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CONTINUOUS SEXED DAIRY F_1 PRODUCTION TO ALLEVIATE POVERTY: COMBINING THE ECONOMICS AND THE GENETICS

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SUMMARY

We developed an economic model comparing the profitability of Kenyan peri-urban dairy smallholder production systems for different dairy breeds: purebred Friesians, F_1 cows produced by AI, and by Sexed (female) *in vitro* fertilised, F_1 Embryo Transplant (SIFET). Annual profit per cow (averaged over the cow's lifetime) was AUD73 for naturally bred Friesians, AUD120 for F_1 cows produced by artificial insemination, and AUD205 for F_1 cows produced by sexed *in vitro* fertilised embryo transplant.

INTRODUCTION

Much of the milk produced in Kenya (and East Africa in general) is produced by dairy smallholders, who may have two or three animals (Waithaka, *et al.* 2002), and who obtain feed for their cows largely by the 'cut and carry' system, often from public places such as roadsides. Poverty is widespread in Kenya, and the milk produced by the dairy smallholder, however small, produces invaluable income as well as food for the family. Crossbreeding of dairy cattle can lead to economic gains, particularly if adaptive traits such as disease resistance are included in the breeding objectives (Swan and Kinghorn, 1992; Syrstad, 1989; Touchberry, 1992). Heat tolerance is equally important in much of Kenya (King, 2006). In Kenya, particularly in the cooler highlands, crossbreeding a local Zebu cow with a Friesian bull results in a cow that is almost as thrifty and healthy as a Zebu (and almost as productive as a Friesian), so the F_1 cross is a recommended choice (Rege., 1998, Rutledge, 2001) rather than a Friesian or backcross. However, this requires the farmer to either purchase an expensive crossbred heifer or to own a Zebu cow as part of their dairy smallholding. Zebus are hardy but not very productive and the cow would have a 50/50 chance of producing an almost worthless male calf following the considerable cost of the pregnancy, resulting in a net loss.

The ability to produce female (using sexed semen) F_1 calves without the need for the farmer to keep a Zebu cow could result in increased profitability and security for the farmer and her family. A combination of techniques, including sexed exotic breed semen, slaughterhouse egg harvesting from Zebu cows, *in-vitro* fertilisation and embryo transplant, could provide this nirvana for the dairy smallholder farmer, whose main aim is to have a well adapted and highly productive dairy cow under delicately limited sets of resources. Currently, there is no systems in-place to sustainably deliver such a genotype to the smallholder dairy farmer in Kenya and the Eastern African region at large. This paper presents the possible costs and benefits analysis of using semen, and in-vitro fertilization of Zebu cow eggs and embryo transplant, (SIFET) using available data in Kenya.

MATERIALS AND METHODS

Lifetime profitability as used, for example by Thorpe (1994), allows for varying intercalving intervals, age at first calving and numbers of lactations of various breeds and crossbred animals to be included in an overall profitability framework. It is important to estimate the whole lifetime profitability of an animal (including the rearing period), rather than the profitability only during the part of the cow's lifecycle when she is actually producing a calf or milk which does not allow for the age at first calving. Under the local dairy smallholder conditions age at first calving may be almost four years, depending on the management level and represents a significant production cost for the farmer.

Lifetime profitability is divided by the total number of years the cow is kept, to give annual profit. The lifetime profit produced by a cow is calculated as shown below:

$$\begin{bmatrix}\text{lifetime}\\\text{profit}\\\text{from}\\\text{cow}\end{bmatrix}_{type} = \begin{bmatrix}\text{total}\\\text{income}\\\text{from}\\\text{cow}\end{bmatrix}_{type} + \begin{bmatrix}\text{salvage}\\\text{value}\\\text{of}\\\text{cow}\end{bmatrix}_{type} - \begin{bmatrix}\text{cost of}\\\text{acquisition}\\\text{of}\\\text{cow}\end{bmatrix}_{type} - \begin{bmatrix}\text{cost of}\\\text{maintenance}\\\text{of cow}\end{bmatrix}_{type}$$

Information on calving intervals, milk yields, longevity was obtained from King (2006), Waithaka (2002), Bebe (2003a, 2003b), Kahi (2000), Syrstad (1989), from discussions with local dairy enterprises, and from staff at the International Livestock Reasearch Institute, Nairobi, Kenya. Energy requirements were from Moran (2005). Intercalving intervals were assumed to be 460 days (Friesian) and 429 days (F_1). Milk yields were 3000 (Friesian) and 2200 (F_1) litres per lactation. Farm gate milk sale price was 20 Kenya Shillings (AUD 0.36) a litre. No allowance was made for milk composition. Obtaining ovaries from slaughtered cows is very easy. It typically takes ten minutes to find and remove the ovaries of each slaughtered cow, and abattoir payments were assumed to be approximately AUD150 per collection cycle of 100 ovaries. Every ovary was assumed to yield five ova, of which 20% resulted in implantable embryos. Pregnancy rate following embryo transplant was assumed to be 50% and calf survival rate was 80%, while 90% of calves were assumed to be female. Labour costs depended on skill levels, shown in Table 1.

Table 1. Labour costs (AUD)

per hour	class
5.45	professional
2.18	skilled
1.27	semiskilled
0.36	rural unskilled
0.15	farmer notional

Table 2. Some Profit Components

	Friesian	Sexed *in vitro* fertilised embryo transplant crossbred	Artificially inseminate Friesian Zebu crossbred
cost of acquiring/growing an in-calf heifer (AUD)	525	328	249
age at first calving (years)	32	32	32
intercalving interval (days)	460	429	429
number of lactations	4	7	7
milk per lactation (litres)	3000	2200	2200
cow maintenance cost/day (AUD)	0.7	0.5	0.5
total feed & labour cost required for milk production (AUD)	2654	3474	3474
total cow maintenance cost (AUD)	1229	1645	1645
total income from milk (AUD)	4364	5600	5600
net income from milk (AUD)	480	481	481
net income from calf sales (AUD)	222	1726	722
salvage value (AUD)	389	357	357
years owned	8	11	11
total profit (AUD)	566	2236	1311
annual profit (AUD)	74	205	120

RESULTS AND DISCUSSION

Reported yields and inferred profitability differed greatly throughout Kenya's highly diverse regions, so this study was based on information from peri-urban inland regions with seasonal but generally adequate rainfall, and where milk market is more or less guaranteed.

Table 3 Sensitivity

component	change
base: increase in SIFET profitability compared with F_1 AI	70.56%
milk price	-4.08%
SIFET calf mortality rate	-3.58%
cost of ET	-3.11%
milk yield	-2.79%
SIFET cow longevity	-2.39%
embryo cost	-0.33%
age at first calving	-0.05%
F1 cow longevity	0.00%
male calf sale price	0.02%
F1 calf mortality rate	0.08%
sale price of heifer	0.73%
intercalving interval	2.57%
sex ratio of female sorted semen	2.69%
SIFET female sale price	3.18%

The milk production of Kenyan smallholder dairy cows is considerably less than Australian dairy cow production largely because of shortage of feed at most stages of the life cycle. Although the total lifetime feed and labour costs for the crossbreds are, because of their longevity in herds, greater than the Friesian, the increased number of lactations results in increased profitability.

Depending on farm location, F_1 crossbred cows are usually healthier, survive longer, are more fertile, eat less and produce more milk than purebred exotic dairy cows under moderate management conditions that characterize many smallholder dairy cattle systems in Kenya and the neighbouring countries (Table 2).

The sensitivity of this model is measured by how much the annual profit (expressed as a percentage increase of the SIFET calf over the AI crossbred calf) changes following a one percent change in one of the components of profitability, as shown in Table 3. No interactions between the various components of profitability were estimated for this model.

Annualised profitablity is particularly sensitive to milk price, so a 1% increase in milk price results in a counterintuitive reduction of profitability of the SIFET calf of 4.08%. This is because milk production is only slightly profitable, and if the milk price increases, the profitability of the cow that produces a male F_1 calf (usually from unsexed semen) is increased relative to the cow that produced a calf as a result of a sexed embryo. Likewise an increase in the intercalving interval increases the advantage of the cow producing a female calf (especially as a result of a sexed embryo). The model is also quite sensitive to the mortality rate of the SIFET calf. It seems unlikely that the SIFET calf would have a higher mortality rate than the AI calf, especially as the majority of SIFET calves would be female (that have lower perinatal mortality rates) whereas the AI calves would be equal numbers of males and females.

The annual profitability (measured over the animal's lifetime) of the purebred and crossbreds is shown in Table 4. The annual profitability of both types of crossbred was greater than the purebred Friesian: the Friesian produced an average profit of AUD74, the AI crossbred AUD120 and the SIFET crossbred AUD205. The main profit driver is the relative value of a female dairy calf compared with the value of a male calf. This may not be the case in production systems such as crop-livestock systems of the Ethiopian highlands, where the value of the male calf is considerable because of its value as a draught animal. In such systems sexed embryos would not be as economically attractive. Besides, it could be of relevance in areas where diseases such as Trypanosomiasis may be controlled by crossbreeding exotic dairy breeds such as Jerseys with the trypanotolerant N'dama cattle, especially where the F_1 has a particularly strong advantage over backcrosses in terms of trypanosomis and heat tolerance.

Table 4. Annual profitability of Friesian and F_1 cows, averaged over their lifetimes

	Annual Profit (AUD)	annual profit increase compared with Friesian	annual profit increase compared with crossbred AI
Friesian	74		
AI crossbred	120	63%	
SIFET crossbred	205	177%	71%

The advantages of SIFET may not only apply to sub-Saharan Africa. Many developing and developed countries, including Australia have a shortage of replacement dairy cows, which results in little selection of heifers joining the herd, and possibly reduced voluntary culling. Although sexed semen *per se* is more of an economic option for use in AI in developed countries, SIFET may also be an option worth investigating, whether for generating purebred or for crossbred F_1 animals.

CONCLUSIONS

With the input parameters used in this model, a farmer would make approximately 71% more profit when using a continuous flow of F_1 cows, compared with F_1 cows bred using AI on zebu cows. This is largely because milk is currently only slightly profitable to produce, and male calves have a relatively low sale price compared with female calves. When compared with naturally bred Friesians, profitability per cow per year is increased by 63% for the AI crossbred and by 177% for the SIFET crossbred.

These results suggest that further investigations and more detailed feasibility studies, including on-farm trials, should be undertaken to access the viability of a sexed *in vitro* fertilisation embryo transplant program.

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