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Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices

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Abstract

A stratified random sample, cross-sectional survey of 1755 households in the Kenya highlands was conducted between June 1996 and April 1998 to evaluate the rationale underlying smallholders' breeding decisions. Additional data were collected in a follow-up survey of 50 households sub-sampled from the main survey sample. Cattle-keeping households were 987, of which 62% kept Friesian (FR) and Ayrshire (AY), 22% kept East African Zebu, Boran and Sahiwal (ZB) cattle and 16% kept Guernsey and Jersey (GJ) breeds. Farmers keeping ZB and GJ ranked producing milk for family consumption the most important reason for keeping cattle, whereas those keeping FR and AY ranked producing milk for cash income most highly. Farmers' relative preference for GJ, AY and FR for high milk yield over hardiness was respectively 3.46, 7.58 and 17.63 times more when compared with preference for ZB. Additional attributes rated highly in the *Bos taurus* breeds were high butterfat yields, heavier bodyweight, unselective feeding behaviour in zero-grazing systems, hardiness and disease resistance in semi-zero- and free-grazing systems and high market value. Breeding practices tended to favour the use of dairy breeds of larger body size, particularly Friesian, which is inconsistent with technical recommendations that favour the use of the smaller dairy cattle breeds. These findings suggest that multiple objectives, including the need for more milk, adaptability to local feed conditions and diseases, and the provision of non-market production such as manure, insurance and financing roles of cattle, underlie smallholders' breeding decisions in the Kenya highlands.

Keywords: Smallholder systems; Breed preferences; Breeding practices; Dairy cattle; Kenya highlands

1. Introduction

Smallholder farmers in developing countries usually take a broad perspective to dairy production. Dairying is practised to produce milk for feeding the family and for sale, to produce manure to support crop production and to provide dairy animals for insurance and financing emergency cash needs and for social status (Udo and Cornelissen, 1998). This broad perspective to dairy production deviates from

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livestock development policies, which generally focus on the marketed inputs and outputs of livestock systems and on the services directly linked to these. The differences in perspectives to dairy production hamper the formulation of effective livestock policies aimed at improving the livelihoods of smallholders. For instance, a frequent recommendation for smallholder systems is the use of small mature sized dairy breeds (Guernsey and Jersey). The use of larger breeds (Friesian and Ayrshire) and/or upgrading to high exotic grades is generally discouraged because of their higher nutritional demand, low milk yield, poor adaptability and low production efficiency under smallholder conditions (e.g. Rege, 1998; Kahi et al., 2000; Wakhungu, 2000). However, smallholders in developing countries have often not followed the recommended breeding practices: they have preferred to keep the large mature size dairy breeds as a key component of their intensification strategies (Tulachan et al., 2000; Devendra, 2001; Bebe et al., 2002).

Adoption of technical recommendations at the farm level is dependent upon the social, cultural, economic and environmental conditions facing the farmers who own and use the animals (Solano et al., 2000). Breeding strategies generally evolve in response to changes in production systems, farmers' preferences and production objectives and farmers' knowledge about breed characteristics and market opportunities (Amer et al., 1998; Jabbar et al., 1999). Among the developing countries, Kenya has one of the most rapidly expanding dairy sub-sectors (ILRI, 2000). Smallholder farmers using exotic dairy cattle breeds, mainly in the highland areas, dominate the dairy sub-sector (Omore et al., 1999). Presently, smallholders own about 80% of the estimated three million dairy cattle population, comprising Friesian, Ayrshire, Guernsey, Jersey and *Bos indicus* cattle (local zebu, Boran and Sahiwal). Scarcity of feed resources and their poor quality are major constraints to improving production and reproductive performance (Methu et al., 2000, 2001). Diseases, mainly East Coast fever and Anaplasmosis, result in significant losses of animals from smallholder herds, which usually hold no more than three cattle. Nevertheless, the herds represent important liquid capital assets (Bebe et al., 2003). Given these production features it is important to know, not only which breeds farmers consider to be the most suitable to their circumstances, but also their perceptions of the breed attributes and the factors which affect their breeding decisions. This can help to focus research on traits of importance and to inform extension and to target public and private programmes supporting smallholder dairy producers. This study evaluated breed preferences and breeding practices by smallholders in order to understand better the rationale underlying breeding decisions by smallholder farmers in the Kenya highlands.

2. Materials and methods

2.1. Data collection

A stratified random sample cross-sectional survey of 1755 households in the Kenya highlands was conducted between June 1996 and April 1998 to obtain the reasons for keeping cattle and information on breed preferences and breeding practices. A detailed description of the study sites, survey methodology and herd management is presented in an earlier part of this study (Bebe et al., 2003). Each respondent keeping cattle was asked to rank his or her reasons (first, second and third) for keeping cattle: production of milk for family consumption; production of milk for cash income; advice from extension service; attractive looks of the animal; prestige from owning cattle; traction use; and cattle as collateral for loans. Based on the most frequent cattle breed in the herd, the respondents gave their primary preference for keeping that breed: high milk yield; high butterfat yield; attractive looks of the animal; unavailability of semen of a preferred breed; traction ability; hardiness (disease resistance, drought tolerance, mobility); and the advice of the extension service. Information was also gathered on how each respondent obtained the foundation dairy stock: direct purchase; gift (from a relative or a development project); or through upgrading from *Bos indicus* cattle. Respondents gave information on their animal husbandry experience, the perceived importance (1 = low, 2 = average and 3 = high) of diseases affecting their herds and the sources of breeding services (bull or artificial insemination (AI)) during the previous year.

A follow-up cross-sectional survey, based on semi-structured interviews of 50 households randomly selected from a stratified sample of the main survey, was carried out to obtain additional information on mating patterns and preferences attached to attributes of various cattle breeds. Stratification was by level of intensification in dairying activities, available household resources and level of market access using a combined method of principal component and cluster analysis applied to the main cross-sectional survey sample (Staal et al., 2001). Additional information on mating patterns was obtained from the 50 respondents through probing each respondent about the breed of their foundation cow(s) and the breed of sires mated both to the foundation female(s) and the subsequent heifer progenies over the generations. Identification of the breed attributes of importance to these 50 smallholders was through respondents' rating of the breed they kept on a scale of 1 (low preference) to 4 (very high preference) for: milk yield; butterfat content; body weight; fertility; disease resistance (with respect to tick-borne diseases); feeding behaviour and market value.

2.2. Statistical analysis

For statistical analysis, a broad classification of dairy breeds into large and small mature bodyweight was adopted (Matthewman, 1993). The small mature size *Bos taurus* breeds comprised Guernsey and Jersey (GJ) and the large mature size *Bos taurus* breeds comprised Friesian (FR) and Ayrshire (AY). The *Bos indicus* comprised East African Zebu, Boran and Sahiwal (ZB). A non-parametric Kruskal–Wallis test was used to investigate the differences between cattle breeds in the relative importance (3 = first, 2 = second and 1 = third) attached to reasons for keeping cattle in the main cross-sectional survey.

Stated primary preferences for different cattle breeds expressed by smallholders in the main cross-sectional survey were quantified using logistic regression models. The dependent variables were breed proportions, GJ/(GJ + ZB), AY/(AY + ZB) and FR/(FR + ZB), and the independent variable was the array of stated preferences (seven levels). Hardiness was chosen as the reference preference for the model as this was the most frequent preference stated for ZB, the breed against which GJ, AY and FR were to be compared. Age of head of the household and the year dairy cattle were introduced on the farm were grouped by source of foundation stock and the differences between these variables were compared using a *t*-test.

The respondents in the follow-up survey also attached preference ratings (ranked from 1 to 4) to attributes of breeds they were keeping. As very few of the farmers in this survey had husbandry experience with Jersey and Guernsey breeds, statistical evaluation was only performed for preference ratings attached to attributes of Friesian and Ayrshire breeds. The Mann–Whitney rank-sum test was used to compare mean ratings for the attributes between these two breeds.

3. Results

3.1. Reasons for keeping cattle

Of the 987 cattle-keeping households in the main cross-sectional survey, 43% kept Friesian, 19% kept Ayrshire, 16% kept Guernsey and Jersey cattle breeds and 22% kept *Bos indicus* cattle (East African Zebu, Boran, Sahiwal). The average ranking of reasons for keeping cattle (Table 1) indicated that farmers attached greater importance to milk production for feeding the family and for cash income than any other stated reason ($P < 0.01$). Farmers keeping Friesian and Ayrshire breeds gave a slightly higher priority to milk production for cash income, whereas those keeping *Bos indicus* cattle, Guernsey or Jersey breeds gave a slightly higher priority to milk production for feeding the family.

3.2. Preferences attached to cattle breeds

Table 2 displays the frequencies for cattle breed groups by primary preference reason, grazing system and agro-ecological zone. Attributes most frequently preferred (by more than 10% of the households) were high milk yield (Friesian, Ayrshire, Guernsey and Jersey, *Bos indicus*), hardiness (*Bos indicus*, Guernsey and Jersey, Ayrshire), traction ability (*Bos indicus*) and high butterfat yield (Guernsey and Jersey, Ayrshire) in that order. Relatively, *Bos*

Table 1
Means with their standard errors of rankings (3 = first, 2 = second, 1 = third) for reasons for keeping cattle stratified by cattle breeds owned in cross-sectional surveys of 987 smallholder farms in the Kenya highlands

Reasons for keeping cattle	Cattle breed			
	East African Zebu, Boran and Sahiwal	Guernsey and Jersey	Ayrshire	Friesian
Main cross-sectional survey				
Milk for family consumption	2.18±0.06	2.15±0.07	1.95±0.06	1.98±0.04
Milk for cash income	1.69±0.05	1.98±0.06	2.05±0.06	2.09±0.04
Attractive looks of the animal	1.15±0.03	1.23±0.05	1.20±0.04	1.19±0.03
Advice from extension	1.02±0.01	1.10±0.03	1.09±0.02	1.09±0.02
Traction use	1.10±0.03	1.01±0.01	1.00±0.01	1.02±0.01
Prestige from owning cattle	1.04±0.02	1.03±0.02	1.03±0.01	1.04±0.01
Others[a]	1.22±0.04	1.21±0.05	1.31±0.05	1.27±0.03
Number of respondents	217	157	189	424

[a] Others: means to obtain loans and unspecified reasons.

Table 2
Frequencies for cattle breeds stratified by stated primary preference for keeping breed, grazing system and agro-ecological zone in cross-sectional surveys of 987 smallholder farms in the Kenya highlands

	Cattle breed			
	East African Zebu, Boran and Sahiwal (ZB)	Guernsey and Jersey (GJ)	Ayrshire (AY)	Friesian (FR)
Stated primary preference (%)				
Hardiness	37	23	13	5
High milk yields	22	47	59	78
Traction ability	15	1	0	0
Semen of choice unavailable	10	4	7	4
High butterfat yield	5	10	12	6
Attractive looks	5	8	6	4
Extension advice	6	7	3	3
Grazing system (%)				
Free	52	14	15	15
Semi-zero	28	24	45	34
Zero	20	62	40	51
Agro-ecological zone (%)				
Medium potential	72	20	29	28
High potential	28	80	71	72
Number of respondents	217	157	189	424

Frequencies for *Bos indicus* (ZB) vs. *Bos taurus* (GJ, AY, FR) differ significantly ($P<0.01$) for Grazing systems and for Agro-ecological zones.

indicus breeds (ZB) were more frequently found in medium potential agricultural areas under free-grazing and *Bos taurus* dairy breeds in high potential agricultural areas under semi-zero- and zero-grazing systems ($P < 0.01$).

Table 3 gives the odds ratios and their 95% confidence intervals estimated from logistic regression for the stated primary preferences for cattle breeds. The odds ratio presented is a measure of the relative preference for an attribute in a given breed

Table 3
Odds ratios (and their 95% confidence intervals) from logistic regression for the stated primary preferences for *Bos taurus* compared with *Bos indicus* cattle breeds in a cross-sectional survey of 987 smallholder farms in the Kenya highlands

Stated primary preference	Guernsey and Jersey	Ayrshire	Friesian
Hardiness[a]	ref.	ref.	ref.
High milk yields	3.46 (1.91, 6.25)	7.58 (4.10, 14.03)	17.63 (10.06, 30.92)
High butterfat yield	3.16 (1.23, 8.10)	6.36 (2.52, 16.04)	4.00 (1.58, 10.14)
Attractive looks	3.05 (1.13, 8.22)	3.58 (1.25, 10.22)	3.94 (1.48, 10.45)
Traction ability	0.07 (0.01, 0.56)	Not estimable	0.25 (0.07, 0.89)
Extension advice	2.26 (0.83, 6.21)	1.59 (0.48, 5.26)	2.75 (1.02, 7.38)
Semen of choice unavailable	0.60 (0.20, 1.77)	1.85 (0.75, 4.56)	1.59 (0.67, 3.76)

[a] Hardiness was the reference of comparison in the model as it was the most frequently stated preference for *Bos indicus* (ZB).

when compared with ZB. An odds ratio equal to one (1) indicates no difference in the stated primary preferences, a higher primary preference when greater than one and a lower primary preference when less than one. The odds ratio is significant when its 95% confidence interval excludes one (1). Farmers' relative preferences for GJ, AY and FR for high milk yield and butterfat yields over hardiness were, respectively, 3.46 and 3.16, 7.58 and 6.36, and 17.63 and 4.00 times more when compared with preference for ZB ($P < 0.001$). *Bos taurus* dairy breeds were more often preferred than ZB for their ''attractive'' looks ($P < 0.05$), but the latter were more often preferred for their traction ability.

Table 4
Means with their standard errors of preference rating (1 = low preference, 4 = very high preference) of the attributes of Friesian and Ayrshire cattle breeds by smallholder farmers in a survey in the Kenya highlands

Breed attribute	Cattle breed	
	Ayrshire	Friesian
Body weight[b]	1.21±0.14	1.64±0.17[a]
Butterfat content[b]	1.16±0.11	1.07±0.07
Fertility[b]	1.09±0.07	1.25±0.12
Milk yield	3.63±0.21	3.85±0.09
Feeding behaviour[b]	2.05±0.21	1.68±0.15
Market value[b]	1.79±0.21	2.18±0.18[a]
Disease resistance[b]	2.16±0.23	1.25±0.14[a]
Number of respondents	15	21

[a] Significant difference ($P < 0.05$) by Mann–Whitney rank-sum test.
[b] Complementary information not in the main cross-sectional survey.

Extension advice encouraged higher preference for FR when compared with ZB ($P < 0.05$). The unavailability of semen of a preferred breed did not significantly influence farmers' breed preferences.

Table 4 gives additional information on the relative preference rating for the attributes of Friesian and Ayrshire breeds from 36 of those 50 households in the follow-up survey sample. Farmers rated Ayrshire higher than Friesian for disease resistance ($P < 0.001$). During the semi-structured interviews, farmers said that Ayrshire also had good mobility, which they thought suited them better to semi-zero- and free-grazing systems where animals have to walk relatively long distances to watering points. Farmers rated Ayrshire more favourably than Friesian for feeding behaviour ($P = 0.08$). Farmers' perceptions, elicited through the semi-structured interviews, were that Ayrshires had lower daily feed requirements than Friesians. On the other hand, they perceived Friesians to be less selective in feeding, a characteristic more desirable in zero-grazing systems, where change in feeds offered is more frequent in both quantity and quality because of scarcity in feed resources. Farmers rated Friesian higher than the Ayrshire breed for body weight and reported Friesian to be of higher market value ($P < 0.05$).

3.3. Past and present breeding practices

Smallholders obtained foundation dairy stock mainly through direct purchase (83% of the households) rather than through upgrading from *Bos indicus* cattle or gifts (e.g. from development projects or relatives) (Table 5). The few farmers who

Table 5
Frequencies (%) and the means with their standard errors of age of household's head and the year dairy cattle was introduced by source of foundation stock for 987 smallholder farms in the Kenya highlands

Source of foundation stock	Households (%)	Age of head of the household (y)	Year dairy cattle introduced
Purchased	83	50 ± 0.5^{b}	1981 ± 0.4^{a}
Gift	14	50 ± 1.2^{b}	1980 ± 1.0^{a}
Upgraded from zebu	3	56 ± 2.5^{a}	1974 ± 2.0^{b}

[a,b] Means with different superscript letters are significantly different at $P<0.05$.

had upgraded local zebu to dairy cattle were on average 6 years older and started dairying in the 1970s, about 7 years earlier than those who had purchased their foundation stock ($P < 0.05$). Fig. 1 shows a summary of the mating patterns from information available from 45 households of those 50 households randomly selected from the main survey sample. For each breed of cow, the bars represent the proportion of cows mated to a specified breed of sire over the generations traced from the foundation cow. The results suggest that smallholders have tended to mate cows of Friesian and Ayrshire breeds to sires of these breeds, whereas farmers with Guernsey cows have tended to mate them more often to Friesian and Ayrshire than Guernsey bulls.

Table 6 summarises the breeding practices reported for the year preceding the main cross-sectional survey. Natural mating was more frequent than AI service regardless of the breed of cattle owned. However, AI service was more frequently used for *Bos taurus* than for *Bos indicus* breeds ($P < 0.001$). Farmers who obtained AI services did so five times more frequently from farmer co-operatives and private providers than from government services ($P < 0.001$). Record keeping of production performance was infrequent for all the breed groups. Years of husbandry experience were similar across breeds. On average, herds dominated by *Bos indicus* breeds were larger than those dominated by *Bos taurus* breeds ($P < 0.01$). Farmers keeping *Bos taurus* breeds attached less importance to the risk of tick-borne diseases than those that kept *Bos indicus* cattle ($P < 0.01$). This is associated with the fact that *Bos taurus* cattle are more often managed under stall-feeding systems where the incidence of these diseases is relatively lower.

4. Discussion

4.1. Farmers' production objectives and breed preferences

The dominance of *Bos taurus* dairy breeds (78% of the farms) over *Bos indicus* breeds (22% of the farms) indicates high priority to exotic dairy breeds for milk production by smallholder farmers in the Kenya highlands. According to farmers' rankings, the major objectives for keeping cattle were milk production for feeding the family and for generating cash income. However, priority attached to these objectives differed depending on the breed of cattle kept, indicating the influence of farmers' production objectives. Farmers giving top priority to the commercial objective must be able to produce a marketable milk surplus for income generation. Smallholders try to meet this objective by keeping Friesian and Ayrshire breeds, which they consider as high milk producers (Tables 2 and 4). On the other hand, Guernsey and Jersey breeds, that were perceived as lower milk producers, were more often kept by households pursuing subsistence objectives as top priority (Table 1). This is probably because the level of investment needed for these breeds, being of smaller size, is lower relative to Friesian and Ayrshire.

Farmers acknowledged some differences between Friesian and Ayrshire breeds with respect to market value, disease resistance and suitability for different management systems. The heavier bodyweight rating attached to Friesian over Ayrshire can partly explain why Friesian was considered to have higher market value. Heavy bodyweight attracts high market value, which is important when selling cows either for slaughter or to other farmers for production, a

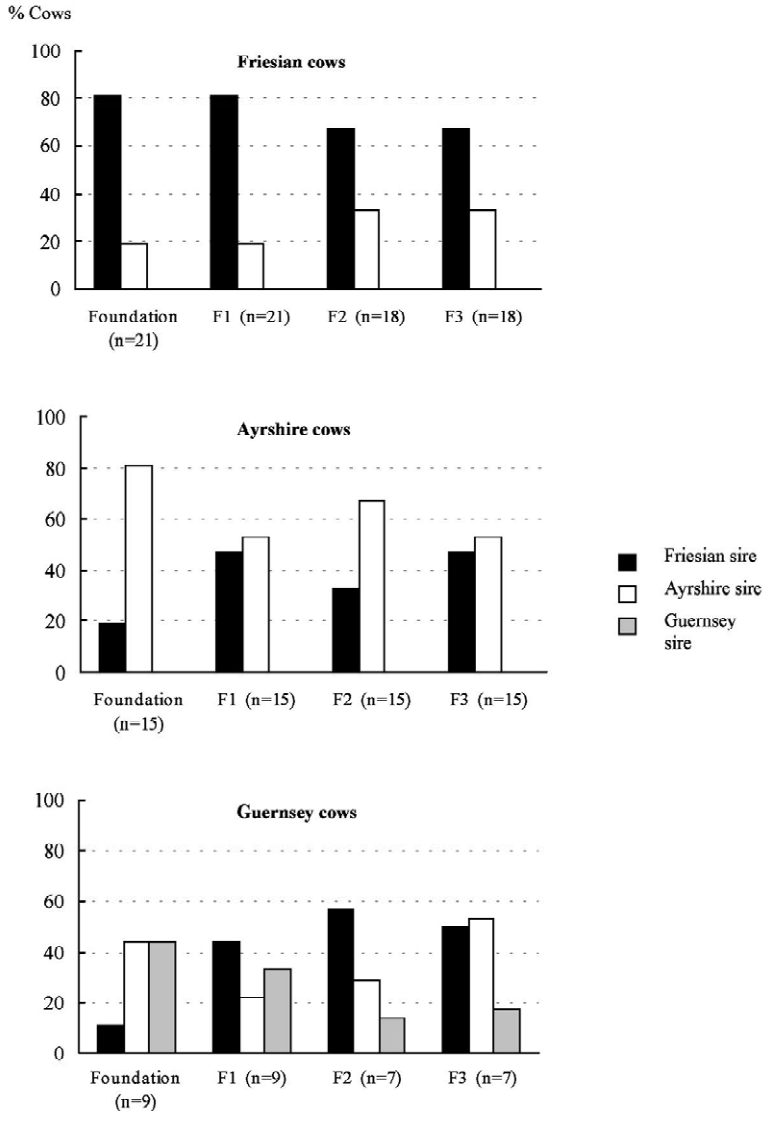

Fig. 1. Proportion of cows for each breed by the breed of sires mated to the foundation cows and the subsequent heifer progenies over the generations.

practice common among smallholder dairy farmers in the Kenya highlands (Bebe et al., 2003). Because of their higher market value Friesians represents a better storage of wealth for smallholders who use cattle to accumulate fluid capital assets and for insurance and financing emergency cash needs (Udo and Cornelissen, 1998; Bebe et al., 2003).

The unselective feeding behaviour associated with Friesians, as perceived by respondents in this study, would be important to farmers in zero-grazing systems where they have to respond to seasonal changes in the availability of feed resources. It allows for adjusting to the intermittent and abrupt changes in the quantity and quality of feeds offered

Table 6
Breeding practices according to cattle breeds owned in 987 smallholder farms in cross-sectional surveys in the Kenya highlands

Breeding practice	Cattle breed			
	East African Zebu, Boran and Sahiwal	Guernsey and Jersey	Ayrshire	Friesian
Sources of breeding services (%)[a]				
Bull from other farms	58	54	51	44
Bull from own farm	28	5	7	7
AI from farmer cooperatives	9	21	18	25
AI from private providers	2	6	16	17
AI from government services	2	12	6	6
AI from projects	1	2	2	1
Record keeping (%)				
Yes	7	17	16	24
No	93	83	84	76
Husbandry experience (y)	16.3±0.70	16.2±0.83	15.1±0.75	16.4±0.50
Herd size (*n*)[b]	6.0±0.21	2.5±0.43	3.7±0.16	3.9±0.60
Importance of tick-borne diseases[c]	1.9±0.02	1.5±0.02	1.3±0.02	1.4±0.01
Number of respondents	217	157	189	424

[a] Chi-squared test for general association between source of service and breed group $P=0.001$.
[b] Student *t*-test $P<0.05$ for *Bos indicus* vs. each of the *Bos taurus* breeds.
[c] 1 = important, 3 = very important. Mann–Whitney *U*-test $P=0.01$ for *Bos indicus* vs. each of the *Bos taurus* breeds.

(Methu et al., 2000, 2001; Zemmelink and Ibrahim, 2000). The unselective feeding behaviour of the Friesian may be associated with a larger rumen capacity due to its larger body weight compared with the Ayshire. This would allow for a longer retention time in the rumen, and hence more extensive digestion, especially when feeds are of low quality (Illius and Gordon, 1991; Lechner-Doll et al., 1991). In a study of manure management practices in the Kenya highlands, farmers indicated that obtaining manure is one of their objectives when using the feeds that are available (Lekasi et al., 1998). Manure production is an important function of dairy cattle and their integration with cropping systems in the highlands. Dairy farmers intensify dairy production through the importation of nutrients in the form of dairy feeds, and the resultant manure contributes to the provision of plant nutrients and organic matter for crop production.

Farmers considered the Ayrshire to be less susceptible than the Friesian breed to diseases (especially those transmitted by ticks) and to have better mobility. These attributes were preferred for semi-zero- and free-grazing systems, reflecting the importance of adaptive traits to smallholders in situations where the relative risk of exposure to environmental stresses is likely to be higher. This is important because most smallholder farmers do not have adequate access to veterinary services, feeds and credits to purchase inputs (Devendra, 2001; Romney et al., 2000). Therefore, where environmental stresses are high, attention should be given to breeds with good adaptive characteristics while at the same time aiming at higher productivity. This underscores the need to carefully consider production circumstances of smallholders when recommending the use of specific cattle genotypes.

Results from several studies (Syrstad, 1996; Rege, 1998; Kahi et al., 2000; Wakhungu, 2000) have been used to discourage the use of larger breeds in favour of smaller ones because the former have higher nutritional demands and have performed poorly in terms of milk yield, adaptive traits and production efficiency. Despite this discouragement larger dairy breeds continue to dominate on smallholder farms found in developing countries (Tulachan et al., 2000;

Devendra, 2001) and this study is an indication that smallholders' breeding practices do not conform to the recommended breeding practices. Smallholders' breeding practices reflect broad objectives, which combine more milk with adaptability to the prevalent diseases and local feed resources and to the additional benefits, generally non-marketed, such as manure, insurance and financing roles of cattle. Recognition that these multiple objectives influence breeding decisions is of central importance to the formulation of effective livestock policies aimed at improving the livelihoods of smallholders and serving the interests of the consumers of dairy products. Therefore, breeding practices targeted at smallholders should take into account smallholders' production systems, preferences, production objectives and their knowledge of breed characteristics.

4.2. Breeding practices

In this study the cattle breeds dominant in herds differed by system of cattle management. *Bos indicus* breeds were predominant in free-grazing systems, whereas *Bos taurus* dairy breeds were predominant in more intensive systems where management strategies favoured smaller herds with higher milk production potential (Bebe et al., 2003). Friesian and Ayrshire were the predominant dairy breeds on 62% of the farms. The large population of dairy cattle in public and private large-scale dairy farms in the Kenya highlands during the 1960s and 1970s provided smallholders with the opportunity to directly purchase their foundation stock (Conelly, 1998). Consequently, the majority of smallholders (83%) did not have to start their dairy herds by upgrading Zebu cattle. Instead, they procured dairy cattle of breeds of their choice from what was locally available and they maintained these by mating to dairy breeds, with the tendency towards the use of Friesian and, to a lesser extent, Ayrshire (Fig. 1).

Very few farmers raised their own bulls for breeding because, apparently, they preferred to use their limited fodder supplies for cows for milk production (Bebe et al., 2003). Most farmers (63%) bred their cows to bulls owned within the community (Table 6). However, the fact that few farmers owned a bull implies that these bulls may be used to mate close relatives, potentially increasing the inbreeding levels in the population. Furthermore, most of the bulls would be of unknown pedigree, although generally of known genotype, implying that systematic selective breeding is lacking. Increased inbreeding and the use of unproven bulls and limited AI services may have unfavourable long-term effects on productivity through the degradation of the herd genotype.

Partly as a result of the decline in government services, most AI was provided to smallholders by dairy co-operatives and private producers. Unsubsidised AI is expensive relative to natural service, mainly because of the poor state of rural roads and other transport costs, and these are unlikely to change in the near future. Consequently, it is expected that natural mating will continue to predominate on smallholder farms. The organisation by farmers' co-operatives of village bull schemes using bulls of proven genetic merit may be an attractive alternative to AI. Bull schemes can be successful if bull centres are established within a reasonable distance for farmers to walk their cows for service. Associated health services will be required, however, to control breeding diseases and to minimise exposure to, for example, tick-borne diseases.

Animal recording in Kenya is undertaken by Dairy Recording Services of Kenya (DRSK), which is a farmers' organisation dominated by large-scale farmers. Few smallholders in the survey area kept performance records. To encourage smallholder participation in performance recording, DRSK needs to provide information that enables a farmer to compare the performance of his/her own herd with those of his/her community in order to stimulate competition and provide incentives to improve production. Village co-operatives may be a suitable starting point for such basic recording (Trivedi, 1998).

5. Conclusions

The breeding decisions of smallholder dairy producers in the Kenya highlands conform to producers' multiple objectives. These include the need for increased milk production, adaptability to local feed conditions and diseases and the provision of non-market production (e.g. manure, and the insurance, financing and social roles of cattle).

Breeding policies targeting smallholder systems will be more effective when incorporating the multi-functional roles that cattle play in these systems. Recognition of this broad basis for breeding decisions is central to the formulation of effective livestock policies aimed at improving the livelihoods of smallholders and serving the interests of consumers of dairy products.

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