digestible protein ingested by sheep determined the digestible dry matter intake.

Conclusion

The cultivar of Napier grass influenced the plant height, dry matter content, dry matter intake and digestibility and digestible dry matter intake by Red Maasai sheep. The tallest and shortest cultivars at harvest were Songo Nandi L13 and Pakistan Hybrid. In the current study, Napier grass harvested between 63.3 and 65.6 cm was more nutritious than that harvested taller. Cultivars KK1, KK2 and KK3 were more digestible compared to all other Napier grass cultivars. The highest dry matter, dry matter intake, dry matter digestibility and digestible dry matter intake in Red Maasai sheep was in Bana grass, KK1 and Uganda L14, Clone 13, KK1 and Clone 13 respectively. The lowest values of the nutritional components were recorded in Kitui L7, Ex-Mariakani and Songo Nandi L13, Ex-Mariakani and Ex- Mariakani and Songo Nandi L13 respectively. The DMD, DMI and DDMI in French Cameroon, Kitui L7, Songo Nandi L13 and Uganda L14; Bana grass and French Cameroon and KK1 and KK2 were similar. Ex–Mariakani, KK1, Machakos Hairless and Pakistan Hybid; Clone 13 and KK1 and Bana grass, Clone 13, French Cameroon, KK3 and Songo Nandi L14 recorded different DMD, DMI and DDMI from all the remaining Napier grass cultivars studied.

Recommendations

Napier grass should be harvested between 63.3 and 65.6 cm to provide nutritious diets to Red Maasai sheep. However, Bana grass and Clone 13 are the most suitable to provide diets that achieve high dry matter intake and digestible dry matter intake in Red Maasai sheep.

References

Anindo, D.O. and Potter, H.L. (1994). Seasonal variation in productivity and nutritive value of Napiergrass at Muguga Kenya. E. Afr. Agric. For. J. 52: 106-111.

AOAC, (1990). Association of official Analytical Chemists. Washington D.C.

Farrel, G. (1999). Biomass reduction in Napier grass infected with the smut pathogen, Ustilago kamerunensis, In J.S Sutherland (editor). Toward increased use of demand driven Technology. End of Project Conference, Research Report pp. 232-236.

Irungu, K.R.G., N.O. Ondabu, J.K. Kitilit and R.N. Kenana (2006). The nutrient intake and Digestibility by sheep fed Bana grass and three new cultivars of Napier grass. Proceedings of 10th Biennial KARI Conference, Kenya Agricultural Research Institute.

Irungu K.R.G., R.K. Keingatti and A.N. Abate (1999). Performance of beef steers fed brewers grain ensiled with hay or forage sorghum. Proceedings of 6th Biennial KARI Conference, Kenyagricultural Research Institute pp 432-439.

Jaetzold R., H. Schmidt, B. Hornetz and C. Shisanya (2006). The Farm Management Handbook of Kenya. Central Kenya. Volume II, 2rd Edition. Ministry of Agriculture, Kenya.

Kariuki, J.N. (1998). The potential of improving Napier grass under smallholder dairy farmers' Conditions in Kenya. PhD Thesis Wageningen University, Netherlands.

Mison, D.J. (1990). Forage in ruminant nutrition. Academic press, London

Muia J.M.K. (2000). Use of Napier grass to improve smallholder milk production in Kenya. PhD Thesis Wageningen University, Netherlands.

Onyango, T.A. (1986). Feeding value of forage sorghum "E6518" at different stages of growth. MSc Thesis. University of Nairobi.

Preston, T.R. and R.A. Leng (1987). Matching livestock systems to available feed resources in the tropic and sub-tropics. Panambull Books, Amidale, Australia.

SAS, (2003). Users Guide, release 6.03 Edition, Cary, NC, USA.N.

Schneider, H. and W.P. Flatt (1975). The evaluation of feed through digestibility experiments. University of Georgia press. Athens.

Wouters, A.P. (1987). Dry matter yield and quality of Napier grass on-farm level 1983-1986. Research Report, Ministry of Livestock Development, Nairobi Kenya pp. 39.

Animal Health Care and Marketing input Services in Turkana County: Policy Implication

Kidali., J.[1], S. Omondi[1] and J. Njanja[1]

Kenya Agricultural and Livestock Research Organization.
P. O. Box 32 - 00902- Kikuyu, Kenya
*Corresponding Author: John A. Kidali: Email. Kidalijohn@yahoo.com; Tel:+254 722 529 770

Abstract

This study was carried out in Turkana South Sub-County in Turkana County to obtain an insight into the constraints encountered by livestock keepers on animal health, livestock production, marketing and policy implication in the Arid and Semi-arid lands. Data were collected using a survey of 400 households, fifteen focus groups with livestock keepers, key informant interviews and a workshop. Frequency counts and percentages were used to analyse data.The results showed the major constraints to livestock production were diseases 42.75%, drought 23.75%, rustling 16.75%,prosopis 9.25%, and lack of organized livestock markets 7.5%. Priority livestock diseases affecting goats were: Contagious Caprine Pleura Pneumonia 52.75% and helminths 20%,mange 15%, and haemorrhagic septicaemia 12.25%.; sheep included helminth 59.25%mange 24% and haemorrhagic septicaemia 16.75%.; camels:haemorrhagic septicaemia 53.5%, mange infestation 25.75%, camel cough 11.75% and camel pox 9%.,cattle: Contagious Bovine Pleura Pneumonia 50.75%, anthrax 19%, mastitis 16.5% and lumpy skin disease 13.75%. Donkeys: faucal impaction 53.75%, tetanus 26.75% and anthrax 19.5 %. Constraints encountered while seeking animal health care were: inadequate personnel 27.75%, poor infrastructure 24.25%,inaccessible livestock inputs 16.25%, illiteracy 14.75%, lack motivation for CAHWs10% and insecurity 6.5%. While the key constraints hindering trade in livestock products were: poor infrastructure 42.75%, insecurity/banditry 21.75%, disease outbreak 15.25%, market brokers 11% and lack of market information 9.25%. It is recommended that the key constraints limiting animal health care, and trade in livestock products could best be addressed through County government policy framework that establishes strategic partnerships.

Keywords: Animal health, marketing and policy implication.

Introduction

Fifty of the livestock sub-sector has is concentrated in the Arid and Semi-Arid lands (ASALs) of Kenya and is the major economic and social activity for the pastoralists. The large herd of the pastoralists is used for spreading production risk associated with diseases and other natural calamities like drought. Kenya's ASALs have received low priority in allocation of development resources (GoK, 2004). Statistics indicate that 45% of the total land in Kenya is agriculturally productive of which 17% of the cultivable land is suitable for rain fed intensive agricultural production (CBS, 2003).The high demand for agricultural land in the high potential areas is due to increasing agricultural populationThe ASALs need to be given a higher precedence in resource allocation in order to ensure definite supply of agricultural produce. Increase in output per unit of livestock can be realised through breeding, better feeding and disease management, enhanced indirectly through improved access to markets, market information and value addition to livestock products. A credit programme was established under the Kenya Veterinary Association Privatization Scheme in 1994 to facilitate veterinarians to enter into private practice (Wamukhoya, et al. 1995 and Tambi et al 1997). This did not perform as expected in filling the gap left by the government especially in the arid and semi-arid lands. Absence of effective collaboration between the pastoralists' community and state structures has often led to untargeted project implementation frameworks. (Lokong, M. 1987) since in most cases pastoralists are not involved in the design. This suggests that alternative approaches should be developed to address key constraints related to livestock diseases, availability of water and trade in the ASALs through partnership and linkages between County government, NGOs,

donors and pastoralists.The main objective of the study was to obtain information on animal health care, livestock production and marketing constraints and suggested intervention in Turkana County.

Materials methods

Study area

The study was carried in Turkana South sub-county which has a human population of 226,379 (Census report 2009). The sub county, borders Turkana North to the North, Marsabit to the East, Samburu to the South East, Baringo and West Pokot to the South and Uganda to the West. Turkana South has five divisions namely; Loima, Lokichar, Kalokol, Kerio and Turkwel. The sub-county is classified as arid and semi-arid, characterised by low rainfall averaging 120mm per year and high temperatures ranging from 24^0c to 38^0c. The Major community occupying the Sub-County is the Turkana.

Data Collection methods.

The sub-county (N = 226,379) formed the population from which a sample size was determined using the formula by Kothari (2008): n = N/ 1+N (e2). Quantitative data was obtained through across sectional survey using a structured questionnaire administered to 400 households randomly selected from five divisions in the Sub-County. Qualitative data (Kumar, 1993; ; Kruger, 2002;) were collected through workshops, 15 focus groups discussion and interviews with participants purposively selected to obtain an insight into the constraints encountered by livestock keepers, animal health constraints, livestock production and marketing.

Data analysis.

The data coding, entry and cleaning was done using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics which included frequencies and cross-tabulations were generated and used to characterize pastoralists' perceptionon animal health constraints, livestock production, marketing and management.

Results and Discussion

Livestock production

The pastoralists ranked the livestock kept in order of preference in accordance by the use of pair wise ranking as shown in Table 1. Shoats and camels were the preferred livestock species. This could be attributed to the prevailing climatic conditions characterised by erratic rainfall and inadequate pastures which favour species accustomed to browsing on shrubs.

Table 1: Priority livestock species kept and reasons for preference the Turkana community

Livestock species	Frequency (f) (N=400)	Percentage	Ranking reasons for preference			
			1	2	3	4
Goats	140	35	Income (54)	Security(20)	High birth rate (16)	Skin (10)
Sheep	123	30.75	Income (50)	Security (26)	High birth rate (14)	Skin (10
Camels	60	15	Drought resilience (29)	Dowry (14)	Milk (11)	Income(6)
Cattle	53	13.25	Income (24)	Milk (16)	Meat (8)	Hides (5)
Donkey	24	6	Transport (18)	Income(6)		

Livestock Constraints

Table 2 presents livestock constraints. Pastoralists perceive diseases and drought as the main constraints limiting livestock production. Other constraints included rustling, prosopis conditions and lack of reliable

markets. Given that livestock is the main source of livelihood and incomes to the community, diseases could effectively be addressed through partnerships between the cvunty government and stakeholders in the sector including the Veterinary department, KALRO and NGOs. Drought is almost a permanent feature in the region in view of climate variability. Nevertheless the recent discovery of a large body of underground water in the region could signify a sigh of relief and improve both human and livestock welfare if the County and National government prioritise the mining of this important resource.

Table.2: Mainlivestock production constraints

Constraints	Frequency	Percentage
Livestock diseases	171	42.75
Drought	95	23.75
Rustling	67	16.75
Prosopis associated conditions	37	9.25
Lack of reliable market	30	7.5
	N=400	100%

Prioritization of livestock diseases

Pastoralists prioritized livestock diseases based on impact on morbidity, mortality and loss of incomes in five divisions in Turkana South sub-county in table as shown in Table 3. Important diseases affecting the priority livestock i.e. goats, sheep and camels were: CCPP, helminths and Haemorrhagic septicaemia respectively. Cattle and Donkeys were affected by CBPP and Faucal Impaction respectively. Management of these diseases is vital in improving productivity and trade.

Table 3: Important diseases to pastoralists.

	Priority diseases in terms of impact on mortality, morbidity and loss of income											
Livestock species kept	1	N	%	2	N	%	3	N	%	4	N	%
Goats	CCPP	211	52.75	Helminth	80	20	Mange	60	15	HS	49	12.25
Sheep	Helminth	237	59.25	Mange	96	24	HS	67	16.75			
Camels	H S	214	53.5	MI	103	25.75	CC	47	11.75	CP	36	9
Cattle	CBPP	203	50.75	Anthrax	76	19	Mastitis	66	16.5	LSD	55	13.75
Donkey	FI	215	53.75	Tetanus	107	26.75	Anthrax	78	19.5			

CCPP: Contagious Caprine Pleura pneumonia; HS:Hemorrhagic Septicemia: MI:Mange Infestation: CC:Camel Cough's:Camel Pox: CBPP: Contagious bovine pleura pneumonia: LSD:Lumpy Skin Disease: FI: Faucal ImpactionN: Number of respondents

Table4: Constraints encountered by the community while seeking animal health care services and advice

Constraints	Frequency	Percentage
Inadequate personnel	111	27.75
Poor infrastructure	97	24.25
Inaccessible livestock inputs	67	16.75
Illiteracy	59	14.75
CAHWs `lack of motivation	40	10
Insecurity/banditry	26	6.5
	N=400	100%

Inadequate personnel, poor infrastructure and inaccessibility to livestock inputs were the major constraints encountered by the community while seeking animal health care services.

Marketing constraints

The marketing constraints mentioned by pastoralists are indicated in Table 5.

Table 5:Five priority livestock products marketing constraints as perceived by pastoralists

Constraints	Frequency	Percentage
Poor infrastructure	171	42.75
Insecurity/Banditry	87	21.75
Diseases outbreak	61	15.25
Market brokers	44	11
Lack of market information	37	9.25
	N=400	100%

Lack of market infrastructure which include holding grounds, watering facilities andpoorroad network are an impediment to marketing of livestock. Insecurity, disease outbreak, market brokers and lack of market information collectively limit livestock trade in the region.

Stakeholders in Animal health sector

Stakeholders in animal health in the region include the Ministry of Agriculture Livestock and Fisheries, and NGOs: Oxfam, Catholic Diocese of Lodwar, VSF-Belgium and World Vision. The lessons learnt from this study suggest that interventions by individual organisations have had no impact andlacks sustainability in solving pastoralists' problems. Each organization works independently of the other and in spite of thisa lot of resources are invested in ASALS by various organizations, but sofar theempowerment of the communities has not been achieved. There is need for the organisations working in the area to work together as a team. This Synergy and complementarity has the potential to enhance livestock production, marketing and strengthen linkages, knowledge and information sharing through partnership. This calls for the County government to come up with policies which would provide a frameworkfor joint effort in the livestock sector to improve productivity, animal health care and marketing services.

Conclusion

The pastoral community has high regards towards livestock keeping as source of their livelihood. Shoats and camels are the most preferred livestock species due to the climatic conditions which favour species accustomed to browsing on shrubs. Priority diseases indicated for goats, sheep and camels were: CCPP, helminths and Haemorrhagic septicaemia respectively. Cattle and Donkeys were affected by CBPP and Faucal Impaction respectively. Marketing was affected by lack of infrastructure, Insecurity, and disease outbreak. Animal health service provider are GoK and NGOs. Each organization works independently of the other and in spite of the many resources invested in ASALS by various organizations, empowerment of the communities has not been achieved. There is need for the stakeholders working in the region to collaborate and to complement each other in order to promote livestock production, marketing and to strengthen linkages, knowledge and information sharing through partnership.

Recommendations

The County government should formulates policies that promotes partnerships and linkages with all actors in livestock value chain in order to complement each other. The County government should form linkages and partnership with Kenya Agricultural Livestock Research Organization (KALRO), in the area so that they can work together in solving problems relating to the diseases mentioned. The County government

should formulate a policy that insures livestock products are added value at the County. The exploitation of the recently discovered underground water will eliminate conflicts over water and grazing grounds as there will be crops residue for livestock and enough food through irrigated land.

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References

Government of Kenya (2009) Human population census report. Ministry of planning and vision (2030).

GoK. (2004). Strategies for Revitalizing Agriculture, 2004-2014.

Kenya National Bureau of Statistics (2003).

Kothari, C.R. (2008). Research Methodology, Methods and Techniques. 2 Revised International New Delhi: New Age Publishers.

Kumar, K. (1993). An overview of Rapid Rural Methods in development settings.

J.P.F. D'Mello and C. Davendra (eds.). Rapid Appraisal Methods. Wallingford:CAB International p. 8-25.

Kruger RA (2002). Designing Focus group interviews. University of Minnesota.

Lokong, M. (1987) Dialogue Education -A tool for the equitable incorporation ofnomadic pastoral communities in national development with special reference to Turkana of North West Kenya. Diploma thesis, University of Reading.

Tambi, E.N., Mukhebi, A.W., O.W. Maina and Solomon, H.M. (1997). Privatization ofAnimal Health Services: an Evaluation of the Kenya Veterinary AssociationPrivatization Scheme (KVAPS).

Wamukhoya, J., Gathuma, M. and E.R. Mutiga, (1995). Spontaneous Private VeterinaryPractice in Kenya. In FAO electronic Conference on principles for the rationaldelivery of public and private veterinary services, Food and Agriculture Organization (FAO), Rome.

Economics of Production of New Zealand White, California White Rabbit Breeds and their Cross Under Two Feeding Regimes

Wanjala, F. N [1*], M.M Wanyoike[1], C.K Gachuiri[1]

[1]College of Agriculture and Veterinary sciences, Animal production department, University of Nairobi, P.O Box 29053 -00625 Nairobi, Kenya.
*Corresponding author's Emai**l:** nasimiyu.wanjala@yahoo.com

Abstract

A study was conducted to establish the cost of raising weaner rabbits to fryer market weight of 2 kg under two feeding systems: concentrate based diet and forage based diet. The commonly kept breeds; New Zealand White (NZW), California White (CAL) and their Cross (Z×C) were selected for this study. Total feed intake ranged from 5.2 to 5.9Kg and 7.5 to 9.7Kg on the concentrate and forage based diets respectively and was significantly higher ($P<0.01$) on the forage based diet. The respective total feeds cost ranged from KES 159.60 to 183.20 and KES106.40 to131.90. Thus in spite of the high feed intake lowest total cost was recorded on the forage diet due to low unit cost of the feed compared to the concentrate diet. Regardless of the feeding regime, the crossbreds recorded the least feed intake thus lowest feed cost compared to the pure breeds. When production level and cost were extrapolated for a 100 doe unit for a production cycle of one year, the concentrate based diet was more profitable because of higher fryer crops per doe per year compared to the forage based diet. It was also concluded that more revenue was generated when animals were sold as breeding stock than as meat at the prevailing market prices, regardless of the feeding regime.

Key word: feed intake, feed costs, rabbit breeds

Introduction

Feed cost is estimated to represent over 70% of the total cost of producing livestock intensively (Oluyemi, 1984). The cost of feed is particularly high when concentrates are used (Cheeke, 1986). This high cost is driving a shift to farm animals that are able to utilize non-conventional feeds such as the rabbit (Mmereole et al, 2011). Several researchers have demonstrated the economic importance of non-conventional feeds in livestock feeding (Ekpo et al, 2009). Farinu (1994) and Ekpo et al (2009) concluded that it was economical to rear rabbits on diets consisting of cassava based concentrate and forage.

Though rabbits have been reported to perform best when fed on high concentrate diets, (Farinu, 1994), the ever increasing costs of grains has created a need to augment both the energy and protein requirements with forages (Mmereole et al, 2011; Farinu, (1994) It is also noteworthy that rabbits fed on forages as sole diet generally grow at a lower rate and attain the target slaughter weight at a later age, necessitating supplementation with concentrates.

Materials and methods

Animals, Experimental Design and Management

The experiment was carried out at the rabbit unit, Department of Animal Production, College of Agriculture and Veterinary Sciences (CAVS), University of Nairobi, Upper Kabete Campus, Nairobi, Kenya between September 2012 and September 2013. This area is characterized by low temperatures with a mean minimum and maximum of 12.6°C and 23.4°C respectively.

Twenty females of each breed (NZW and CAL) were mated with the respective breed bucks to obtain the purebred litters. To obtain the crossbreed (Z×C) another twenty NZW females were mated with CAL males. The animals were recruited into the experiment on weaning at six weeks of age. For the two feeding regimes a total of 360 kits (60 litters with a minimum number of 6 kits weaned per litter) were evaluated for growth performance and feed intake.

A complete random design (CRD) 3 × 2 factorial arrangement was used with the breed (two purebreds and their cross) and feeding regime (concentrate and forage based diet) as the treatments. At weaning, the litters were randomly allocated to either of the feeding regimes and fed until they attained a 2kg live weight. The weaners were housed in twos (regardless of the sex) in a 70 x 50 x 45cm metallic cage equipped with feeders and waterers to give three replicates per litter per doe per feeding regime. Where a litter was more than six kits, the cage allowed adequate space for housing of three kits together. A cage was treated as a unit.

Experimental diets and feeding

The concentrate ration was formulated to meet the recommended nutrient requirements of growing rabbits by NRC, (1977) and pelleted. This concentrate ration and water was offered *ad libitum* to all the does.

Growers on concentrate based diet were offered feed *ad libitum* but water was restricted to two hours daily (between 9-11am) for the first three weeks post weaning corresponding to the first three weeks of the experiment. The water and indirectly feed restriction has been reported to reduce digestive disorders common in weaners (Elmaghraby, 2011) then *ad libitum* to the end of the feeding trial.

For the forage based diet, Rhodes grass (*Chloris gayana*) hay was chopped to about 1-2cm. Prior to feeding in earthen bowls, the hay was sprayed with molasses diluted with water at the ratio of 5:1 water to molasses respectively (to improve palatability) and then offered *ad libitum*. The amount of hay offered and refusals were weighed weekly and the intake estimated as the difference between the two weights. The rabbits on the forage based diet were also supplemented at 50% of expected *ad libitum* intake on the concentrate diet intake (i.e. 25g/d, 35g/d, 45g/d, 55g/d for week 6-9) then fixed at 60g/d per animal from the 10th week to the end of the experiment.

Determination of reference carcass

Five fryers per breed per feeding regime (total 30) were randomly selected for slaughter to evaluate the carcass characteristics. The rabbits sampled for slaughter were between the weights of 2000 – 2500g. The carcasses were dissected in accordance with the norms of the World Rabbit Science Association (WRSA) (Blasco and Ouhayoun, 1996).

Data Collection

To determine the effect of breed and feeding regime on performance of grower rabbits, the following data was collected: Initial body weight of weaners at 6 weeks of age, live weight (average of the animals per cage) were recorded on weekly basis until the end of the trial (2kg weight). Feed intake was calculated as the difference between feed offered and the left-over on a weekly basis. Feed conversion efficiency was calculated as the amount of feed intake per unit of live weight gain. Mortalities were recorded as they occurred.

Assessment of feed costs and returns

Cost of feed was calculated based on prevailing cost of ingredients per kilogram as at the time the experiment was conducted (sh.31 kg^{-1} for concentrate and sh.10 kg^{-1} for Rhodes grass hay)

The quantity of feed consumed per unit weight gain of rabbits was used to assess the cost of feed kg^{-1} weight gain. The shilling to dollar exchange rate was at 85.

The price of meat per kg was calculated at the prevailing market price of Ksh. 400 kg^{-1}. Price of pelt was also calculated at the prevailing market price set by the Kenya Leather Developmental Council (KLDC) of Ksh. 50 per piece.

Statistical analyses

The data was captured using Excel 2007 spreadsheet, Windows 2007. The data were subjected to Analysis of Variance (ANOVA) using the package Genstat software (VSN International, 2011) for windows. When analysis of variance indicated significance for treatment effects, specific differences between means were ranked using the Bonferroni Test.

Results and Discussion

The chemical composition of the formulated concentrate diet and the Rhodes grass hay are presented in Table 1 and 2 respectively.

Table 11: Chemical composition of the concentrate ration Dry Matter basis

Chemical composition	Percentage
Moisture	11.40
Crude protein	16.05
Ether extract	4.12
Crude fiber	11.29
Total ash	8.56
Nitrogen free extract	48.58
Calcium	1.14
Phosphorus	0.56
DE (kcal/kg)	2910.18
ME (kcal/kg)	2820.82

Table 12: Chemical composition of Rhodes grass hay on DM basis

Parameter	(%)
CP	8.32
OM	86.95
DM	91.4
Ash	13.05
CF	34.2
NDF	66.25
ADF	40.51
Lignin	8.58

The results for total feed intake, average weekly gain, total weight gain, total feed costs, mortality rates and the cost per unit weight gain for the two feeding regimes are presented in Table 3.

Table 13: Feed intake, weight gains and cost of weight gain of grower rabbits fed on concentrate and roughage based diet

	Feeding regime 1 (Concentrate based diet)			Feeding regime 2 (Forage based diet)				
	New Zealand White	California White	Crossbreed	New Zealand White	California White	Crossbreed	SEM	Sig
Total feed intake (kg)	5.912±67^{by}	5.591±32^{abxy}	5.148±20^{ax}	8.635±43^{dy}	9.66±88^{ez}	7.533±3.0^{cx}	0.16	***
Concentrate supp (kg)				1.6	1.68	1.48		
Total hay intake (kg)				7.03	7.98	6.05		
Average weekly gain (g)	198.5±2.2^{cx}	200.0±7.1^{dx}	208.9±3.2^{dex}	140.5±2.9^{ax}	147.1±5.8^{abx}	156.6±3.7^{bx}	10.0	***
Total weight gain (g)	1227±22^{abx}	1319±1.9^{bxy}	1278±2.1^{abx}	1255±8.52^{abx}	1291±11^{abx}	1201±10.20^{ax}	34.6	**
FCR	4.818±0.1^{bxy}	4.23±0.03^{abxy}	3.966±0.02^{ax}	6.898±0.05^{cx}	7.393±0.11^{cx}	6.272±0.06^{cx}	0.232	***
Total feed Cost(sh)	183.2±2.1^{dxy}	173.3±0.99^{dxy}	159.59±0.7^{cx}	120±0.43^{abx}	131.9±0.88^{bxy}	106.4±0.30^{ax}	3.21	***
Cost/Kg weight gain(sh)	150.1	131.3	124.9	96	102.2	88.6		
Average post weaning mortality rate (%)	14.6±0.82^{b}			6.3±0.31 ^{a}			0.21	***

$^{a,b,c.d,e}$Means within same row with different superscripts are significantly different between the feeding regimes. ^{x,y,z} Means within same row with different superscripts are significantly different within a feeding regime. NS- Non significant (P>0.05); P<0.05) **; (P<0.01***)

Feed intake

Feed intake was significantly different between the feeding regimes (P<0.01) and also within a feeding regime (P<0.05) with the Z×C recording the lowest feed intake. Under feeding regime1 the Z×C had the lowest feed intake due to earlier attainment of 2kg target weight; (12 weeks) than both NZW and CAL (13 weeks). This feed intake trend was also reported by Mutettika (1987) and Ozimba and Lukefahr (1991). The Z×C rabbit also had the lowest feed intake under the feeding regime 2 for the same reason that it attained the target weight earlier (15 weeks) than the pure breeds (17 and 18 weeks for NZW and CAL respectively). Feed intake was higher on the forage based diet than on the concentrate based diet attributed to the longer time to attainment of the target weight which ranged from15 to 18 weeks.

Weight gain

Weekly average weight gains were highly significantly different (P<0.01) between the feeding regimes but not within a feeding regime with higher growth rates on the concentrate based diet. Regardless of the

feeding regime the crossbreed recorded highest average growth rates of the three genotypes followed by CAL and the NZW in that order. The better performance of the crossbred could be attributed to hybrid vigor. The higher weight gain of rabbits under concentrate based diet was due to greater nutrients density of the diet and is in agreement with Pinheiro et al (2011) who noted a better performance of rabbits under intensive system on high concentrate diets compared to those under extensive system on forages.

Cost per kilo weight gain

Lower total feed intake on similar feeds translated to lower feed cost thus the Z×C recorded lowest feed costs than the purebreds regardless of the feeding regime. The total feed cost were significantly (P≤0.01) different across the three genotypes within a feeding regime as well as between the feeding regimes. The average cost was Ksh.172 and Ksh.119 per unit live weight gain for feeding regime 1 and 2 respectively. In spite of higher feed intake on the forage based diet, the average total feed cost was less because of lower unit cost of the feed at Ksh. 10 for Rhodes grass hay compared to Ksh. 31 for the concentrate diet.

Therefore the cost per kilo weight gain was lower under feeding regime 2 and was lowest for the Z×C at Sh.88.6 (USD 1.04) followed by NZW and CAL. The crossbred also had the most favorable cost per kilo weight gain at Sh.124.9 (USD 1.47) while the NZW had the highest at Sh.150.1 (USD 1.77) under feeding regime 1.

These observations are in agreement with Ozimba and Lukefahr (1991) who noted that at 70 d the Z×C and CAL yielded better returns than NZW under intensive systems of feeding. Ekpo et al (2009) cited Obikaonu and Udedibe (2006) also concluded that rabbit production systems based on unconventional feeds (cassava tuber meals) led to lower cost of production due to lower cost of the raw material. The results of this study further suggest that the NZW is a better breed on less intensive forage based diets feeding systems than the CAL.

Cost of producing a kilo of edible meat and returns analysis

Table 4 shows the costs incurred and the estimated revenue from edible meat yield for the two feeding regimes.

Table 14: Cost of producing a kilo of edible meat for the two feeding regimes

	Feeding regime 1 (concentrate based diet)			Feeding regime 2 (Forage based diet)				
	New Zealand White	California White	Crossbreed	New Zealand White	California White	Crossbreed	SEM	Sig
Reference carcass weight(g)	1086	1122	1199	1078	1294	1061	51.0	NS
Total feed Cost(Ksh)	183.2^{dy}	173.3^{dy}	159.6^{cx}	120^{abxy}	131.9^{by}	106.4^{ax}	3.21	***
Cost/Ref carcass(sh/kg)	168.7^{ax}	154.5^{by}	133.1^{cz}	111.3^{dx}	101.9^{ey}	100.3^{ey}	4.71	***
Average cost/Ref carcass per feeding regime(sh/kg)	152.09^{a}			104.5^{b}			2.13	***

$^{a,b,c.d,e}$Means within same row with different superscripts are significantly different between the feeding regimes. ^{x,y,z} Means within same row with different superscripts are significantly different within a feeding regime. NS- Non significant (P>0.05); P<0.05) **; (P<0.01***)

As expected the cost of producing a kilo of edible meat was lowest for feeding regime 2 (sh.104.5) compared to feeding regime 1(sh.152). To enable the cost and returns analysis for the two feeding regimes, calculation for a 100 breeding does unit for 1 year production cycle was done with the following assumptions:

1. A rabbit production unit with 100 breeding does and production time of 1 year, doe mortality of 22% (Farghaly et al, 1994) per year thus available does at 78.
2. 5.2 litter crops per doe per year (when weaning and rebreeding is done at 6 weeks post-kindling).
3. Pre weaning mortality at 8.3% with average litter size at birth of 8.6 thus average number of kits at weaning of 6.
4. Other information required for this analysis was generated from the current study and included:
   I). Post weaning mortality at 14.6% and 6.3% for regime 1 and 2 respectively, thus fryers available for market will be 5.12 and 5.62 per litter.
   II). Offtake rate (fryers crops per doe per year) at 4.3 and 3.1 for feeding regime 1 and 2 respectively (based on respective time to slaughter weight attainment of 12 and 17 weeks).
   III). The total feed cost per fryer was Ksh.172 and 119 on feeding regimes 1 and 2 respectively based on the total average feed costs for the three groups of animals in each feeding regime.
   IV). Average dressed weight of 1.1357kg and 1.1443kg for feeding regime 1 and 2 respectively.
   V). Average cost of producing 1 kg of edible meat at Ksh. 152.1 and Ksh.104.5 for feeding regime 1 and 2 respectively (Table 21).
5. Price of rabbit meat at Ksh.400 per kg and price of skin at Ksh.50 per piece.
6. Animals sold as live animals at 2 kg at Ksh. 850 (according to APD rates).

As shown in Table 5, higher returns would be realised by adopting the more intensive feeding system which results in more animals being available either for slaughter or sale of live animals in a year.

Table 15: Cost and returns analysis

	Concentrate based diet	Forage based diet
Meat	4,056,579	3, 234,415
Skin	446,484	353,318
Total Income	4,503,063	3,587,733
Total feed cost	1,542,514	844,991
Profit Margin	2,960,548	2,742,742
Breeding stock profit margin	6,078,440	5,161,685

The difference in profit margin between the feeding regimes where the rabbits were slaughtered would be 217,806 (USD 2,562) per annum in favour of the more intensive feeding system. The same trend persists when the animals were sold live with even larger differences in realisable income of 916,755 (USD.10,785) in favour of the intensive feeding system. The returns were higher with both feeding systems when the animals were sold live than when animals are slaughtered and sold as meat.

Conclusion and recommendations

The crossbreed performed better than the purebreds regardless of the feeding regime. Though the less intensive forage based feeding system translated to lower cost of production per unit weight of product, fewer animals would be available for disposal which would result in lower returns from a 100 doe breeding unit. Therefore, the results of this study suggest that use of concentrate feeds in rabbit production should

be promoted by the stakeholders due to the better productivity when compared to forage use. However due to high costs for such feeds which resource poor farmers cannot afford, the government, feed manufactures, donors and other stakeholders should come up with ways to reduce these costs for example through use of cheaper raw materials, provision of subsidies and/or financing.

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References

AOAC (1998). Association of official analytical chemists) Official methods of Analysis of AOAC International 16th Ed. Vol. 1.

Blasco, A. and Ouhayoun, J. (1996). Harmonization of criteria and terminology in rabbit meat research. Revised proposal. World rabbit Sci., 4, 93-99.

Cheeke, P.R. (1986). Potentials of rabbit production in tropical and subtropical agricultural systems. J. Anim. Sci. 63: 1581-1586.

Ekpo S.S., Solomon, I., Isaac, L.J., Ekpo, K.O and Leo, O.O, (2009). Carcass Characteristics and Economic Benefits of Weaner Rabbits Fed Cassava Tuber Meals. Asian Journal of Animal and Veterinary Advances, 4: 214-218.

Elmaghraby M M A (2011). Effect of Restricted Access to Drinking Water on Growth, Feed Efficiency and Carcass Characteristics of Fattening Rabbits. Asian Journal of Animal Sciences 5 (2): 136-144.

Farghaly, H.M., El Darawany, A.A., Yamani, K.A.O. (1994). Mortality rate in purebred commercial rabbits under Egyptian conditions, In Baselga M. (ed.), Marai I.F.M. (ed.). Rabbit production in hot climates

Farinu, G.O., (1994). Effects of feeding a compound diet based on non convectional feedstuffs on growth and carcass characteristics of rabbits. World Rabbit Sci., 2: 123-126.

Mmereole. F., Egoh J.O. and Obinne, J.I. (2011). Growth performances and cost analysis of weaner rabbits fed varying dietary levels of crude protein supplemented with Tridax procumbens. Pak. J. Nutr. 10:120-123.

Mutettika, D.B. (1987). Effects of level of supplementation to diets of Rhodes grass (Chloris gayana) hay, maize (Zea mays) leaves and sweet potato (Ipomea batatas) vines on performance of grower rabbits. Thesis submitted to the Department of Animal production, University of Nairobi, Kenya.

NRC (1977). Nutrition Requirements of Rabbits, Nutrient Requirements of Nonhuman primates: 2nd Ed. Nation Academy of Sciences, Washington,D.C.

Ozimba, C. E., and Lukefahr. S.D. (1991). Comparison of rabbit breed types for post weaning litter growth, feed efficiency, and survival performance traits. J. Anim. Sci. 69:3494– 3500.

Oluyemi, J.A. (1984). Techniques of feed formulation. Proceedings of the Feedmill Management and Training Workshop, Department of Agricultural Economics, April 10-May 2, 1984, Ibadan, Nigeria, pp: 138-144.

Pinheiro, V., Mourão J.L., Monteiro, D. and Silva, S. (2011). Growth performances and behavior of growing Rabbits housed on cages, closed parks or open-air system. Proceedings 10th World Rabbit Congress – September 3 - 6, 2012– Sharm El- Sheikh –Egypt,1097-1100.

VSN International (2011). GenStat for Windows 13th Edition. VSN International, Hemel Hempstead, UK. Web page: GenStat.co.uk.

Growth Response of African Catfish (*Clarias Gariepinus*) to different protein levels in a Semi- Intensive Production System

Mwangi J.M.[1], Maina J.G., Gachuiri C.K. and Orina P.S.*

Department of Animal Production, University of Nairobi, Kenya
*Kenya Marine and Fisheries Research Institute, Sagana, Kenya
[1] Corresponding author: jackson.mwangi@yahoo.com Tel:+254 721 552 936

Abstract

The African catfish (*Clarias gariepinus*) has great potential for aquaculture because of its fast growth and tolerance to poor water quality conditions. However, its high protein requirement makes its feeds expensive. A study was done in Kirinyaga County to evaluate the effects of pond fertilization and protein levels on pond water quality and growth performance of *C. gariepinus*. The fish were stocked at 10 fish/ m^2 in happas placed in two earthen ponds measuring 150m^2 for 128 days. One pond was fertilized while the other one was unfertilized. Four isocaloric diets (3000kcal/ kg) having protein levels of 35% (Diet 1: control), 25% (Diet 2), 30% (Diet 3), and 35% (Diet 4) were formulated and costed (KSh/ kg) 47.78, 34.54, 38.27, and 42.57 respectively. All diets contained rice milling byproducts (except the control) and were fed to the fish in triplicate happas. Water temperature and dissolved oxygen, measured weekly, remained above 24°C and 3mg/l respectively. Fish growth performance, measured biweekly, increased with increasing dietary protein levels and was higher among fish placed in the fertilized pond. Fish fed Diet 4 (35% protein) in the fertilized pond had the best final weight, weight gain, apparent FCR and specific growth rate. The highest protein efficiency ratio was attained by the fish fed Diet 2 (25% protein) in the fertilized pond but this was not significantly different ($P>0.05$) from that of the fish fed Diet 2 and Diet 3 (30% protein) in the unfertilized and fertilized ponds respectively. The low cost 25% protein diet (Diet 2) resulted in comparable growth performance to the other diets and is therefore suitable for production of *C. gariepinus* in fertilized earthen ponds.

Key words: *Clarias gariepinus*, cost, pond fertilization, protein level, rice milling byproducts

Introduction

The African catfish (Clarias gariepinus) is an omnivorous fish species that has better utilization of high protein than high carbohydrate diets (FAO, 2015). This is a challenge to its sustainable culture because the protein fraction of diets is usually more expensive than carbohydrates (Munguti et al., 2012). The protein requirements recommended for catfish (32- 36%) (National Research Council, 1993) were determined using young fish under optimum environmental conditions with the objective of achieving maximum growth rates. There was no consideration given to production costs or maximizing profits (Parker, 2002). Therefore, there is need to evaluate the performance of C. gariepinus under varying protein content in their diets in order to assess growth and economics of growth. In this study, rice milling byproducts, which were abundant in the study site in Kirinyaga County (Government of Kenya, 2009), were used to reduce the cost of the formulated diets.

A major challenge encountered in the culture of *C. gariepinus* is the poor pond water quality (de Graaf and Janssen, 1996) caused by uneaten decomposing food and excreta that contains ammonia from protein metabolism (Parker, 2002). Pond fertilization results in growth of algae which assimilate ammonia from pond water and increase dissolved oxygen concentration in the pond water during photosynthesis (Knud-Hansen, 1998). There is therefore need to investigate the effect of fertilization on water quality and *C. gariepinus* performance.

Materials and methods

Study site

This study was carried out at the National Aquaculture Research Development and Training Center, 2 km outside of Sagana Town in Kirinyaga County.

Proximate analysis of feed ingredients

Rice bran was purchased from a large scale rice miller in Kirinyaga County while the other feed ingredients were purchased from feed ingredient suppliers in Nairobi. Proximate analysis of the feed ingredients was done according to the procedures outlined by the Association of Official Analytical Chemists (AOAC, 1998).

Experimental diets and design

Four isocaloric diets (3000kcal/ kg) having protein levels of 35% (Diet 1: control), 25% (Diet 2), 30% (Diet 3), and 35% (Diet 4) were formulated and costed (KSh/ kg) 47.78, 34.54, 38.27, and 42.57 respectively. All diets (except the control) contained rice milling byproducts, maize, wheat pollard, soybean meal and freshwater shrimp meal as shown in Table 1 below. The diets were fed to the fish three times a day at 3-10% of body weight (de Graaf and Janssen, 1996). The fish were stocked at 10 fish/ m^2 in happas placed in two earthen ponds measuring 150m^2 for 128 days. One pond was fertilized while the other one was unfertilized. The design of the experiment was a 4 by 2 factorial experiment in completely randomized design.

Management of fish

Clarias gariepinus fingerlings (weighing approximately 2- 4g) were bought from Jambo fish farm in Kiambu County and transported to the study site. They were acclimatized to pond conditions for one week and fed on the control diet (Diet 1) before the start of the feeding trial. At the end of the week, they were weighed in groups of 20 fish and randomly allocated to the happas measuring 2m^2 (a stocking density of 10 fish/ m^2). The happas were located in two earthen ponds measuring 150m^2 and limed at the rate of 2500kg of agricultural lime per hectare prior to stocking (Ngugi *et al*., 2007). One pond was fertilized with chicken manure two weeks before stocking at 25kg dry weight/ 100m^2 and thereafter 3kg dry weight/ 100m^2 every 10 days (Tacon, 1988). The other pond was left unfertilized. Water quality parameters consisting of Dissolved Oxygen (DO), pH, ammonia, nitrates and nitrites were monitored weekly. The DO was measured using an oxygen probe, while pH was measured using a pH meter, and ammonia, nitrates, and nitrites were measured using their respective kits.

Data collection and analysis

All the fish were weighed and their lengths taken in order to adjust the feeding rates and to calculate the growth performance, survival %, feed utilization, and nutrient utilization every two weeks. All data obtained were then subjected to a one way and two way Analysis of Variance (ANOVA) using Genstat Discovery 14th edition. The significant differences between treatment means were tested at $P<0.05$ statistical significance level and significant ones were separated using Tukey's multiple comparison procedure.

Table 1: Composition of diets used (As- is basis)

Ingredients (%)	DIETS			
	Diet 1	Diet 2	Diet 3	Diet 4
Maize grain	22.13	10.00	10.00	10.00
Rice bran (fine)	0.00	20.00	20.00	20.00
Rice grain (broken)	0.00	15.80	8.54	0.00
Corn oil	0.00	4.93	2.18	0.00
Soybean meal, solvent extracted	15.00	15.00	15.00	15.00
Wheat pollard	10.00	10.00	10.00	10.00
Freshwater Shrimp Meal	45.74	22.04	32.18	42.48
Dicalcium Phosphate	0.20	0.13	0.10	0.10
Limestone	3.33	0.00	0.00	0.00
HCL-Lysine	0.30	0.00	0.00	0.00
DL-Methionine	0.30	0.10	0.00	0.00
Ascorbic acid	2.00	1.00	1.00	1.42
Salt	0.50	0.50	0.50	0.50
Vitamin/ Mineral premix	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated composition (air- dry basis)				
Digestible Energy, Kcal/ kg	3000.00	3000.00	3000.00	3023.68
Crude Protein (%)	35.00	25.00	30.00	35.00
Calcium (%)	3.07	0.97	1.36	1.77
Phosphorous (%)	0.62	0.50	0.55	0.59
Crude fiber (%)	3.80	5.07	5.15	5.17
Lysine (%)	2.68	1.55	1.94	2.33
Methionine (%)	1.18	0.64	0.70	0.85
Cost/ kg (KSh.)	47.78	34.54	38.27	42.57

The vitamin/ mineral premix provided the following per kg of feed: Vitamin A, 5000 IU; Vitamin D_3, 1000 IU; Vitamin E, 150 IU; Vitamin K_3, 3 mg; Vitamin B_1, 10 mg; Vitamin B_2, 15 mg; Vitamin B_6, 7.5 mg; Vitamin B_{12}, 0.025 mg; Niacin, 100 mg; Pantothenic acid, 27.5 mg; Biotin, 0.5 mg; Folic acid, 3 mg; Choline, 500 mg; Vitamin C, 300 mg; Manganese, 75 mg; Iron, 20 mg; Zinc, 22.5 mg; Copper, 2.5 mg; Cobalt, 0.1 mg; Iodine, 0.7 mg; Selenium, 0.06 mg. The cost of corn oil, ascorbic acid, transport of ingredients, pelleting and packaging of the diets are not included in the total cost of the diets. Diet 1 contains 35% protein (control); Diet 2 contains 25% protein; Diet 3 contains 30% protein; Diet 4 contains 35% protein.

Results and discussion

Effects of pond fertilization and protein levels on Clarias gariepinus performance

There was no significant interaction ($P>0.05$) between pond fertilization and protein level. The initial weights of the fingerlings allocated to the Diet 2 (25% protein) and Diet 4 (35% protein) in the fertilized pond were significantly higher ($P<0.05$) than those of fingerlings allocated to all the diets in the unfertilized pond as shown in Table 2 below. Analysis of covariance was done

Table 2: Effects of pond fertilization and protein levels on the growth performance of *C. gariepinus* stocked in earthen ponds for 128 days

[1]Parameters	Fertilized pond				Unfertilized pond				SEM	P value
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 1	Diet 2	Diet 3	Diet 4		
Initial weight (g)	3.7^{ab}	4.9^{b}	3.7^{ab}	4.6^{b}	2.4^{a}	2.3^{a}	2.3^{a}	2.4^{a}	0.3	0.2
Final weight (g)	236.2	211.2	265.2	284.0	221.6	182.7	240.5	230.5	23.7	0.8
Weight gain (g)	232.9	207.9	261.9	280.7	218.3	179.4	237.2	227.2	23.7	0.8
Feed intake (g)	440.7	322.4	415.7	440.0	443.4	365.1	432.6	390.8	31.6	0.3
AFCR (feed: gain)	1.9	1.6	1.6	1.6	2.0	2.0	1.8	1.7	0.1	0.2
PER	1.5^{ab}	2.4^{d}	2.1^{cd}	1.8^{abc}	1.4^{a}	2.0^{cd}	1.9^{bc}	1.7^{abc}	0.1	0.3
SGR (%/ day)	4.2	4.2	4.3	4.4	4.2	4.0	4.3	4.2	0.1	0.9
Condition factor	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.02	0.6
Mortality (%)	3.1	1.1	2.0	2.7	3.5	5.3	5.1	3.9	1.2	0.2

Diet 1 contains 35% protein (control); Diet 2 contains 25% protein; Diet 3 contains 30% protein; Diet 4 contains 35% protein; AFCR- Apparent Feed Conversion Ratio; PER- Protein Efficiency Ratio; SGR- Specific Growth Rate. Means within a row without superscripts/ with similar superscripts do not differ significantly (P>0.05). [1]Means, n= 480.

and the covariate was not significant in any of the parameters. The best average final weight, weight gain, Apparent Feed Conversion Ratio (AFCR) and Specific Growth Rate (SGR) were attained by the fish fed the 35% protein diet (Diet 4) in the fertilized pond. The lowest feed intake was attained by the fish fed the 25% protein diet (Diet 2) in the fertilized pond but this was not significantly different (P>0.05) from the feed intake of the fish fed the other diets. The highest Protein Efficiency Ratio (PER) was also attained by the fish fed Diet 2 in the fertilized pond but this was not significantly different (P>0.05) from that of the fish fed Diet 2 and Diet 3 (30% protein) in the unfertilized and fertilized ponds respectively. The best condition factor was attained by the fish fed the control diet (Diet 1) in the fertilized pond while the lowest mortality was attained by the fish fed Diet 2 in the unfertilized pond.

These results are comparable to work done on *C. gariepinus* by Ahmad (2008), Ali and Jauncey (2005), Degani *et al.* (1989), and Machiels and Henken (1985) who all concluded that growth performance of *C. gariepinus* increased with increasing dietary protein levels. The results are also comparable to work done by Bok and Jongbloed (1984) on *C. gariepinus* and Kang'ombe *et al.* (2006) on *Tilapia rendalli* (Boulenger) who observed that pond fertlization caused rapid fish growth without adversely affecting water quality. However, the variability of natural foods among fertilized ponds implies that they cannot be solely relied on as a feed source for catfish production (Robinson and Li, 2005). Therefore, catfish require formulated feeds for maximum performance (Robinson *et al.,* 2001).

Effects of pond fertilization on water quality of C. gariepinus ponds

Ammonia, nitrate and nitrite levels in the pond water were not detected throughout the experimental period. Water temperature and Dissolved Oxygen (DO) remained above 24°C and 3mg/ l respectively; these are close to recommended values for catfish culture at 21.1°C and 5 mg/ l respectively (Parker, 2002). The average DO and water pH of the fertilized pond were higher than those of the unfertilized pond but these values were not significantly different (P>0.05) as shown in Table 3 below.

Table 3: Water quality parameters of the fertilized and unfertilized ponds

[1]Parameters	Fertilized pond	Unfertilized pond	P Value
Dissolved Oxygen (mg/ l)	4.970 ± 1.576	3.769 ± 1.084	0.224
pH	8.190 ± 0.163	7.979 ± 0.551	0.056

Means within a row without superscripts do not differ significantly (P>0.05); [1]Means, n= 27

There is little documentation of effects of pond fertilization on water quality specifically for *C. gariepinus* monoculture. The work done by El Naggar *et al.* (2008) found that water quality parameters were influenced by fertilization type (either organic or inorganic) and not stocking density of Nile tilapia (*Oreochromis niloticus*), *C. gariepinus* and Silver carp (*Hypophthalmichthys molitrix*) in polyculture. Similarly, Jha *et al.,* (2004) working on Koi carp (*Cyprinus carpio vr. koi*) larvae in outdoor concrete tanks fertilized with cow dung or poultry manures found significantly lower dissolved oxygen values at a fertilization rate of 39 kg/ 100m^2.

The pH of pond water increases with increasing manure application. Manure increases primary productivity of the pond (phytoplankton growth) which photosynthesize during the day thus reducing the amount of dissolved carbon dioxide (carbonic acid) in the water (Knud- Hansen, 1998). Ammonia, a waste product of protein metabolism by fish, occurs in pond water in ionized (NH_4^+) and un- ionized form depending on the water pH (Knud- Hansen, 1998). Un- ionized ammonia is more toxic to fish and occurs more in high pH and warm temperature conditions. It is stressful to fish at concentrations greater than 0.1 mg/ l and is lethal at 0.5 mg/ l (Parker, 2002). The phytoplankton growth in the fishpond assimilates ammonia from the pond water and increases the concentration of dissolved oxygen in the pond water during photosynthesis (Knud- Hansen, 1998).

Cost- benefit analysis

Assuming a sale price of (KES/ kg/ fish) 300 and that all variable costs and fixed costs are constant for all the treatments except the feed and manure costs, the fish in the fertilized pond had higher gross margins compared to those in the unfertilized pond except for those fed the Diet 1 (control). The highest gross margins were attained by the fish fed Diet 4 (35% protein) in the fertilized pond while the lowest gross margins were attained by the fish fed Diet 2 (25% protein) in the unfertilized pond as shown in Table 4 below. The fish fed the 25% protein diet (the least expensive diet) in the fertilized pond had comparable growth performance to the fish in the other treatments and had a positive gross margin. This makes the 25% protein diet (Diet 2) suitable for *C. gariepinus* culture in fertilized earthen ponds. According to Ahmed (2007), feeds contribute 70% of the total variable cost of semi intensive culture of fish while Hecht (2007) identified expensive feeds as a key factor that limits aquaculture development in East Africa. The use of a low cost feed to bring down the cost of production will therefore enhance aquaculture growth in the region.

Table 4: Cost benefit analysis of *C. gariepinus* culture

	Fertilized pond				Unfertilized pond			
Dietary protein level (%)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 1	Diet 2	Diet 3	Diet 4
Feed intake/ fish (kg)	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Feed cost/ kg (KES)	47.8	34.5	38.3	42.6	47.8	34.5	38.3	42.6
Total Feed cost/ kg/ fish (Feed intake*Feed cost) (KES)	21.1	11.1	15.9	18.7	21.2	12.6	16.6	16.6
[1]Manure amount/ fish (kg)	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0
[2]Manure cost/ kg (KES)	12.0	12.0	12.0	12.0	0.0	0.0	0.0	0.0
Total manure cost/ kg/ fish (KES)	4.8	4.8	4.8	4.8	0.0	0.0	0.0	0.0
Gross expenditure/ fish (KES) (Total Feed cost+ Total manure cost)	25.9	15.9	20.7	23.5	21.2	12.6	16.6	16.6
Final weight of fish (kg)	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Fish cost/ kg (KES)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
Gross income/ kg/ fish (KES) (Final weight of fish* Fish cost)	70.9	63.4	79.6	85.2	66.5	54.8	72.2	69.2
Gross margin/fish (KES) (Gross Income- Gross expenditure)	45.0	47.4	58.9	61.7	45.3	42.2	55.6	52.5

[1]Manure amount/ fish (kg) was calculated for 240 fish in the pond fertilized at 25 kg Dry Matter (DM) manure/ 100 m^2 pond, two weeks before stocking plus 3 kg DM manure/ 100 m^2 pond, every 10 days (de Graaf and Janssen, 1996) for 120 days; [2]Manure cost/ kg (KSh) was calculated from a 50 kg gunny bag of manure costing KSh 600; Diet 1 contains 35% protein (control); Diet 2 contains 25% protein; Diet 3 contains 30% protein; Diet 4 contains 35% protein

Conclusion and recommendations

- The use of rice milling byproducts to formulate low cost feeds for *C. gariepinus* should be encouraged in rice growing regions of the country.
- A diet having 25% protein is suitable for the culture of *C. gariepinus* in fertilized earthen ponds.
- Locally available manure should be used to fertilize earthen ponds for *C. gariepinus* culture to improve water quality and consequently improve fish performance.

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References

Ahmad M.H. (2008). Response of African catfish, Clarias gariepinus, to different dietary protein and lipid levels in practical diets. Journal of the World Aquaculture Society 39 (4): 541- 548.

Ahmed N. (2007). Economics of aquaculture feeding practices: Bangladesh. In M.R. Hasan (ed.). Economics of aquaculture feeding practices in selected Asian countries. FAO Fisheries Technical Paper. No. 505. FAO, Rome. 33– 64 pp.

Ali M.Z. and Jauncey K. (2005). Approaches to optimizing dietary protein to energy ratio for African catfish Clarias gariepinus (Burchell, 1822). Aquaculture Nutrition 11: 95– 101.

AOAC (1998). Official methods of analysis of AOAC International. 16th edn. AOAC, USA.

Bok A.H. and Jongbloed H. (1984). Growth and production of Sharptooth catfish, *Clarias gariepinus* (Pisces: Clariidae), in organically fertilized ponds in the Cape Province, South Africa. *Aquaculture* 36 (1): 141–155.

de Graaf G.J. and Janssen J.A.L. (1996). Artificial reproduction and pond rearing of the African catfish Clarias gariepinus in sub- Saharan Africa- A handbook. FAO Fisheries Technical paper No. 362. FAO, Rome. 1-72pp.

Degani G., Ben-Zvi Y. and Levanon D. (1989). The effect of different protein levels and temperatures on feed utilization, growth and body composition of Clarias gariepinus (Burchell 1822). Aquaculture 76: 293-301.

El Naggar G.O., Ibrahim N.A. and Abou Zead M.Y. (2008). Influence of fertilizers' types and stocking density on water quality and growth performance of Nile tilapia- African catfish in polyculture system. 8th International Symposium on Tilapia in Aquaculture. 157- 172 pp.

FAO (2015). Cultured aquatic species information programme: Clarias gariepinus (Burchell, 1822). FAO, Rome. See: http://www.fao.org/fishery/culturedspecies/Clarias_gariepinus/en accessed on 23rd June, 2015.

Government of Kenya (2009). National rice development strategy plan (2008- 2018). Ministry of Agriculture, Kenya. 4 pp.

Hecht T. (2007). Review of feeds and fertilizers for sustainable aquaculture development in sub-Saharan Africa. In M.R. Hasan, T. Hecht, S.S. De Silva & A.G.J. Tacon, eds. Study and analysis of feeds and fertilizers for sustainable aquaculture development, pp. 77–110. FAO Fisheries Technical Paper No. 497, FAO, Rome.

Jha P., Kripan Sarkar K., Barat S. (2004). Effect of different application rates of cowdung and poultry excreta on water quality and growth of Ornamental Carp, Cyprinus carpio vr. koi, in Concrete Tanks. Turkish Journal of Fisheries and Aquatic Sciences 4: 17-22.

Kang'ombe J., Brown J.A. and Halfyard L.C. (2006). Effect of using different types of organic animal manure on plankton abundance, and on growth and survival of Tilapia rendalli (Boulenger) in ponds. Aquaculture Research 37: 1360- 1371.

Knud- Hansen C.F. (1998). Pond fertilization: Ecological approach and practical application. Aquaculture Collaborative Research Support Program, Oregon State University, USA. 1- 50 pp.

Machiels M.A.M. and Henken A.M. (1985). Growth rate, feed utilization and energy metabolism of the African catfish, Clarias gariepinus (Burchell, 1822), as affected by dietary protein and energy content. Aquaculture 44 (4): 271–284.

Munguti J., Charo-Karisa H. , Opiyo M.A, Ogello E.O., Marijani E., Nzayisenga L. and Liti D. (2012). Nutritive value and availability of commonly used feed ingredients for farmed Nile tilapia (Oreochromis niloticus L.) And African catfish (Clarias gariepinus, Burchell) In Kenya, Rwanda and Tanzania. African Journal of Food, Agriculture, Nutrition and Development 12 (3): 6135- 6155.

National Research Council (1993). Nutrient requirements of fish. National Academies Press. Washington D.C., USA. 1– 56 pp.

Ngugi C.C., Bowman J.R., Omolo B.O. (2007). A new guide to fish farming in Kenya. USAID, USA. 34– 48 pp.

Parker R. (2002). Aquaculture Science. 2nd edn. Delmar, Thomson Learning, USA. 233– 367 pp.

Robinson E.H. and Li M.H. (2005). A summary of catfish nutrition research conducted under a cooperative agreement between MAFES and Delta Western Research Center. Bulletin 1144. Mississippi State University, USA. 1– 11pp.

Robinson E.H., Li M.H., Manning B.B. (2001). A practical guide to nutrition, feeds, and feeding of catfish (2nd rev.). Mississippi State University, USA. 1– 30 pp.

Tacon A.G.J. (1988). The nutrition and feeding of farmed fish and shrimp- A training manual. FAO, Italy. See: http://www.fao.org/3/contents/df5b9a52-a4f5-51c2-bb7a-4034683b51c5/AB467E04.htm#ch3.2.4.2 accessed on 23rd June 23, 2015.

Aquaculture, Emerging Livestock and Alternative Source of Livelihood

Analysis of Quail Production and Marketing Value Chain in Mount Kenya Region: A Case Study of Nyeri County.

*Matiri, F[1] Chelimo, J[2] and Mathenge, J.[3]

[1]Kenya Agriculture and Livestock Research Organization- Embu, P.O. Box 27, Embu, Kenya

[1]Kenya Agriculture and Livestock Research Organization - Naivasha, P.O., KENYA

[3]Kenya Wildlife Services, P.O.Box 72363 00200, NAIROBI

Corresponding author: francismatiri@yahoo.com

Abstract

Livestock sector contributes over 30% of the Agriculture's Gross Domestic Product. National Poultry Policy exist but not explicit on emerging poultry enterprises like quail production hence constraints, sources of information and main actors in this emerging enterprise are not well known. Therefore main objectives of the study were identify constraints , sources of information and the main actors in the value chain among others. Sixty households were randomly selected from County quail producers and refined questionnaire administered. Focus Group Discussions were also conducted using a checklist, data analyzed using SPSS package and qualitative methods respectively and report written. The main constraints identified included; lack of products market/low market demand, high inputs costs and inadequate skills among others. Also, most quail producers have access to credit from financial institutions and the main sources of information are; other farmers and internet sources. The main actors in the value chain were breeders and producers with very few consumers and no processors, wholesalers and retailers. Therefore, it can be concluded that quail production is dominated by resource endowed farmers but mainly depend on informal sources of information and activities in the value chain concentrated at only breeding and production with insignificant activities at the marketing level. Hence, there is need to bring formal institutions on board so that they can provide appropriate production and marketing information for reduced production costs and market penetration. There is also need for the formal organizations to provide scientific evidence on the nutritive value of quail products to enhance consumer awareness.

Key words: actors, constraints, marketing, production, quail.

Introduction

Nationally, the livestock sector contributes over 30% of agriculture's Gross Domestic Product (GDP) and employs more than 50% of the agricultural labour force (KARI, 2007). About 45% of the total land area is agriculturally productive, with the other parts being arid and semi-arid and mainly used for pastoral farming and characterized by low unreliable and poorly distributed rainfall (FAO, 2005). Around 12% of Kenyan households keep chicken with a household average stock size of 12 chicken/household (Kimani and Irungu, 2008). Poultry sector contributes about 55% to the livestock sector and around 30% of the agricultural GDP, translating to around 7.8% of the total GDP (Rok, 2007).

There is a national poultry policy that is articulate in addressing the challenges and short comings in the industry and is consistent with current government strategies such as Vision 2030 and the Agricultural Sector Development Strategy (ASDS). It addresses the need to create mechanisms that will ensure that the current poultry production is increased and sustained through improved feeding, husbandry practices, enhanced bio-safety and the development of appropriate local breeds based on traits of socio economic importance. To address marketing and value addition challenges, the policy is forthright to facilitate development of market infrastructure, address the cost of poultry value addition equipment and technology, promote processing and enhance safety regulation mechanisms for high quality poultry products (MoLD, 2010). However the policy document is not explicit on how the emerging poultry enterprises like quail need to be nurtured and promoted for enhanced productivity.

Livestock production and by extension poultry keeping is a major undertaking in the region as also reported in the 2009 National census whereby exotic and indigenous cattle, sheep, goats, indigenous and commercial chicken were shown as major enterprises in the area. It was also indicated in the same report that in terms of poultry, the area had a population of 3039786 and 2489837 indigenous and exotic chickens respectively survey conducted in 2005 by Kenya Integrated Household Budget Survey (KIHBS) suggests that 76, 52and 0.8% of the households were keeping cattle, chicken and other poultry respectively (Ministry of planning, 2009). This report also showed that poultry farming is practiced by majority of Kenyan population, with 66 and 67% being kept in urban and rural areas respectively. Ministry of planning, 2006 reported that 66 and 67% of urban and rural households was practiced poultry farming.

Quail production in Kenya is a recent undertaking that emerged in the mid 2010. The incubation period of the species ranges from 16-18 days and the birds mature and lay eggs in six to seven weeks. In Kenya large scale quail farming is still an emerging activity that peaked in 2013

The main species of quails that are kept in the Kenya include; Japanese quail (Coturnix japonica), buttonquail (Turnix sylvaticus) and Chinese painted quail (Coturnix chinensis).

In Kenya, quails are classified as game birds whose farming is regulated/licensed under the Wildlife Conservation Act (2013) by KWS.

The objectives of the study were to to identify constraints and opportunities in quail production and marketing, the existing information and its sources for quails production and marketing and the main actors and their main roles in quail production and marketing value chain

Methodology

Sample frames of five main quail breeding and producing Counties were captured from KWS licensing database and the Quail breeders/producers associations. Nyeri and Nyandarua counties were selected based on biophysical and socio-economic characteristics (agro-ecological zones, land sizes, quail population, history of quail keeping etc). Sample frames of all quail producers in each Sub-County were developed. In each Sub-County a proportional sample depending on the sample population in each Sub-County was randomly selected to constitute a sample size of 60 producers in the entire County. However, data was collected from 59 respondents because one of the sample members was not available during the time of the survey. A structured questionnaire was developed, pretested refined and administered by trained enumerators. Data was entered into a spreadsheet and analysed using SPSS Software. Four focus groups were also constituted, focus group discussions (FGDs) conducted and data analysed using qualitative tools. These included Venn diagrams, trend and timelines, recall methods and seasonal calendars among others.

Results

General Characteristics of Quail Producers

Gender, level of education, main source of income and main occupation of the respondents is as summarized in Table1.

Table1: General characteristics of quail owners

General characteristics	Criteria	Frequency	Percentage
Gender	Male	34	57.6
	Female	25	42.4
Source of income	On farm	26	44.1
	Off farm	33	55.9
Household head	Male	51	86.4
	Female	8	13.6
Occupation	Farming	23	39.0
	Formal employment	13	22.6
	Self employed	23	39
Education Levels	No formal education	2	3.4
	Primary school level	11	18.6
	Secondary School level	23	39.0
	Post-secondary school	23	39.0

Main Quail Production and Marketing Constraints

The main constraints associated with quail production and marketing are as summarized in Table2 and Table 3

Table 2: Main quail production constraints

Production constraint	Frequency	Percent: N=59
Lack of products market	4	7.5
High feeds' costs	18	34.0
Inadequate skills for pests and diseases control	3	5.7
Increased production cost	4	7.5
High mortality	6	11.3
Lack of adequate incubation skills	6	11.3

Table 3: Main quail marketing constraints

Constraint	Frequency	Percent (%): N = 59
Low market demand	17	53.1
Low quail products acceptability	6	18.8
Inadequate capital	5	15.6
Lack of transport	2	6.3
Unstable markets	2	6.3

Quail Production Credit Sources

Main sources of credit for quail production is as summarized in table four

Table 4 Sources of quail production credit

Credit source	Frequency	Percent: N=59
Welfare	7	25.9
Sacco's	7	25.9
Relatives	2	7.4
Financial institution	11	40.7

Quail Production and Marketing Information Sources

Main sources of quail production and marketing sources in the study area are as summarized in tables four and figure one.

Table 4: Quail production information sources

Information sources	Frequency	Percent: N=59
internet	53	29.4
Other farmers	52	28.9
KWS	37	20.6
Breeders	19	10.6
Agro dealers	9	5.0

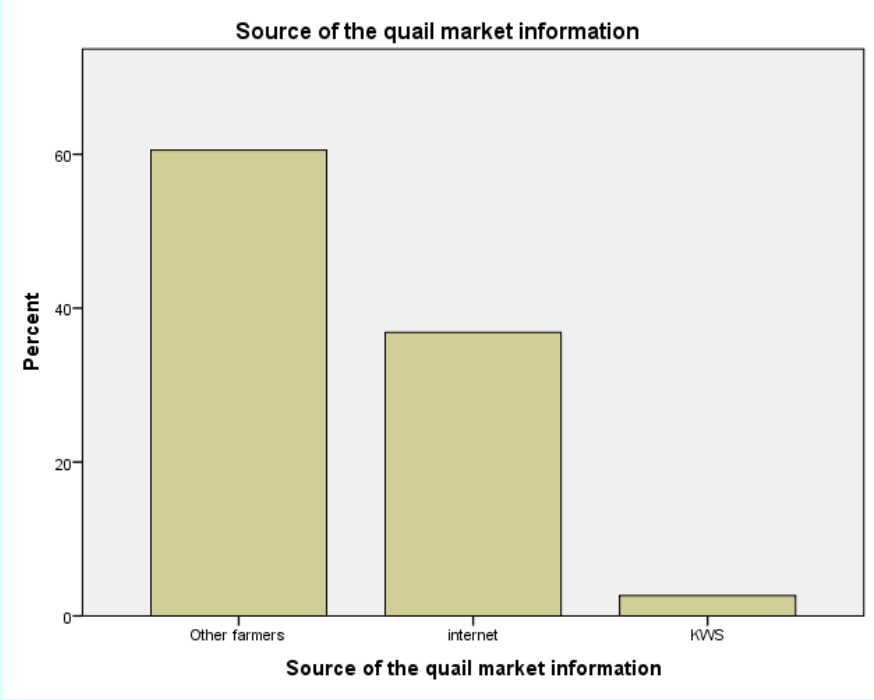

Figure 1: Main sources of marketing information

Main Actors and their Roles in Quail Production and Marketing Value Chain

A summary of the main actors in quail production and marketing value chain and their rolse is as shown in Table 5.

Table 5: Main actors in quail production and marketing

Level of the chain	Main roles	Remarks/Inferences
1. Input suppliers /agro-dealers	provision of feeds and supplements	- Mainly prefer products from Unga feeds
2.Hatchery Owners/breeders	provision of chicks and mature birds, production information	- It is capital intensive
3. Producers	provision of eggs mainly to the breeders and local consumers	- Very few consumers could afford the high prices that were being offered by the breeders
4. Consumers	- purchase of eggs from the producers	- Mostly the needy that believed that quail eggs have health benefits, got out of reach due to high prices
1.Processors, Distributors Wholesalers	-	- None were identified
4.Brokers /Middlemen	Linking breeders and egg producers	- Were there when the market prices were high but no longer there - The number of players were few
4. Retailers	-	- None were identified

Quail Products Market Trends

Quail products market trends between 2012 and 2014 was as shown in Figure 2.

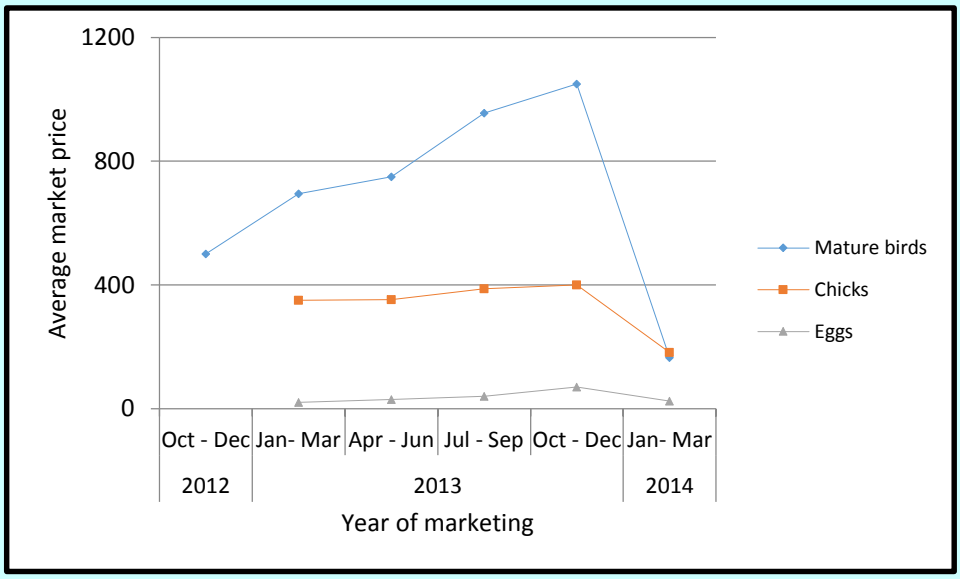

Figure 2: Market trends in the study area

Discussions

It was evident from the results that most of the respondent had off-farm income, were either in formal employment or self employment and had secondary school level of education and above. Hence, it can be argued that most of the quail farmers are not dependent on farming and entered into quail production as a business (quick income generation). This is collaborated by the fact that most of the quail producers relied

on financial institution for credit support, implying that they have collaterals to secure funding, an indication that they are resource endowed. It was also clear from the results that quail production and marketing has a wide range of production and marketing constraints and if this emerging enterprise has to be sustained, appropriate production and marketing strategies need to be developed and promoted. This is further collaborated by the fact that the main production and marketing information is accessed from farmers and internet other than the formal institutions like KALRO and MoLD whose core mandate is technologies generation promotion. The results also clearly showed that the main actors were concentrated at the production level of the value chain (more so at breeding and eggs production levels), with very few consumers and no actors at processing, wholesale and retail levels of the value chain. In terms of the market trend, quail products prices started increasing very fast from early 2012, reached the peak in early 2014 (January-December) and started descending very fast (bubble bursting).

Conclusion

Quail production had become an important emerging enterprise in the study area for a period of only three years and its production was concentrated to those endowed with resources (off-farm income, formal/self employed) whose main objective was to make quick income from the emerging enterprise. Lack of active participation of the mandated organizations like KALRO and MoLD may have been the cause of the many constraints that the farmers endure with leading to seeking alternative sources of information like other farmers and internet, which may not be appropriate and reliable. Breeding and eggs production levels being the most active part of the value chain and exaggerated market prices (not in consonance with production cost) may have led to fast market saturation and accelerated downward market prices after a short period of time. Lack of scientific/concrete evidence on the nutritive value/benefits associated with quail products may have also to creation of suspicion at the consumption level, hence decreasing demand.

Recommendations

If this emerging enterprise has to be revamped, there is need for effective participation of the organizations that have core mandate in technologies generation and promotion so as to develop and promote appropriate production technologies. There is also need to explore the potential of external markets and create market for quail products to reduce dependency on the local markets. So as to create awareness at the consumption level on the nutritive value and/or health benefits associated with quail products, research organizations like KALRO and KEMRI need to play a leading role to provide this information.

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References

KARI (2007). KARI Strategic Plan.

Kimani and Irungu (2008). Contribution of the Livestock Sector to Kenya GDP. A Consultancy Report to ASCU. Unpublished Report, Nairobi Pp. 25.

Ministry of Livestock Development (2010). Poultry Policy Approved.

Ministry of National Planning and Vision 2030 (2009). National Census Report.

Rok (2007). Kenya Integrated Household Budget Survey (KIHBS). Vol. 1, Basic Report Pp. 329.

Evaluation of Fish Farming Management Practices and Rice Milling Byproducts in Kirinyaga County, Kenya

Mwangi J.M.[1], Maina J.G. and Gachuiri C.K.

Department of Animal Production, University of Nairobi, Kenya
[1] Corresponding author: jackson.mwangi@yahoo.com Tel: 0721552936

Abstract

The contribution of fish farming to the Gross Domestic Product (GDP) of Kenya is small despite many government initiatives to improve it. A survey was conducted to evaluate the management practices and production systems of fish farming in Kirinyaga County. The production of rice milling byproducts and their potential to be used in catfish and tilapia diets in Kirinyaga County were also evaluated. Semi structured questionnaires were used to collect data from fish farmers and rice millers. The sample size was determined using data from the District Fisheries offices (290 active fish farmers) and the Yamane formula (Yamane, 1967). All rice millers in the County were interviewed. A total of 109 fish farmers were interviewed and they had 137 fish ponds among them. The source of start- up capital had a significant effect ($P<0.05$) on the number of fish ponds per farmer: Those farmers who started fish farming using their own savings had more ponds than those funded by the Economic Stimulus Program (ESP). The main challenges faced by fish farmers in the County were predation (26.4%) and the high cost of feeds (20.7%). Six large scale millers and 50 small scale millers were interviewed. The installed capacity, current production level and rice bran cost were all significantly higher ($P<0.05$) in the large scale mills compared to the small scale mills. Yields of broken rice and rice bran from large and small scale mills were not significantly different ($P>0.05$). Rice bran samples from large mills (N=3) had higher levels of crude protein and crude fat and lower levels of crude fiber and ash compared to samples from small mills (N=4). This indicates mixing of rice bran with rice hulls in the one stage milling process of small scale mills thus lowering the feeding value of the former. Rice milling byproducts are available all year round in Kirinyaga County therefore fish farmers should be encouraged and trained to use them to bring down their feed costs.

Introduction

The capture fisheries and aquaculture industry in Kenya contributes 0.5 % of the Gross Domestic Product (GDP) with about 14% of this being contributed by aquaculture (Kenya National Bureau of Statistics (KNBS), 2014). This is a very small contribution to the country's GDP despite the many Kenyan government initiatives to increase fish production (Maina *et al*., 2014). The most recent initiative was carried out under the Economic Stimulus Program (ESP) of 2009 (Aquaculture for Food Security, Poverty Alleviation and Nutrition (AFSPAN), 2012). There is little documentation of the impact of the ESP on fish management practices thus the need to quantify it in order to identify and mitigate the limits to aquaculture growth.

Fish farming in Kenya is mainly practiced under the semi intensive management system (FAO, 2015). Under this system, feeds account for approximately 70% of the total variable costs (Ahmed, 2007) and were identified as a key factor that limits aquaculture development in East Africa (Hecht, 2007). Agro-processing byproducts, such as those obtained from the milling of rice (*Oryza sativa* L.), have great potential for lowering the cost of feeds (Munguti *et al.,* 2012). Kirinyaga County, one of the beneficiaries of the ESP, is the main rice growing region in Kenya (Government of Kenya, 2009) and thus has abundant rice milling byproducts that can bring down the cost of fish feeds. However, they have not been fully exploited for that purpose hence the need to document, quantify and analyze their nutritional composition in order to increase their utilization in fish feeds.

The objectives of this study were therefore to do the following:

i) Establish the management practices of catfish and tilapia in Kirinyaga County.
ii) Evaluate the types of rice milling byproducts and quantities available through the year.

Materials and methods

Study site

The study was done in Kirinyaga County where fish farmers from the following locations of Ndia Subcounty were interviewed using a semi structured questionnaire: Mwerua, Kareti, Kiini and Mukure. Rice millers in six trading centres of Kirinyaga County namely, Wang'uru, Kagio, Kutus, Mutithi, Kimbimbi and Thiba were also interviewed.

Sampling procedure

The study targeted a sample of fish farmers in Ndia Subcounty and all rice millers in Kirinyaga County. Data on the total number of fish farmers in Ndia Subcounty was obtained from the Ndia Divisional Fisheries Development Extension office. A total of 325 fish ponds were constructed under the economic stimulus program but only 290 ponds were active at the time of the survey. The required sample size was determined using the Yamane formula of 1967 (see (1) below) and the farmers were identified using stratified random sampling.

$$n = \frac{N}{1+Ne^2} \quad (1)$$

Where n= sample size; N= population size (290 active farmers); e= desired level of precision

$$n = \frac{290}{1 + 290(0.05^2)} = 169\ fish\ farmers$$

Data collection

A semi structured questionnaire was used to collect data from the sampled fish farmers and all the rice millers. The fish farmers were asked their fish management practices and the challenges that they faced. The rice millers were categorized as small scale (single pass rice mills) and large scale (multiple pass rice mills) for purposes of the study. They were asked the amounts of rice milling byproducts that they produced through the year and the challenges that they faced. Seven samples of rice bran, approximately 100g each, from randomly selected small scale mills (four) and large scale mills (three) were collected from Mwea and Ndia Subcounties to determine their proximate composition. The people selected for the interviews had to be either the owners of the fish ponds or they took part in the management of the pond.

Chemical analysis

Proximate analysis of the rice bran samples collected during the survey was carried out according to AOAC (1998) procedures.

Data analysis

The data collected was cleaned, edited, sorted and entered into the computer program Microsoft Excel of Windows 7 Professional. It was then analyzed using Statistical Package for Social Sciences (SPSS) version 18. This generated descriptive statistics consisting of frequencies, means, standard deviations and percentages that facilitated inferential analysis using t- test.

Results and discussion

Fish farming management practices in Ndia Subcounty

A. Types of fish culture in Ndia Subcounty

A total of 109 questionnaires were administered to fish farmers by trained enumerators and found that the fish farmers had various types of fish culture methods on their farms in a total of 137 fish ponds as shown in Table 1 below.

Table 1: Fish culture in Ndia Subcounty

Fish culture	Frequency	Percentage
Tilapia monoculture	72	52.60
Tilapia and Catfish polyculture	43	31.40
Catfish monoculture	11	8.00
Ornamental fish monoculture	11	8.00
Total	137	100.00

Majority of the respondents (52.6 %) kept Tilapia in monoculture while 31.4 % kept Tilapia and Catfish in polyculture. Respondents having Catfish monoculture and Ornamental fish culture were the least at 8% each.

B. Influence of start- up capital source on number of fish ponds per farmer in Ndia Subcounty

The farmers who used their own savings to start fish farming had significantly higher ($P<0.05$) number of ponds compared to those who were funded by the Economic Stimulus Program (ESP) either partially of fully as shown in Table 2 below.

Table 2: Influence of start- up capital source on number of fish ponds per farmer

Start- up capital	Frequency	Mean	Standard deviation	P value
Own saving	13	3.23^{b}	4.126	0.007
ESP	86	1.47^{a}	1.326	
Own saving and ESP	10	1.60^{a}	0.699	
Total	109			

Means with different superscripts within a column are significantly different ($P<0.05$)

C. Pond fertilization management in Ndia Subcounty

Table 3 below describes the types of fertilizers used by fish farmers in Ndia Subcounty. The majority of farmers (49.5 %) used both organic and inorganic fertilizer while 28.4 % used organic fertilizers and 9.2 % used inorganic fertilizers only. Only 12.8 % of the farmers did not use any fertilizer in their ponds. This question had a 100 % response.

Table 3: Types of fertilizers used

Fertilizer type	Frequency	Percentage
Inorganic	10	9.20
Organic	31	28.40
Both	54	49.50
None	14	12.80
Total	109	100.00

D. Feeding management of fish in Ndia Subcounty

Table 4 below describes the cost per kg of fish feeds in Ndia Subcounty. The commercial feeds given to Tilapia and Catfish in polyculture had the highest average cost per kg (KSh 70.36). The home made feeds given to Catfish in monoculture had the highest average cost per kg (KSh 80). The single ingredient feeds given to Tilapia in monoculture had the highest average cost per kg (KSh 29.63).

Table 4: Cost per kg of fish feed in Ndia Subcounty

Feed cost/ kg (KSh)	N	Minimum	Maximum	Mean	Std. Deviation
Commercial feed					
Catfish monoculture	6	14	75	42.38	21.801
Tilapia monoculture	40	10	100	68.38	17.628
Tilapia and Catfish polyculture	21	30	90	70.36	14.88
Home made feed					
Catfish monoculture	1	80	80	80	-
Tilapia monoculture	13	5	80	40.77	29.072
Tilapia and Catfish polyculture	6	30	80	55.83	22.454
Single ingredient feed					
Tilapia monoculture	8	10	80	29.63	31.277
Tilapia and Catfish polyculture	4	8.9	20	12.588	5.0508

E. Tilapia and Catfish feeding management in Ndia Subcounty

Table 5 below describes the fish farmers in Ndia Subcounty who fed Catfish monoculture and Tilapia monoculture the same feeds. This question was mainly applicable to respondents who had Catfish monoculture and Tilapia monoculture on their farms. This represented 8.26% of the total respondents and the majority (77.78%) fed Catfish and Tilapia the same feeds while 22.22% did not.

Table 5: Fish farmers who fed Tilapia and Catfish in monoculture the same feeds

Response	Frequency	Percentage
No	2	22.22
Yes	7	77.78
Total	9	100.00

F. Feeding and pond fertilization management practices in Ndia Subcounty

Table 6 below describes the feeding management and pond fertilization practices of fish farmers in Ndia Subcounty. There was a 100% response to this question where all the fish farmers mainly practiced feeding of fish and fertilization of the fish ponds. This is the semi intensive culture of fish which is the most common production system in Kenya (FAO, 2015).

Some of the fish farmers fed the fish without fertilizing the ponds while only 4.65% of farmers having Tilapia and Catfish in polyculture fertilized their fish ponds without feeding the fish.

Table 6: Feeding management and pond fertilization practices of fish farmers in Ndia Subcounty

Feeding and fertilization management	Catfish		Tilapia		Tilapia and Catfish		Ornamental	
	N	%	N	%	N	%	N	%
Feeding with fertilization	8	72.73	60	83.33	39	90.70	8	72.73
Feeding without fertilization	3	27.27	12	16.67	2	4.65	3	27.27
No feeds, with fertilization	-	-	-	-	2	4.65	-	-
Total	11	100.00	72	100.00	43	100.00	11	100.00

G. Challenges faced by fish farmers in Ndia Subcounty

Fish farmers in Ndia Subcounty mainly faced the challenge of predation by birds and other animals (26.4%). The second highest challenge (20.7%) was the high cost of feeds yet they did not use the locally available rice milling byproducts to bring down the cost of feeds. They also faced other feed related challenges such as feed unavailability (4.2%) and poor feed quality (1.8%). The high cost of fish feeds was identified by Hecht (2007) to be a key factor that limits aquaculture development in East Africa. This and other challenges faced by fish farmers in Ndia Subcounty were documented as shown in Table 7 below.

Table 7: Challenges faced by fish farmers in Ndia Subcounty of Kirinyaga County

Challenges	Frequency	Percentage (%)
Predators	120	26.4
High cost of fish feeds	94	20.7
Lack of market for fish	72	15.9
Water unavailability	31	6.8
Poor pond water quality	30	6.6
Human theft	23	5.1
Feed unavailability	19	4.2
Over reproduction of tilapia	19	4.2
Fish diseases	17	3.7
Poor feed quality	8	1.8
Lack of capital	7	1.5
Parasites	6	1.3
Slow growth	5	1.1
Cultural limitations	3	0.7
Total	454	100

Availability of rice milling byproducts as feed resources

Rice milling data was collected from six large scale rice mills in Mwea Subcounty and 50 small scale rice mills in Mwea and Ndia Subcounties as shown in Table 7 below. The average amount of paddy rice milled annually by large scale mills was more than two times that milled by small scale mills. However, the mean rice bran yield from the two mill types (117.0 t/yr from large scale mills vs 168.1 t/yr from small scale mills) were not significantly different (P>0.05). This is because small scale rice mills are characterized by one stage milling process where the rice hulls are mixed with the bran (Heuze' and Tran, 2015; Government of Kenya, 2009). This increases the amount of the latter: rice bran accounts for less than 10% of unmilled rice while rice hulls account for 20%.

Chicken rice (this is broken rice mainly used to feed chicken) production levels is not significantly different (P>0.05) in large scale and small scale rice mills. This breakage is caused by milling paddy rice (unmilled rice) that is too dry or immature. It is therefore controlled by milling mature rice at the right moisture content (qualitatively determined). Total broken rice amount accounts for 1- 17% of the rice grain (Heuze' and Tran, 2015). The installed capacity, current production level and rice bran cost were all significantly higher (P<0.05) in the large scale mills compared to the small scale mills.

The use of rice bran in fish feeds was tested in 2002 with the comparison of the effect of a pig finisher pellet, a test diet pellet and rice bran on the growth performance of *O.niloticus* and *C. gariepinus* polyculture in fertilized earthen ponds at Sagana Fish Farm, Kenya (Liti *et al.,* 2002). The ponds were fertilized using Di-Ammonium Phosphate (DAP) and urea. The rice bran treatment recorded the highest values of afternoon Dissolved Oxygen (DO), pH and feed conversion ratio and significantly lower (P<0.05) fish growth, fish yield and profit at a market price of USD 1.56 per fish. However, it had the lowest break- even price and the least investment cost compared to the other two diets.

Table 8: Rice milling production characteristics

Production characteristics	Large scale millers			Small scale millers			P value
	N	Mean	Std Dev	N	Mean	Std Dev	
Installed capacity (tones/ hr)	6	4.278	2.562	47	0.001	0.001	0.009
Current production level (tones/ hr)	6	2.375	0.707	21	0.069	0.095	<0.001
Paddy rice milling cost (KSh/ kg)	6	2.467	0.698	49	2.336	1.571	0.842
Rice bran production (tones/ yr)	6	117.0	135.5	38	168.1	311.8	0.697
Rice bran cost (KSh/ kg)	5	13.07	2.127	47	6.94	2.138	<0.001
Chicken rice production (tones/ yr)	2	19	26.16	25	12.19	27.28	0.737
Chicken rice cost (KSh/ kg)	2	32.50	10.61	28	42.68	13.78	0.318

Std Dev: Standard Deviation

Table 9: Proximate composition of rice bran from rice millers in Kirinyaga County (Dry matter basis)

Composition (%)	Large scale mills			Small scale mills			
	1	2	3	1	2	3	4
Dry matter	88.68	89.48	90.95	90.76	89.69	89.54	91.82
Crude protein	15.53	14.13	14.52	7.42	9.73	11.49	3.45
Crude fiber	13.16	9.84	13.17	31.37	27.41	19.06	33.6
Crude fat	19.54	16.83	23.67	9.31	11.56	16.69	10.6
Ash	10.86	10.73	11.24	18.13	15.79	14.8	16.8
NFE	29.59	37.95	28.35	24.53	25.2	27.5	27.37

NFE: Nitrogen Free Extract

Crude protein and crude fat levels were higher in rice bran from large scale rice mills compared to small scale rice mills while crude fiber and ash levels were lower than those in the latter. This is because rice bran from small scale mills is mixed with rice hulls during the one stage processing (Heuze' and Tran, 2015).

Conclusion

The Economic Stimulus Program had an influence on fish management practices in Ndia Subcounty of Kirinyaga County, Kenya. In addition, rice milling byproducts are available in Kirinyaga throughout the year but the fish farmers in the County have not adequately utilized them to bring down their feed costs.

Recommendations

Fish farmers in Kirinyaga County should be encouraged and trained to use the locally available rice milling byproducts to bring down their feed costs.

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References

AFSPAN Work Package 3 (2012). Preliminary report on desk study on regional/ international cooperation activities. Report 02; Deliverable 3.1. Seventh Framework Program. 75- 90pp.

Ahmed N. (2007). Economics of aquaculture feeding practices: Bangladesh. In M.R. Hasan (ed.). Economics of aquaculture feeding practices in selected Asian countries. FAO Fisheries Technical Paper. No. 505. FAO, Rome. 33– 64 pp.

AOAC (1998). Official methods of analysis of AOAC International. 16th edn. AOAC, USA.

FAO (2015). National aquaculture sector overview: Kenya. FAO, Rome. See: http://www.fao.org/fishery/countrysector/naso_kenya/en accessed on 4th June, 2015.

Government of Kenya (2009). National rice development strategy plan (2008- 2018). Ministry of Agriculture, Kenya. 4pp.

Hecht T. (2007). Review of feeds and fertilizers for sustainable aquaculture development in sub-Saharan Africa. In M.R. Hasan, T. Hecht, S.S. De Silva & A.G.J. Tacon, eds. Study and analysis of feeds and fertilizers for sustainable aquaculture development, pp. 77–110. FAO Fisheries Technical Paper No. 497, FAO, Rome.

Heuze' V. and Tran G. (2015). Rice bran and other rice byproducts. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. See: http://www.feedipedia.org/node/750 accessed on 11th May, 2015.

Kenya National Bureau of Statistics (2014). Statistical abstract. Kenya National Bureau of Statistics, Kenya. 119pp.

Liti D.M., Mac'Were O.E., and Veverica K.L. (2002). Growth performance and economic benefits of Oreochromis niloticus/Clarias gariepinus polyculture fed on three supplementary feeds in fertilized tropical ponds. Ninth Work Plan, Feeds and Fertilizers Research 2 (9FFR2). Final Report In: McElwee K., Lewis K., Nidiffer M., and Buitrago P. (eds), Nineteenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP, Oregon State University, Corvallis, Oregon. USA. 11- 16pp.

Maina J.G., Mbuthia P.G., Ngugi J., Omolo B., Orina P., Wangia S.M., Karuri E.G., Maitho T. and Owiti G.O. (2014). Influence of social- economic factors, gender and the Fish Farming Enterprise and Productivity Project on fish farming practices in Kenya. Livestock Research for Rural Development 26 (2).

Munguti J., Charo-Karisa H. , Opiyo M.A, Ogello E.O., Marijani E., Nzayisenga L. and Liti D. (2012). Nutritive value and availability of commonly used feed ingredients for farmed Nile tilapia (Oreochromis niloticus L.) And African catfish (Clarias gariepinus, Burchell) In Kenya, Rwanda And Tanzania. African Journal of Food, Agriculture, Nutrition and Development 12 (3).

Describing Early Growth Patterns of Kuchi using Gompertz Growth Function

Lihare G.O.,[12] Wasike C.B. [1,2] and Kahi A.K [1]

[1]Animal Breeding and Genetics Group, Department of Animal Sciences, Egerton University, PO Box 536, 20115 Egerton, Kenya;
[2]Maseno University, Department of Animal Sciences, Maseno University , P.O Box private Bag Maseno.
Corresponding author: G. O Lihare; Maseno University, Department of Animal Sciences, Maseno University, P.O Box private Bag Maseno, glihare@yahoo.com +254 723 948 819.

Abstract

The aim is this study was to determine the early growth patterns of the Kuchi using Gompertz growth function. Kuchi longitudinal growth data from hatch to week 12 of age was used to model the growth curves and estimated the associated parameters (asymptotic weight, A, scaling parameter, b and maturity index, k). The PROC GLM of SAS (2003) was used for analysis of variance of body weight at each age accounting for the fixed-effects of hatch and sex. Gompertz growth model was fitted to the longitudinal growth data using the non linear regression of Curve Expert professional 2.2.0 (2013) to describe the growth pattern and derive the growth curve parameters of each bird. Average absolute growth rate (AGR), average relative growth rate (RGR), degree of maturity (u) and average absolute maturity rate (AMR) were calculated for particular age intervals for each bird. The PROC GLM of SAS (2003) was used for analysis of variance of all the growth rate and curve parameters accounting for the fixed-effects of hatch and sex. The study revealed significant difference ($P < .05$) in asymptotic body weight (A) and initial specific growth rate (b) between males and females. AGR was significantly different ($P < .05$) between sexes at week 12 while RGR was only significant at week 0. The study found kuchi female to have higher maturity rate but reached maximum AMR earlier (at week 10) than counterpart males who had relatively slow maturity rate but continued to increase in absolute maturity rate past week 12 of age.

Key words: IC ecotypes, growth patterns, growth model, growth curve parameters

Introduction

Indigenous chicken (IC) (*Gallus domesticus*) contribute significantly to the livelihood of the resource poor households in developing countries through provision of nutrition and income (Fisseha et al., 2010; Olwande *et al*., 2010; Okeno *et al*., 2012). They are tolerant to most tropical diseases and harsh environmental and therefore require low initial investment capital (Busuulwa, 2009). Kenya has different ecotypes of IC including Kuchi which is an indicator of varied genetic evolution under different economic and social circumstances hence presenting a viable potential for genetic improvement through systematic selection schemes. Kuchi is commonly found in Tanzania where it has been found to be for meat production and a good starting material for genetic improvement in body weight (Lwelamira *et al*., 2008; Lwelamira and Kifaro, 2010). Much work has been done on growth performance of various Kenyan IC ecotypes (Magothe *et al*., 2010; Ngeno, 2011; Magothe *et al*., 2012) but very little has been done on Kuchi in Kenya. Due to positive findings in Tanzania, Kenyan farmers are now starting to utilize Kuchi for meat production ignorant of its growth/genetic attributes. The aim is this study was to determine the early growth patterns of the Kuchi ecotype using Gompertz growth function and estimate its growth curve parameters.

Materials and Methods

Data source

Data was collected from the growing offspring of the kuchi breeding stock kept at Indigenous Chicken Improvement Project (INCIP) research unit in Egerton University. A total of 69 offspring (26 males and 43 females) were used to generate data for the study. A total of 483 body weight observations were used in the analysis. The parent birds were fed on laying diet at a rate of 140g/bird/day and bred by mating

particular females and males. The eggs were collected cleaned, weighed and incubated within 5 to 7 days. Chicks were weighed at hatch and fitted with identification tags. The chicks were kept in deep litter brooder from day one up to the end of week four at density spacing of 12 birds in every square meter after which they were transferred to a deep litter rearing pen within the same house. The birds were fed on feeds formulated within the farm as follows; 80g per bird per day from 0 to 4 weeks and growers mash at a rate of 120g per bird per day from week 5 to 12 of age. Clean water was provided daily ad libitum and heat in the brooder using infrared bulbs. The initial temperature in the brooder was set at 32^0C and this was gradually reduced by 2^0C every week so as to attain room temperature (25^0C) by the end of four weeks when the chicks were taken out of the brooder. Routine disinfection of brooding and rearing pens was done appropriately. All birds were vaccinated appropriately against, Gumboro, Infectious bronchitis, Fowl Typhoid and Newcastle diseases. The birds were treated for disease conditions which emerged. Bi-weekly weight data was taken from hatch to week 12 of age and sex was determined by phenotypic appearance from week 12.

Data analysis

Fixed effect analysis was carried out to determine the effects with significant influence on growth. The PROC GLM of SAS (2003) was used for analysis of variance of body weight at each age. The fitted model accounted for the fixed-effects of hatch (i =1… n) and sex (male, female). In the analysis of body weight at hatch, egg weight was fitted as a covariate, while in all other ages; body weight at hatch was fitted as a covariate. Least squares means were separated using the probability differences option. The model fitted was

$$y_{ijk} = \mu + H_i + S_j + e_{ijk} \qquad (1)$$

where: Y_{ijk} = body weight of the k^{th} bird at a particular age; μ=overall mean H_j = fixed effect of j^{th}hatch (i=1…n); S_i = fixed effect of i^{th} sex(i = male, female) and e_{ijk}= error term associated with each body weight at a particular age.

Gompertz growth function were fitted to the longitudinal growth data set for each individual bird using the non linear regression of Curve Expert professional software 2.2.0 (2013) to describe the growth pattern and derive the growth curve parameters of each bird. Equations for the models fitted according to (Fitzhugh, 1976) are as below:

$$y_t = Ae^{-be^{-kt}} \qquad (2)$$

Where y_t is the observed live weight at age t, A is the asymptotic or mature weight, b is the initial specific growth rate, k is the maturity index and t is the age in weeks.

Average absolute growth rate (AGR), average relative growth rate (RGR) degree of maturity (u) and average absolute maturity rate (AMR) at particular ages for each bird were calculated as per the definition of Fitzhugh (1976). Analysis of variance for the estimated body weights and associated parameters was performed according to equation (1) above.

Results and Discussions

The overall mean body weights at hatch, and weeks 2, 4, 6, 8, 10 and 12 were (31 g, 66, 133, 246, 401, 578and 728) respectively. The overall hatch weight from the study is in range with those of most Kenyan IC (Magothe *et al*, 2009: Ngeno, 2011) apart from Kakamega and Narok ecotypes (Ngeno et al, 2010) which were found to have relatively higher hatch weight (38.08g and 37.42g) respectively. Body weights were similar from hatch to week 8 after which males weighed heavier indicating monomorphic and dimorphic growth for the respective growth periods. The male superiority in body weight from week 8 could be attributed to the influence of the male sex hormone (testosterone) which increases in males as they approach puberty. There was however no significance ($P < .05$) difference in observed body weight between male and female Kuchi in all the ages from hatch to week 12. Other Kenyan IC ecotypes have showed significant difference ($P < .05$) in body body weight between sexes at week 6 (Magothe *et al*, 2009).

Study on characterization of local chickens in Naigeria (Apuno *et al*, 2011) revealed a significant influence of sex on body length and shank length (P < .01) and live body weight (p <.05). The mean body weight at week 12 for female (644.180) g and male (780.883) g kuchi were lower compared to those obtained in Tanzania (726.96 g) and (954g) respectively under intensive system (Lwelamira *et al*, 2008). The low body weight could be attributed to low ambient temperature of Njoro-Kenya where the study was conducted compared to Tanzania. Egg weight did not have significant effect (P < .05) on hatch weight but hatch weight was found to have significant effect (P < .05) on body weights at ages close to hatch and this decreased with age. Table 2 shows the growth curve parameters of Kuchi by Gompertz model. Estimate of asymptotic body weight (A) and initial growth rate (b) ware found to significantly different (P< .05) between male and female Kuchi.

Table 3: Least squares means for growth parameters of Kuchi ecotype by Gompertz growth model

Model	Female	Male	Overall
Bw0	22.472(1.136)[a]	22.137(1.544)[a]	21.057(6.145)
b	1.412(0.016)[a]	1.535(0.021)[b]	1.475(0.085)
k	0.173(0.035)[a]	0.106(0.048)[a]	0.165(0.192)
A	1329.908(57.734)[a]	2279.054(78.649)[b]	1707.376(303.002)

The findings of AGR and RGR are graphically presented in figures 2. AGR was significantly different (P < .05) at week 12 but similar from hatch to week 6 after which males showed superiority. The AGR reached maximum for females at week 10 (10.753) but continued to increase slowly for the male counterparts at week 12. Ngeno (2011) found most Kenyan IC ecotypes to have significant difference (P < .05) in AGR between sexes from hatch to week 14 of age. Most IC genotypes in Kenya were found to reach maximum AGR between weeks 10 and 14 of age (Ngeno, 2010; Magothe *et al*., 2009). ABR of Kuchi in this study was slightly lower from hatch to week 4 and slightly higher from week 8 to week 12 compared to those of other Kenyan IC ecotype but similar at week 6 of age (Magothe *et al*., 2010). RGR for males was significantly (P < .05) higher at hatch compared to that of females but remained similar for both sexes for the rest ages up to week 12. RGR for both males and females showed a drastic decline from hatch to week 2 with the males having lowest RGR. There was a slight increase in RGR after week 2 followed with further decline with the males being slightly superior to females.

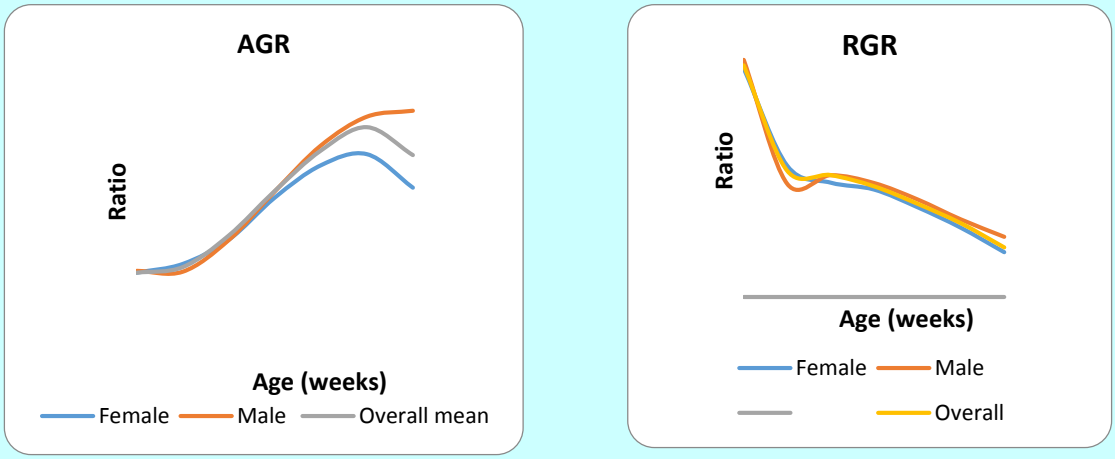

Figure 2: Graphical presentation of absolute (AGR) and (RGR) growth rates for kuchi male female and overall means

Least square means for degree of maturity (u) were significantly difference (P < .05) between sexes for all the ages from hatch to week 12 of age. There was significant difference (P < .05) in least square means of absolute maturity rate (AMR) for ages BW2, BW4, BW6, BW8 and BW10. Female Kuchi were found to

mature faster than their male counterparts from hatch to week 12 of age. AMR was higher for female from hatch up to a peak at week 10 of age after which there was a decline in convergence with the male AMR which was still on the rise

Conclusion and Reccommedation

The study has revealed a relatively poor early growth performance in kuchi compared to the other IC ecotypes in Kenya. The early growth of kuchi is monomorphic from hatch and it become dimorphic with age particularly from week 8. Kuchi females mature faster than their counterpart females and they attain maximum absolute maturity rate at week 10. Although the male kuchi have lower rate of maturity, their AMR continues to increase beyond week 10 where the counterpart female reaches their maximum. Further work is necessary determine the age at inflection, age at maturity and actual size at maturity of male and female Kuchi ecotype

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References

Apuno A.A, Mbap, S.T. and Ibrahim T., 2011. Characterization of local chickens (Gallus gallus domesticus) in Shelleng and Song Local Government Areas of Adamawa State, Nigeria. Agriculture and Biology Journal oF North America.

Fisseha, M, Azage, T & Tadelle, D. 2010. Indigenous chicken production and marketing systems in Ethiopia: Characteristic and opportunities for market-oriented development. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers' project, International Livestock Institute (ILRI) Addis Ababa Ethiopia.Working Paper No. (24).p.6.

Fitzhugh, H. A. Jr. 1976. Analysis of growth curves and strategies for altering their shape. Journal of Animal Science 42:1036-1051- 70.

Lwelamira J, Kifaro G C., Gwakisa P., 2008. Breeding strategies for improving performance of Kuchi chicken ecotype of Tanzania for production under village conditions. Livestock Research for Rural Development, Volume 20, Article #171.

Lwelamira, J and Kifaro, G.C, 2010. Desired-gain selection indices for improving performance of two Tanzania local chicken ecotypes under intensive management. African Journal of Agricultural Research Vol. 5 (2), pp. 133-141.

Magothe.T.M, Muhuyi.W.B, and Kahi.A.K, 2010. Influence of major genes for crested-head, frizzle-feather and naked-neck on body weights and growth patterns of indigenous chickens reared intensively in Kenya.

Magothe T.M, Okeno T.O, Muhuyi W.B and Kahi A.K, 2012. Indigenous chicken production in Kenya: Current status. World's Poultry Science Journal, Vol. 68 pp 119-132.

Ngeno K. 2010. Genetic Analysis of Growth Patterns in Different Ecotypes of Indigenous Chicken Populations in Kenya: Thesis, Graduate School, Egerton University.

Olwande, P.O., Ogara W.O., Okuthe S.O., Muchemi G, Okoth E., Odindo M.O. and Adhiambo R.F., 2010. Assessing the productivity of indigenous chickens in an extensive management system in southern Nyanza, Kenya: Tropical Animal Health and Production 42:283–288.

Effects of Weaning age on Carcass Quality of Rabbits Reared on Smallholder Farms in Kenya

Mahunguane S.J.S,[1 2*] Ambula M.K.[1], Bebe B.O.[1]

[1]Department of Animal Sciences, Egerton University, P. O. Box 536-20115, Egerton, Kenya
[2]Department of Animal Science Instituto Superior Politécnico de Gaza, P. O. Box 1, Lionde, Mozambique
*Corresponding author: sebasmahun@gmail.com

Abstract

A study was conducted in which thirty six rabbits in a 2 x 2 x 3 factorial arrangement in a completely randomized design (CRD) was used to assess the effects of weaning age (4 or 8 weeks), diet (commercial pellets or mixed diets) and breed (New Zealand White, Californian White or Chinchilla) on carcass quality of rabbits reared by smallholder farmers in Kenya. Rabbits slaughtered at six months had their live-weight influenced by the interaction effects of weaning, diet and the breed ($p<0.05$). Dressing percentage was higher for rabbits fed on commercial pellets than those fed on mixed diet ($p<0.05$) but was not sensitive to weaning age. However, weaning age had significant effect on weights of first and second retail cuts. Compared to other breeds, Californian white weaned at 4 weeks and those fed on commercial pellets had heavier ($p<0.05$) loin (0.686 kg) and hind leg weights (0.433kg). The thoracic cage weight varied with weaning age and diets ($p<0.05$). It is therefore concluded that under smallholder rabbit rearing conditions, weaning age as well as diet offered and the breed reared affects carcass quality measured as killing out percentage or weight of retails cuts.

Key words: rabbits, carcass quality, diets, smallholders, breed, retail cuts.

Introduction

The per capita meat consumption in developing countries, including Kenya is below 10 kg/year, compared with an average of 80 kg/year in developed countries (FAO, 2013). With the rapid urbanization and rising incomes, demand for meat of high quality is projected to continue surging upwards creating market opportunities for meat producers. However, smallholder livestock keepers may miss out because of inadequate uptake of market sensitive management strategies. An example of this is rabbit which is a white meat animal which is attractive to more health conscious consumers who place specific demands on quality attributes. Rabbit producers have to invest in adjusting management interventions to produce for such markets and research has to generate knowledge to enable them improve housing systems, management, nutrition and reproduction, breeding and genetics and disease control (Lukefahr & Cheeke, 1990; Serem *et al*., 2013).The rabbit industry in many countries is still weak for many reasons which might include the lack of feasible and well established market, deficient product supply, unfair prices, inefficient promotion and competition with other meats (Mailu *et al*., 2012). These factors can be alleviated by producing quality rabbit meat to attract the consumer without compromising the price.

Over half (53%) of smallholder farmers in Kenya keep rabbits to earn some income while over a third (37%) keep rabbits for home consumption and only a few (10%) value rabbits as pets (Mailu, Wanyoike, Serem, & Gachuiri, 2014). Commercial orientation in rabbit production has to be supported by rewarding remunerations to producers.

There are indications that management practices on smallholder farms may not be remuneratively rewarding because the average number of litters/doe/year attained is between 4 and 5, far below performance attained in commercial rabbit production which attain over 7 litters/doe/year (Lukefahr & Cheeke, 1990). Few litters will have low off take and may be associated with long kindling interval in the range of 4 to 12 weeks period of parturition to mating (Borter & Mwanza, 2010). Rabbit flocks with prolonged interval between parturition and mating practice a delayed weaning age, which may be explained by diet quality and choice of breed.

Objective of this study was to assess the effect of breed, diet and weaning age on carcass quality (weight) of rabbits reared on smallholder farms in Kenya.

Materials and Methods

Animals and experimental design

Thirty six live rabbits were purchased from different smallholder farmers registered with the Rabbit Breeders Association of Kenya (RABAK) in two Counties, where commercial smallholder rabbit production is concentrated in the country. Farmers were selected through stratified random sampling procedure designed to account for heterogeneity in management practices (feeding, age at weaning and breed) from which rabbits were purchased for the study. On the farms, sampling targeted two weaning ages (4 and 8 weeks), two feeding diets (commercial pellets supplemented with hay or mixed diet of commercial pellets and forages (dry or fresh) and three breeds (New Zealand white, Californian white and Chinchilla). This conformed to a completely randomized design (CRD) with a 2 x 2 x 3 factorial arrangement in which each rabbit constituted an experimental unit.

Measuring carcass quality

Rabbits were fasted for 10 hours before slaughtering, with free access to fresh and clean water. Slaughter and dressing methods followed normal commercial procedures (Cavani and Petracci, 2004). Live weight was recorded before slaughtering and hot carcass weight chilled at +4^{o}C for 24 hours. (Blasco and Ouhayoun, 1993), From hot carcass weight, was computed the dressing out percentage and weights of first retail cuts (loin and hind legs) and second retail cuts (thoracic cage).

Statistical analysis

Carcass quality was assessed on basis of live weight, dressing percentage, loin, thoracic cage and hind legs. The statistical model fitted the effects of main factors (weaning age, diet and breed) and their two and three way interaction effects on the carcass quality indicators: $Y_{ijkl} = \mu + W_i + F_j + B_k + (WF)_{ij} + (WB)_{ik} + (FB)_{jk} + (WFB)_{ijk} + \varepsilon_{ijkl}$ with μ: general mean; W_i: effect of weaning age; F_j: effect of feeding diet; B_k: effect of breed; WF: interaction between weaning age and feeding; WB: interaction between weaning age and breed; FB: interaction between feeding diets and breed; WFB: interaction between the three factors, were analyzed using analysis of variance in general linear model procedure (SAS, 2009).

Where the effect of any of the factors was significant ($p<0.05$), probability differences between groups were tested using Tukey's test.

Results and Discussion

Table 1 shows a summary of results from analyses of variance, indicating the significance of F values for main and interaction effects. Table 2 presents the least square means for the carcass quality measures and the main factors and interaction effects. The model explained a large proportion of variance in carcass weight (46 to 87%) while the main effects of weaning age, diet and breed showed significant effect on most of the carcass quality measures. The three way interaction was significant for live weight (LW) and hot hind legs weight (HHLW) only while the two interactions were insignificant for chilled weights for hot thoracic cage weight (HTCW) and chilled thoracic cage weight (CTCW).

Live weight was influenced by the interactive effect of weaning age, diets and the breed ($P<0.004$); interaction between breed and weaning age ($P<0.001$) while weaning age and diets ($P<0.036$) had effect on hot carcass weight and dressing percentage influenced only by diets ($P<0.004$).

Table 1: ANOVA Summary

Sources		F values for each tested model variable								
	DF	LW	HCW	DoP	HLW	CLW	HHLW	CHLW	HTCW	CTCW
Weaning age	1	28.2***	21.9***	1.17 NS	19.14***	19.5***	14.6***	3.47 NS	9.96**	4.16 NS
Diet	1	75.2***	66.0***	10.1 ***	38.9***	41.9***	61.6***	38.2***	32.9***	15.6***
Breed	2	5.27*	5.11*	1.94 NS	4.89*	11.8***	2.73 NS	16.7***	0.58 NS	0.36 NS
W X D	1	0.98 NS	4.91*	2.93 NS	6.72*	8.06**	0.01 NS	3.35 NS	0.14 NS	0.00 NS
W X B	2	18.5***	10.7***	0.12 NS	8.98**	12.2***	14.3***	13.3***	2.95 NS	1.08 NS
B X D	2	0.26 NS	0.86 NS	0.70 NS	0.31 NS	0.51 NS	0.64 NS	9.43***	3.32 NS	2.62 NS
W X D X B	2	6.90**	3.05 NS	0.12 NS	3.02 NS	3.18 NS	3.53*	2.78 NS	0.87 NS	0.37 NS
Model	11	15.1***	12.0***	1.82 NS	9.02***	11.4***	10.8***	11.8***	5.32***	2.60*
					Model values					
R MSE		0.19	0.13	3.53	69.8	64.8	36	31.8	23.5	31.7
CV		8.42	11.9	6.86	16.0	15.5	11.75	11.1	13.8	18.9
R squared		0.87	0.85	0.46	0.81	0.84	0.83	0.84	0.71	0.54

W=weaning age; D=feeding diets; B=breed HCW=hot carcass weight; DoP= dressing out percentage; HLW=hot loin weight; CLW=chilled loin weight; HHLW=hot hind legs weight; CHLW=chilled hind legs weight; HTCW=hot thoracic cage weight; CTCW=chilled thoracic cage weight; NS=non-significant; *P<0.05; **P<0.01;***P<0.001 for p values of F.

The interaction effects of breed and weaning age had significant effects (P<0.001) on loin for both hot and chilled weight.

Interaction between weaning age, breed and diet had effect on hot hind legs weight (P<0.045) while chilled hind legs are influenced by weaning age and breed (P<0.0001). Hot thoracic cage weight is influenced by weaning age (P<0.004) and feeding (P<0.0001), and chilled is influenced by diet (P<0.001).

Table 2: Least-squares means for carcass and retail cuts weight of rabbits from different weaning ages, breed and feeding diets

			Carcass traits								
Feeding diets	Weaning age	Breeds	LW (kg)	HCW (kg)	DoP (%)	HLW (g)	CLW (g)	HHLW (g)	CHLW (g)	HTCW (g)	CTCW (g)
Mixed	4	NZW	2.0^{bc}	1.0^{b}	49.1^{a}	394^{b}	392^{b}	281^{b}	280^{b}	181^{a}	180^{a}
		CL	2.3^{b}	1.3^{b}	50.9^{a}	439^{b}	435^{b}	308^{b}	308^{b}	160^{a}	158^{a}
		CH	1.9^{bc}	0.9^{b}	47.3^{a}	317^{b}	267^{b}	260^{b}	230^{b}	150^{a}	137^{b}
	8	NZW	1.6^{c}	0.83^{b}	49.9^{a}	329^{b}	328^{b}	218^{b}	218^{b}	142^{b}	142^{b}
		CL	1.9^{bc}	0.9^{b}	50.3^{a}	359^{b}	353^{b}	230^{b}	230^{b}	146^{b}	144^{b}
		CH	1.9^{bc}	0.9^{b}	49.5^{a}	337^{b}	310^{b}	260^{b}	253^{b}	133^{b}	123^{b}
Compel	4	NZW	2.8^{a}	1.5^{a}	53.0^{a}	640^{a}	635^{a}	396^{a}	395^{a}	211^{a}	209^{a}
		CL	2.9^{a}	1.67^{a}	56.9^{a}	686^{a}	682^{a}	433^{a}	433^{a}	218^{a}	215^{a}
		CH	2.3^{b}	1.26^{b}	54.6^{a}	440^{b}	380^{b}	300^{b}	290^{b}	207^{a}	193^{a}
	8	NZW	1.9^{bc}	0.9^{b}	49.5^{a}	335^{b}	333^{b}	273^{b}	271^{b}	152^{a}	151^{a}
		CL	2.3^{b}	1.2^{b}	53.8^{a}	451^{b}	447^{b}	332^{a}	331^{a}	182^{a}	181^{a}
		CH	2.7^{a}	1.4^{a}	51.5^{a}	493^{a}	447^{b}	390^{a}	353^{a}	217^{a}	203^{a}
	MSE		0.19	0.14	3.53	69.8	64.8	36.1	31.8	23.5	31.7
	Significance		***	S	NS	NS	NS	*	S	NS	NS

HCW=hot carcass weight; DoP= dressing out percentage, DoP=HCW/Live weight*100; HLW=hot loin weight; CLW=chilled loin weight; HHLW=hot hind legs weight; CHLW=chilled hind legs weight; HTCW=hot thoracic cage weight; CTCW=chilled thoracic cage weight; NS=non-significant; S=significant (0.05<P<0.1); *P<0.05; ***P<0.001; ^{a,b,c} means within same column with different superscript differ statistically (*P<0.05)*.

Weaning early (4 weeks) and feeding commercial pellets increased the live weight for Californian and Chinchilla breeds, hot carcass weight was higher in Chinchilla and New Zealand White weaned at 4 weeks and fed commercial pellets supplemented with Rhodes hay (*Chloris gayana.* Similar results were obtained by Zita *et al.* (2007); Xiccato *et al. (* 2000, 2004). Weaning age had no effect on dressing out percentage instead it was high in rabbits fed commercial pellets with hay supplementation without breed effect (Bianospino, Wechsler, Roça, & Moura, 2006). In this study dressing out percentage might have been influenced by other factors related to management not considered in the fitted model giving R-square 0.455.

The first retail cuts were high in Californian and New Zealand white weaned at 4 weeks and fed commercial pellets supplemented with Rhodes hay (*Chloris gayana*) 686 g, 640g and 433g 396g for hot loins and hind legs respectively. These results are different to the findings of (Bianospino et al., 2006) which loin ranged from 295.5 to 308.7 grams and hind parts from 401.4 to 412 in straightbred and crossbred respectively, yet second retail cut (thoracic cage), yielded less on rabbits weaned at 8 weeks and fed mixed diet for all the three breeds.

Conclusion

Based on above results, weaning at 4 weeks for rabbits fed commercial pellets on smallholder farms in Kenya improves live weight, hot carcass weight and weight of first retail cuts (loin and hind legs) while the second retail cuts (thoracic cage) weights improve with commercial pellets feeding. Therefore it is concluded that under smallholder rabbit rearing conditions there is an effect of weaning age on carcass quality in terms of weight of dressed out carcass and weight of retails cuts availed to the market by smallholder rabbit farms in Kenya.

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References

Bianospino, E., Wechsler, F. S., Roça, R. O., & Moura, A. S. A. M. T. (2006). Growth , Carcass and Meat Quality Traits of Straightbred and Crossbred Botucatu Rabbits. World Rabbit Science, 14(April), 237–246.

Blasco, A., & Ouhayoun, J. (1993). Harmonization of Criteria and Terminology in Rabbit Meat Reserch. Revised Proposal. World Rabbit Science, 4(2), 93–99.

Borter, D. K., & Mwanza, R. N. (2010). Rabbit Production in Kenya , Current Status and Way Forward.

Cavani, C., & Petracci, M. (2004). Rabbit Meat Processing and Traceability. In 8th World Rabbit Congress (pp. 1318–1336). Pueblo, Mexico.

FAO. (2013). FAO Atatistical Yearbool 2013- Wold foof and agriculture. Rome. Retrieved from www.fao.org/puplications

Lukefahr, S. D., & Cheeke, P. R. (1990). Rabbit project planning strategies for developing countries . (1) Practical considerations. Livestock Research for Rural Development, 2(3).

Mailu, S. K., Muhammad, L., Wanyoike, M. M., & Mwanza, R. N. (2012). Rabbit Meat Consumption in Kenya. Minich Personal RePEc Archive, (41517). Retrieved from http://mpra.ub.uni-muenchen.de/41517.

Mailu, S. K., Wanyoike, M., Serem, J. K., & Gachuiri, C. K. (2014). Rabbit breed characteristics, farmer objectives and preferences in Kenya: A correspondence analysis. Discourse Journal of Agriculture and Food Science, 2(4), 118–125. Retrieved from www.resjournals.org/JAFS.

SAS, I. I. (2009). SAS/STAT 9.2 User's Guide (Second Edi). Cary, NC: SAS Institute Inc.

Serem, J. K., Wanyoike, M. M., Gachuiri, C. K., Mailu, S. K., Gathumbi, P. K., Mwanza, R. N., … Borter, D.

K. (2013). Characterization of Rabbit Production Systems in Kenya. Journal of Agricultural Science and Aplications, 2(3), 155–159. http://doi.org/10.14511/jasa.2013.020304.

Xiccato, G., Trocino, A., Sartori, A., & Queaque, P. I. (2000). Early Weaning of Rabbits: Effect of Age and Diet on Weaning and Post-Weaning Performance. World Rabbit Science Association: Proceedings 7th World Rabbit Congress, 8(july), 483–490.

Xiccato, G., Trocino, A., Sartori, A., & Queaque, P. I. (2004). Effect of parity order and litter weaning age on the performance and body energy balance of rabbit does, 85, 239–251. http://doi.org/10.1016/S0301-6226(03)00125-8.

Zita, L., Tůmová, E., Skřivanová, V., & Ledvinka, Z. (2007). The effect of weaning age on performance and nutrient digestibility of broiler rabbits. Journal of Animal Science, 2007(10), 341–347.

Nutritional Composition of Donkey Milk: A Case Study of Limuru Sub-County, Kiambu County

Njau W. R.[1*] and Osuga I,M. Isaac[1]

[1]Department Of Agriculture Resource Management, Kenyatta University, P.O. Box 43844-00100, Nairobi. Kenya.
*Corresponding author e-mail: wanjahi.njau@gmail.com

Abstract

Milk is the most nutritious natural liquid. Milk components contribute significantly to meeting nutrient requirements of young animals while minimising incidences of diseases. Very young children (infants) and the elderly may be intolerant to cow's milk, its protein and cholesterol. Thus viable substitutes are needed to complement cow's milk in such cases. This case study was carried out in Limuru sub County Kiambu County. Donkey milk exemplifies a geographical shift from diet conscious consumers to change to nutritious as well as diets with health benefits. This article describes significant research findings on nutritional benefits and composition of donkey milk in comparison with cow milk. It determines nutritional components of donkey milk. It describes variations in milk components between cow and donkey milk by comparing both and analysing their differences. The study was intended to promote donkey welfare as a dairy animal and improve food security for the most vulnerable groups especially for the young infants in dry areas. Despite the limited data on donkey dairy production perspectives should fuel more research for commercial investments. Effective education and data dissemination are among requirements to develop an unbiased science of cow and donkey milk nutritional and functional value and its contribution to optimal human health

Key words: Donkey milk, Nutritional components

Introduction

Donkey milk has nutritional properties that are more similar to human milk than any other mammalian animal. Therefore it can be used to feed young children and for general human consumption. The aim of this project was to identify the nutritional composition of donkey milk and compare it with that of cow milk. It is believed that donkey does no harm to people with cow milk protein allergy and can be used as an alternate to cow's milk.

Social cultural restraints among several communities in Kenya have resulted to the low uptake of donkey milk. Many people in rural areas have a negative attitude towards donkeys and their contribution to people's livelihoods remain unacknowledged and unsupported. Donkey milk is rarely consumed and to do so is considered a taboo. However, it is used by the Maasai women to treat children with pneumonia or severe cough (Mutharia, 1995). Recently donkey milk has been used for sale to Indians and foreigners from Europe mainly Italians for human consumption. Among the local communities it has been used for to nourish vulnerable groups such as young children and the elderly

Donkey milk has been used successfully as an alternative food for infants with food allergies for example cow's milk protein allergy (Salimei and Fantuz, 2012). The flavour and appearance of donkey milk has been found to be attractive to children. One of the challenges with donkey milk is the seasonal supply during the year. Fertility of a donkey female is strictly connected with the photoperiod and delivering is normally limited to a range of a few months in a year. Furthermore donkey breeding is so dispersive and milk yield is low.

Materials and methods

Description of site

The project research was carried out in Limuru Sub County in Kiambu County. It is located in the central part of the country between 1^0 06′ 00″ s latitude and a longitude of 36^0 37′ 00″ E

Data collection

Collection of milk samples

Samples were collected from 3 donkeys and 2 cows at 3 different times for each. Milk sample were collected from donkey keepers before the start of their daily routines. Those from cows were collected before delivery into the cooperatives. The milk from both cows and donkeys were manually milked. They were collected in sterilized containers and taken to the laboratory and transported by use of an ice box. A total of 15 samples were collected for Physico-chemical analysis. The samples were analyzed on the same day.

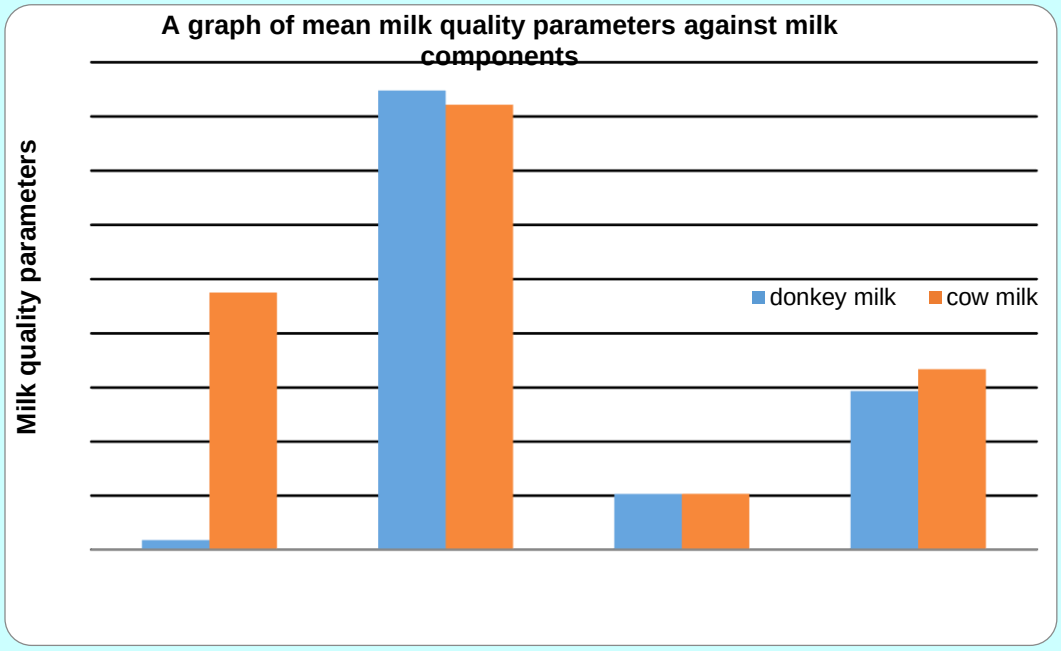
Examination of milk samples

Physico-chemical characteristics of the milk samples were determined using milk analyzer (LACTICHECK) to determine milk constituents (fat, solid non fat, protein and % of water added) and physical characteristics (density in $g/^{cm3}$).

Statistical analysis

Data was analyzed by use of SAS (Statistical analysis system) for windows V8 version 2001. Analysis of variance (ANOVA) was used to determine the statistical differences of milk quality parameters. These were used to analyze the association between milk quality parameters and effect of different independent variables on the milk quality.

Results



Y axis: represents milk quality parameters (what are the units?)

X axis: represents milk components

Table 1: Physico-chemical quality of cow and donkey raw milk in the study area

Mean values of Physico-chemical quality parameters		
Milk quality parameters	Donkeys	Cows
Fat	0.1778[b]	4.7533[a]
SNF	8.47778[a]	8.21667[b]
Density	1.0311333[a]	1.032233[a]
Protein	2.93556[b]	3.338333[a]
% water	-	-

Values in row with different letters have significant difference

Fat had a significant difference at p<.0001

SNF had a significant difference at p<.05

There was no significant difference in density

Protein had a significant difference at p<.05

Discussion

Significant difference in fat was due to species differences. Cows are able to efficiently synthesize fibre in the rumen to produce volatile fatty acids used by mammary glands to synthesize milk thus the high fat content. Donkeys also had a low fat content as it's a heavy worker which breaks down body fat to produce energy. The body condition of donkeys was poor compared to that of cattle. There was no significant difference in density. The solid non fats SNF means were higher on donkey milk than that of cow milk. Significant difference was due to the low fat content donkey milk has a higher SNF that contains of the following components whey proteins, lactose, caseins and minerals. The SNF content may have been lower in cows as they were in a late stage of lactation compared to donkeys which had recently foaled.

The significant difference between cow and donkey milk may be as a result of cows utilising protein efficiently than donkeys. Due to microbial digestion in rumen more proteins were used to synthesise milk. Although the donkeys were able to carry out microbial digestion in the large intestines they were less efficient in protein utilisation as most of it was used to regenerate tissues due to their work. Cows were also able to generate more proteins from non-protein nitrogen sources through microbial digestion compared to donkeys which are not able to derive proteins from NPN. The significant may have been caused by nutritional factors as donkeys were mainly fed on pastures from roadside verges which had more crude fibre than protein compared to cattle which were fed on fresh pastures and fodder with adequate protein. Cows were supplemented with high quality concentrates but donkeys were not. The percentage of water added was not detected by the lacticheck machine showing that milk was not adulterated.

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References

Salimei, E and Fantuz, F. (2012). Equid Milk for Human consumption. International dairy journal vol 24 (pp. 130-142).

Mariani, P.L. (2011). Donkey milk nutraceutical characteristics: Biochemical evaluation of nutritious and clinical properties. XXIII Series. School of advanced studies. University of Camerino.

Mutharia, L. (1995). A Participatory assessment of pastoral resources and their utilisation in selected areas of Kajiado district. Study 1: Oloryiankalani Group Ranch. Study 2. Eselenkoi/Emutoroki Group Ranch. Intermediate technology Kenya, Nairobi. 71p and 69p.

Nikkhah, A. (2011). Equidae milk provides substitutes for cow and human breast milk. Tubitak journal of animal science, 36(5): 470-475.

Changes in Agri-Business Practices, Productivity and Wealth Creation among the Dairy Beneficiaries of Contracted Extension Service Delivery Model

Bebe B.O[1,2] and Mwangi J.G[1]

[1]Research and Extension Division, Egerton University P. O. Box 536-20115, Egerton, Kenya
[2]Department of Animal Sciences, Egerton University P. O. Box 536-20115, Egerton, Kenya
[2]Corresponding author: omedobebe@gmail.com

Abstract

A paradigm shift is occurring in the delivery of extension services to farmers in Kenya from public delivered services to pluralistic actor service delivery that is encouraging greater participation of private sector delivered services in which the farmers contract for the services according to their priority needs. This paper assessed changes in uptake of agri-business practices, productivity and wealth creation among the dairy beneficiaries of Contracted Extension Service Delivery Model (CESDM) implemented by Kenya Agricultural Productivity and Agribusiness Project (KAPAP) since 2010 in selected twenty Counties in the country. Data was obtained in quasi experimental household survey of intervention (beneficiaries) and control (non beneficiaries) and baseline samples and from project database of value chains performance. The assessment compares changes in the intervention with control and the baseline samples. We find that there was a large increase in the proportion of beneficiaries accessing extension services from private service providers and expressing satisfaction with contracted service delivery, but only a marginal increase in willingness to pay or paying for contracted services. The beneficiaries attained higher dairy productivity by about 6 per cent in milk production and 62 per cent in gross margins per animal per year but majority of them continued to sell milk through informal market outlets. On aggregate, CESDM posted positive net benefits and multiplicative economic power with the best performing dairy chains multiplying every shilling invested 4 to 46 times. This earned beneficiaries wealth, KES 4993 a farmer at a cost of KES 353 for services, inputs and equipment. The findings demonstrates that contracted extension services can be a viable and rewarding approach to delivering extension services to smallholder farmers. However, to encourage private sector participation to grow and sustain demand-driven extension service delivery will require strengthening farmer institutions such as cooperative societies through which farmers can contract for priority services that they need and make payments at the cooperative level rather than at individual farmer's level because farmers that are paying for private sourced service are still too few to sustain remunerative private sector investment. We contribute to use of quasi experimental design in evaluating project impacts on community and add to evidence supporting the promotion of private delivered extension services for smallholder farmers.

Keywords: Dairy value chain; Private extension service provision; Benefit Cost Ratio; Quasi experimental design sampling.

Introduction

In Kenya, the delivery of agricultural extension services has largely been a public good. Government investments in extension services are for improving service delivery to enable farmers to access and put into use new knowledge, skills and technologies. At the farmer level, the acquired knowledge, skills and information about the technologies is an output whilst the technology adopted is an outcome and its impact is the change in productivity, income or food security situation. The evaluation of benefits of extension services to beneficiaries is at the outcome and impact levels (Spielman 2008; White2009). Most of the impact evaluations of extension programmes in Africa report positive and significant impacts, but the results are disputed because agricultural production and productivity has over the years remained stagnant (Taye 2013). This reflects challenges in impact evaluation of extension interventions, which includes failure to control for extraneous factors, design effects and estimating the counterfactual conditions. Applying quasi-

experimental design is one approach to have rigorin design and quantification of changes attained with the intervention (Barahona 2010; Davis et al. 2010).

Extension service delivery in Kenya is however undergoing paradigm shift with government encouraging private sector participation to grow and sustain demand-driven extension service delivery. For instance, in 2010 the Kenya Agricultural Productivity and Agribusiness Project (KAPAP) launched Contracted Extension Service Delivery Model Approach (CESDM) in selected Counties but in value chains that were selected by farmers. Under this model, farmers contract for extension services from consortia of service providers whom they pay from the grants they manage.

Service providers flag-off agribusiness opportunities to trigger demand-driven agribusiness extension services then they mobilize interested farmers to join farmer business groups (Common Interest Groups (CIGs) that are nurtured into formal cooperative societies. The payment to service providers for their professional services in four trances starting with an initial 10%, followed by 20%, 30% and finally 40% of the service fee based on attainment of negotiated and agreed benchmark outcomes. The beneficiaries manage the grants and they must endorse outcomes to authorize the payments for services rendered. This is an innovation integrated in the service delivery to correspond to progressive wealth creation by the beneficiaries.

By design, the objective of the model was to enable beneficiaries to create wealth from increased productivity, value addition and linking producers to reliable and stable markets. This paper therefore aims to determine whether the contracted service delivery model after four years of implementation had demonstrable changes in agri-business practices, productivity and wealth creation among the beneficiaries in dairy value chains.

Study Methodological

The study applied quasi-experimental design to assess the changes in agri-business practices, productivity and wealth creation and food security status from household's perspective that may be associated with the implementation of CESDM and specifically in the dairy value chains. Households were randomly sampled in a stratified cross-sectional survey. Stratification was by model beneficiaries (control and intervention) selected in representative ecological zones within a county to account for diversity of farming systems, socio-economic characteristics and the value chains. The intervention sample at the inception of the model comprised those who had self-selected into the value chains. The performance of the intervention sample obtained in 2010 at the inception of the model was therefore the baseline sample performance. The control sample were constructed from within the project area on the criteria that the location of residence was not currently implementing the model, household was not a direct beneficiary of the model and the location was reasonably far from the intervention sample but shared similarities in farming and agro ecological characteristics.

A random sample of 2547 households was obtained in the ratio of 6:4 for the intervention (n=1475) and control (n=1065) samples from across agro-ecological zones within a county to account for the diversity of farming systems, socio-economic characteristics and value chains. Of the 20 counties implementing the model, 15 were randomly sampled (Table 1).

Table 1: Counties sampled and those out of sampling with their corresponding representative Counties

Sampling	Counties				
Sampled Counties	Garissa	Tana River	Kwale	Taita Taveta	Makweuni
	Kisii	Nakuru	Nyandarua	Nyeri	Meru
	Busia	Siaya	Kakamega	Transnzoia	West Pokot
Counties out of sampling	Wajir	Kilifi	Homa-bay	Butere-Mumias	Embu
Representative counties for those out of sampling	Garissa	Kwale	Siaya	Kakamega	Meru

The model was evaluated with quantitative and qualitative data obtained from the household survey complemented with project database, Focus Group Discussions (FGDs) and key informant interviews. The data was analysed at three levels: household, value chain and stakeholder levels. Analysis performed compared the intervention with control and the baseline samples.

Results and Discussion

Design and implementation of the contracted extension service delivery model

To be a beneficiary of the contracted extension service delivery model (CESDM), a farmer has to register with a farmer business group. Figure 1 illustrates the features of CESDM in which farmer group receives and manages the grants from the project to pay for contracted services and receive co-financing to purchase equipment and inputs for value chain development. The feature of CESDM is demand-or market-driven model where the farmer group pays to support development of functioning market which is important for service provision and transformation of CIGs into co-operative societies is incorporated for sustainability (Wongtschowski et al. 2013).

The model funding agency (KAPAP) facilitated service provision by building the capacity of service providers and availed grants to farmer groups and monitored attainment of the agreed set target outcomes. While service providers earned fees for their professional services, the individual farmers within a group earned incomes from their enterprise.

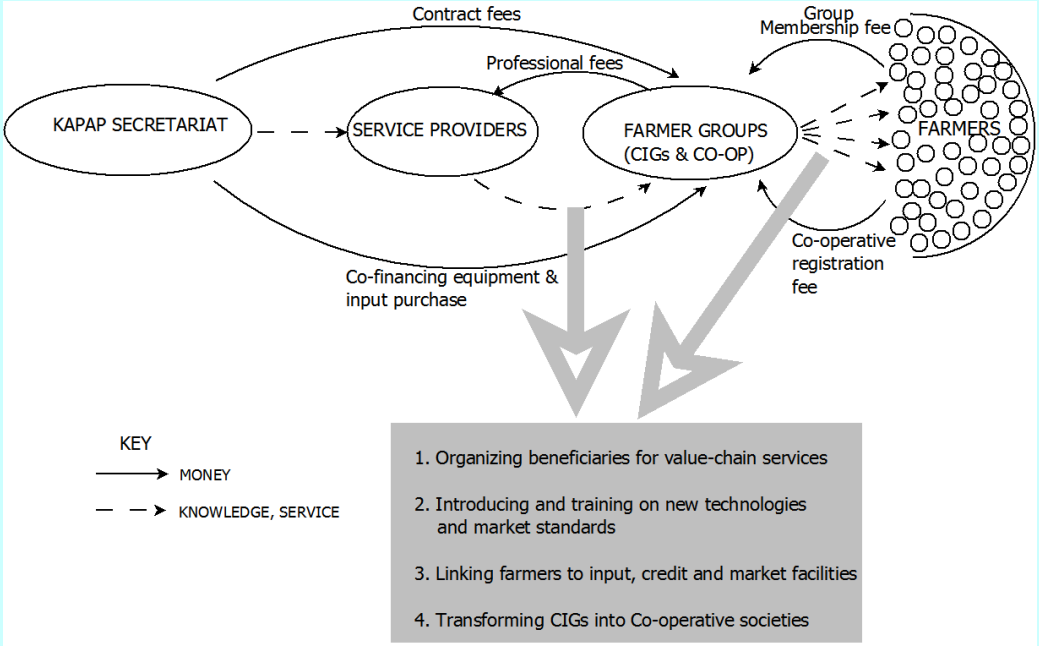

Figure 1: The Contracted Extension Service Delivery Model (CESDM) implemented by Kenya Agricultural Productivity and Agribusiness Project

Changes in accessing contracted extension services

Household survey results show that the implementation of CESDM resulted in a large increase in the proportion of beneficiaries accessing extension services from private service providers (Table 2). Compared to baseline and control samples, there was an increase in proportion of intervention sample accessing services from service providers (40 to 70%), input dealers (10 to 49%), and processors(60 to 75%) and from research (53 to 75%) while they reduced in proportion accessing services from public extension (45 to 15%). This provides evidence that the model was effective in mobilising, sensitising and empowering the

beneficiaries to seek demand-driven extension services to shift away from supply-driven extension services.

Table 2: Percent (%) change in sourcing of extension services among sample farmers

Sample	Public extension	Research	Processors	Input dealers	Service providers
Baseline	45.5	3.5	7.8	6.8	5.8
Control	75.6	25.5	22.6	45.6	35.7
Intervention	30.3	78.6	82.5	55.8	75.5
% Change					
Intervention vs Baseline	-15.2	75.1	74.7	49.0	69.7
Intervention vs Control	-45.3	53.1	59.9	10.2	39.8

Compared with base and control samples (Table 3), the intervention sample showed an increase from17 to 63% in those expressing satisfaction with contracted service delivery, but only a marginal increase of 4% in those willing to pay or are paying for contracted services. A large proportion of farmers (≥75%) expressed willingness to pay for contracted services but only a few were already paying for contracted services (≤11%) and therefore percentage change in those willing to pay or are paying for contracted services is marginal (3.9%). This suggests that farmers find difficulties at individual level to pay for extension services and implies organizing farmers in cooperatives will be necessary for sustaining demand for contracted services. A previous study by Ozor et al. (2013) also reported that majority of farmers in Nigeria (95.1%) were willing to pay for improved extension services irrespective of their poor income status so long as the extension services remained relevant to their felt needs. In a similar study, Chukwuone et al. (2006) found out that one of the most effective strategies through which farmers can pay for the cost of private extension services is through the farmers' cooperative societies.

Table 3: Percent (%) change in proportion of farmers satisfied, willing to pay, or are paying for contracted extension services by sample farmers

Sample	Satisfied with services	Willing to pay for services	Pays for services
Base	26.2	-	
Control	71.4	74.7	7.1
Intervention	88.7	78.6	10.7
% Change			
Intervention vs Base	62.5	-	-
Intervention vs Control	17.3	3.9	3.9

Figure 2 illustrates the frequency of contracted extension services that farmers ranked top three most effective for value chain development. In order of decreasing importance, these were training (48%), formation of CIGs (25%), market access (15%), formation of cooperatives (13%) and business proposal development (10%). These responses points to high value that farmers attach to building their capacity in knowledge, skills and technology as well as building supportive business institutions and entrepreneurial skills, which can enhance their capacity to innovate (Kilelu et al. 2014).

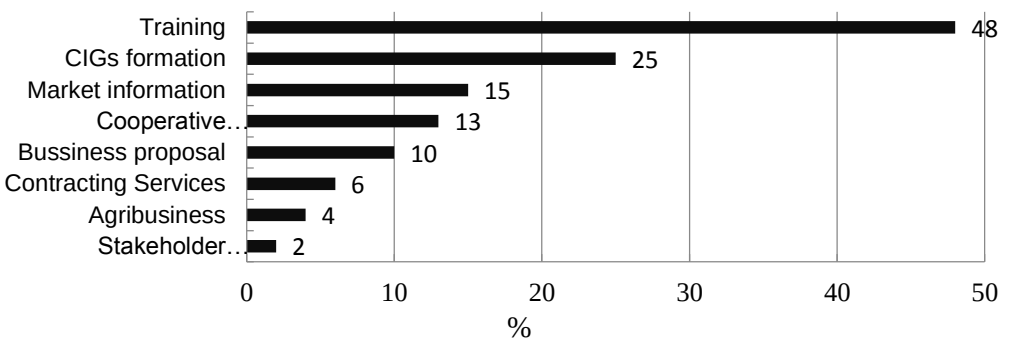

Figure 2: Frequency (%) of the top most effective interventions in decreasing order of importance expressed by sample farmers

Changes in dairy productivity

Compared to control household sample, intervention households attained higher dairy productivity by about 6 per cent in milk production and 62 per cent in gross margins per animal per year (Table 4). The gains realised by the model beneficiaries above their base and control sample counterparts would suggest that provision of demand-driven services enabled farmers to better access knowledge, skills and technologies and remunerative market prices which corroborates with the implementation of model (Figure 1). Change in productivity is an important outcome to provide for marketed surplus milk for income to grow wealth, which is in line with the goal in agri-business intervention.

Table 4 : Percent (%) change in milk production and gross margins by sample farmers participating in the contracted extension services

Sample	Milk (kg/cow/year)	Gross margins (KES/cow/year)
Base	1020	
Control	2922	11615
Intervention	3087	18909
% Change		
Intervention vs Base	202.6	
Intervention vs Control	5.6	62.8

Changes in milk marketing

Results presented in Table 5 show that majority of the intervention sample farmers still prefer to sell milk in the informal market outlets (15 to 46%) to traders and neighbours rather than in the formal market outlets (3 to 23%) to cooperatives, processors or hotels. Following the implementation of CESDM, the beneficiaries selling milk to cooperatives increased (by 4 to 13%) but there was a decrease among those selling milk to traders (13%), processors (1 to 5%) or to a gain farmer cooperative (nKCC) (2 to 5%) when compared to base and control samples. This would suggest that CESDM is progressively encouraging more farmers to participate in the formal milk market outlets mainly through formation of cooperatives.

Table 5: Percent (%) changes in farmers' participation in milk market outlets

Sample	nKCC	Processors	Cooperatives	Hotels & institutions	Traders	Neighbours
Base	7.7	10.6	10.0	6.0	27.6	38.1
Control	5.6	6.5	19.3	6.2	14.1	48.4
Intervention	3.2	5.7	23.3	7.4	15.1	46.3
% Change						
Intervention vs Base	-4.5	-4.9	13.3	1.4	-12.5	8.2
Intervention vs Control	-2.4	-0.8	4.0	1.2	1.0	-2.1

Despite being trained in new technologies, only a few farmers had been trained in milk value addition and therefore adoption of milk value addition is very low probably due to lack of specialised equipment for milk value addition (Table 6). New partnerships and strategies developed jointly with other actors such as County Governments and NGOs were initiated to purchase value addition equipment that could be pooled for use by the beneficiaries.

Table 6: Percent (%) changes in farmers trained in and practicing milk value addition among the sample farmers

Sample	Trained in milk value addition	Adding value to milk
Base	1.2	6.6
Control	2.2	5.7
Intervention	1.1	4.7
% Change		
Intervention vs Base	-0.1	-1.9
Intervention vs Control	-1.1	-1.0

Wealth creation

Table 7 presents the benefits to beneficiaries and the costs of implementing contracted extension service delivery by dairy values and the aggregate for all value chains. Analysis uses data for the period between 2010 when the model was implemented to December 2014 at the time the model was evaluated. At the model aggregate, the Benefit Cost Ratio (BCR) shows that every shilling invested in contracting extension services generated KES 15.2 while Return on Investment (ROI) show that every invested shilling was multiplied 14 times. For the dairy value chains, best performing ones multiplied every shilling invested 4 to 46 times, implying that implementation of the model was associated with positive net benefits and multiplicative economic power and therefore contracted extension services can be viable. This enabled beneficiaries to earn wealth, which at the model aggregate was KES 4993 a farmer at a cost of KES 353 for services, inputs and equipment. Some dairy value chains performed above the model aggregate in wealth created per farmer, earning as high as KES 10376 to 77450 at a cost of KES 1125 to 1922 for services, inputs and equipment. The large differences in value chain economic performance may be related to leadership and management capacities of the farmer groups because each group set their own outcome benchmarks on basis of baseline performance levels.

Table 7: The Benefit Cost Ratio (BCR), Return on Investment (ROI) and cost per farmer served in implementing the contracted extension service delivery in dairy value chains

County	Benefit Cost Ratio (KES)	Return on Investment (KES)	Cost per farmer served (KES/farmer)	Earnings (KES/farmer)
Kakamega	46	45	682	31057
WestPokot	40	39	1922	77450
Nyeri	21	20	226	4779
TaitaTaveta	9	8	1125	10376
Meru	5	4	146	705
Makueni	-52	-53	274	-14091
Nakuru	-61	-62	644	-39195
TransNzoia	-87	-88	131	-11421
Nyandarua	-100	-101	220	-22092
Kilifi	-180	-181	435	-78132
Kisii	-219	-220	342	-74881
Model overall	15	1415	353	4993

Changes in household food security

From the household survey data, a comparison was made by samples for the proportion of households that expressed experiencing food security during the year. Figure 3 presents the results. Compared to control households sample, the intervention sample had more households experiencing food security in most months of the year, which is evidence that participation in the model enabled a household to attain increased farm productivity and subsequently attain improved food security situation. The change in food security can be partly associated with positive change in dairy productivity that was observed among the intervention sample (Table 4) as farmers could have adequate milk for family consumption and surplus to market for income with which they can buy other crop farm inputs or food stuffs that the household may need.

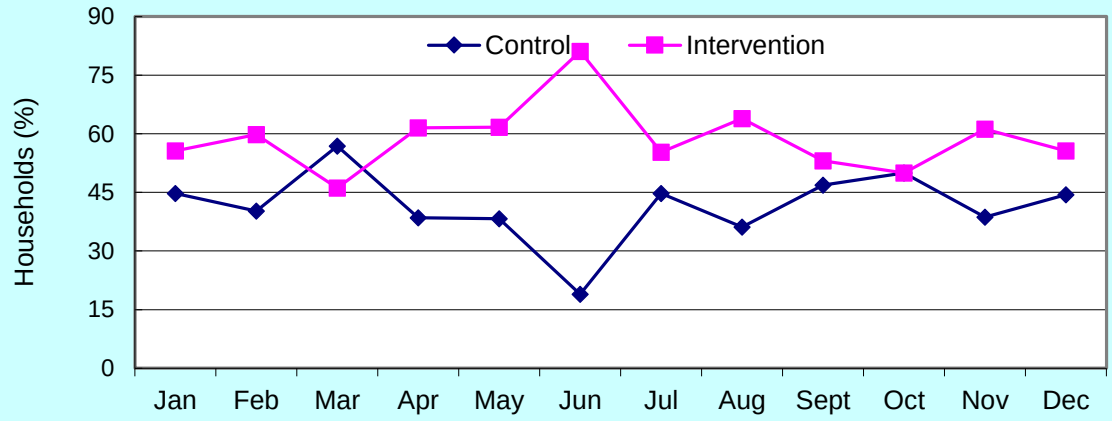

Figure 6: Per cent (%) households by sample expressing that they are food secure during the year

Conclusion and Recommendation

The main objective of the model was to create wealth from increased productivity, value addition and linking producers to reliable and stable markets. This study has provided evidence that contracted extension service delivery can bring positive desirous changes in agri-business practices, productivity and

wealth creation as well as household food security among the beneficiaries. The findings demonstrates that contracted extension services can be a viable and rewarding approach to delivering extension services to smallholder farmers. However, to encourage private sector participation to grow and sustain demand-driven extension service delivery will require strengthening farmer institutions such as cooperative societies through which farmers can contract for priority services that they need and make payments at the cooperative level rather than at individual farmer level. This is because smallholder farmers paying for private delivered extension services are still too few to sustain remunerative private sector investment in extension services. In strengthening farmer cooperatives, attention should be paid to enabling them attain a critical mass/volume of production in order that they secure and sustain reliable markets for sustainable incomes/ profits for both the households and cooperatives. It is desirous for the Cooperative leaders and managers that they institutionalize the Quality Management System and Governance in their entities to ensure continuous improvement, effective service delivery and accountability to their members to retain and grow membership numbers and confidence.

References

Barahona, C. 2010. Randomised control trials for the impact evaluation of development initiatives: statistician's point of view. ILAC working paper 13. Rome, Italy. Institutional learning and change initiatives.

Chukwuone N.A., A.E. Agwu and N. Ozor. 2006. Constraints and strategies toward effective cost-sharing of agricultural technology delivery in Nigeria. Journal of International Agricultural and Extension Education, Texas A&M USA,Vol. 13(1): 29-41. Available at: http://www.aiaee.org/attachments/145_Chukwuone-Vol-13.1-4.pdf.

Davis, K., Nkonya, E., Kato, E., Mekonnen, M., Odendo, M., Miiro, R. &Nkuba, J. 2010. 'Impact of farmer field schools on agricultural productivity and poverty in East Africa', IFPRI Discussion Paper 00992, International Food Policy Research Institute, Washington, DC, viewed 27 August 2013, from http://www.ifpri.org/sites/default/files/publications/ifpridp00992.pdf

Kilelu,C. W., L. Klerkx & C. Leeuwis. 2014. How Dynamics of Learning are Linked to Innovation Support Services: Insights from a Smallholder Commercialization Project in Kenya, The Journal of Agricultural Education and Extension, 20:2, 213-232, DOI: 10.1080/1389224X.2013.823876.

Ozor, N., C.J. Garforth, and M.C. Madukwe. 2013. Farmers' willingness to pay for agricultural extension service: Evidence from Nigeria. Journal of International Development Vol. 25 Issue 3: 382-392; DOI: 10.1002/jid.1849. Available online at: http://onlinelibrary.wiley.com/doi/10.1002/jid.1849/abstract.

Taye, H. 2013. Evaluating the impact of agricultural extension programmes in sub-Saharan Africa: Challenges and prospects', African Evaluation Journal 1(1), Art. #19, 9 pages. http://dx.doi.org/10.4102/ aej.v1i1.19.

Spielman, D. 2008. Encouraging economic growth in Ethiopia: Perspectives on agricultural input markets, agricultural extension and advisory services, and agricultural education and training. http://users. ox.ac.uk/~econstd/Brief_DSpielman.pdf.

White, H. 2009.'Some Reflections on Current Debates in Impact Evaluation', Working Paper 1, International Initiative for Impact Evaluation, New Delhi.

Wongtschowski M., J. Belt, W. Heemskerk, D. Kahan (ed). 2013. Royal Tropical Institute, Amsterdam; Food and Agriculture Organisation, Rome; Agri-Profocus, Arnhem.page 15.

Effects of Probiotics Feeding Technology on Weight Gain of Indigenous Chicken in Kenya

Atela J. A [a] ,Tuitoek J. [a] and Onjoro P. A.[a] Kibitok N.K[a]

[a]Animal nutrition Group, Department of Animal Sciences, Egerton University, P.O Box 536, Egerton-20115, Kenya.
Corresponding author**: judithatela@gmail.com**

Abstract

This experiment was conducted and designed to evaluate the effects of feeding value of the feedstuffs utilized by Indigenous Chicken in farms. The suitability and choice by chicken in a cafeteria feeding system and the possibility of improvement using a selected commercial Molaplus poultry probiotics was done. Fifteen chicken were allocated in 5 cages (3 birds each) and allowed a free choice diet of various feedstuffs like maize, millet, sorghum, ''omena'', rice germ, sunflower meal and soya bean meal and water provided *ad libitum*. The results indicated that maize grains was the most preferred feed by the growing indigenous chicken (72%) compared to sorghum (1%) intake. The effect of graded levels of multi-strain Molaplus probiotics on performance of indigenous chicken fed the local feedstuffs was then done. One hundred and fifty (150) indigenous Chicken 16 weeks of age were randomly allocated in cages, into 6 groups, each group with 5 replicates (n = 25). The control group received the basal diet formulated. The treatment groups received the same basal diets supplemented with 5ml of molaplus probiotic solution in 250ml, 500ml, 1000ml, 1500ml, and 2000ml drinking water adlibitum for a 7 week trial. The results showed that dietary supplementation with molaplus probiotics significantly increased weight gain. Cummulative body weights were higher for the treatment level with 5ml molaplus poultry probiotics in1000ml of drinking water at the 7th week of treatment than for the other weeks and levels of treatment and control. In conclusion, Supplementing Indigenous Chicken with probiotics in drinking water can significantly improve the weight gains.

Key words: Molaplus poultry microbes; probiotics; indigenous chicken feeding; chicken feed technology; cumulative weight gain

Introduction

Free-range indigenous chicken in rural areas serve as a major source of protein and income to rural farmers in Kenya, but their upkeep is often associated with nutritional limitations; as a result egg and meat outputs for indigenous chickens are generally low compared to those for exotic birds (Gakige *et. al*., 2015). Probiotics are "any feed supplement with live microbials which affect the host animal beneficially by improving the intestinal microbial balance and the use can promote growth in poultry by ensuring a more effective utilization of nutrient intake." (Zhang *et. al.*, 2013). The species currently being used in probiotic preparations are varied and many they include, *Lactobacillus acidophilus, Lactobacillus lactis, Lactobacillus casei, Lactobacillus helveticus, Lactobacillus bulgaricus, Lactobacillus salivarius, Lactobacillus plantarum, Streptococcus thermophilus, Enterococcus faecium, Enterococcus faecalis, Bifidobacterium spp.* and *Escherichia coli* (Khobondo *et. al.,* 2015). In particular, Lactobacillus, Bacillus and Clostridium-based probiotics have been shown to increase the digestibility of nutrients in chicken ((Timmerman *et. al*., 2009). Taking the beneficial effects of probiotics into account, the study aimed at testing the effects of multistrain poultry probiotics and local feed resources available to Indigenous Chicken and their effects on cumulative weight gains in the chicken. Supplementation of 5 ml of molaplus poultry probiotics in 1000 ml of water is recommended in order to maximise beneficial effects in chicken (Molaplus.Com); higher concentrations do not always result in better performance (Khobondo *et. al*., 2015). This study investigated whether feeding graded levels of multi-strain probiotics delivered beneficial effects to indigenous chicken. The hypothesis that supplementing probiotics in drinking water increases weight gain was tested. The product used in the present study was supplied by Molaplus Ltd. Kenya. When used in poultry production, they avail, chelated

minerals, ant-oxidant, enzymes, vitamins, organic acids, lactic bacteria, yeast and phototropic bacteria (Molaplus.com).

Materials and methods

A feeding trial was conducted using one hundred and fifty (150) indigenous chicken sourced at two months old from free range small scale farmers from Kisumu and Baringo counties, Kenya. The trial was done in a randomized complete block design. The birds were randomly allocated the 5 test diets, into 6 groups and each group with 5 replicates (n = 25) per treatment. The dietary treatments and water were offered ad libitum. The molaplus poultry microbes solution was added into drinking water by giving a specific concentration of 5ml of Molaplus microbes solution in different volumes (250, 500, 1000, 1500, 2000 ml) of the respective water once a day at 0900 hours. The Molaplus poultry microbes is a complex solution of various beneficial Micro-organisms which are found naturally and are used in food manufacturing. When used in poultry production, they avail, chelated minerals, anti-oxidant, enzymes, vitamins, organic acids, lactic bacteria, yeast and phototropic bacteria (Molaplus.com). The experimental was done for a period of 60 days. Weight gains of the chicken were monitored by weighing them weekly at 0900 hours before morning feeding. Final weight gain was calculated for seven weeks experimental period to get the best level of concentration of molaplus probiotics solution of microbes that achieved the best weight gain.

Data analysis and Statistical models

Data from the experiment was subjected to Analysis of Variance (ANOVA) using the general linear model (GLM) of SAS software (Statistical Analysis Systems 2002) with the model containing treatment effects on the parameters measured. Differences between treatment means were separated using LSD.

Results and Discussion

Table 1: Nutrient Composition of feed ingredients used in making basal feed for indigenous chicken

	OMENA	MAIZE	RICE	GROWERS	MILET	SORGHUM
CF%	2.2	3.0	8.9	7.3	3.8	3.5
CP%	49.8	10.6	13.7	16.6	11.1	10.7
DM%	92.4	89.8	90.1	90.8	86.3	87.8
EE%	2705	2814	2987	3161	2693	3147
AAµg/ml	74.5	27.3	1.0	1.3	3.6	6.1
AFLATOXINSppb	4.8	11.1	6.2	15.8	3.1	15.2
Intakeg/d	5.2	32.7	1.0	1.0	4.3	0.3
%Intake	11	74	2	2	9	1

CF=crude fibre, CP=Crude protein, DM=Dry Matter, EE=Ether Extract, AA=Amino Acid

Table 1 describes the nutrient composition of major feed substances utilized by farmers in the two counties. The crude protein and energy (Dry Matter) content of the feedstuffs are similar to the conventional ranges of feed ingredient composition. The aflatoxins levels in the feeds were significantly higher than the 10ppb that is recommended conventionally in humans and poultry. Maize was the most preferred feed (72%) while the intake of sorghum was higher in the beginning but reduced later drastically probably because of the tannin content in sorghum; an anti nutritive factor limiting digestion in feeds. The cafeteria intake formular that the chicken gave us in this trial was 72% maize, 12% omena, 11% millet, 2% rice germ and 1% sorghum which was then used to formulate for them a ration for the next experiment. Given that these

are free ranging chicken that are not usually supplemented, it is difficult to know exactly what is the daily nutrient intake per day in free ranging environment, but because the chicken has compensatory feed characteristics, the cafeteria gave us their intake per day.Chicken usually consume just enough food to meet their energy requirements since the control of feed intake is believed to be based primarily on the amount of energy in the diet (Badubi et. al.,2006). Increasing the dietary energy concentration leads to a decrease in feed intake thus affecting growth. Energy requirements in chicken are expressed in terms of metabolizable energy (ME) per day and the dietary requirements for protein are actually requirements for the amino acids contained in the protein. Amino acids obtained from dietary protein are used by the chicken to fulfil a diversity of functions such as growth, meat or egg production. Protein is a key nutrient and its deficiency in a feed reduces growth (Kingori et. al.,2010). Khobondo (2015) reported that protein deficiency in a feed reduced growth rates in broilers as a consequence of depressed appetite and intake of nutrients. Age is an important factor that contributes to a bird's response to nutrient composition of a diet. In fact, muscular protein deposition decreases as the bird advances to maturity but indigenous chicken are known to be slow growing with a low carcass weight (Okeno et. al., 2012). Protein efficiency is better at the lower level of dietary protein on indigenous Chicken. If dietary protein is inadequate, there is a reduction or cessation of growth or productivity and a withdrawal of protein from less vital body tissues to maintain the functions of more vital tissues. As such, protein requirements considerably vary according to the physiological status of the indigenous chicken, such as the rate of growth or egg production. Other factors contributing to variations in protein requirements of the chickens include sex, age, breed and body size. Matching the feed protein levels with animal protein requirements is crucial for maximizing animal performance (Gakige et. al., 2015). For optimum production, protein and energy supplementation has to be provided since they are limiting under the free range system. Olwande et. al. (2010) reported that a dietary protein level of 13 % was adequate for indigenous chicken aged between 14 and 21 weeks while King'ori et al. (2010) observed that indigenous chicken require a protein level of 16 % to optimize feed intake and growth between 14 and 21 weeks of age. Furthermore, Islam et. al. (2014) reported that indigenous chicken supplemented and fed diets containing 17 to 23 % CP had similar feed intakes and growth rates, suggesting that a 17 % CP diet was sufficient for chicken. The increase in protein requirement could be due to difference in production system practiced and technological improvements with time in rearing.

Table 2: Cumulative weight gain means for indigenous chicken fed on *molaplus* poultry microbes for a period of 7 weeks

Molaplus probiotics (ml)	0	250	500	1000	1500	2000
Weight gain (g)						
Week1	40±0.02^{a}	100±0.02^{b}	120±0.02^{b}	50±0.02^{a}	40±0.02^{a}	30±0.02^{a}
Week2	90±0.02^{a}	280±0.02^{b}	240±0.02^{b}	230±0.03^{b}	180±0.02^{b}	120±0.02^{a}
Week3	190±0.03^{a}	320±0.03^{b}	260±0.02^{a}	270±0.03^{a}	210±0.03^{a}	150±0.03^{a}
Week4	200±0.03^{a}	420±0.03^{b}	360±0.03^{b}	290±0.03^{a}	300±0.03^{b}	200±0.03^{a}
Week5	210±0.03^{a}	450±0.03^{b}	370±0.03^{b}	300±0.04^{a}	330±0.03^{b}	220±0.03^{a}
Week6	220±0.04^{a}	540±0.04^{b}	440±0.04^{b}	380±0.05^{a}	460±0.04^{b}	250±0.04^{a}
Week7	230±0.04^{a}	460±0.04^{bc}	360±0.03^{b}	580±0.04^{c}	440±0.04^{c}	260±0.04^{ab}

Means with different superscripts within rows are significantly different ($p<0.05$); Mean±SE

Table 2 presents the growth performance and feed efficiency of scavenging indigenous chicken given of chicken supplemented with varying levels of molaplus poultry microbes. Body weight gains were higher for chicken supplemented with molaplus probiotics compared to those on control. Weight gains were highest (580g) in chicken supplemented with 5ml of Molaplus poultry microbes solution in 1000ml drinking water at 7weeks compared to the rest of the treatment levels. The result shows that treatment of 5ml/1000ml molaplus poultry at week 7 had the best peak weights as compared to the control (0ml) at significant level of ($p<0.05$). There was a higher significant weight gains in week 1 between the treatment levels of 250ml and 500ml and the control, 1000ml, 1500ml, 2000ml. It is clearly evident that the live weight gains were significantly higher in experimental birds as compared to control ones at all levels during the

period of 8weeks of trial. Studies on the beneficial impact of probiotics on IC performance have indicated that probiotic supplementation had positive effects. According to Tatjana et. al (2005) the use of probiotics in farm animals results in faster weight gain for the same amount of food consumed. In this study the body weights of probiotics adminstered chicken were significantly increased ($p<0.05$) at treatment with 5ml in 1000ml drinking water in week 7 in comparison with those of chicken on control. The effect of probiotics started after two weeks of treatment. At 3rd week, the probiotics supplementation showed significant increase in the body weight compared with the control group, at the same age, there were significant differences among the five probiotics treatment groups, with group of level 5ml/1000ml having the significantly higher body weights than the other levels of treatment as well as control group. This positive effect of probiotics on body weight persisted until 7th weeks of trial. The differences in the body weight became greater towards the end of the trial period. On 6th week, the three levels (5ml/250ml,500ml and 1500ml) of probiotics groups showed significant increase in the body weight compared with the 5ml/1000ml and 2000ml group as well as the control group. The birds fed on probiotic level 5ml/1000ml exhibited higher body weights among groups at all times of this trial. In a similar study, Timmerman *et. al.* (2006) reported that the administration of probiotics via the drinking water had beneficial effects on broiler performance. Moreover, the birds fed on probiotic level of 5ml/1000ml water showed best cummulative weight gain than the other levels of probiotics as well as control group. This finding is in agreement with Alkhalf et. al. (2010) who demonstrated that probiotic supplemented to the chicken improve the body weight and daily weight gain. However, inconsistent effects of probiotics are also reported, which are likely influenced by administration dose, diet composition and the probiotic strains. Multi-strain probiotics when used may be more effective than single-strain probiotics (Zhang *et. al.*,2013). These results are also in agreement with Kabir (2009) who demonstrated increased live weight gain in probiotic fed chicken. Huang *et. al.* (2004) reported that higher inclusion levels did not always result in better performance in chicken.

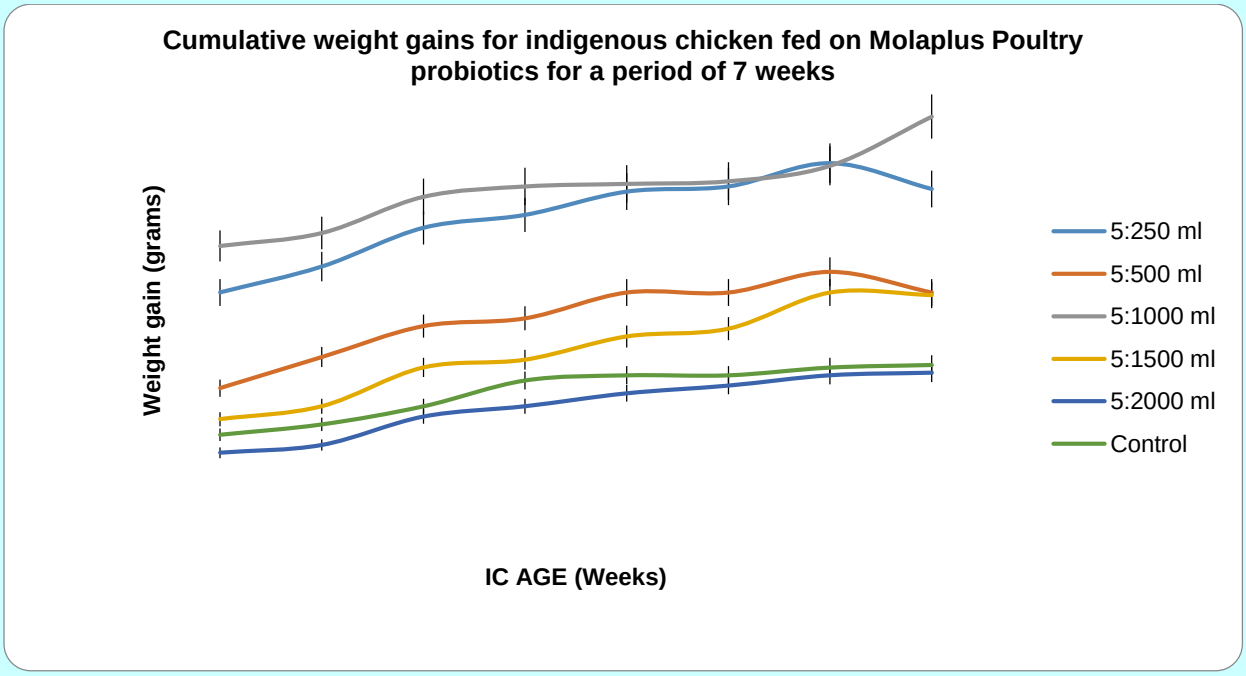

Figure 1: Cumulative weight gains for indigenous chicken fed on Molaplus poultry microbes

Conclusion

Supplementing Indigenous Chicken with probiotics in drinking water can significantly improve the weight gains.

Recommendation

Supplementation of local feeds with molaplus poultry microbes at the concentration of 5ml in 1000ml in the IC drinking water could improve body weight gains in indigenous chicken.

Acknowledgements

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References

Alkhalf, A., Alhaj, M., & Al-homidan I. (2010). Influence of probiotic supplementation on blood parameters and growth performance in broiler chickens. Saudi Journal of Biological Sciences, 17(3), 219–225.

Alloui, M., Szczurek, W. & Świątkiewicz, S. (2013). The Usefulness of Prebiotics and Probiotics in Modern Poultry Nutrition: a Review / Przydatność prebiotyków i probiotyków w nowoczesnym żywieniu drobiu – przegląd. Annals of Animal Science, 13(1), pp. 17-32.

Badubi, S. S., Rakereng, M., &Marumo, M. (2006). Morphological characteristics and feed resources available for indigenous chickens in Botswana. Livest. Res. Rural Dev, 18(1).

Gakige J K, King'ori A M, Bebe B O and Kahi A K 2015: Effects of targeted phase supplementary feeding on gut morphology of scavenging ecotypes of indigenous chickens in Kenya. *Livestock Research for Rural Development. Volume 27, Article #193.*

Islam, R., Kalita, N., & Nath, P. (2014). Comparative performance of Vanaraja and Indigenous chicken under backyard system of rearing. Journal of Poultry Science and Technology, 2(1), 22-25.

J O Khobondo, T K Muasya, S Miyumo, T O Okeno2, C B Wasike, R Mwakubambanya, A M Kingori and A K Kahi (2015) Genetic and nutrition development of indigenous chicken in Africa. Livestock Research for Rural Development Volume 27 (7) 2015.

Khobondo J O, Ogore P B, Atela J A, Onjoro P S, Ondiek J O and Kahi A K 2015: The effects of dietary probiotics on natural IgM antibody titres of Kenyan indigenous chicken. *Livestock Research for Rural Development. Volume 27, Article #230.*

Okeno, T. O., Kahi, A. K., & Peters, K. J. (2012). Characterization of indigenous chicken production systems in Kenya. Tropical animal health and production, 44(3), 601-608.

Olwande, P.O., Ogara, W.O., Okuthe, S.O., Muchemi, G., Okoth, E., Odindo, M.O. and Adhiambo, R.F. (2010) Assessing the productivity of indigenous chickens in an extensive management system in Southern Nyanza, Kenya. Tropical Animal Health and Production. 42, 283-288.

Timmerman, H. M., Veldman, A., Van den Elsen, E., Rombouts, F. M., & Beynen, A. C. (2006). Mortality and growth performance of broilers given drinking water supplemented with chicken-specific probiotics. Poultry Science, 85(8), 1383-1388.

Zhang, AW; Lee, BD; Lee, SK; Lee, KW; An, GH; Song, KB; Lee, CH.(2005). Effects of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality, and ileal mucosa development of broiler chicks. *Poult. Sci*, *84*, 1015–1021.

Kingori, A. M., Wachira, A. M., & Tuitoek, J. K. (2010). Indigenous chicken production in Kenya: a review. International Journal of Poultry Science.

SAS, SAS User's Guide Statistics. (2002) SAS Institute, Inc., Cary, NC., USA.

A look into future of Friesian cattle utilization in smallholder systems in Kenya highlands: Application of climate analogue concept

Wangui J.C., Ondiek J.O. Oseni, S.O., Bebe B.O.

Animal Nutrition Group, Department of Animal Sciences, Egerton University, P. O. Box 536, 20115 Egerton, Kenya

Abstract

The study applied climate analogue concept to identify spatialanalogue sites to Njoro in 2050's in Kenya. Shawa area in Nakuru County andGituamba area in Laikipia County had 100% occurrence in all runs and consistently had similarity indexes of 0.8-0.9 and 0.7-0.8 respectively, therefore, selected as the likely climate analogue sites to Njoro in 2050's. Analysis of variance using GLM procedure of SAS (2008) indicated significant difference (*p=0.0001*) in all climatic variables for Njoro and its future climate analogue sites in 2050's. Time series using regression analysis indicated a positive trend in mean monthly minimum temperature; FA1 (0.07 ^{O}C, R^2= 0.806) andNjoro (0.02 ^{O}C, R^2= 0.294), mean monthly maximum temperaturesNjoro (0.03 ^{O}C, R^2= 0.301) and FA1 (0.02 ^{O}C, R^2= 0.070) resulting to an increasing mean monthly temperatures. All sites had a positive trend for annual rainfall; Njoro (3.30 mm, R^2= 0.044), FA2 (2.32 mm, R^2= 0.023) FA1 (1.00 mm, R^2= 0.005) and OND season and a negative trend for MAM season. Rainfall trend was however contrary to modelled prediction. From the results there is a need to study the magnitude to which projected changes in climatic variables will affect Friesian cattle breed and smallholder farmers utilizing the breed.

Key words: Climate change, analogue sites, rainfall and temperature trends

Introduction

Kenya has the most robust dairy industry in Sub Saharan Africa withmore than70% of dairy cattle population in East and South Africa(Thorpe *et al*., 2000). The industry contributes significantly to the economy providing about 30% and 4% to livestock and national GDP respectively(FAO, 2011), as well as offering livelihoods to over 1.5 million Kenyans along the dairy value chain(Ngeno*et al.,* 2013). Smallholderfarmersdominate the industry, owning over 80% of the more than 3.5 million dairy cattle and supply over 70% of the marketed milk(FAO, 2011; Mawa *et al.*, 2014). Notably, over 80% of dairy cattle and consequently highest population of smallholder farmers are in central and rift valley highlands (Bebe*et al.*, 2003; Export Processing Zones Authority, 2005; Mawa *et al.*, 2014). Perhaps, this may have been imputed by availability of dairy cattle initial stock left by white settlers, suitable climatic conditions for dairying, favorable government policies, institutional support, land subdivision, proximity to urban areas and growing demand for dairy products(Thurston, 1987; Thorpe *et al*., 2000; Ngigi, 2004). Dairy cattleutilized in the system are exotic breeds (Friesian, Ayrshire, Guernsey and jerseys) and their crosses with local zebu, with highest preference for Friesian cattle(Bebe *et al*., 2003; FAO, 2011; Omondi & Njehia, 2014). Preference for the breed is associated with its high milk yield, unselective feeding in confined systems and large body translating to higher salvage value(Bebe *et al*, 2003). Although, the breed has the perceived benefits, its utilization remains contentious owing to pitiable management in smallholder system, high cost of inputs and threats posed by changing climate.Significantly, climate change effects are emerging as new multifaceted threat to sustainable utilization of the breed and therefore livelihood of millions of Kenyans reliant on it along the dairy value chain. Numerous studies have been carried out focusing on strategies to enhance profitable utilization of the breed in smallholder systems in Kenya, but little has been done on sustainable utilization of the breedin future with climate change threats.

IPCC (2012), defines climate change asthe identifiable changes in the mean state of climate propertiespersisting over decades due to natural and anthropogenic activities. Notable changes in climate in Kenya are increase in ambient temperatures and variation in rainfall properties. These changes are to

worsen in future, affectingpervasively on smallholder production systems utilizing exotic genotypes that are poorly adapted to the tropics.Compared to naturalised and indigenous breed, Friesian cattle has been shown to be least adapted and highly vulnerable to effects of climate change in the tropics (Beatty *et al.,* 2006; Mcmanus *et al.,* 2009; McManus *et al.*, 2011). The breed will be affected directly through thermal load and indirectly through water scarcity, dietary changes and increased pressure of diseases and parasites(Ngeno *et al*., 2014). This will translate to reduced production, increase in infertility and susceptibility to diseases which will require higher level of inputs, which are already a constraint in smallholder farmers. There is therefore a need to understand the future climatic conditions the breed will experience and the associated challenges smallholder farmers keeping the breed will face.Such knowledge will be useful in guiding adaptation options applicable and beneficial in small holder dairy production systems ensuring sustainable utilization of the breed with climate change threats.

Climate analogue tool developed by Consultative Group on International Agricultural Research (CGAIR) program on Climate Change Agriculture and Food Security (CCAFS) offers such aplatform. The toolhelps connect modelled predictionsto areas they already exist globally by generating similarity indices. A similarity index, indicates the likelihood of identified site to be analogous to reference site based on climatic parameter and climate scenarios applied. Ramírez-Villegas *et al.* (2011), defines climate scenario as a combination of prediction target year, SRES emission scenario and Global Climate Models. The analogue sites can either be areas presently sharing climatic conditions with reference site or experiencing future climatic conditions for the reference site (CGAIR, 2011; Ramírez-Villegas *et al.,* 2011).

Objective of this study, therefore, was to apply climate analogue concept to identify potential climate analogue sites to Njoro in 2050's in Kenya anddetermine theirclimatic differences.This will help assess the likely climatic challengesthe breed and smallholder farmers reliant on it will experience in the 2050's.

Materials and methods

Study area

The study was carried out in Njoro in the Rift valley highlands of Kenya, selected for its high population of smallholder farmers utilizing Friesian cattle breed. Njoro lies between latitude 00° 19' 00" Sand longitudes 36° 06' 00" E. It islocated in Low Highlands (LH3) and Upper midlands (UM4) ecological zones and has an altitude of 2168 M to 2800 M above sea level. The area receives a bimodal rainfall, with long rains in March to June and short rains in October to November. Annual rainfall ranges between 1000 mm to 700 mm in the upper and lower ecological zones respectively. Generally, the area is cool and wet with mean minima temperatures of 10.5^{o} C and maxima of 25.5^{o} C, which is suitable formixed crop- livestock farming (MoALF, 2013).

Calculation of climate analogue sites to Njoro in 2050's

Njoro ward has the highest population of smallholder farmers utilizing Friesian cattle in Njoro Sub County. Through consultation with sub county department of livestock and fisheries officers, a sitehaving highest concentration of smallholder farms was identifiedand coordinates (Latitude -0.382, Longitudes 35.937) recorded. Using the coordinates, climate analogue tool online platform, available at http://www.ccafs-analogues.org/tool/ (CGAIR, 2011), was used to calculate the analogues. Backward time direction was applied with GCMs ensemble option and SRES A1B emission scenario to calculate future analogue sites. Climate variables of interest were mean monthly temperatures and total monthly rainfall, which were ran separately and combined. When combined a weight of 0.5 was given to each variable to ensure equal contribution in analogues calculations.Todetermine effects of seasonality, rotations (none, monthly mean temperature, monthly rainfall and both) applicable were applied. For all runs, default site resolution of 30 arc seconds was maintained. Minimum threshold of similarity index was set at 0.5, but only sites withmore than 0.7 were selected for further consideration. For seasonal similarity, a nine month growing period from March to November was assumed as a replica to Njoro. Outputs from the runs with respective rotations were eight TIFF file formats. Using ArcGIS (ArcMap 10.3) software, the images were processed to enable reclassification of similarity indexes based on pixel density. Classes of 0.1 were used with 0.5 set as the

minimumclass in the legend. Kenya divisions shape file as at 1998, was overlaid on each processed image and used to identify sites and their respective similarity indexes. Only sites whose polygon had more than 75% uniformity for a given similarity index were considered.

Climatic data for Njoro and its 2050's climate analogue sites

Three sites for each class of similarity index (0.7- 0.8, 0.8-0.9and 0.9- 0.99)were selected (Table 1), with preference to those closest to reference site(Ramirez-Villegas *et al*., 2011), Njoro. For each class of similarity index, the site with highest percentage of occurrence was considered as the most likely analogue site to Njoro in 2050's. The sites were denoted as FA1 and FA2 for similarity index classes (0.8<) and (0.7- 0.8) respectively. Climatic data; mean monthly temperatures (minimum, mean and maximum), daily monthly rainfall for Njoro, FA1 and FA2 sites were sourced from Meteorological stations within the sites.

Statistical analysis

Sites frequenciesfor all the runs were used to calculate their percentage occurrences. To determine the mean differences in climatic variables forNjoro and its climate analogue sites in 2050's (FA1 and FA2), a model of variance with General Linear Model (GLM) procedure of SAS (2008) was used, with the model.

$$Y_{ij} = S_i + E_{ij}$$

Where, Y_{ij} is climatic variables, S_i is the fixed effect of sites and E_{ij} is the random error component associated with Y_{ij}. The same model was fitted in regression analysis to determine trends of each climate variable over time.

Results and discussion

Results for all climate variables (mean monthly temperatures and total monthly rainfall) runs, with respective rotations (temperatures, rainfall, none and both) showed potential climate analogues sites to Njoro in 2050's in Kenya. This agrees with CGAIR (2011), that about 70% of climatic conditions existing today, have been, are, or will be experienced elsewhere in the world.

Climate analogue sites to Njoro in 2050's based on total monthly rainfall

Total monthly rainfall with none rotation run (Figure 1) produced thehighest number of analogue sites having similarity index 0.5 ≤, with more than 80% of Kenya being analogue to Njoro in 2050's. This can be explained by the general similarity of bimodal rainfall,with long rains in March to May (MAM) and short rains in October to December (OND) in the country (King'uyu *et al*., 2009; Mcsweeney *et al*., 2010;Huho *et al*., 2012; ATPS, 2013; Huho & Kosonei, 2013; Musau *et al*., 2015). The sites ranged from the low altitude areas in the coastal region and arid and semi-arid (ASALs) areas to high altitude areas in the highlands. Indication that altitude, topography and vegetation cover did not influence calculation of Njoro's future in 2050's with this run. On the other hand, application of rainfall rotation in the run (Figure 2), eliminated ASALs restricting sites to highlands and coastal areas. However, sites with 0.8< similarity index were located in rift valley and western Kenya highlands. Rainfall rotation, therefore, eliminated seasonality effects (Ramirez-Villegas *et al.,* 2011) producing only sites with rainfall properties to Njoro in 2050's. Inter Tropical Convergence Zone (ITCZ) migration influence Kenya rainfall properties at macro level, with landscape characteristics and proximity of an area to large water bodies having a greater influence at micro level(Herrero *et al*., 2010; Washington & Pearce, 2012; Daron, 2014).

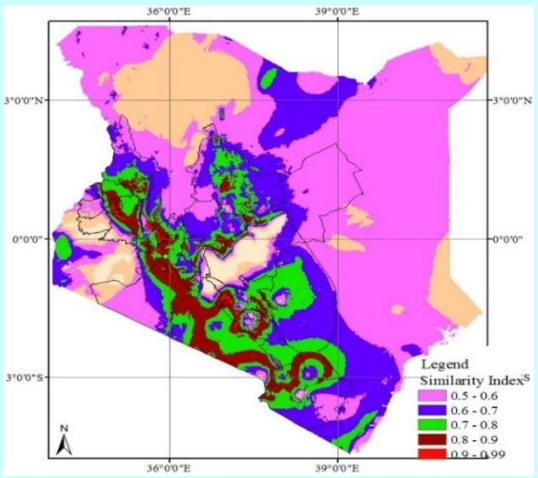

Figure 7: Analogues sites to Njoro in 2050's based on mean monthly rainfall with None rotation

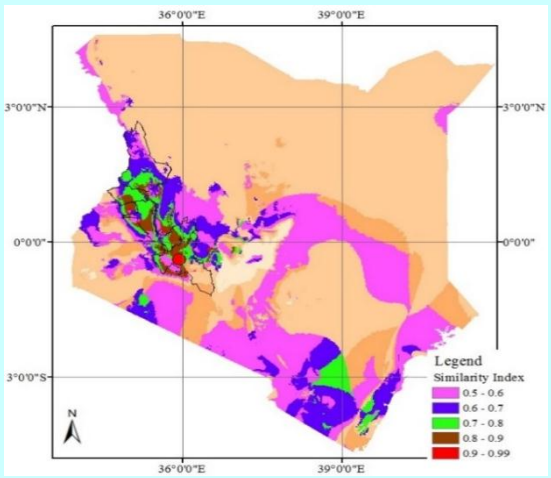

Figure 8: Analogues sites to Njoro in 2050's based on mean monthly rainfall with rainfall rotation

Climate analogue sites to Njoro in 2050's based on mean monthly temperatures

Mean monthly temperaturesshowed more restricted analogues sites to Njoro in 2050's unlike total monthly rainfall runs. Mean monthly Temperatures with none rotation (Figure 3) produced areas in central UasinNgishu and isolated highland areas in Narok and Nakuru counties as having highest similarities index (0.8 <). These areas share seasonal temperature fluctuations and variability with Njoro due to similarity in topography and altitudes. However, application of temperature rotations (Figure 4), shifted similarity indexes and analogue sites. Similarity index for Uasin Gishu and Narok sites decreased to 0.7 – 0.8, while isolated areas in eastern part of Nakuru county had similarity index of 0.8 -0.9 and isolated areas on the leeward side of Mount Kenya in Laikipia county had the highest similarity index of 0.9 -0.99. Temperature rotations, restricted climate analogue sites to upper midland areas which experience higher temperatures to Njoro presently. Rongai in the eastern part of Nakuru county have been reported to experience annual temperature ranges of 25 ^{o}C to 37 ^{o}C (Ngeno*et al.*, 2014) and Nanyuki in Laikipia county 22 ^{o}C to 26 ^{o}C (Glopp, 2007) which are comparably high to Njoro presently with 10 ^{o}C to 25 ^{o}C (MoALF, 2013). Uniquely, mean monthly temperatures runs did not produce Njoro as its own future analogue site in 2050's indicating, temperatures experienced presently in Njoro will likely shift by 2050's (CGAIR, 2011; Ramírez-Villegas *et al.*, 2011).

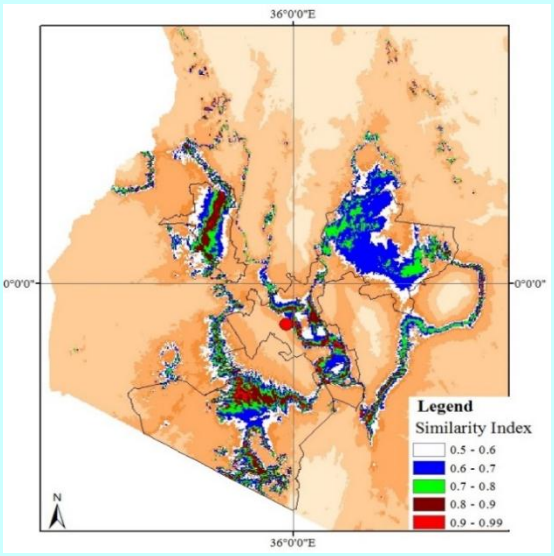

Figure 9: Analogues sites to Njoro in 2050's based on mean monthly Temperatures with none rotation

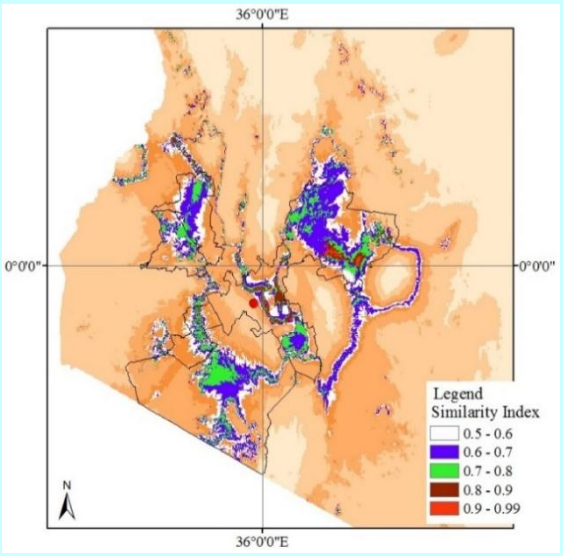

Figure 10: Analogues sites to Njoro in 2050's based on mean monthly Temperatures with temperatures rotation

Climate analogue sites to Njoro in 2050's based on total monthly rainfall and mean monthlytemperatures combined

Climate form the basic and most important physical factor affecting biota. Importantly, in livestock, climate parameters; rainfall and temperatures, influence animal's bioclimatology, forage and water availability and diseases and parasites prevalence (ATPS, 2013; Rotter and Van De Geijn, 1999). Combining rainfall and temperature in a study is therefore more informative than considering individual climate variables (CGAIR, 2011; Ramírez-Villegas *et al.,* 2011).

Runs using total monthly rainfall and mean monthly temperatures combined at equal weights (0.5 each) with all rotations, produced climate analogue sites to Njoro in 2050's that were greatly influenced by temperatures, deviating only on similarity indexes. Ramírez-Villegas *et al.* (2011) also observed a similar trend and noted that, rainfall was only sensitive when given a weighting of over 80%. This may be due to high rainfall variability between seasons, years and decades increasing its prediction uncertainty compared to temperatures. The variability have been attributed to ITCZ migration which is sensitive to Indian Ocean surface temperatures and vary year to year affecting rainfall onsets, amount, distribution and cessation (McSweeney *et al.,* 2010). Application of none (Figure 5) and both (Figure 6) rotations agreed on all sites, producing almost similar images. The two rotations agreed on areas in central UasinNgishu, isolated highland areas east and south of Nakuru and east of Narok highlands as having highest similarity index (0.8- 0.9) to Njoro in 2050's. Other areas included, few spots at the foot of Mt Elgon in Trans Nzoiacounty and others south of West Pokot county.

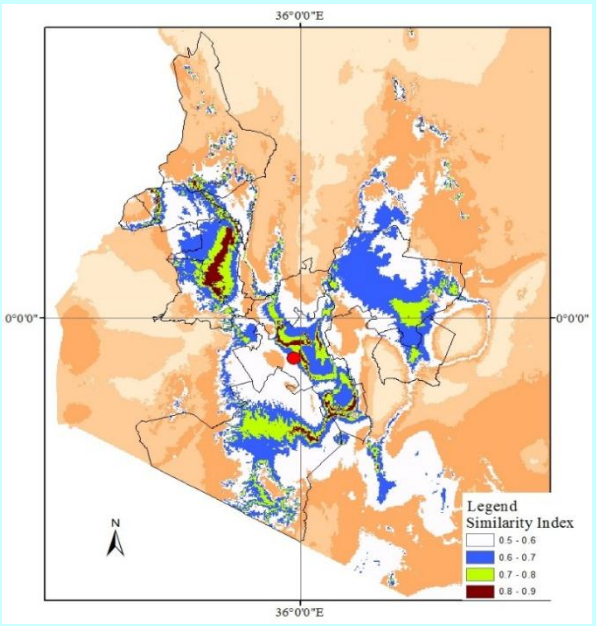

Figure 11: Analogues sites to Njoro in 2050's based on mean monthly Temperatures and total monthly rainfall with none rotation

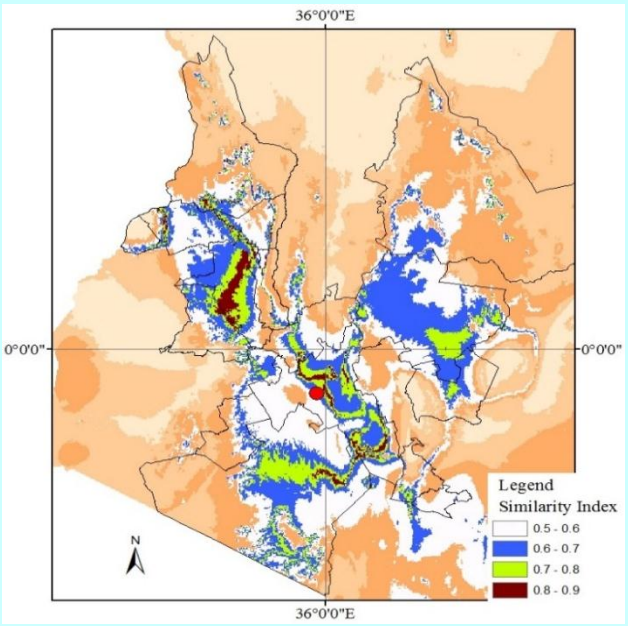

Figure 12: Analogues sites to Njoro in 2050's based on mean monthly Temperatures and total monthly rainfall with both rainfall and temperatures rotation combined

Like with mean monthly temperature runs, application of temperature rotations in total monthly rainfall and mean monthly temperature combined runs (Figure 7), produced the fewest climate analogue sites with highest similarity index (0.8 <). The sites were restricted in the Eastern part of Nakuru County with a few spots at the foot of Mt Elgon in Trans NzoiaCounty and a few south of West PokotCounty.Rainfall rotations (Figure 8) produced similar sites as with none and both rotation but lowered similarity indexes in the south of Nakuruto 0.5- 0.6, east of Narok highlands to 0.5 -0.7 and at the foot of Mt Elgon in Trans Nzoia county to 0.5- 0.6.

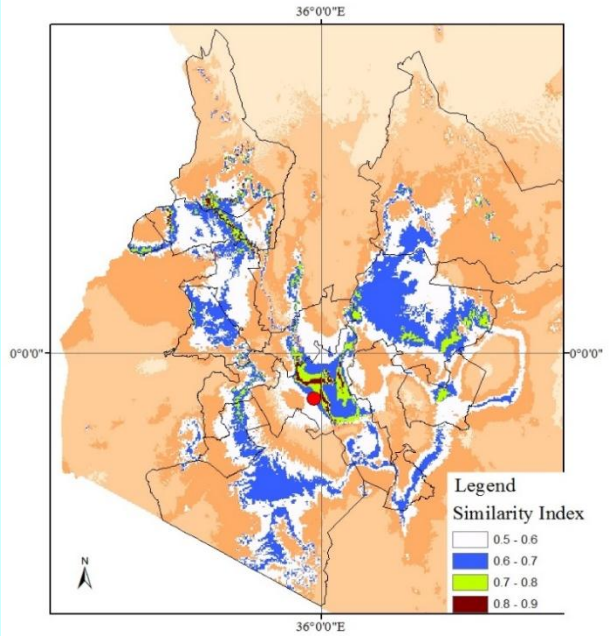

Figure 13: Analogues sites to Njoro in 2050's based on mean monthly Temperatures and total monthly rainfall with temperatures rotation

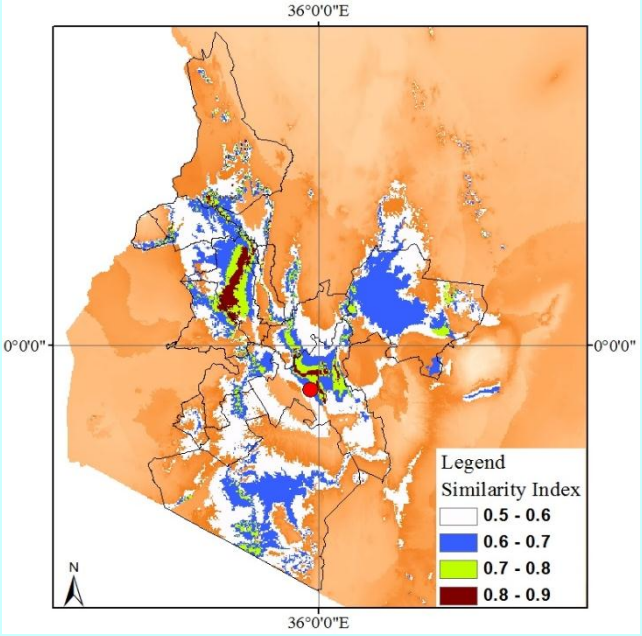

Figure 14: Analogues sites to Njoro in 2050's based on mean monthly Temperatures and total monthly rainfall with Rainfall rotation

Determining the most likely spatial climate analogue site to Njoro in 2050's

Climate analogue sites to Njoro in 2050's varied with climatic variables and rotations applied. Three sites consistent for a given similarity index,in all runs were selected and their percentage occurrence calculated from their frequencies. Selection was based on sites whose polygon had more than 75% of single pixel coverage and had more than 25% occurrences in all runs for a specific class of similarity index (Table 1). Shawa area in Nakuru county with a similarity index of 0.8- 0.9 and Gituamba in Laikipia county with a similarity index of 0.7- 0.8 were the most likely future climate analogue sites to Njoro in 2050's. The two sites were denoted as FA1 and FA2 respectively to represent the likely future climatic conditions for Njoro in 2050's at two levels of probabilities deduced from their similarity indexes.

Table 16: Percentage occurrences for climate analogue sites to Njoro in 2050's in all eight runs using climatic variables mean monthly rainfall and temperatures and respective applicable rotations (None, Temperatures, Rainfall and Both temperatures and rainfall)

		Climatic parameters and rotation									
		Temperature		Rainfall		Rainfall and Temperatures					
Similarity index	Site	**N**	T	N	R	N	T	R	B	Freq	% Occurrence
0.90-0.99	Elburgon	0	0	1	1	0	0	0	0	2	25
	Kapseret	0	0	1	1	0	0	0	0	2	25
	Soy	0	0	1	1	0	0	0	0	2	25
0.80-0.90	Shawa	1	1	1	1	1	1	1	1	8	100
	Ngeria	1	0	1	1	1	0	1	1	6	75
	Moiben	0	0	1	1	1	0	0	1	4	50
0.70-0.80	Gituamba	1	1	1	1	1	1	1	1	8	100
	Lare	0	0	1	1	1	1	0	1	5	62.5
	Rongai	0	0	1	1	1	1	1	1	6	75

Where N is none rotation, T is temperature rotation, R is rainfall rotation and B is both temperature and rainfall combined rotation

Comparing long term climate variables for Njoro, FA1 and FA2

Available long term data of total monthly rainfall and mean monthly temperatures (Maximum, minimum and mean) used were obtained from government institutions and individual farm.Rainfall and temperatures data for Njoro was obtained from Egerton University for 71 and 30 years respectively up to 2015. Rainfall data for FA1 was obtained from Gogar farm in Rongaifor 74 years up to 2015 and temperatures data from Kenya meteorological department for 29 years up to 2014. Data for FA2 was obtained from Water Resources Management Authority (WRMA) in Rumuruti for 51 and eight years for rainfall and temperatures respectively up to 2015. WRMA and Gogar farm were used as the best closest metrological observation sites to the study sites due to lack of such infrastructures in the study areas.

Analysis of variance using GLM of SAS 2008 was used for analysis. Njoro differed significantly (*p=0.0001)* for all climatic variables with FAI and FA2(Table 2),indicating, climatic conditions for Njoro will likely shift in future. Although the two future analogue sites to Njoro in 2050's vary in projected level of change in climatic variables, both agree on increasing temperaturesand declining rainfall for Njoro in 2050's. Increasing temperature have also been observed in other studies within the region (Gichangi*et al.*, 2015; Musau*et al.*, 2015; IPCC, 2014; Daron, 2014; Washington & Pearce, 2012). However, rainfall projections in Kenya show mixed signals, with some studies reporting an increasing trend (Mcsweeney*et al.*, 2010), decreasing trend (Ngeno*et al,* 2014) and others not reporting lack of a discernable trend (Gichangi*et al.*, 2015; UNDP, 2012; Washington & Pearce, 2012).

Table 17: Climatic variables for Njoro and its future climate analogue sites FA1 and FA2

Climatic variable	Site		
	Njoro	FA1	FA2
Mean Monthly rainfall	86.27	80.27 (-6.00)	61.46 (-14.81)
Standard error	2.143	2.114	2.538
Mean monthly Minimum temperatures	10.22	11.52 (+1.30)	20.63 (+10.41)
Standard error	0.162	0.167	0.300
Mean monthly Maximum temperatures	23.33	25.44 (+2.11)	25.23 (+1.90)
Standard error	0.196	0.202	0.363
Mean monthly temperatures	16.79	18.49 (+1.70)	23.22 (+6.43)
Standard error	0.124	0.128	0.230
Significance	*P=0.0001*	*P=0.0001*	*P=0.0001*

Values in parenthesis indicates differences in climate variables between respective future climate analogue sites and Njoro

FA1 gives climatic properties synonymous with those experienced on transition zone between the wet low highlands and hot low lands. FA2 on the other hand gives climatic conditions with temperatures influenced by lowlands and rainfalls characteristics of the low midlands. FA2 variations were notably high and can be explained by use of data sets from Rumuruti. Though adjacent toGituamba, they differ in altitude which influences their climatic properties. Gituamba is on a transition altitude between Nyandarua highlands and Laikipia low midlands, the later where Rumuruti is located. The two areas, therefore,may likely differ in climatic properties.

Trends in climatic variables for Njoro and its future analogue sites FA1 and FA2

Unlike the modelled projections for Njoro in 2050's. Observation data indicates an increasing trend for both rainfall and temperatures. Njoro had the highest annual rainfall increase since 1964(3.30 mm, R^2= 0.044), FA2 (2.32 mm, R^2= 0.023) while FA1 had the lowest increase (1.00 mm, R^2= 0.005) as shown in Figure 9.

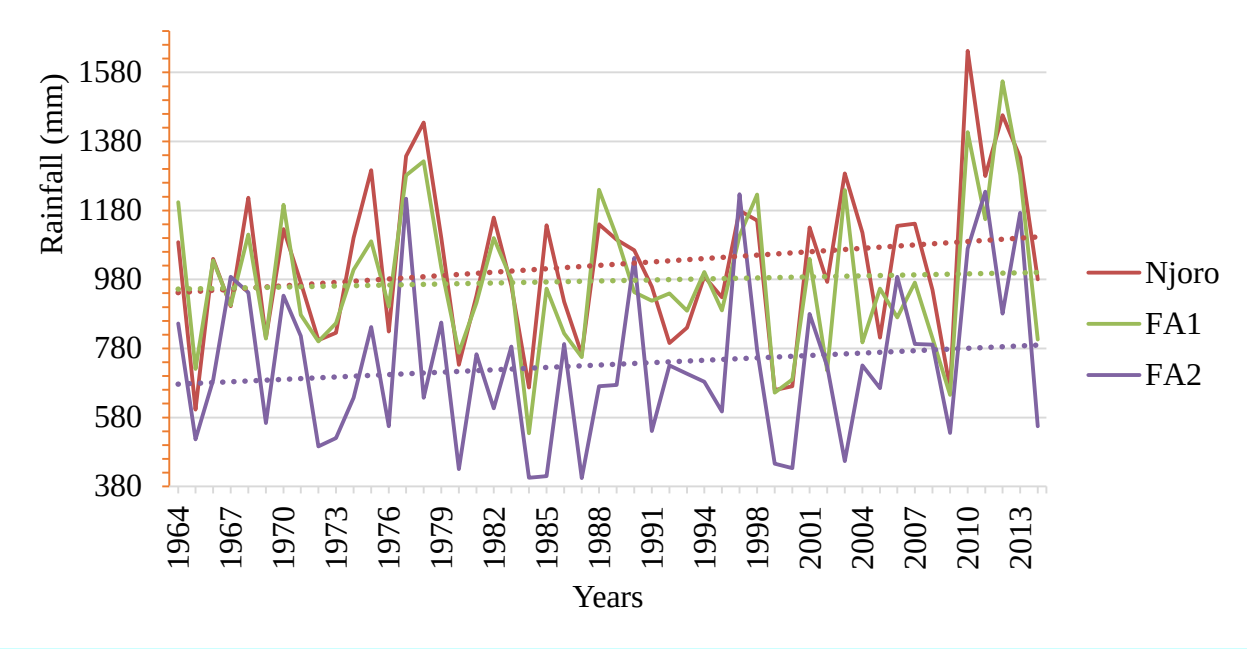

Figure 15: Total Annual Rainfall trend for Njoro, FA1 and FA2

The increase is however observed to be higher in the October- November- December (OND) short rains season (Fig. 10). FA2 had the highest increase (2.39 mm, R^2= 0.086), Njoro (2.03 mm, R^2= 0.099) while FA1 had the lowest (0.95 mm, R^2= 0.021).

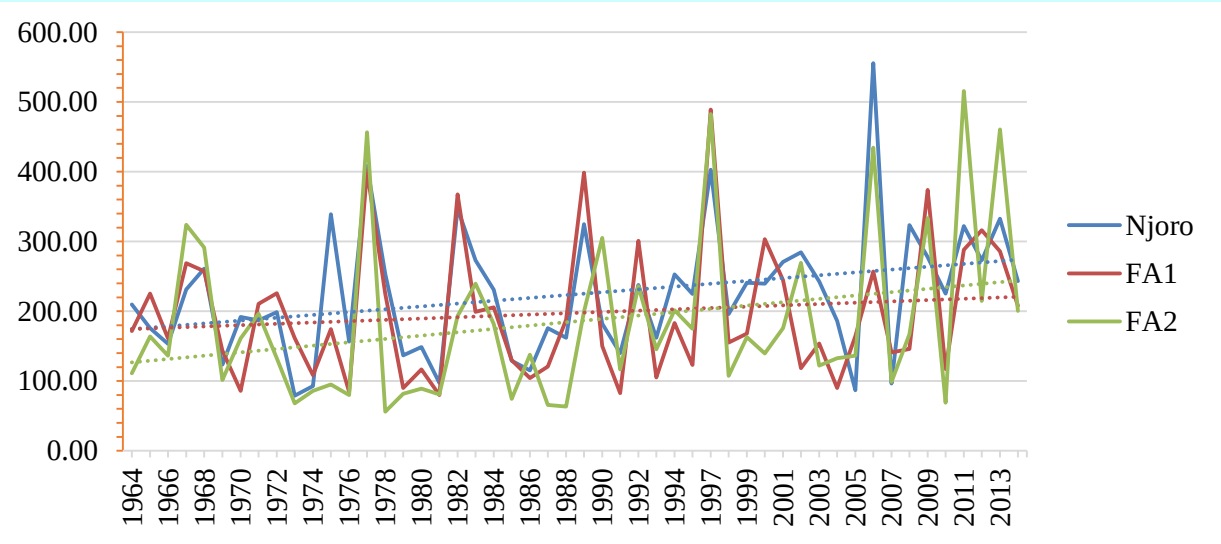

Figure 16: Total OND Rainfall for Njoro, FA1 and FA2

On the contrary, rainfall trend for March- April- May season showed a declining trend for all sites (Fig. 11). Njoro had the highest seasonal decrease (-0.40 mm, R^2= 0.002), FA2 (-0.27 mm, R^2= 0.001) while FA1 (-0.17 mm, R^2= 0.001).

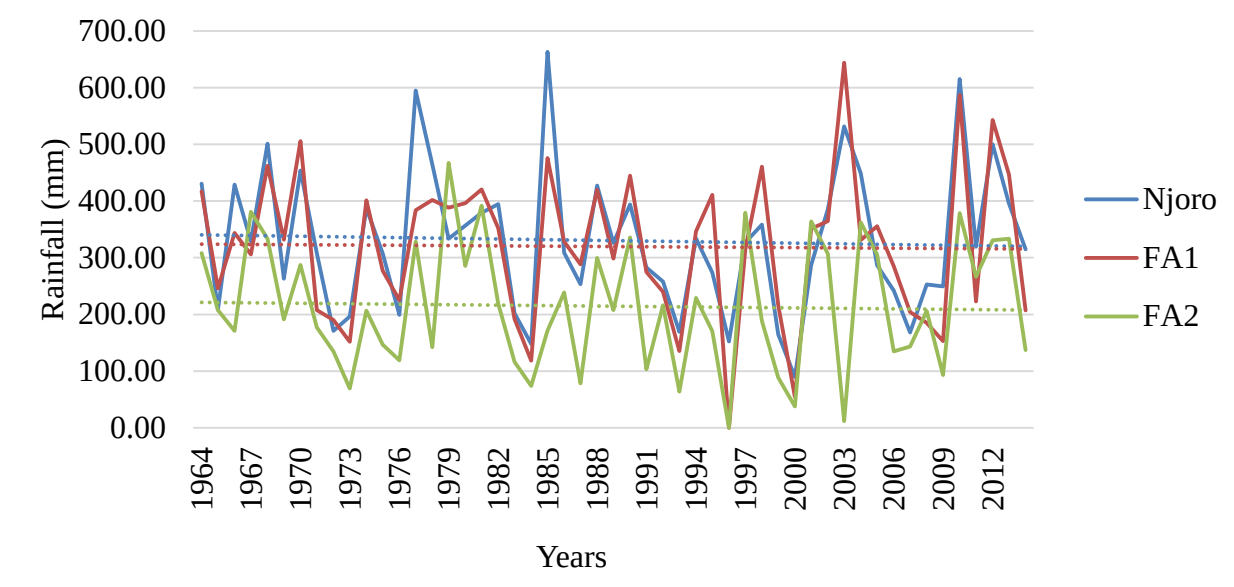

Figure 17: Total MAM rainfall trend for Njoro, FA1 and FA2

Determining climatic trends in climate change studies requires use of climatological standard normals for considered climate elements (World Meteological Organisation, 2007). The standard normals are averages of climatological data for consecutive periods of 30 years (WMO, 2007). Using this definition, FA2 tempearure elements were not considered due to limitingavailable dataset(eight years).Temperature time series for Njoro and FA1 agreed with modeled predictions (Table 2) of an increasing trend (Fig. 13).

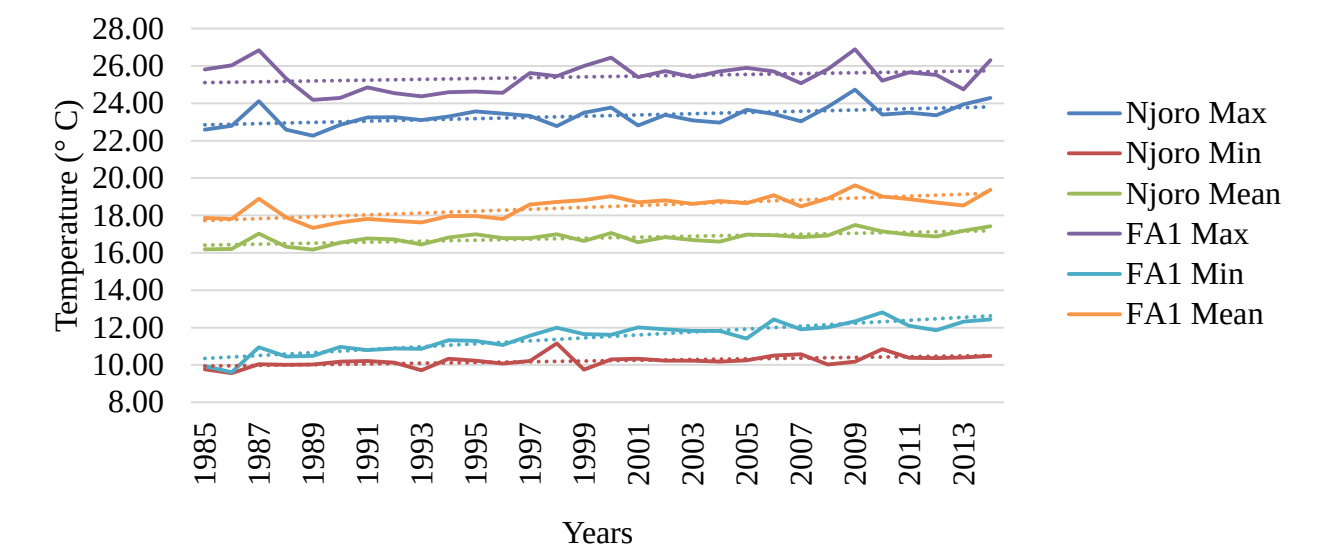

Figure 18: Maximum, Minimum and Mean Temperatures for Njoro and FA1

For all temperature elements, FA1 mean annual minimum temperature showed the highest rate of increase (0.07 ^{O}C, R^2= 0.806) compared to Njoro (0.02 ^{O}C, R^2= 0.294). Mean annual maximum temperature increase was higher for Njoro (0.03 ^{O}C, R^2= 0.301) than in FA1 (0.02 ^{O}C, R^2= 0.070). This resulted to a higher rate of increase for FA1 Mean annual temperature (0.05 ^{O}C, R^2= 0.561) compared to Njoro (0.03 ^{O}C, R^2= 0.514). Increase in maximum and minimum temperatures corelates to increase in warmer days and nights respectively. It is therefore evidence that both elements will increases in Njoro and FA1. From the results,

Njoro has a higher rate of increase for maximum temperature, translating to increasing warmer days compared to FA1 while the inverse is likely.

Conclusion

Climate is a physical factor affecting biological systems and changes in climatological elements affects their functions. Modelled prediction for Njoro in 2050's indicate that temperatures will likely increase while rainfall though contrary to observed trends will likely decline. This changes will have direct and indirect effects on Friesian cattle utilisation in smallholder production systems. Direct effects will likely be through increased heat load predisposing the animals to challenges caused by the stress. Such challenges include increased susceptibility to diseases, reduced production and reproductive performance, ultimately reducing incomes through increased inputs. This will further be aggravated by synergistic interaction with indirect effects. Likely indirect effects will be through reduced water available for livestock use, changes in feeds quality and costs and increase in climate related vectors and diseases. Continued utilization of the breed in smallholder systems, therefore, may likely be compromised without proper adaptation options. Further studies are needed to determine the magnitude to which the changes in climatological elements will affect the Friesian cattle. The likely future analogue sites to Njoro in 2050's, offers an appropriate study area from where farmers can learn of their anticipated challenges in future. Further, study profiling climate smart adaptation practicesenhancing sustainable utilisation of the breed can be compared to those in Njoro for informed policy formulation.

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References

(ATPS), A. T. P. S. N. (2013). Vulnerability and adaptation strategies to climate variability of the Bos-taurusdairy genotypes in Nandi South and Rongai Counties in Kenya(Kplangat Ngeno,Blockline O.Bebe), (73), 1–28.

Beatty, D. T., Barnes, a, Taylor, E., Pethick, D., McCarthy, M., & Maloney, S. K. (2006). Physiological responses of Bos taurus and Bos indicus cattle to prolonged, continuous heat and humidity. Journal of Animal Science, 84(4), 972–85. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16543576

Bebe, B. O., Udo, H. M. J., Rowlands, G. J., & Thorpe, W. (2003). Smallholder dairy systems in the Kenya highlands: Breed preferences and breeding practices. Livestock Production Science, 82(2-3), 117–127. http://doi.org/10.1016/S0301-6226(03)00029-0.

FAO. (2011). Dairy Development in Kenya, by Muriuki.

Herrero, M., Ringler, C., Steeg, J. Van De, Koo, J., & Notenbaert, A. (2010). Climate variability and climate change and their impacts on Kenya's agricultural sector. ILRI, Nairobi. Kenya, 1–56.

Huho, J. M., & Kosonei, R. C. (2013). the Opportunities and Challenges for Mitigating Climate Change Through Drought Adaptive Strategies : the Case of Laikipia County , Kenya, 4(3), 453–465.

Huho, J. M., Ngaira, J. K. W., Ogindo, H. O., & Masayi, N. (2012). The changing rainfall pattern and the associated impacts on subsistence agriculture in Laikipia East District, Kenya. Journal of Geography and Regional Planning, 5(7), 198–206. http://doi.org/10.5897/JGRP12.018.

IPCC (2012). Summary for policy maker. In: Managing the risks of extreme events and disasters to advance climate change adaptation.

Josef D.Daron. (2014). Regional Climate Messages for East Africa, 1–30.

King'uyu, S., Kilavi, M., Omeny, P., Muigai, E., & Njogu, A. (2009). Climate Change Indices for Kenya. Journal of Meteorology and Related Sciences, 49–55. Retrieved from http://www.kms.or.ke/phocadownload/vol 5 paper 6.pdf.

Mawa, I.L, Kavoi, M.M, Baltenweck, I, Poole, J. (2014). Profit efficiency of dairy farmers in Kenya: An application to smallholder farmers in Rift Valley and Central Province. Journal of Development and Agricultural Economics, 6(11), 455–465. http://doi.org/10.5897/JDAE2014.0561

Mcmanus, C., & Paludo, G. R. (2009). Heat tolerance in Brazilian sheep : Physiological and blood parameters, 95–101. http://doi.org/10.1007/s11250-008-9162-1

Mcsweeney, C., New, M., & Lizcano, G. (2010). General Climate, 1–26.

Musau, J., Sang, J., Gathenya, J., & Luedeling, E. (2015). Hydrological responses to climate change in Mt. Elgon watersheds. Journal of Hydrology: Regional Studies, 3, 233–246. http://doi.org/10.1016/j.ejrh.2014.12.001.

Ngeno, K., Omasaki, S. K., & Bebe, B. O. (2014). Assessment of the Vulnerability and Adaptation Strategies to Climate Variability and Change of the Bos taurus Dairy Genotypes under Diverse Production Environments in Kenya Assessment of the Vulnerability and Adaptation Strategies to Climate Variability a, 3(7), 186–196. http://doi.org/10.5455/jva.20130717125129. Online.

Ngigi, M. (2004). Conference Paper No . 16 Successes in African Agriculture : The Case of Smallholder Dairying in Eastern Africa *, (16).

Omondi, W., & Njehia, B. (2014). Herd Characteristics on Smallholder Dairy Farms in Western Kenya. Journal of Animal Science Advances, 4(8), 996. http://doi.org/10.5455/jasa.20140827111904.

Ramirez-Villegas, J., Lau, C., Hooker, J., Jarvis, A., Ann-Kristin, K., Arnell, N., … Tom, O. (2011). Climate Analogues : finding tomorrow's agriculture today. CGIAR Research Program on Climate Change, Agriculture and Food Security.

Thorpe, W., Muriuki, H. G., Omore, A., Owango, M. O., & Staal, S. (2000). Dairy development in Kenya: the past, the present and the future. Animal Production Society of Kenya KARI Naivasha.

Thurston, A. (1987). Smallholder agriculture in colonial kenya: the official mind and the swynnerton plan.

Washington, R., & Pearce, H. (2012). Climate Change in East African Agriculture: Recent Trends, Current Projections, Crop-climate Suitability, and Prospects for Improved Climate Model Information, (February). Retrieved from http://ccafs.cgiar.org/resources/tools-maps-models-and-data/testing-climate-models-agricultural-impacts.

Animal Production Society of Kenya
P.O Box 34188-00100, NAIROBI KENYA
apskkenya@gmail.com