Journal of Animal and Veterinary Advances 3 (12): 846-851, 2004

Productive and Reproductive Performance of Purebred *Bos taurus* Cattle in Three Large Scale Farms in Kenya

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Abstract: Records of cows born during the period 1983 to 1997 in three large scale farms (Ngongogeri, Tatton Demonstration Unit - TDU and Laikipia) belonging to Egerton University, Njoro, Kenya were used to estimate the productive and reproductive performance of the Friesian (F), Ayrshire (A), Guernsey (G) and Jersey (J) cattle breeds. The influence of environmental factors on these traits was also determined. The productive traits involved included lactation milk yield (MY) and lactation length (LL) while the reproductive traits were age at first calving (AFC) and calving interval (CI). As expected, some traits were influenced by the environmental factors (year and season of birth and calving, lactation number and herd). Breed was a significant ($P<0.1$) source of variation for the productive traits (MY and LL) alone and not for the reproductive traits. As expected, the F breed had the highest (2808 kg) and J the lowest MY (1872 kg). The J breed had the lowest values for all the traits. Despite the low MY, the J had the youngest AFC (1041 days) and the shortest CI (430 days). The level of performance of these breeds was much lower compared to their performance in the elsewhere in Kenya. This indicates that low genetic progress in productive and reproductive traits of the *B. taurus* breeds in Egerton University farms has contributed to the decrease in milk production over the years. The low levels of performance in these farms indicate that considerable improvement could be achieved by improving the production environment. It is concluded that decisions aiming to increase the production efficiency in these farms should not solely be based on the productive and reproductive performance of cows but also on the improvement of the production environment.

Key words: breeding programmes, dairy cattle, dairy production, Egerton University, tropics

Introduction

The dairy sub-sector would fit well within Kenya's poverty alleviation goals because the demand for dairy products is massive. This means that there still exists a wide scope for profitable dairy production. The dairy industry was liberalized in 1992. Liberalization created the expectation that there would be faster market growth together with an increase in the variety of dairy products at competitive prices for consumers. However, the process of liberalization did introduce developments that provided additional challenges to dairy farmers and these have in turn been reflected in the market. Milk production has remained constant for most of the period following the commencement of liberalization.

Milk production in Kenya is undertaken by both specialized large-scale and small-scale farmers. The small-scale farmers produce more than 70% of the total amount of marketed milk in the country. In both production systems, Friesian cattle are the dominant breed but Ayrshire and Channel island breeds are also found. Some large-scale farmers in the drier and sub humid areas cross Sahiwal with *Bos indicus* breeds (Peeler and Omore, 1997).

Milk production in Egerton University farms can be described as large–scale since production is wholly commercial. In these farms, the Friesian (F), Guernsey (G), Ayrshire (A), Jersey (J) and their crosses are represented. There has been a steady decrease in milk production in these farms. Two possible causes of this negative trend are identifiable; decrease in number of dairy cows and inadequate management level especially in the side of feeding and disease control. However, whether the low genetic progress in productive and reproductive traits of the available genotypes has contributed to this decrease in milk production is not clear.

The objectives of the present study were (i) to estimate the productive and reproductive performance of four *Bos taurus* breeds and (ii) to determine the influence of environmental factors on productive and reproductive traits. The productive traits involved in this study were: lactation milk yield (MY) and lactation length (LL) while reproductive traits were; age at first calving (AFC) and calving interval (CI).

Material and Methods

Data Sources and Environment: Data were obtained from three main Egerton University farms namely Ngongogeri, Tatton Demonstration Unit (TDU) and Laikipia. Ngongogeri and TDU farms are situated in the main campus of Egerton University in the Njoro division of Nakuru district approximately 200km Northwest of Nairobi. Nakuru district lies between longitudes 35° 25′ and 35° 36′ East and latitudes 0° 13′ and 1° 10′ South on the floor of central Rift Valley. The altitude of this area is between 1,800 – 2,400 m above the sea level. The annual rainfall lies between 760 mm - 1,270 mm. The first rains generally fall towards the end of March. They are heavy in April

and May and decrease gradually until October. The second rains start towards the end of October and last until December or January. The highest temperatures (monthly average, 30°C) occur during January and February, while the lowest temperatures (monthly average, 24°C) occur in June and July (Jaetzolt and Schmidt, 1983).
The Laikipia farm is located in Nyahururu municipality approximately 60km Northeast of the main campus of Egerton University. The farm stands right on the equator off the Nakuru – Nyahururu road approximately 11 km Southwest of Nyahururu town. It lies on latitudes 0° 18′ and 0° 51′ South and longitudes 36° 11′ and 37° 24′ East. The latitude lies between 1,800 and 2,600 m above the sea level. The annual average rainfall is between 400 – 750 mm. The rainfall pattern in this region is similar to that experienced in the Njoro division above. The average temperature is 20°C with the highest temperatures occurring during January and February and the lowest temperatures occurring in June and July (Jaetzolt and Schmidt, 1983).

Herd Management: Animals in these three farms are extensively managed. They are grazed on natural pastures and are also fed on hay mixed with molasses to improve on palatability. Supplementation with concentrates is done to lactating animals during milking which is done twice a day. Calves are reared under semi-intensive management. They are allowed to suckle during the first week after which they are introduced to bucket feeding in their respective pens. Weaning is done at the age of three months. In TDU, calves are offered little hay, pellets and minerals after the 2nd week. Bull calves are sold out while some are retained in the farm for natural mating. Breeding of heifers takes place between 18 – 24 months. All farms use either natural breeding or artificial insemination (A.I). When AI is used, the semen is from the Central Artificial Insemination Station (C.A.I.S), Kabete. In cases where the cows do not conceive after AI services, they are mated naturally with bulls bred within these farms. Cows with low production, reproductive performance and old ones are culled. Health management involves vaccination, deworming and dipping which are done regularly.

Data Collection: The study was based on all the available farm records for the cows born during the period 1983 to 1997. The original data set consisted of 1847 records from 429 purebred cows. Accurate pedigree information for the cows with performance records was difficult to obtain and therefore all known relationships between the cows were ignored in the present analyses. When all known relationship information is incorporated in the analysis, non-random mating, changes in genetic means and reduction in the genetic variance as a result of selection are accounted for (Sørensen and Kennedy, 1986 and Kennedy *et al.*, 1988).
Initial analyses were carried out using SAS (SAS, 1998) to clean up the data for the subsequent analysis. This comprised the elimination of incomplete records e.g., those with missing breeds or lactation number. Also deleted were those records with improperly recorded and/or miscoded variables, for example, cows whose dates of birth and calving were inconsistent with known management practices. Records where LL was less than 60 days or greater than 1000 days were discarded. After this editing, the number of records available for analysis were 479 for MY and LL, 117 for AFC and 455 for the CI from 117 purebred cows. Table 1 gives the number of records by breeds and traits.

Statistical Analysis: Production; lactation milk yield (MY, kg) and lactation length (LL, days) and reproductive traits; age at first calving (AFC, days) and calving interval (CI, days) were analyzed. The data set covered a period of 15 years of birth (1983-1997) and 12 years of calving (1987-1998). Data were analyzed using PROC GLM of SAS (1998). For the analysis of the productive traits and CI, the following fixed effect linear model was used;

$$Y_{ijklmn} = \mu + B_i + Y_j + S_k + L_l + H_m + e_{ijklm}$$

where
Y_{ijklmn} is the observation on the n^{th} cow belonging to the i^{th} breed, calving in the j^{th} year, k^{th} season, in the l^{th} the lactation number and m^{th} herd.
μ is the underlying population constant common to all records
B_i is the effect of the i^{th} breed.
Y_j is the effect of the j^{th} year of calving.
S_k is the effect of the k^{th} season of calving.
L_1 is the effect of the lactation number
H_m is the effect of the m^{th} herd
e_{ijklmn} is the random residual, assumed to be normally distributed with the mean 0, and variance σ^2_e.

The breed consisted of four classes for the four *B. taurus* (F, A, G and J). The years of calving included each year from 1987 to 1998. Four season were defined: January to March for the first dry season; April to June for the main wet season; July to September and October to December as the secondary dry and wet season, respectively. Lactation number of cow consisted of the first through fourth lactation numbers, which were coded 1 to 4. The

Table 1: The number of records by breed and trait

Breed	Traits[a]			
	MY	LL	AFC	CI
Friesian	306	306	81	292
Ayrshire	49	49	9	45
Guernsey	74	74	16	72
Jersey	50	50	11	56
Total	479	479	117	455

[a]MY = lactation milk yield; LL = lactation length; AFC = age at first calving; CI = calving interval.

Table 2: Means, standard deviation and tests of significance from analsis of variance for productive and reproductive traits

Traits[a]	Means	SD	CV %	Independent variables[b]				
				Breed	Year	Season	Lactation number	Herd
My, kg	2670	819	30	***	***	NS	**	***
LL, days	271	77	28	†	***	NS	NS	***
AFC, days	1055	123	12	NS	***	†	NF	*
CI, days	455	128	28	NS	NS	NS	NS	NS

aSee Table 1 for description of traits

[b]Year = year of clalving for MY, LL and CI but year of birth for AFC, Season = season of calving for MY, LL and CI but season of birth for AFC

†P<0.1; *P<0.05; **P<0.01; ***P<0.001; NS = Not Significant, NF = Not Fitted in the Model

Table 3: Least square means and standard errors of productive and reproductive traits by breed sub-classes[a]

	My		LL		AFC		CI	
Breed	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Friesian	2808	70	271	7	1098	23	455	12
Ayrshire	2573	131	253	12	1099	52	471	22
Guernsey	2189	119	269	11	1078	42	486	19
Jersey	1872	141	242	13	1040	49	430	23

[a]See Table 1 for description traits.

fifth and greater lactation number were combined and coded as class 5. The herd consisted of the three Egerton University farms namely, TDU, Ngongogeri and Laikipia farms. For the analysis of AFC, a similar model was used but lactation number was not fitted and the season and the year of calving were replaced by the season and year of birth, respectively. The season of birth consisted of similar classes as described for the season of calving but the years of birth included years from 1983 to 1997.

Results

Means and standard deviation of the traits studied are shown in Table 2. Also shown are the levels of significance of the different sources of variation. The coefficient of variation (CV) for the traits fell within the normal range. Breed was a significant (P<0.1) source of variation for the productive traits (MY and LL) alone and not for the reproductive traits. Apart from CI, the year of calving and year of birth significantly influenced the productive traits and AFC, respectively. Surprisingly, the seasons of calving (for MY, LL and CI) and birth (for AFC) were not significant (P>0.05). The lactation number was significant (P<0.01) for MY and not for the other traits. As expected, herd significantly (P<0.05) affected MY, LL and AFC. Regional differences, which were substantial, were covered by fitting the herd effects.

Table 3, presents the least square means and standard errors of productive and reproductive traits by breed sub-classes. As expected, the F breed had the highest and J the lowest MY. The J breed had the lowest values for all the traits. Despite the low MY, the J had the youngest AFC and the shortest CI. This confirms the negative relationships that exist between productive and reproductive traits.

The least square means and standard errors of productive and reproductive traits by environmental factors breed sub-classes are presented in Table 4. As expected, there were differences in performance among years. This is

Table 4: Least square means and standard eroors of productive and reproductive traits by environmental factors breed sub-classes[a]

	My		LL		AFC		CI	
Factor	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Year[b]								
1983	-	-	-	-	1084	44	-	-
1984	-	-	-	-	1452	130	-	-
1985	-	-	-	-	1132	129	-	-
1986	-	-	-	-	1148	48	-	-
1987	2445	113	245	11	1178	52	435	18
1988	2078	222	223	21	1093	31	512	35
1989	2334	239	237	22	1084	41	422	38
1990	2115	257	263	24	1090	49	472	40
1991	2523	160	235	15	1064	61	463	26
1992	2696	110	249	10	1085	61	437	18
1993	2454	104	218	10	871	48	435	17
1994	2016	157	275	15	840	130	465	26
1995	2123	145	268	14	942	45	456	23
1996	2053	142	285	12	910	78	453	22
1997	2304	154	328	14	1107	77	501	25
1998	3182	269	284	25			475	50
Season[b]								
Jan-Mar	2300	109	257	10	1076	38	459	18
Apr-Jun	2452	104	271	10	1128	34	461	17
Jul-Sep	2359	92	256	9	1071	35	457	15
Oct-Dec	2331	95	253	9	1040	32	465	15
Lactation number								
1	2084	102	261	10	-	-	458	17
2	2347	105	251	10	-	-	467	17
3	2329	103	267	10	-	-	460	17
4	2552	112	257	10	-	-	461	18
>5	2489	113	259	11	-	-	456	17
Herd[c]								
TDU	2833	72	322	7	1044	27	482	12
N	2104	92	222	9	1028	32	451	15
L	2143	152	232	14	1164	51	448	26

[a]See Table 1 for description of traits
[b]Year = year of calving for MY, LL and CI but year of birth for AFC; season = season of calving for MY, LL and CI but season of birth for AFC
[c]TDU = Tatton Demonstration Unit; N = Ngongogeri; L = Laikipia farm

attributable to both annual fluctuations in weather conditions and possibly, phenotypic trends. However, in the present study, phenotypic trends were not estimated. Despite lack of statistical significance, the pattern of constant estimates for season for productive traits followed the expected trend. Cows calving during the long rains (April to June) had the best productive performances – highest MY and longest LL. On the other hand, productive performance was lowest for cows calving in the dry season (January to March). The trend of MY associated with lactation number followed a well-established pattern. Lactation milk yield peaked numerically at 4th lactation number and declined thereafter. Surprisingly, TDU had the highest MY and longest LL than the other University farms. However, cows in Ngongogeri were younger at first calving and had the shortest CI than cows in the other farms.

Discussion

In this study, data from three Egerton University farms located in the Rift Valley of Kenya were used. These data provided information on the relative productive and reproductive performance of purebred F, A, G and J cattle. These breeds are been used widely in dairy production systems in Kenya (Peeler and Omore, 1997). The aim was to estimate their performance under a production system considered to be commercial and enjoying a high management levels. Such analysis is important in the sense that they form the first step towards the general improvement of performance in these farms through the design of efficient breeding systems.

The influence of environmental factors on productive and reproductive traits was expected. The annual difference in these traits was mainly due to non-systematic year to year fluctuations in performance. Normally, seasonal variation in animal performance is expected to be primarily a manifestation of variation in feed quantity and quality. This study suggests that productive traits were more sensitive to these fluctuations than was reproductive traits. The productive performance was lowest for cows calving in the dry season (January to March) indicating that calving in the first quarter of the year is undesirable. In Kenya, the dry months are also the hottest months. Therefore, both suboptimal nutritional and heat stress may explain the seasonal variation in performance. The better productive performance observed in TDU was surprising. This was against the common belief that since Ngongogeri farm is more commercial than TDU and has better facilities and a larger land size for pasture establishment then it is supposed to have genetically better animals than TDU.

As expected, the level of performance of the breeds represented in this study was much lower in this environment compared to their performance in the temperate regions. This is explainable in terms of lower levels of nutrition and general husbandry practices. However, the level of performance was lower that other estimates of the same breed elsewhere in Kenya. For example, for the F breed over the years, milk production from farms greater than 20ha in size has increased from a mean of 3577 kg/cow in 1985 (Rege, 1991) to 5,056 kg/cow in 1997 (Ojango, 2000). In the same period, the mean CI decreased from 412 days in 1985 (Rege, 1991) to 406 days (Ojango, 2000). For the J breed, Musani and Mayer (1997) reported an estimate of 2,112 kg/cow of milk per lactation in a large-scale farm in the central Rift Valley. The poor management of the Egerton University farms is further confirmed by the low reproductive performance. There is a significant relationship between attainment of age at first calving and plane of nutrition. A low plane of nutrition will delay onset of first estrus. Therefore, nutrition of heifers needs attention if early estrus is to be exhibited. The CI are prolonged in Egerton University farms probably due to failure to detect heat either because of nutritionally-induced silent heat, substandard supervision or sheer lack of experience in heat detection.

In the Egerton University farms, no efforts have been directed towards the estimation of breeding values and the selection of genetically superior animals and it is therefore not surprising that estimates of genetic performance fall short of progress achieved elsewhere. Nevertheless the genetic variation in the traits can be used for genetic improvement in these farms. There is therefore the need for the development of efficient and effective breeding programmes that would combine the resources in these farms if they were to be made profitable. In Kenya, there are no effective breeding programmes for any dairy cattle breed, owing to various constraints, e.g. small herd size, lack of systematic identification, inadequate animal performance and pedigree recording, organizational shortcomings etc. Nucleus breeding programme can be a good strategy for genetic improvement of cattle in developing countries which lack the money and structure required for operating an efficient improvement programme based on AI and field recording in the whole population (Smith, 1988). Such a programme does not require expensive infrastructure because recording is only done in the nucleus herd.

With the level of scientific expertise in Egerton University and the resources in its farms, it is not difficult to establish nucleus herds within these farms. The main objective of the nucleus herds would be the genetic improvement of the different dairy cattle breeds. The nucleus with the help of certain departments would also be involved in activities directly related to the farmers e.g. extension advice, open days, demonstrations and in identifying with the local community through the supply of superior breeding stock (Kahi and Rege, 2001). Performance and pedigree recording and selection would be the major preoccupation of the nucleus. Currently in these farms, efficient performance and pedigree recording is lacking. There are usually many unplanned benefits from a coordinated breeding programme involving performance and pedigree recording in that participants learn much more about the actual performance of their animals and use that to boost their technical expertise and profits (Kahi *et al.*, 2004).

Conclusions

In this study, evidence was presented that the low genetic progress in productive and reproductive traits of the *B. taurus* breeds in Egerton University farms has contributed to this decrease in milk production over the years. The low levels of performance in these farms indicate that considerable improvement could be achieved by improving the production environment. Therefore, decisions aiming to increase the production efficiency in these farms should not solely be based on the productive and reproductive performance of cows but also on the improvement of the production environment. Generally, performance in these farms could be improved through:

Training of the available farm staff in various aspects of animal husbandry

Opening up and utilizing the available expertise within the Faculty of Agriculture.

Proper parasites and disease control programme.

Conservation of feeds for use during the dry seasons.
Supplementation with concentrates and minerals. The amount of concentrates offered to a cow should not be fixed but should be based on the production levels. These farms have the resources to formulate and produce concentrates both for farm use and commercial purposes.
Proper breeding management to avoid late and early breeding of heifers and cows. This can be achieved by the use of the teaser bulls to detect animals on heat and also by carrying out pregnancy diagnosis at the right time.
Proper performance and pedigree recording, which would assist in predicting accurate breeding values for the selection of genetically superior animals. While each farm has the capacity to keep its own records on cards, these could be computerized and stored in a central location for ease of data processing and evaluation.

Acknowledgements

We thank the Farm Managers of the TDU, Ngongogeri and Laikipia farms for permission to use records from their farms, their staff for assisting in the data collection and Egerton University for funding this study and providing the necessary facilities.

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