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Effects of feeding systems and breed of cattle on reproductive performance and milk production on smallholder farms

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Abstract

This study tested the hypothesis that smallholders' feeding systems are not matched with the breed of cattle kept consequently resulting in poor reproductive performance and milk production as smallholders intensify their feeding systems from free- to zero-grazing while replacing *Bos indicus* with *Bos taurus* cattle breeds. Data on feeding systems and individual cow performances were obtained in a stratified random sample cross-sectional survey of smallholder farms in the Kenya highlands between June 1996 and April 1998. On average, first calving age was 31.7 months, days-open period was 301.6 days and milk per day of a calving interval was 3.8 litres with smallholders spending 4 times more on purchase of concentrates (Ksh 2591.3) than on fodder (Ksh 655.3) for each Tropical Livestock Unit (TLU) per year. Purchase of fodder for each TLU was 2.3 times more (P<0.05) in zero-grazing than in free-grazing system, but purchase of concentrates was not significantly different between the systems. Feeding system had influence on (P<0.05) reproductive performance but not on milk production. Although Friesian were fed about 1.4 times more (P<0.05) concentrates than the Ayrshire, Guernsey/Jersey and *Bos indicus* cattle, reproductive performance and milk production was not significantly different between the *Bos taurus* breeds. Milk production and reproductive performances in smallholder dairy farms reflect low levels of feeding, which is due to limited cash flow related to the low risk-bearing capacity of smallholders. Membership to co-operative society is one way to improve smallholders' access to better quality feeds, possible through credit arrangements.

Keywords: Age at first calving, days-open, feeding systems, milk production, purchase of fodder and concentrates

Introduction

In any dairy production systems, feeding systems have the greatest influence on reproductive performance and milk production. Because of pressure on land and therefore pressure for feeds on smallholder farms, a frequent recommendation for smallholders is to use small mature sized dairy breeds (Guernsey and Jersey). In practice smallholder farmers in the Kenya highlands prefer the larger dairy breeds (Friesian and Ayrshire), perhaps because of their potentially higher milk yields despite having higher nutritional demands and having performed poorly under smallholder feeding systems (Ojango, 2000; Wakhungu, 2000).

In response to the continuously shrinking landholdings, smallholder dairy farmers in the Kenya highlands have intensified and continues to intensify their feeding systems from free-grazing to zero-grazing (Bebe, *et al*., 2002). Feeding intensification is through gathering of forages from common properties, the growing on small plots of napier grass (*Pennistetum purpureum*) and the feeding of crop residues supplemented with purchased forages and concentrates. In practice, feeding is often opportunistic, characterised by intermittent and abrupt changes in the quantity and quality of forages offered (Methu *et al.*, 2000). Purchase of fodder and concentrates requires regular access to cash, labour and access to the market centres supplying feeds. To effectively address the research and development needs of smallholder dairying as the trend towards intensification continues, knowledge of the effects of smallholders' feeding systems and cattle breed choice on reproductive performance and milk production on smallholder dairy farms is necessary. The objective of this study was to investigate the effects of feeding systems and breed of cattle on the level of reproductive performance and milk production on smallholder dairy farms in the Kenya highlands.

Study area and herd management systems

The Kenya highlands comprise areas with elevations 1000 m above sea level, annual mean temperatures of 10 to 18 ^{0}C, a bimodal rainfall pattern with >800 mm annually and fertile soils with good potential for biomass production. Feeding systems include free-, semi-zero- and zero-grazing, representing increasing levels of intensification. In the free-grazing systems, farmers graze cattle on private or public owned pastures during the day and keep them within the homestead at night. Zero-grazing is a cut-and-carry, stall-feeding system in which napier grass and crop residues are the basal feeds. Concentrate supplementation is generally restricted to milking cows. Semi-zero-grazing is a combination of free-grazing and stall-feeding, depending on the seasonal availability of feeds and labour. The dairy breeds comprise Friesian, Ayrshire, Guernsey and Jersey breeds and the *Bos indicus* cattle comprise local zebu, Boran and Sahiwal.

Survey methodology

A stratified random sample cross-sectional survey of smallholder farms in the Kenya highlands was conducted between June 1996 and April 1998 in nine districts. These were Kiambu, Nairobi, Machakos, Kirinyanga, Maragua, Murang'a, Nakuru, Nyandarua and Narok. Stratification was by agro-ecological potential (for cropping and dairying) and milk market access. The agro-ecological potential (medium and high) was according to land use defined by Jaetzold and Schmidt (1983) and milk market access (low, medium and high) was according to human population densities, local demand for milk, type of roads (tarmac, passable all weather, seasonally passable), and the availability of milk marketing institutions.

Applying Geographical Information Systems techniques, five sub-locations (the smallest administrative unit within a district) were selected within each land-use system in a district by a stratified random sampling method. Two pairs of major landmarks (permanent features such as trading centres, schools and churches) in each of the selected sub-locations were randomly selected on a map, and transect lines were drawn between each pair. Sampling was then done as closely as possible following the marked transects. A trained enumerator interviewed each fifth farm household, first on the right and then on the left. A total of 1755 farm households from 106 sub-locations were interviewed. The total sample size in a sub-location represented approximately 1% of the total number of farm households based on population census figures of 1989 (C.B.S., 1994).

Data collection

Data collection was through farm household interviews, conducted in the local language by trained enumerators using a pre-tested, structured questionnaire. Guided by the structured questionnaire, enumerators obtained both farm-level and individual animal performance data from each of the respondents. Data collected at the farm-level included farm size, herd size, and estimated costs of fodder and concentrates purchases in the past year. Purchase of fodder included the costs of hired labour to gather forages from common properties. Purchased fodder and concentrates were considered to reflect the level of use of external feed resources and were computed in Kenya shillings per Tropical Livestock Unit (TLU) per year (Ksh/TLU/y). The TLU units used were 1 for bull, 0.7 for cow, 0.5 for heifer and young bull, and 0.2 for calves.

Individual animal data were collected from each farm household keeping cattle. The variables included breed; age at first calving; milk yield on the day prior to the survey; the dates of the two most recent consecutive calvings; the date of the first known service post-calving and the date of drying-off for the most-recent calvings. The most frequent breed on a farm was recorded as the dominant breed kept by the household. Dates of calving, service and drying-off were used to compute days-open, lactation length and milk yield per day of lactation and per day of calving interval. Days-open was defined as the period between dates of calving and the subsequent pregnancy. As a check for days-open, the dates of two most-recent calvings and the date of subsequent post-calving service were used.

Statistical analysis

Because 90% of farms owned only one to three cows, the unit of analysis was farm, stratified by ecological potential (medium and high) and milk market access (low, medium and high) giving six strata. In line with the sampling design, farm nested within the strata was fitted as random variable while feeding systems and breed of cattle were fixed effects in Proc Mixed procedure of SAS (SAS, 1999). The interaction term of feeding system and breed was omitted in the final model because preliminary analysis indicated no significant effect. Pair-wise comparison of least square means was performed to detect significant differences between feeding systems and breeds of cattle.

Results

Age at first calving, days-open and milk yield

Table 1 presents the least square means (with their standard errors) for age at first calving, days-open and milk yield per day of a calving interval as influenced by feeding systems and breed of cattle kept on smallholder farms. Significant differences are based on pair-wise comparisons of least square means. Age at first calving was 1.6 months earlier in zero-grazing compared to free-grazing farms ($P<0.05$). Farms keeping *Bos indicus* cattle attained later ($P<0.05$) age at first calving compared to those keeping Guernsey/Jersey (4.2 months), Friesian (3.7 months) and Ayrshire (3.2 months), but farms keeping *Bos taurus* breed did not significantly differ for age at first calving.

Days-open of 355 days estimated on zero-grazing farms was longer ($P<0.05$) compared to free-grazing (by 84.8 days) and to semi-zero-grazing (by 76.2 days) farms. Compared to farms keeping *Bos indicus* cattle, days-open was shorter ($P< 0.05$) on those keeping Guernsey/Jersey (141.8 days) and Friesian (91.2 days), but no significant difference between farms keeping *Bos indicus* and Ayrshire, and between those keeping the *Bos taurus* breeds. Whereas there was no difference in milk production per day of a calving interval due to feeding systems, milk production was higher ($P< 0.05$) on farms keeping Guernsey/Jersey (2.0 litres/day), Friesian (1.9 litres/day) and Ayrshire (1.2 litres/day) compared to those keeping *Bos indicus* cattle.

Figure 1 shows the number of households that reported feeding and buying basal and supplementary feeds during the year prior to the survey and not ten years previously. Agro-industrial by-products formed the main supplementary feeds for the majority of those reporting using napier and crop residues as the major basal feeds. Some households used poultry litter as an alternative supplement to concentrates. The changes in feeding practices over the past ten years reflect an increasing use of feed resources from outside the farms. For those reporting feeding napier or poultry litter during the year prior to the survey and not ten years previously, a third (34%) purchased napier and over a third (38%) purchased poultry litter.

Table 2 presents the least square means (and their standard errors) for purchased fodder and concentrates as influenced by feeding systems and breed of cattle kept on smallholder dairy farms. On average, smallholders spent 4 times more on purchase of concentrates (Ksh 2591.3/TLU/year) than on fodder (Ksh 655.3/TLU/year) for each TLU. Purchase of fodder was 2.3 times more on zero-grazing than on free-grazing farms (P<0.05), but the purchase of concentrates was not significantly different between these farms. For each TLU kept on annual basis, semi-zero-grazing farms purchased less concentrates, lower by 45 to 57% compared to zero-grazing and free-grazing farms (P<0.05).

Keeping of *Bos taurus* significantly (P<0.05) influenced purchase of concentrates but did not influence purchase of fodder. Compared to farms keeping *Bos indicus* cattle, those keeping Friesian, Ayrshire or Guernsey/Jersey breeds purchased about 3 times (2.7 to 3.1) more fodder for their animals (P< 0.05). Purchase of concentrates was 30 to 38% more on farms keeping Friesian breed compared to those keeping Ayrshire, Guernsey/Jersey and *Bos indicus* cattle breeds (P < 0.05).

Purchase of fodder and concentrates for the animals

Figure 1 shows the number of households that reported feeding and buying basal and supplementary feeds during the year prior to the survey and not ten years previously. Agro-industrial by-products formed the main supplementary feeds for the majority of those reporting using napier and crop residues as the major basal feeds. Some households used poultry litter as an alternative supplement to concentrates. The changes in feeding practices over the past ten years reflect an increasing use of feed resources from outside the farms. For those reporting feeding napier or poultry litter during the year prior to the survey and not ten years previously, a third (34%) purchased napier and over a third (38%) purchased poultry litter. Table 2 presents the least square means (and their standard errors) for purchased fodder and concentrates as influenced by feeding systems and breed of cattle kept on smallholder dairy farms. On average, smallholders spent 4 times more on purchase of concentrates (Ksh 2591.3/TLU/year) than on fodder (Ksh 655.3/TLU/year) for each TLU. Purchase of fodder was 2.3 times more on zero-grazing than on free-grazing farms (P<0.05), but the purchase of concentrates was not significantly different between these farms. For each TLU kept on annual basis, semi-zero-grazing farms purchased less concentrates, lower by 45 to 57% compared to zero-grazing and free-grazing farms (P<0.05). Keeping of *Bos taurus* significantly (P<0.05) influenced purchase of concentrates but did not influence purchase of fodder. Compared to farms keeping *Bos indicus* cattle, those keeping Friesian, Ayrshire or Guernsey/Jersey breeds purchased about 3 times (2.7 to 3.1) more fodder for their animals (P< 0.05). Purchase of concentrates was 30 to 38% more on farms keeping Friesian breed compared to those keeping Ayrshire, Guernsey/Jersey and *Bos indicus* cattle breeds (P < 0.05).

Discussion

Evaluation of reproductive performance and milk production on dairy farms is important for producers and extension staff as indicators of management standards. This may serve to motivate the producers to change management strategies targeting those weaker components of their management practices. Smallholder farmers in the Kenya highlands are confronted with increasing pressure on land and therefore pressure for animal feeds. Consequently, they intensify their feeding but using bulk (low nutrient density) feeds even when replacing free-grazing with zero-grazing and replacing *Bos indus* with *Bos taurus* cattle. Bulk feeds comprised crop residues, purchased forages gathered from common properties and greater use of planted napier fodder, indicating attempts to meet livestock requirements using a wide variety of feeds. Though bulk feeds are of poor quality, demand was apparently high as indicated by the growing of fodder for sale and the selling by some non-cattle-keeping households of crop residues and poultry litter to cattle-keeping households (Figure 1).

Based on the prevailing cost of concentrates of about Ksh 11 per kg, the average of Ksh 2591 of concentrates used for each TLU annually indicates that farmers fed on average 0.6 kg of concentrates daily for each TLU. This translates to about 1.2 kg of concentrates daily for cows because cows form 60% of the herd. The larger amounts of concentrates fed on farms with Friesian (1.6 kg/day/cow) compared with other breeds (£ 1.2 kg/day/cow) indicates efforts by smallholders to meet the higher nutritional requirements of the Friesian breed. Efforts to meet animal nutritional requirements are also evident on zero-grazing farms through larger amounts of fodder and concentrates fed to animals compared to levels fed on free- and semi-zero-grazing farms (Table 2). However, the level of concentrates feeding is still too low to satisfy the nutritional requirements of Friesian, explaining why milk production levels were not significantly different amongst the *Bos taurus* cattle breeds (Table 1). Consequently, smallholders did not realise higher milk yield when using the larger dairy breeds with higher potential for milk yield than when using smaller

Table 1. Least square means (and their standard errors) for age at first calving, days-open and milk yield per day of a calving interval as influenced by feeding systems and breed kept on smallholder dairy farms

Effect of:	Age at first calving (mo)	Days-open (days)	Milk per a calving interval day (l/day)
Feeding systems			
Free-grazing	32.5 (0.8)[a]	270.5 (28.2)[b]	3.9 (0.4)[a]
Semi-zero-grazing	31.8 (0.7)[ab]	279.1 (28.4)[b]	3.6 (0.4)[a]
Zero-grazing	30.9 (0.7)[b]	355.3 (22.8)[a]	3.8 (0.5)[a]
Breed kept			
Friesian	30.8 (0.6)[b]	284.2 (18.9)[b]	4.4 (0.3)[a]
Ayrshire	31.3 (0.8)[b]	314.4 (28.6)[ab]	3.7 (0.4)[a]
Guernsey/Jersey	30.3 (0.9)[b]	233.6 (39.3)[b]	4.5 (0.5)[a]
Bos indicus cattle	34.5 (0.8)[a]	375.4 (30.2)[a]	2.5 (0.5)[b]
Average for the sample	31.7	301.6	3.8
Farms with records (n)	545	325	570

Means within a column with different letter superscript are statistically different (P<0.05)

Table 2. Least square means (and their standard errors) for purchased fodder and concentrates as influenced by feeding systems and breed kept on smallholder dairy farms

Effect of:	Fodder purchased (Ksh/TLU/y)	Concentrates purchased (Ksh/TLU/y)
Feeding systems		
Free-grazing	422.9 (198.9)[b]	2797.6 (697.4)[a]
Semi-zero-grazing	570.4 (187.6)[ab]	1934.8 (666.1)[b]
Zero-grazing	972.6 (171.7)[a]	3041.6 (629.7)[a]
Breed kept		
Friesian	736.5 (149.2)[a]	3215.4 (562.3)[a]
Ayrshire	818.2 (193.5)[a]	2471.7 (686.3)[b]
Guernsey/Jersey	798.3 (235.6)[a]	2333.9 (805.7)[b]
Bos indicus cattle	267.6 (227.4)[b]	2343.8 (783.5)[b]
Average for sample	655.3	2591.3
Farms with records (n)	736	706

Means within a column with different letter superscript are statistically different (P<0.05)

dairy breeds with lower potential for milk yield. In these smallholder production systems the advantage of large dairy breeds over smaller ones is likely related to heavier body weight, which attracts a higher market value when selling cows either for slaughter or to other farmers. This added value can be critical in enabling the resource-poor households to accumulate and, when required, liquidize financial capital at times of emergency cash needs.

Ojango and Pollott (2002) have reported an average yield of 4551 ± 1639 kg of milk in a lactation length of 300 ± 54 days in Kenyan large-scale commercial dairy farms. This is about two to three times higher than the estimated yield on these smallholder farms (1700 to 2240 litres per lactation length of about 450 days). The higher milk production on large-scale commercial farms can be attributed to better access to limited resources: better quality feeds such as total mixed rations (TMR) and the practice of following a more consistent animal health program. Feeding of concentrates is considered attractive when the milk/concentrate price ratio is greater than one (Walshe, Grindle, Nell and and Bachmann, 1991). Kenya has an attractive prevailing milk/concentrate price ratio varying from 1.2 to 1.5, but because cash flow is limited, smallholders use only limited amounts, particularly for lactating cows.

Milk production and reproductive performances levels on these smallholder farms in the Kenya highlands are typical to other smallholder farms elsewhere, for instance Tanzania, (Msanga, Bryant, Rutam, Minja and Zylstra, 2000) and India (Patil and Udo, 1997). As with milk production, age at first calving and days-open cannot improve under inadequate quantity and quality feeding. More low-quality feeds in the diet can help to maintain animals but cannot improve milk production and reproductive performance. Smallholders have to use increased amount of purchased feeds of better quality to significantly improve production and reproductive performances of their animals.

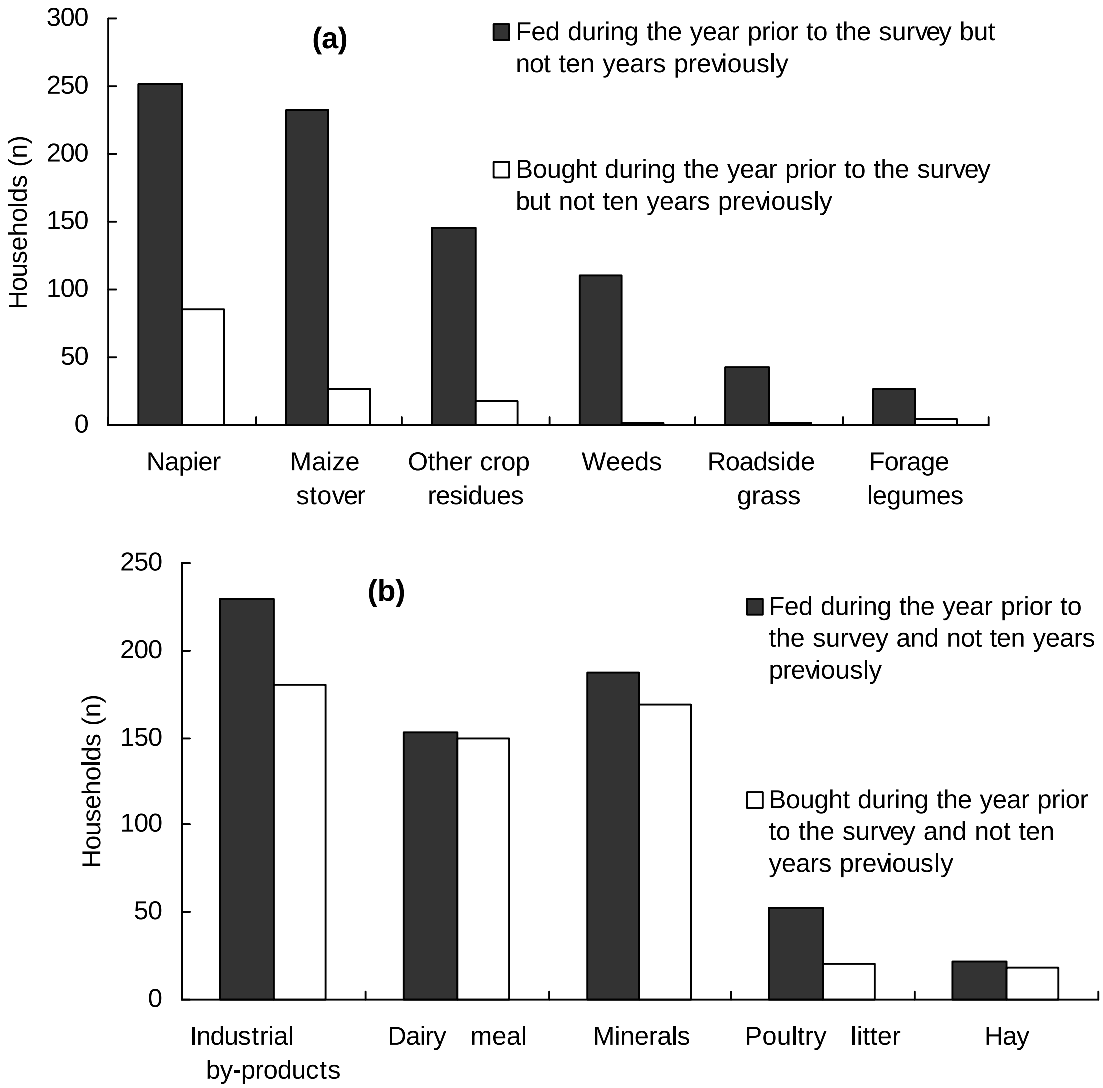

Figure 1. Number of households in the sample that reported feeding and buying the (a) basal feeds and (b) supplementary feeds during the year prior to the survey but not ten years previously

Although under zero-grazing systems smallholders attained age at first calving earlier compared to when under free- and semi-grazing farms, days-open were longer on zero-grazing farms (Table 1) despite the animals being fed more fodder and concentrates (Table 2). Early age at first calving was likely achieved through a management strategy in which smallholders only retain fewer heifers, possibly only when a need for a replacement is anticipated, or purchasing heifers that are ready for service. This strategy would reduce competition for the limited feed resources and allow targeting the limited feeds to cows for milk production, to ensure milk supply is as long as possible for feeding the family and for cash income. However, keeping cows on milk for as long as possible has the consequences of prolonging days-open. Attaining shorter days-open require regular feeding of high energy concentrate feeds before and after calving for cows to regain the weight above that they had at the time of calving (Balanos, Meneses and Forsberg, 1996; Ferguson, 1996). Because smallholders are unable to ensure regular supplementary feeding, they may have to wait for cows to resume ovarian activity naturally. This explanation is supported by an earlier observation from a farm survey of smallholder farms in the Kenya highlands in which only 17% of the cows were found inseminated within two months post-calving (NDDP, 1994).

For smallholder dairy farmers to improve milk production and reproductive performance above the levels presently attained, smallholders will need adequate access to good quality feeds such as concentrates for supplementing the low-quality basal feeds of napier and crop residues. One way that smallholders may have access to better quality feeds is joining a co-operative movement, through which they can obtain a regular supply of inputs on credit arrangements.

The associations between animal performance and feeding practices reported in this study are based on farmers' recall information gathered quickly. Although this is a source of large variation, obtaining more accurate estimates from longitudinal studies with short intervals between farm-visits are more expensive and information is usually obtained only from fewer farms.

Conclusion

Milk production and reproductive performances of cattle breeds in these smallholder farms reflect low levels of feeding, which is related to limited cash flow of resource-poor households. As a result the cattle diets were primarily based on low-quality bulk feeds, even when households replaced *Bos indus* in free-grazing with *Bos taurus* cattle in zero-grazing management. Therefore when designing feeding interventions to support improved reproductive and milk production performance on smallholder farms it would be necessary to consider feed resource availability in the locality and the economy of the household, which is characterised by limited cash flow and low risk bearing capacity. Membership to co-operative society is one way to improve smallholders' access to better quality feeds, possible through credit arrangements.

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