

Use of High Density SNP Genotypes to Determine the Breed Composition of Cross Bred Dairy Cattle in Smallholder Farms: Assessment of Reproductive and Health Performance

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ABSTRACT: Reproductive performance and disease data were recorded for 2 years on 1,824 dairy cows in smallholder farms using participatory approaches and on-farm recording. Most animals experienced one service to conception. Calving intervals were long, ranging between 261 and 761 days, with an average of 451±101days. Herd level of production (HeL) had significant effect on calving interval. However, there was no difference between crossbreds with different levels of exotic breed percentage or in different HeL classes in disease incidence. Most animals had less than 2 treatment events, despite the high disease burden in the study areas. Mortality rates were low, ranging from 2.13% to 2.65%. Even though the crossbred animals had higher performance compared to indigenous animals, the gains obtained were below what would be possible with better management. These results suggest that crosses with low exotic proportions would be the most optimal for the production systems studied.

Keywords: dairy, genetics, reproductive-efficiency.

INTRODUCTION

The use of crossbred animals has been the basis of smallholder dairy enterprises in East Africa and many other tropical systems. Given increasing land pressure in traditional highland regions, farmers have begun to establish dairy farming in marginal areas that are relatively hotter and with higher disease burdens. Despite this shift, the germplasm being used is still the same as in the highlands, even though farmer capacity in these regions often does not match the higher demands of exotic animals. As a result, these systems often experience sub-optimal performance for crossbred cattle. It is important to match the production environment and animal breed type in order to maximize the productivity of these animals.

In sub Saharan Africa, livestock diseases adversely affect animal productivity due to the limiting cost of control strategies. Such strategies as chemotherapy, vector control, and vaccination have significant costs and require improved management practices. Application of alternative control mechanisms where more adaptable livestock are utilized is ideal.

Calving interval is a key indicator of a cow's reproductive efficiency. Cows raised under sub-optimal conditions often have long calving interval, 400 – 550 days being typical for local zebu cattle (Tegegne et al., 2009). Nutrition and disease burden are the main cause of this for smallholder systems.

This study sought to understand the relationship between breed composition, disease burden profiles and

cow reproductive efficiency. This is important in characterizing the genotype by environment interactions that affect productivity as well as identifying appropriate breed compositions for various production environments. These results represent a novel application of high density SNP genotypes to predict dairy cattle breed composition and relate this to animal performance in smallholder dairy farms.

MATERIALS AND METHODS

Site Selection, Household Selection and Animal Recruitment

Site selection was undertaken in varying agro ecological regions and considered two main factors. 1. Availability of diverse breed types of both indigenous and exotic cattle. 2. Availability of a large number of small stock smallholder farmers. Based on these considerations, 3 sites in the Rift valley (Meteitei, Siongiroi, and Kaptumo), and 2 in Western Kenya (Butere/Khwisero, Kabras) were selected. Only cows that were either lactating or in the 3rd trimester of pregnancy, and which had high probability of staying on farm for 1.5 yrs. were recruited. A total of 1,824 animals were recruited in Kenya representing 715 households. All selected animals were ear tagged and assigned a project ID.

Baseline and Longitudinal Surveys

A baseline survey was conducted to capture socio-economic status of the farmers as well as obtain statistics on the herd status, with regard to animal types and numbers. Other production parameters such as feed availability and source, access to inputs and markets as well as management systems and practices were also assessed. Subsequent to the baseline survey, an in-depth monitoring exercise was conducted where site coordinators visited project farmers every 2 months for 1.5 years to collect available records. Hair samples were obtained from the tail switch of all crossbred cattle and some indigenous breeds. These samples were sent to GeneSeek (Neogen Corporation, Lansing, NE, USA) for genotyping using the Illumina BovineHD Infinium SNP array. Details of the quality analysis and quality control applied to the SNP data are described by Weerasinghe et al. (2013).

Data Analysis

Breed grade was estimated from 566,056 SNP markers as posterior probabilities for membership into defined cattle breed types using a model-based population structure analysis algorithm implemented in the Admixture program (Alexander et al., 2009). The posterior

Table 1. Mortality, trading and Cow exit rate over a 2 year period in smallholder dairy farms in Kenya

	Herd class (HeL)		
	1	2	3
Mortality Rate	2.65	2.13	2.31
Trading Rate	11.37	10.13	13.68
Cow Exit Rate	31.53	31.4	40.55

Herd classes: 1=1 – 4kg milk/d; 2 = 4 – 5kg/d; 3=>5kg/d.

probabilities were used to define the proportion of exotic dairy breed alleles of each animal. These were used to group animals into 5 classes (%dairyness class), where 1= 0-20%, 2=21-35%, 3=36-60%, 4=61-87.5% and 5=>87.5% exotic dairy contribution.

Herd production levels were obtained using a mixed model approach implemented in ASReml (Gilmour et al. 2008). The model used was as follows:

$$y = Xb + Qu + Wsf + e,$$

where y = individual test-day milk yields, and b = solutions for the fixed effects (year-month of test day, TD_j ($j=1-28$), parity k ($k = 1, 2, \geq 3$), %dairyness class l ($l=1$ to 5), and lactation stage in 100 day intervals, m ($m= 1$ to 4)), u = random cow effects, sf = random herd class effects, and e = random residual effects. The incidence matrices X , Q and W related records to fixed effects, cows and farms, respectively. It was assumed that $\text{var}(u) = \sigma_a^2$, $\text{var}(sf) = \sigma_{sf}^2$ and $\text{var}(e) = I\sigma_e^2$. The random herd effects solutions obtained were ranked into the bottom (1-4kg/d), middle (4 – 5kg/d) and top (>5kg/d) one third to create the three herd level (HeL) classes. The performance of different dairy compositions was then compared between the herd classes.

Calving interval was defined as the number of days between two successive calving events. This interval had to be at least 90d to ensure that a pregnancy had actually been confirmed. Any calving event occurring between day 90 and day 260 was considered an abortion. The mixed model used for calving interval analysis in SAS 9.2 (SAS Institute, Cary NC) is shown below

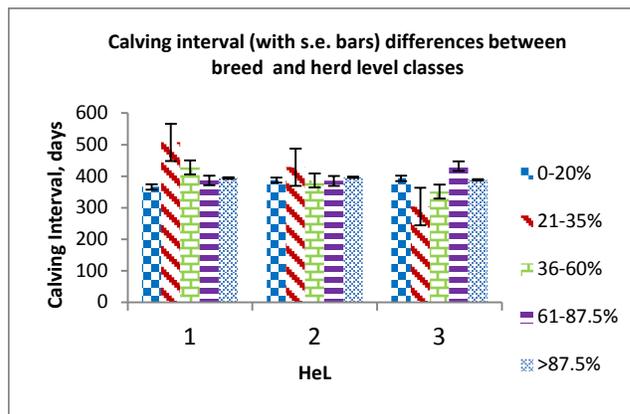
$$y_{ijk} = \bar{\mu} + A_i + G_j + H_k + \varepsilon_{ijk},$$

where y_{ijk} is the calving interval observation, $\bar{\mu}$ the overall mean, A_i the effect of parity, G_j the effect of cattle exotic breed grade and H_k the herd cluster with repeated effect of cow and ε_{ijk} the random error.

Mortality rate was calculated as a fraction of total number of dead cows to herd size; trading rate was a fraction of total number of cows sold relative to herd size while cow exit rate was a fraction of total number of project cows to cow herd size. Herd size was estimated from the sum of animals in the households at baseline, including all acquisitions less animal disposals. All rates were standardized to a rate per 100 animals.

RESULTS

Attrition: Over the course of the study, farmers sold 30% of the starting number of cows. Other animals were withdrawn from the study (4%), died (6%) or were otherwise unavailable for data collection (5%). The herd level mortality, trading and cow exit rates are indicated in



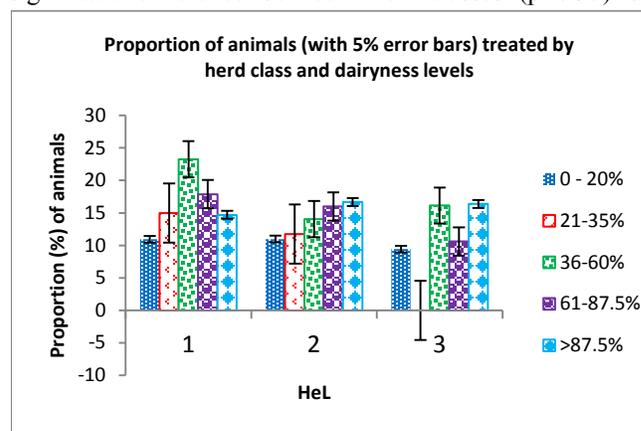
Herd (HeL) classes: 1=1 – 4kg milk/d; 2 = 4 – 5kg/d; 3=>5kg/d

Figure 1. Calving intervals (Days) in smallholder dairy farms by exotic breed level (dairyness) and Herd Class (HeL).

Table 1. Mortality rates were low for all herd classes. Distress selling to offset emergency financial needs was the most important reason for animal disposal, followed by death and other socio-cultural uses. In contrast, only a small proportion of animals (4%) were culled due to poor performance.

Calving Interval: A total of 1,150 animals had calving data. On average, calving interval (CI) averaged 451 ± 101 days, with a range between 261 days to 761 days. There was a distinct bimodal distribution of CI intervals with peaks at 310 to 350d and at 510 to 550 months. Significant differences in CI between parities ($p = <0.0001$) were observed, with higher parities being associated with shorter intervals (data not shown). Calving intervals for HeL classes were significantly different ($p = 0.045$), with 42 ± 18 days separating the lowest and highest HeL class. Animals in the 75% dairy class had higher calving intervals in the high producing herd class (HeL=3) (Figure 1). Animals with greater than 87.5% exotic germplasm tended to have similar CI in all herd classes.

Service to Conception (STC): Most of the animals (>77%) required only one service to conceive. There was no significant difference between HeL classes ($p=0.95$) or



Herd (HeL) classes: 1=1 – 4kg milk/d; 2 = 4 – 5kg/d; 3=>5kg/d

Figure 2 Proportions of animals treated in smallholder dairy farms by exotic breed level (dairyness class) and herd class (HeL).

dairy classes ($p=0.27$) in number of STC.

Disease: No significant difference between dairy classes ($p=0.86$) or HeL classes ($p=0.83$) in frequency of disease events was observed. However, a large number of the affected animals in HeL class 1 were from the 36-60% dairy class (Figure 2). Most animals were only treated once for either East Coast fever (ECF), mastitis, bovine TB, trypanosomosis, foot-and-mouth disease (FMD), anaplasmosis, eye infections or skin disease, which were the most frequent diseases. The lowest proportion of animals was treated in HeL 2.

DISCUSSION

The choice of the Bovine HD SNP panel for breed composition prediction was informed by presence of a larger number of SNP markers from *Bos indicus* breeds compared to previous SNP panels. However, because use of the Bovine HD panel may be cost prohibitive, less dense marker panels would still be predictive as long as the SNP profile is representative of the breeds being evaluated.

In our study, animal usage patterns and dynamics point to significant disposal of lactating animals. Even though the global cow sale rate was comparable to intensive dairy systems elsewhere, the sale of active lactating animals was much higher (60% of lactating cows in these herds were sold in a span of 2 years). These cows had an average dairyness of > 60% and milk production >5kg/day (data not shown). This is in contrast to a typical dairy farm scenario where farmers will keep their cows longer so as to benefit from the higher milk yields obtainable from higher parities. The fact that farmers did not sell their animals to cull poor-performing cows but rather for income indicates a fundamental difference between this smallholder system and other intensive dairy systems.

The low animal mortality observed may relate to significant farmer efforts to mitigate adverse disease effects by applying preventive control measures such as vaccination, dipping and spraying or treatment of sick animals. Despite the high disease burden in the study sites, the majority of animals received treatment only once for any of the top 5 diseases observed. It is important to note that animals surviving to adult age in these systems are possibly more adaptable genotypes compared to those that died as calves.

Many animals required only one service to conceive. This could have been driven by the widespread use of bulls rather than AI for mating. Calving intervals were generally long, probably as a result of silent heat, failure to detect estrus, and early termination of pregnancy. About 18% of the animals evaluated had an abortion. It is interesting that farmers still chose to keep animals with calving intervals greater than 700 days. Whether this is by choice or because of inability to sell the animals is not clear. The longer calving intervals for the low producing herds may be linked to higher disease burdens, given that these animals are reared in marginal and hotter regions and were therefore predisposed to higher disease challenge. Fig. 2 indicates that a higher proportion of animals was treated for HeL 1 compared to the other HeL. Further investigation is needed to verify this.

Anecdotal evidence and previous research suggests that the optimal level of taurine inheritance in crossbred animals lies between 50% and 75% when considering total productivity in terms of fertility, survival, growth rate and milk yield (Bee et al., 2006). This study has however demonstrated that for low input smallholder producers, there are no differences between these crossbred in disease susceptibility. The animals performed more or else at the same level for both higher input and lower input systems. However, animals in the 61-87.5% group tended to have higher calving intervals in high producing HeL class (Figure 1). It is interesting to note that crossbreds with lower exotic breed percentages (21-25%, 36-60%) had lower CI in the high performing HeL class compared to the higher crossbreds. Even though it is clear that increasing the exotic percentage is generally expected to result in greater performance, the cumulative benefits relative to farmer socio-economic status, input level and production environment seem to be quite low for smallholder farmers in the study sites evaluated.

CONCLUSION

Despite the long calving intervals observed in this study, crosses with 21-60% exotic germplasm in high performing herd classes, had shorter calving intervals than crosses with higher exotic composition. Given that their disease incidence profiles in high performing herds are either lower or equivalent to the crosses with higher exotic composition, these crossbreds would be more appropriate for the production systems studied. These results have significant implications for extension services and animal usage patterns in the region. Further studies will however be required to understand the cause of the long calving intervals in relation to farmer practices and disease burden.

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