Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) DOI: 10.7176/JESD
Vol.10, No.18, 2019
www.iiste.org

Socio-Economics Determinants of Selection Criteria for East African Zebu Cattle Breeding for Dairy Production: Case of Kitui County, Kenya

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Abstract
East African Zebu (EAZ) cattle play a very important role in the livelihoods of the Arid and the Semi-arid communities. Despite the breed being the most populous, its contribution to the dairy industry is very low. To ensure success of a breeding program for more milk production, there is need to understand how the indigenous farmers select their breeding cows and bulls for more milk production. A study was therefore conducted in Kitui County to determine the farmers' selection criteria for breeding bulls and cows for more milk production. To determine how farmers, select an animal for breeding, five selection criteria traits for bulls and eight selection criteria for cows were ranked using Friedman non-parametric analysis of variance test and Wilcoxon Test. Multivariate Probit model was used to determine the influence of socio economic factors on bulls and cow selection criteria for EAZ breeding. The mean ranks indicated that the bull's body frame (5.94), udder shape (6.04), teat size and placement (5.8) for cows were regarded as the most important selection criteria.The Multivariate Probit regression results showed that male farmers had a higher preference for bulls' body frame than female farmers. The study concluded that selection criteria in breeding bulls and cows are significantly influenced by socio-economic and demographic factors. Key recommendation from the study is to consider farmers' trait selection criteria in planning and design of a breeding program
Keywords: selection criteria, breeding program, East African Zebu
DOI: 10.7176/JESD/10-18-06
Publication date:September 30th 2019

1. Introduction

For many years EAZ has been the most populous and well adapted breed in the ASALs of Kenya. However, the milk productivity of EAZ has been too low to keep pace with the expected increase of 4% in demand for the dairy products by the year 2025 (Delgado *et al*., 2001)

Breeding programs provide a good opportunity for improving the milk production of the indigenous breeds. However, in most low input production systems, selection criteria are not well defined to warrant success of a breeding program. This has hindered the sustainability of genetic improvement in such systems (Rege *et al*., 2007). Indigenous knowledge for traits selection criteria can only be made available through farmers' participation in the designing of the breeding program.

Farmer characteristics have a strong influence on farmers' preferences for improvements in traits, and therefore, variables describing farmer characteristics should be included in studies analyzing heterogeneity of farmers' preferences (Makokha *et al*., 2007; Martin-Collado *et al*. 2015). Such information would help to ensure that breed improvement interventions are consistent with the needs of the intended beneficiaries.

Attempts have been made in the past to improve the milk production of the indigenous breeds. These attempts have only focused on the marketable output (milk and meat) without due consideration of the multi-functionality attribute expected of the breeds by the farmers. This has consequently rendered the well-intended breeding programs unsustainable (Rege *et al*., 2007).

In order to impose and ensure success of a breeding program, this study aims at determining the selection criteria for bulls and cows traits for breeding EAZ for more milk production and the socio economic factors that determine such selection criteria.

2. Theoretical framework

The study involves decision-making; Random utility maximization theorem is applied. Utility maximization is a goal to maximize satisfaction from allocating limited resources (Greene, 2008). Selection of trait decision was considered under the general utility maximization framework. African farmers are resource poor but rational therefore, they compare the expected utility of both risky and uncertain prospects hence chose the one that yields a higher expected utility value.

A risk averse farmer maximizes utility by selecting the traits that will fulfil all his production objectives (herd increases, milk production, draught power, cultural function). Selection criteria adopted by the farmer must enable him to fulfil all his production objectives hence maximize utility. This is the case if the benefit of adopting such

selection criterion exceeds the benefits realized without such selection criteria.

By letting the utility of trait say B be U_J and the utility of not selecting trait B be U_O then the latent net benefit of selecting or not selecting a certain trait can be expressed as presented in equation 1:

$$Y_j^* = U_j - U_O \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation 1}$$

Y_j^* An unobservable latent function with its observed counterpart being a binary variable Y taking 1 for $Y^*>0$, and 0 for $Y^* \leq 0$. The latent selection decision is determined by the socio-economic characteristics for selecting or not selecting a certain trait j as presented in equation 2:

$$Y_{ij}^* = X_{ij}\beta_j + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Equation 2}$$

When j=bull body frame, appearance, scrotal size (traits under consideration), X represents the socio economic characteristics of the individual farmer *i*. ε is the composite error term (consists of the unobserved farmer socio economic characteristics. Since the latent (net) benefit is observed when the farmer rate the trait as important or not important, equation was mapped to an observable binary variable indicating whether or not the farmer rated the trait important or not important as presented in equation 3:

$$Y_{ij}^* = \begin{cases} 1 \; if \;\; Y_{ij}^* > 0 \\ 0 \; if \;\; Y_{ij}^* \leq 0 \end{cases} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation 3}$$

To estimate substitutability and complementarities in the utility maximization framework, Bhat *et al*. (2015) advocated for the use of multivariate models.

3. Research methodology

The study was conducted in Kitui County, located in Eastern Kenya. Livestock keeping contribute most to the livelihoods in the County. The selection of the study area was mainly based on population of indigenous EAZ cattle and their high dependence for milk needs such that the genetic loss of the breed would result in a threat to livelihoods.

To determine how farmers, select an animal for breeding, five selection criteria traits for bulls and eight selection criteria for cows were ranked using Friedman non-parametric analysis of variance test and Wilcoxon Test. Multivariate Probit (MVP) model was used to determine the influence of socio economic factors on bulls and cow selection criteria for EAZ breeding. Farmers are likely to consider several traits while selecting a cow or bull for breeding. The possible interrelationships between the selection criteria should not be ignored. MVP model accounts for joint decision making by farmers and the potential correlation in the traits preference (Marenya and Barrett, 2007).

MVP allowed the unobserved and or unmeasured factors (error terms) to be freely correlated. One source of correlation may be complementarities (positive correlation) and substitutability (negative correlation) between different selection criteria (Ndiritu *et al*., 2014). Failure to capture unobserved factors and inter-relationship among selection decisions regarding different selection criteria will lead to bias and inefficient estimates. The MVP is an extension of the probit model (Greene, 2008) and is used to estimate several correlated binary outcomes jointly.

The motivation to use MVP is that the characteristics used vary for each individual but not across the different outcomes

$$\boldsymbol{Y_1^* = X'\beta 1 + \varepsilon_1 \; for \; Y_1 = \gamma_{\{Y_1^*>0\}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Equation 4}$$

$$\boldsymbol{Y_2^* = X'\beta 2 + \varepsilon_2 \; for \; Y_2 = \gamma_{\{Y_2^*>0\}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Equation 5}$$

$$\vdots \qquad\qquad \vdots$$

$$\boldsymbol{Y_j^* = X'\beta j + \varepsilon_j \; for \; Y_j = \gamma_{\{Y_j^*>0\}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{Equation 6}$$

Y_j^* Denotes the underlying latent response associated with jth selection criterion, for *j*=1……*J*. Y_j denotes the binary response outcome associated with j selection criterion, Y=1 if the selection criteria is important, Y=1, 0, otherwise. MVP model therefore is expressed as linear combination of deterministic and stochastic parts as follows:

Where X = (1, $x_1 \ldots x_p$)' is a vector of p covariates which do not differ for each selection criterion (the deterministic part) and $\beta j = \beta j0, \beta j1, \ldots\ldots \beta jp'$ is a corresponding vector of parameters, including the intercept, which we seek to estimate. ε_j Represents the stochastic part, the unobservable factors which explain the marginal probability of selecting trait *j*.

4. Results and discussion

4.1 Selection criteria for bulls

Figure 1 shows the mean rank score (ranks) of bull traits preferred by Kitui County farmers for breeding EAZ. Traits associated with fitness 47% (body frame), cultural or aesthetic (appearance) 33% value in bulls were highly valued by the farmers and these traits cannot be underrated as high performing bulls without these attributes were not selected for breeding. Similar findings were documented by Kamuanga *et al*. (2011) where they indicated that mixed livestock-crop farmers have higher preference for animal traction than milk off-take and reproductive

performance.

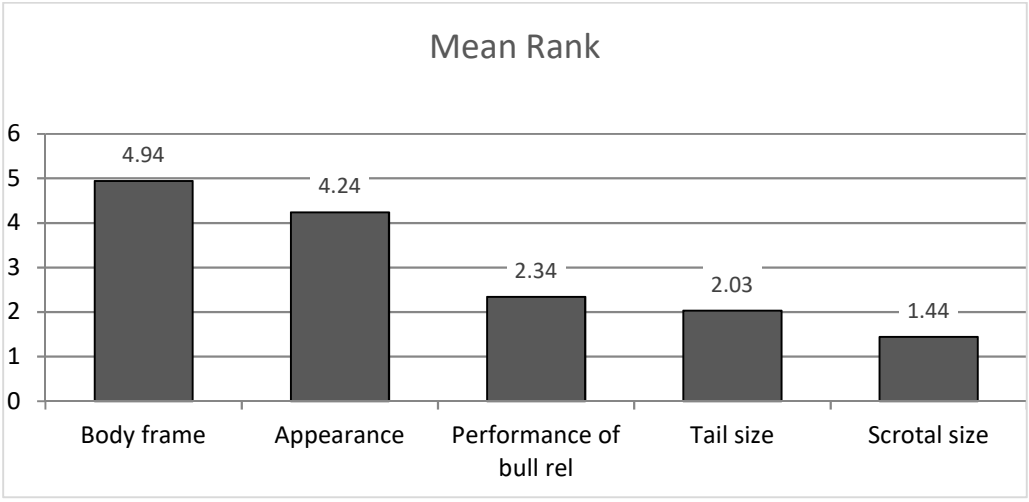

Figure 1: Ranking of bull traits

Bulls in Kitui County are mostly used for traction hence a bull with good traction ability was found to be the most preferred. Bulls with big body frame and size were also desirable because they fetch higher market prices during sale (Jabbar and Diedhiou, 2003). Kassie *et al.* (2009) reported that in Ethiopia bulls were kept for at least two purposes traction and reproduction).Scrotal size indicating reproductive capability in bulls was not as important as the traction ability.

The high preference of appearance (coat color and horns) in bulls than in cows may be attributed to the fact that the appearance of bulls predicts the appearance of the herd. The preference of farmers for a particular coat color might be associated with social cultural practice, market demand and environmental adaptation (Tano *et al*., 2003; Ruto *et al*., 2008; Tada *et al*., 2013).

Performance of the bull's relatives was ranked as the third (9%) most important selection criteria for a bull. Scrotal circumference was ranked last by farmers, who indicated that big and long testes indicate dairy potential in bulls. Scrotal Circumference also indicated the reproductive potential in bulls.

4.2 Selection criteria for cows

In cow trait preference, traits that farmers associate with high milk yield (udder and teat size) had the highest mean rank of 6 ***(figure. 2)***.

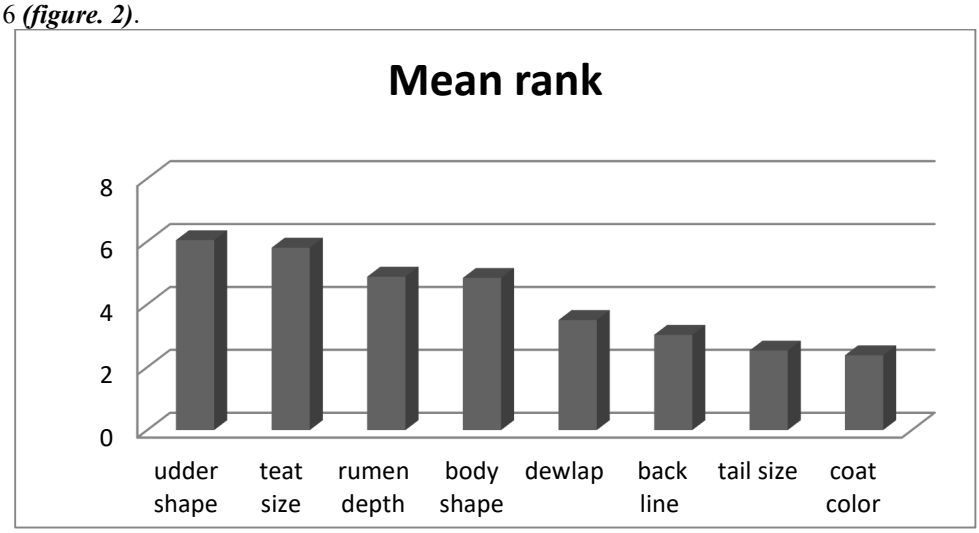

Figure 2: Ranking of cow traits

It has been reported that high preference for milk production traits was common among many traditional African cattle owners because they keep cows primarily for milk (Garoma *et al*., 2013). Udder, teat size and shape are highly heritable, hence any abnormality of the two is easily passed on from the cow to the offspring (Cassell, 2002).

Rumen depth was ranked second. This is attributed to feed and water intake, and consequently milk production and live weight. Although this is preferable for a dairy production system, it might be a challenge in areas experiencing frequent drought such as in Kitui.

High preference for body shape (4.84) was attributed to the importance this trait plays especially in agro pastoral areas where a cow walks in search of fodder and water. A good body shape was essential during gestation in enabling the cow to feed comfortably as well as carrying its foetus to term.

Dewlap presence and appearance was ranked as the fourth most important selection criteria. In general EAZ cattle have a large dewlap. A large dewlap and loose skin provide a large surface area for perspiration under the hot and humid tropical climatic conditions (Kugonza *et al*., 2012). A sturdy back was also considered an important trait in cow selection. Tail length were ranked as the second last selection criteria. Tail length was termed as the most visible trait indicating the milk production of the cow. Long tail with big base was selection criteria indicator trait for high milk yield, high carcass weight, beauty and big offspring.

Socio-economic aspects

Gender: Gender of the household head had a negative influence on the preference of bull's body frame and a positive influence on the preference for bull's appearance ***(Table 1)***. Male farmers had a higher preference for bull's body frame than female farmers did. Use of bulls for draught purposes was a major activity being undertaken predominantly by men and young boys. Ouma *et al*. (2004) also indicated that male household heads tend to prefer bulls with good traction ability more than their female counterparts do. Female farmers had a higher ranking of bull appearance than their male counterparts did. This could be attributed to the natural care of females to the wellbeing of living species (Ainslie, 2005). ***Distance to the water source*** had a positive influence on choice of bulls based on their body frame, appearance and performance of bulls' offspring ***(Table 1)***. Bulls with a big body frame were highly preferred since bulls are used in pulling carts to fetch water. Bulls with horns and hump were preferred to ensure yokes do not come out during fetching water. Bulls which sired offspring with a light color and big body frame were preferred as the offspring were hardy enough to trek long distances in search of water.

Household size had a negative influence on bull body frame ***(Table 1).*** A big household size implies more labor supply. Having many children was also considered as an asset as this guarantees as a supply of labor for herding and farming activities. Household size had a positive influence on choice of bull based on scrotal size and tail size ***(Table 1).*** Scrotal size indicates bulls' fertility; bulls with big scrotum were believed to be very productive hence fast herd increases. Sellen (2003) showed that herd size was positively influenced by the number of people in the household due to consumption needs.

Table 1: Socio-economic factors for bull selection criteria

Variable	body frame	Appearance	performance of relative	tail size	scrotal size
Household size	-0.26(0.11)**	0.04(0.01)	-0.01(0.04)	0.08(0.05)**	0.05(0.08)*
Herd size	-0.01(0.08)	0.06(0.06)	0.14(0.05)**	0.14(0.01)**	0.10(0.04)**
Land size	-0.01(0.02)	0.007(0.015)	-.02(0.010)**	.013(0.02)***	-0.01(0.01)**
Education	0.022(0.017)	0.01(0.02)	0.005(0.012)*	-0.01(0.012)	(0.05) (0.01)
Gender	-0.84(0.41)**	1.02(0.48)**	-0.16(0.31)	-0.31(0.03)	0.36(0.30)
Distance to water	0.09(0.11)**	-0.05(0.03)*	0.01(0.032)**	-0.03(0.03)	-0.06(0.03)
Occupation	4.84(0.14)*	0.88(0.52)**	-0.56(0.28)***	-0.54(0.27)***	0.35(0.22)
Owns phone	-0.08(0.04)	-0.17(0.03)	0.17(0.28)	-0.53(0.28)**	-0.43(0.29)***
Age	-0.08(0.12)	-1.12(0.09)	-0.07(0.01)	0.22(0.14)***	0.18(0.09)

Note: Standard errors in parenthesis; ***p<0.01, **p<0.05 and *p<0.1

Occupation of the farmer had a positive influence on preference of bull based on body frame and appearance ***(Table 1).*** This was attributed to the role a bull play in the farming activities to full time farmers as opposed to off-farm farmers who might have income to hire a bull or other sources of energy for farming activities. Kassie *et al*. (2009) reported that as education level increased, the sensitivity towards body size also increased.

Herd size had a positive influence on performance of relatives, tail size and scrotal size ***(Table 1)***. Bulls with good reproductive performance become highly valued because it ensures fast herd increases (Ouma *et al*., 2007). Sellen (2003) showed that herd size was positively influenced by the number of people in the household due to consumption needs. Performance of relatives (calf performance) increases the probability that the bull will be selected on the premise that a higher utility can be derived (Kamuanga *et al*., 2011).

Age: The older a farmer was the higher the preference for tail size ***(Table 1)***. Older farmers mentioned that tail size was the most visible indicator for milk yield. Long tail with big switch has been considered a selection indicator trait for high milk yield, high carcass weight, beauty and big offspring (Kugonza *et al*., 2012).

4.3. Socio economic determinants of selection criteria for cows

Land size had a negative influence on the choice of the cow based on body shape ***(Table 2)***. Body shape reflected the ability of a cow to withstand walking for long distances in search of pasture. Farmers with big parcels of land have readily available pasture for their cows hence there was no need for the cow to walk for long distances in

search of pasture. ***Land size*** had a negative influence on teat size (***Table 3)***, rumen depth (***Table 2)***, tail size (***Table 2)*** and coat color (***Table 3***). The smaller the land size the higher the preference for teat size, tail size, rumen depth and coat color.

Table 2: Socio economic determinants of traits selection criteria for cows

	Dependent variables			
Explanatory variables	tail size	dewlap size	rumen depth	body shape
Land size	-0.014(0.014)**	-0.022(0.012)	-0.026(0.017)**	0.027(0.011)**
Herd size	0.033(-0.04)*	0.107(-0.06) **	0.126(-0.05) **	-0.01(-0.07)
Household size	0.06(-0.04)**	0.048(-0.02)	-0.045(-0.07)	0.409*(-0.14)
Water distance	-0.06(0.03)	0.072(0.09) **	0.257(0.129) ***	0.92(0.062)**
Experience	-0.005(0.01)	-0.013(0.01)	-0.003(0.015)	0.001(0.019)
Age	0.018(0.011)*	-0.008(0.011)	0.018(0.015)	0.045(0.024)*
Gender	0.353(0.117)	0.589(0.253)	0.758(0.112)**	0.368(0.247)
Occupation	0.357(0.146)	0.981(0.258)	0.163(0.368)**	0.222(0.572)
Education	0.541(0.231)**	0.321(0.224)	0.126(0.094)	0.354(0.023)

Note: Standard errors in parenthesis; ***p<0.01, **p<0.05 and *p<0.1

Herd size: Herd size had a positive influence on dewlap size (***Table 2)***, coat color (***Table 3)*** and rumen depth (***Table 2)***. These three traits are adaptive traits. Agro-pastoral farmers are faced with many challenges especially loss of animals during drought periods. This was the reason cited by many for selecting for traits related to maintaining large herd sizes. Furthermore, herd size is often directly correlated to wealth and status in the pastoral societies. In addition, a significant portion of the herd is a risk management tool rather than a productive asset (Rege *et al*., 2011). ***Household size:*** The bigger the household size the higher the preference for teat size (***Table 3***), tail size (***Table 2)*** and body shape (***Table 2)***. This concurs with Anunda (2012), that household size increased the probability of preference for high milk production traits.

Gender had a negative influence on preference for teat size (***Table 3***) and rumen depth (***Table 2)***. Female farmers had a higher preference for teat size and placement than males. This could be attributed to the role women play in the milking of cows which is usually not a male role in the study area. Hence aside from attributing udder and teat size with high milk yield, good udder and teat enhances milking ease. Milking ease is of essence in maximizing yield since milk let down is controlled by oxytocin hormone whose concentration diminishes with milking time (Rewe, 2015).

Table 3: Socio economic determinants of traits selection criteria for cows

Explanatory variables	**Dependent Variables**			
	Coat color	Backline	Udder shape	Teat size
land size	-0.023(0.01)**	0.021(0.018)*	0.416(0.363)	-0.536(0.365)**
herd size	0.142**(0.047)	0.123(0.043)	0.53(0.005)	0.836(0.584)
household size	-0.073(0.045)	-0.011(0.042)	0.256 (0.131)	0.943**(0.258)
distance to water source	0.043(0.038)	-0.089 (0.029) **	0.587(0.25)	0.59(0.411)
experience	-0.028(0.012)	-0.011(0.001)	0.369(0.194)	0.514(0.258)*
Age	0.014(0.013)	-0.013(0.011)	0.442(0.37)	0.524(0.356)
Gender	0.258(0.139)	0.586*(0.128)	0.486(0.041)	0.3290.023)***
occupation	-0.586*(0.289)	0.347(0.057)	2.21(0.785)	0.941(0.634)**
education	0.589**(0.058)	0.987(0.036)	0.962(0.058)	0.875 (0.067)**

Note: Standard errors in parenthesis; ***p<0.01, **p<0.05 and *p<0.1

Farmers experience in livestock farming*:* The higher the experience in livestock farming the higher the probability of ranking teat size and placement as the most important trait in a cow (***Table 3***). Quddus *et al*. (2017) documented that experience has a strong positive relationship with the adoption of dairy technology. Anunda (2012) echoed that farming experience negatively influenced preference for high milk yields breeds. There was no significant difference in all covariates in the ranking of udder size as the most preferred trait. This implies that udder size was the most preferred trait cutting across all the socio economic factors.

5 Conclusion

Udder and teat size in cows and body frame in bulls were the most important selection criteria in cattle selection. Coat color was ranked higher in bulls than in cows. Bulls' selection was influenced by gender, land size, water distance, household size, occupation of the farmer. Male farmers had a higher preference for bulls body frame than female farmers. Gender had a significant influence on the ranking of rumen depth and teat size, this was attributed to the role women play in the livestock production (milking and feeding of cattle)

6. Recommendation

A breeding program to improve EAZ milk production should consider farmers trait selection criteria, target on solving feed and water shortage and most importantly consider the role of women in livestock production.

Acknowledgement

Special thanks to Agricultural Economics Research Consortium (AERC) for the financial support that enabled me to pursue the program and Kenya Agricultural Livestock and Research Organization (KARLO), Naivasha for the support in the data collection activity.

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