Chapter 3

Small ruminant production in the tropics: a study of smallholder and pastoral/extensive farming systems in Kenya

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Abstract

A survey was conducted by way of personal interviews with 562 respondents comprising 459 farmers and 103 butchers/traders in selected districts in the central and western parts of Kenya, consisting of three predominantly smallholder and four predominantly pastoral/extensive districts. The study aimed to provide a better understanding of smallholder and pastoral/extensive sheep and goat farming systems in the tropics, by taking Kenya as an example. Results show that 58% of pastoral/extensive farmers and 46% of smallholders indicated livestock as their main activity. Small ruminants ranked closely behind cattle in their importance. Thirty four percent of the households kept only sheep, 18% only goats and 48% both species. The survey demonstrated the relative importance to the farmers of tangible benefits of farming sheep and goats (such as regular cash income, meat, manure and, in the case of goats, milk) versus intangible benefits (such as the role of small ruminants as an insurance against emergencies). Regular cash income and an insurance against emergencies were the highest priorities. Seventy eight percent of the farmers reported animal sales over the previous 12 months. Of these, the income was spent on school fees (32%), purchase of food (22%), farm investment (18%), medical expenses (10%), off-farm investment (9%), social activities (5%) and re-stocking (4%). Indigenous genotypes were predominant among pastoral/extensive farmers and mixed crosses predominant among smallholders. A range of traits: growth rate, size, shape, drought tolerance, meat quality, fertility, disease and heat tolerance, prolificacy and temperament were all considered important for both sheep and goats in both farming systems and across the different genotypes. Compared with other pure breeds Red Maasai sheep and Small East African goats were rated poorly in terms of size, shape, growth and fertility but highly in terms of drought and (Red Maasai) heat tolerance by both smallholder and pastoral/extensive farmers. In general, crosses were perceived less favourably than indigenous pure breeds. Size and performance ranked as the most important traits in the choice of breeding males. Approximately half the farmers inherited their males, reared them on the farm and kept them for an average of 2-3 years. Uncontrolled mating within the

household's flock was predominant in both farming systems. Over 98% of the farmers reported incidence of disease, especially pneumonia (in pastoral/extensive areas), helminthosis, tick-borne diseases, diarrhoea and foot-rot. Over 95% of the farmers fed supplements in both dry and wet seasons. Pure exotic and indigenous X exotic genotypes fetched higher prices than indigenous genotypes due to their heavier body weight.

(***Keywords**:* Small ruminants; Smallholder; Pastoral/extensive; Breeding programmes; Tropics)

3.1. Introduction

The importance of small ruminants (i.e., sheep and goats) to the socio-economic well being of people in developing countries in the tropics in terms of nutrition, income and intangible benefits (i.e., savings, an insurance against emergencies, cultural and ceremonial purposes) cannot be overemphasised. Small ruminants also play a complementary role to other livestock in the utilisation of available feed resources and provide one of the practical means of using vast areas of natural grassland in regions where crop production is impractical (Baker and Rege, 1994). Therefore, improvement programmes are necessary to increase and sustain the productivity of small ruminants in these areas so as to meet the demands of the human population on them. However, development of genetic improvement programmes for sheep and goats will only be successful when accompanied by a good understanding of the different farming systems and when simultaneously addressing several constraints – e.g., feeding, health control, management, and cost and availability of credit and marketing infrastructure (Baker and Gray, 2003).

Many small ruminant genetic improvement programmes have not been very successful in developing countries in the tropics (Sölkner et al., 1998; Rewe et al., 2002; Wollny et al., 2002). An important reason is that genetic improvement programmes have mostly been implemented without taking into consideration all the needs of the farmer. In addition, poor performance of imported breeds from the

temperate developed world into tropical countries has created a negative image for genetic improvement programmes (Turner, 1978; Rewe et al., 2002; Ayalew et al., 2003). Few studies have elaborated on the many factors affecting the production and farming of sheep and goats in the tropics. Consequently, there is generally scanty information, from the farmers' perspective, on the entire spectrum of small ruminant farming, a situation limiting the scope of improvement interventions. The current study attempts to provide a better understanding of smallholder and pastoral/extensive farming systems, and complements past studies in the tropics (e.g., Mucuthi et al., 1992; Otieno et al., 1993; Mwendia, 1997; Peeler and Omore, 1997; Mahanjana and Cronjé, 2000; Jaitner et al., 2001; Seleka, 2001; Wollny et al., 2002). The study aims to help in the development of effective breeding programmes for sheep and goats in the tropics. More specifically, the survey aimed to:

a) establish why smallholder and pastoral/extensive farmers keep sheep and goats,
b) determine the relative importance to the farmers of tangible benefits of farming sheep and goats (e.g., cash income from meat, milk and manure) versus intangible benefits (e.g., the role of small ruminants to act as a source of income for future needs - banking or insurance),
c) understand why farmers in different production systems keep particular breeds,
d) know what attributes of sheep and goats farmers think are important,
e) establish from where farmers access their breeding rams and bucks and how long they keep them, and
f) understand the constraints that apply to successful farming of small ruminants.

3.2. Materials and methods

3.2.1. Sampling and questionnaire methodology

The survey was conducted by way of personal interviews with farmers (household survey) and butchers/traders (market survey) by teams of trained enumerators in selected districts in the central and western parts of Kenya (see Table 3.1 and 3.2; Fig. 3.1). The survey of farmers covered seven districts, and that of traders/butchers covered three districts. The household survey was designed such that there were three districts that were predominantly smallholder with mixed crop-livestock farmers (i.e., Nakuru, Nandi and Nyeri) and four that were predominantly pastoral/extensive (i.e., Baringo, Laikipia, Narok and Trans-Mara) (Table 3.2). Nyeri district also contains some medium- and low-potential pastoral/extensive areas, of which one division was selected. Although largely pastoral, Baringo also contains a smallholder, mixed crop-livestock highland area. One largely smallholder division was picked in the highlands and one pastoral division in the lowlands. A number of smallholder households were also selected during the random sampling of the two Laikipia district divisions. One division in Nakuru district was selected from medium-potential and one from high-potential zones in the district. The survey areas within

Table 3.1. Selection of samples per district, division and location in different regions of Kenya[a]

District	Divisions	Locations	Sub-locations
Nakuru	2 (16)	2 (4); 2 (4)	2 (2), 3 (3); 1 (1), 1 (1)
Nandi	2 (9)	2 (15); 2 (9)	3 (3); 3 (3); 3 (3), 2 (2)
Nyeri	2 (7)	2 (5); 2 (7)	3 (4), 3 (4); 3 (7), 3 (4)
Baringo	2 (14)	2 (8); 2 (5)	3 (3), 3 (3); 3 (3), 3 (3)
Laikipia	2 (6)	2 (6); 2 (9)	1 (1), 1 (1); 2 (2), 3 (4)
Narok	2 (8)	2 (4); 2 (5)	2 (2), 2 (2); 3 (3), 3 (4)
Trans-Mara	2 (5)	2 (4); 2 (7)	3(3), 3 (4); 2 (2), 1 (1)
Total	14 (65)	28 (92)	68 (78)

[a]Numbers outside brackets represent numbers sampled while those in brackets represent population totals.

each district were replicated at both the division and location levels, i.e., two divisions and two locations per division were picked in each district using prior information obtained from the field staff (Table 3.1). Most locations had three or fewer sub-locations and all were sampled. For locations that contained more than three sub-locations, three sub-locations were selected at random. Consequently, a total of 14 divisions, 28 locations and 68 sub-locations were sampled representing approximately 6% of all sub-locations in the seven districts (see Kosgey et al. (2004) for further details).

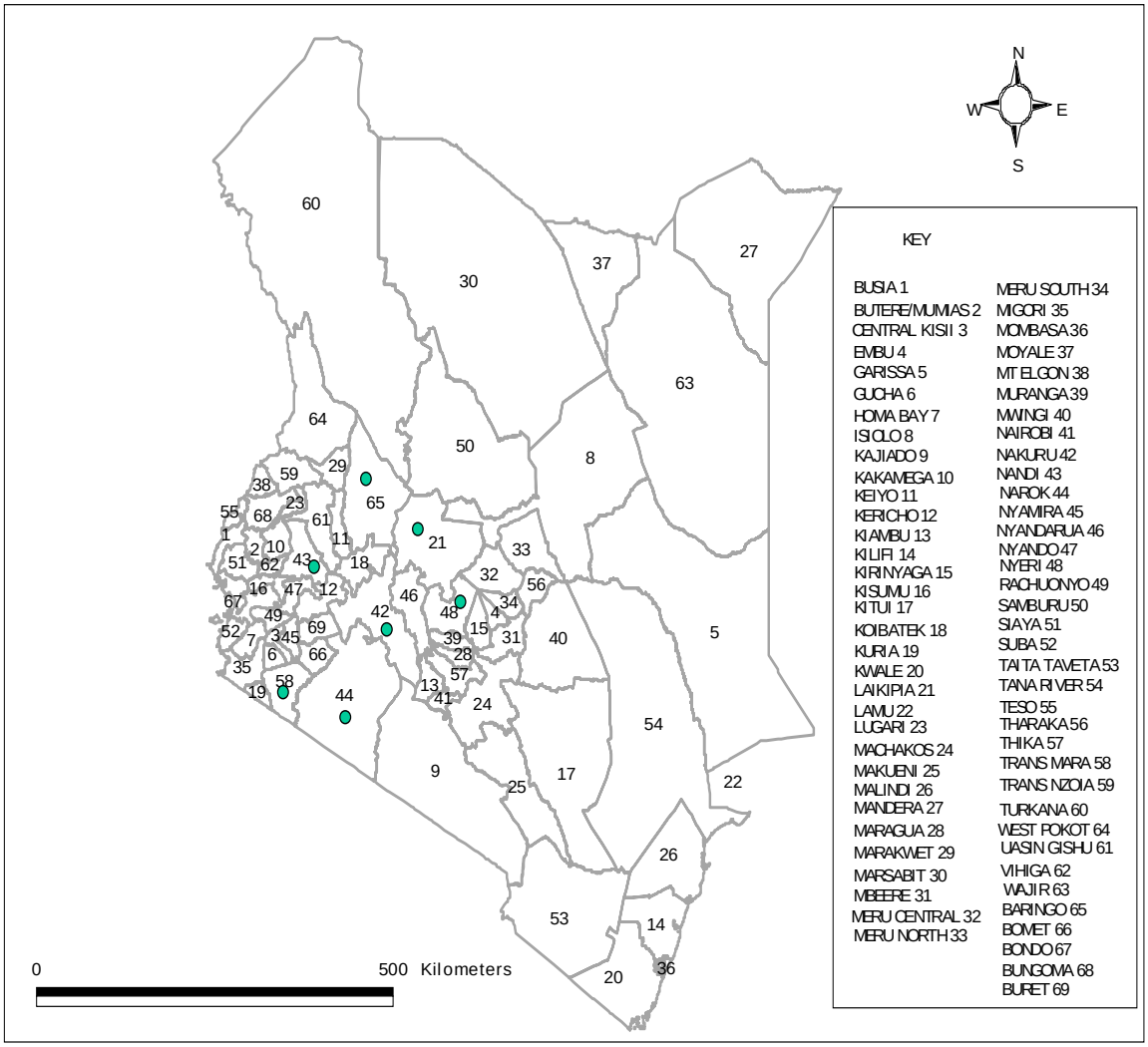

Fig. 3.1. Map of Kenya showing districts surveyed (marked with grey circles)

3.2.1.1. Household survey

The household survey used a set of structured questionnaires which were a slightly modified version of those designed for livestock breed survey in the southern African region (Rowlands et al., 2003). These questionnaires were designed to obtain information from respondents on general household characteristics, purposes of keeping small ruminants, animal breeds, traits of importance, breeding management, flock sizes and flock structures, animal health, feeding management, and marketing and prices of animals. Most questions were asked in the form of open questions. The enumerator ticked the answers given by farmers against a prepared list in the questionnaire, and then, where appropriate, asked the farmer to rank the top three. The main exception was for the question pertaining to traits of perceived importance. In this case the enumerator went through a list of predetermined traits one by one and asked the farmer whether he considered the trait to be either a good, average or poor characteristic of the breed(s) he/she kept, or to be a trait that was not of importance or about which he/she had no opinion.

Sampling was done through clustering of households within a sub-location. A cluster of households was formed within a given radius, the length of which depended on the household density. Transects were drawn within the cluster to make the sampling as random as possible. Only households with sheep and/or goats were picked along the transects, skipping those that did not have any small ruminants. A minimum of five households per sub-location owning sheep and/or goats were sampled for the household survey. The sample number was increased when there were more than 1,000 households in the sub-location according to the last census. In this case a minimum of 0.5% of the households in the sub-location were sampled. Data on households and human populations were obtained from the Central Bureau of Statistics (CBS) 1999 census.

3.2.1.2. Market survey

An interview of butchers/traders was done alongside the household survey in three districts (Baringo, Nakuru and Nandi) to establish meat prices of different categories of animals (i.e., pure exotic, exotic X indigenous crosses and indigenous). Butchers/traders within certain clusters of the household survey (and close by when not occurring within) were interviewed. Where possible a minimum of five butchers/traders were interviewed per sub-location.

3.2.2. Data analysis

Data were entered into a database in Access, the structure of which can be found in Rowlands et al. (2003). For the purposes of analysis the farmers were divided into two farming systems, namely smallholder and pastoral/extensive. A further sub-division into small ruminant species ownership was also used, namely those owning only sheep, those owning only goats, and those owning both sheep and goats. Results are presented mainly in the form of descriptive tabular summaries. Chi-square (χ^2) or *t* tests were carried out as appropriate to assess the statistical significance or otherwise of particular comparisons. Logistic regression with terms for farming system and breed was used to compare the qualities of traits (proportion of farmers ranking a trait to be good) across breeds.

Indices were calculated to provide overall ranking of (a) the purposes of keeping sheep or goats and (b) the traits used for choosing rams and bucks according to the formula:

Index = sum of [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for a tick] given for an individual purpose or trait divided by the sum of [4 for rank 1 + 3 for rank 2 + 2 for rank 1 + 1 for a tick] summed over all purposes or traits.

Similar indices were calculated for ranking importance of livestock by species and source of cash income.

3.3. Results

3.3.1. General household information

Four hundred and fifty nine respondents (218 smallholder and 241 pastoral/extensive farmers) were interviewed for the household survey. Of these 158 (48% and 22%, respectively, of the corresponding totals for smallholder and pastoral/extensive farmers) owned only sheep, 83 (18% and 18%) owned only goats and 218 (34% and 60%) owned both sheep and goats (Table 3.2). The majority of the farmers (89%) were sedentary and the rest nomadic. The majority of pastoral/extensive farmers (58%) indicated livestock to be their main activity (see Table 3.3). The corresponding percentage of 46% for smallholders was significantly lower (χ_1^2 = 5.91, P <0.05). Thirty three percent of smallholders and 25% of pastoral/extensive farmers put crops first. Primary income from salary/wages ranked third.

The importance of small ruminants in the two farming systems is demonstrated in Table 3.4. Goats outranked cattle when goats were the only small ruminant species. This was partly due to the fact that 40% of these farmers did not own and, hence, rank cattle. Where both sheep and goats were owned each species was ranked similarly behind cattle. Sheep were also ranked second behind cattle when goats were not owned. Chickens were ranked third. In general, the rankings of importance of sheep and goats were very similar for both smallholder and pastoral/extensive farmers.

Table 3.2. Number of households by small ruminant species and farming system for the household survey, and numbers of butchers/traders for the market survey

Type of survey	District							
	Nakuru	Nandi	Nyeri	Baringo	Laikipia	Narok	Trans-Mara	Total
Main household survey								
Farming system								
Sheep								
Smallholder	41	40	18	1	3	2	0	105
Pastoral/extensive	19	0	13	2	1	18	0	53
Goats								
Smallholder	8	7	13	8	3	1	0	40
Pastoral/extensive	6	0	2	20	6	4	5	43
Sheep and goats								
Smallholder	19	14	17	11	10	1	1	73
Pastoral/extensive	16	0	6	19	17	50	37	145
Total								
Smallholder	68	61	48	20	16	4	1	218
Pastoral/extensive	41	0	21	41	24	72	42	241
Overall total	109	61	69	61	40	76	43	459
Market survey								
Butchers/traders[a]	25	55	-	23	-	-	-	103

[a](-) sign means survey not done in the district.

Table 3.3. Ranking of source of income within household by small ruminant species and farming system

Income source	Farming system					
	Smallholder			Pastoral/extensive		
	Households[a]	Households[b]	Ranking[c]	Households[a]	Households[b]	Ranking[c]
Sheep	(n=105)			(n=53)		
Livestock	103	45	0.42	52	33	0.49
Crops	99	37	0.39	41	10	0.31
Salary/wages	33	18	0.13	19	9	0.15
Relative's remittances	10	1	0.02	3	0	0.01
Home industries	4	1	0.01	4	1	0.03
Other[d]	5	3	0.02	1	0	0.01
Goats	(n=40)			(n=43)		
Livestock	37	17	0.39	43	19	0.49
Crops	35	14	0.37	23	12	0.26
Salary/wages	18	8	0.17	15	9	0.17
Relative's remittances	4	0	0.02	5	2	0.04
Home industries	3	1	0.02	1	0	0.01
Other[d]	4	0	0.03	3	1	0.03
Sheep and goats	(n=73)			(n=145)		
Livestock	70	39	0.44	145	87	0.49
Crops	71	21	0.39	110	38	0.33
Salary/wages	20	9	0.10	39	14	0.10
Relative's remittances	9	1	0.03	13	2	0.03
Home industries	4	1	0.02	7	0	0.01
Other[d]	3	2	0.02	14	4	0.04

[a]Households considering item to be an important source of income. [b]Households ranking income source first.

[c]Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] divided by sum [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all sources of cash income for a farming system.

[d]Includes business (livestock trading, pharmacy, rental houses and retail shops), bee-keeping and pastorhood (priest).

Table 3.4. Household ranking of the importance of livestock by small ruminant species and farming system

Species	Farming system							
	Smallholder				Pastoral/extensive			
	House-holds[a]	House-holds[b]	House-holds[c]	Ranking[d]	House-holds[a]	House-holds[b]	House-holds[c]	Ranking[d]
Sheep	(n=105)				(n=53)			
Cattle	93	93	87	0.44	45	45	31	0.40
Sheep	105	105	12	0.34	52	52	21	0.40
Chicken	96	93	6	0.20	45	41	1	0.18
Other[e]	18	7	0	0.02	17	7	0	0.02
Goats	(n=40)				(n=43)			
Cattle	23	23	21	0.31	27	27	18	0.30
Goats	40	40	18	0.43	43	43	23	0.47
Chicken	35	33	0	0.22	37	33	0	0.18
Other[e]	7	4	1	0.03	15	6	2	0.05
Sheep and goats	(n=73)				(n=145)			
Cattle	66	65	49	0.39	135	133	86	0.40
Sheep	73	69	13	0.28	144	139	32	0.30
Goats	73	64	9	0.26	145	142	26	0.27
Chicken	72	19	2	0.07	103	15	0	0.02
Other[e]	11	2	0	0.00	71	4	1	0.01

[a]Total households owning species. [b]Households considering livestock species to be important (i.e., a rank of 1, 2 or 3).
[c]Households ranking livestock species first.
[d]Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] divided by sum [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all species for a farming system. [e]Includes pigs, donkeys, rabbits, bees, fish, and other types of poultry (ducks, geese, guinea fowl and turkeys).

3.3.2. Purposes of keeping sheep and goats

Tables 3.5 and 3.6 present purposes of keeping sheep and goats, respectively, and the ranking of the importance of these purposes by farming system. The results indicate the relative importance to the farmers of tangible benefits of farming sheep and goats (such as regular cash income, meat, manure and, in the case of goats, milk) versus intangible benefits (such as the role of small ruminants as an insurance against emergencies). Most smallholder and pastoral/extensive farmers (on average 72%) put first the keeping of sheep either for regular cash income or as an insurance against emergencies. Although not statistically different by a χ^2 test the emphasis among pastoral/extensive farmers tended to be towards regular cash income (Table 3.5). Manure received a higher ranking among smallholder than pastoral/extensive farmers. For goats, regular cash income featured most strongly as an insurance against emergencies (Table 3.6). Only a few farmers kept sheep or goats primarily for breeding in both farming systems, and this purpose was among the lowly ranked. An interesting purpose, rarely reported in Kenya, is the milking of sheep, especially by the pastoral communities where milking was ranked first by 6% of households (see Table 3.5). None of the surveyed farmers kept goats for mohair.

Three hundred and fifty seven (78%) households reported small ruminant sales within 12 months preceding the interview. Their income was spent on school fees (32%), purchase of food (22%), farm investment (18%), medical expenses (10%), off-farm investment (9%), social activities (5%) and re-stocking (4%). The trend of expenditure in both farming systems was similar and generally comparable across small ruminant species, except perhaps for smallholder sheep farmers who appeared to be more selective in their expenditure. This may be due to small flock sizes and hence less total income to share across the different areas of expenditure.

Table 3.5. Purpose of keeping sheep and the ranking of the importance of these purposes by farming system

Purpose	Farming system					
	Smallholder (n=178)			Pastoral/extensive (n=198)		
	Households[a]	Households[b]	Ranking[c]	Households[a]	Households[b]	Ranking[c]
Regular cash income	107	69	0.20	149	80	0.22
Meat	138	16	0.19	156	22	0.16
Insurance/emergency	104	62	0.18	128	59	0.17
Manure	146	6	0.17	106	1	0.09
Planned investment	52	14	0.07	71	6	0.05
Ceremonies/celebrations	73	1	0.07	141	3	0.10
Wool	21	7	0.03	44	13	0.05
Dowry	39	1	0.03	79	0	0.04
Cultural rites	12	0	0.01	62	2	0.04
Milk	8	1	0.01	29	11	0.03
Skin	35	0	0.02	30	0	0.01
Breeding	10	0	0.01	15	0	0.01
Other[d]	24	1	0.01	46	1	0.04

[a]Households ranking purpose important (i.e., 1, 2, 3 or just a tick). [b]Households ranking purpose first.

[c]Index = sum of [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for tick] divided by sum [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for tick] for all purposes of keeping sheep.

[d]Includes blood, fat, pelt, to learn stockmanship and to keep oneself busy.

Table3.6. Purpose of keeping goats and the ranking of the importance of these purposes by farming system

Purpose	Smallholder (n=113)			Pastoral/extensive (n=188)		
	Households[a]	Households[b]	Ranking[c]	Households[a]	Households[b]	Ranking[c]
Regular cash income	80	51	0.21	154	75	0.24
Meat	80	8	0.15	166	29	0.19
Insurance/emergency	69	23	0.14	122	50	0.17
Manure	97	3	0.15	91	0	0.07
Ceremonies/celebrations	45	0	0.05	117	2	0.09
Milk	62	18	0.13	80	20	0.09
Planned investment	39	7	0.06	59	9	0.05
Dowry	30	0	0.03	60	1	0.03
Skin	34	0	0.03	39	0	0.02
Breeding	17	2	0.03	6	0	0.00
Mohair	0	0	0.00	0	0	0.00
Cultural rites	5	0	0.00	43	2	0.03
Other[d]	27	1	0.03	33	0	0.02

[a]Households ranking purpose important (i.e., 1, 2, 3 or just a tick). [b]Households ranking purpose first.

[c]Index = sum of [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for tick] divided by sum [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for tick] for all purposes of keeping goats.

[d]Includes blood, fat, pelt and to learn stockmanship, shelter (clothing), bartering with honey, to keep oneself busy, and control (pick) ticks.

3.3.3. Breeds and breeding management

3.3.3.1. Breeds kept, their origin, lifespan, and traits of economic importance

The number of households that owned different small ruminant breeds by farming system and district are shown in Table 3.7. Households owning mixed crosses were predominant in smallholder production for both sheep and goats, followed by the indigenous genotypes. In the pastoral/extensive system the situation was reversed with most households owning the indigenous genotypes (mainly Red Maasai - 51% of the households and Small East African goat - 70%). Animals were mostly inherited or bought. The exotic genotypes were bought mostly from the market or commercial farms but the indigenous ones were generally inherited. Half of both smallholder and pastoral/extensive farmers reared their own males for breeding purposes on the farm (51% for smallholder and 52% for pastoral/extensive farmers for sheep; 43 and 62% for goats, respectively). When males were not reared, smallholders tended to borrow males (29% for sheep; 28% for goats) whereas pastoral/extensive farmers tended to buy them (28% for sheep; 20% for goats). Artificial insemination was not used in any of the flocks surveyed. In areas where families mixed and herded animals on common fields, matings took place at random with males present in the flocks. The males were then referred to as communal. Such mating, however, was reported by only 4% of farmers on average. Males were kept until about 2-3 years of age on average and up to a maximum of 8 and 6 years for sheep and goats, respectively, in both farming systems. Female sheep and goats were kept until about 4-5 years old on average, and up to a maximum of 14 years for sheep and 12 years for goats in smallholder, and up to a maximum of 10 years for sheep and 15 years for goats in pastoral/extensive systems.

The ranking of the importance of different traits as perceived by farmers for each breed in the two farming systems are presented in Tables 3.8 and 3.9. A range of traits: growth rate, size, shape, drought tolerance, meat quality, fertility, disease

Table 3.7. Number and percentage of households owning small ruminant breeds by farming system and district

Farming system	Breed	District								
		Nakuru	Nandi	Nyeri	Baringo	Laikipia	Narok	Trans-Mara	House-holds	% house-holds[a]
Sheep										
Smallholder	Red Maasai	4	14	7	10	1	1	1	38	21
(n= 178)	Dorper	1	6	2	2	8	0	0	19	11
	Merino	1	6	0	0	0	2	0	9	5
	Other purebreeds[b]	0	4	0	0	0	1	0	5	3
	Mixed crosses	54	34	25	0	7	0	0	120	67
Pastoral/extensive	Red Maasai	13	0	4	20	2	29	32	100	51
(n= 198)	Dorper	7	0	1	0	10	1	2	21	11
	Merino	0	0	0	1	1	17	0	19	10
	Other purebreeds[b]	0	0	0	0	0	15	0	15	8
	Mixed crosses	15	0	14	0	6	10	3	48	24
Goats										
Smallholder										
(n = 113)	Small East African	5	6	6	18	2	1	1	39	35
	Galla	0	0	0	0	1	0	0	1	1
	Other purebreeds[c]	4	0	3	0	2	1	0	10	9
	Mixed crosses	19	15	21	1	8	0	0	64	58
Pastoral/extensive	Small East African	14	0	0	39	1	39	38	131	70
(n = 188)	Galla	0	0	0	0	4	4	0	8	4
	Other purebreeds[c]	0	0	0	1	8	0	1	10	5
	Mixed crosses	8	0	8	0	10	12	3	41	22

[a]These percentages do not add up to 100% because some households own more than one breed.

[b]Corriedale, Hampshire Down and Romney Marsh.

[c]Alpine, Boer, Dual Purpose, Saanen and Toggenburg.

and heat tolerance, prolificacy and temperament were all considered important for both sheep and goats in both farming systems and across the different genotypes (Table 3.8). Other traits, including milk, were of lower importance and there were inconsistencies in the perceptions of the qualities of two of these traits (colour and horns) by smallholder and pastoral/extensive farmers. Compared with other pure breeds Red Maasai were rated highly by both smallholder and pastoral/extensive farmers in terms of drought and heat tolerance, but there were no perceived breed differences in terms of disease tolerance (Table 3.8). In contrast, other pure breeds (including Dorpers and Merinos) were considered generally to have better growth rate, shape and fertility than Red Maasai. Red Maasai were judged to have poor prolificacy but the rating of prolificacy levels for other breeds varied according to farming system (data not shown). Crosses were generally considered unfavourably relative to indigenous breeds for most traits, and in terms of size, growth and heat tolerance they were judged to be significantly poorer than Red Maasai. Similar trends were observed for goats (Table 3.8). Small East African goats were considered to be significantly smaller and to have poorer fertility and prolificacy, but to have better drought tolerance than other pure breeds. In general, crosses were perceived less favourably than indigenous pure breeds. Table 3.9 gives the odds ratios and their 95% confidence intervals for seven of the most commonly reported traits in Table 3.8. The odds ratio presented is a measure of the relative perception for a trait in a given breed when compared with the Red Maasai for sheep and the Small East African for goats. Essentially, if the odds ratio overlaps one (1) then there is no difference in the stated perception of the traits, a better perception when greater than one and a lower perception when less than one. The odds ratio is significant when its 95% confidence interval excludes one (1) (Bebe et al., 2003). For instance, the odds ratio of a farmer rating highly the growth rate of a Dorper was 8.56 that of a farmer rating highly the growth rate of a Red Maasai (Table 3.9). In contrast, the odds ratio for crosses compared with the Red Maasai was only 0.50. In terms of drought and heat tolerance odds ratios for other breeds and crosses compared with Red Maasai ranged from 0.17 to 0.65. Similar patterns were evident for other pure breeds of goats and crosses compared with the Small East African.

Table 3.8. Number of households perceiving different traits for each sheep and goat breed to be important (i.e., poor + average + good) and (in parentheses) the percentage of households perceiving the trait to be good

Trait	Sheep					Goats		
	Red Maasai (n=138)	Dorper (n=40)	Merino (n=28)	Other pure[a] (n=20)	Crosses (n=168)	Small East African (n=170)	Other pure[b] (n=29)	Crosses (n=105)
Size	133	38	27	20	161	166	28	104
	(59)	(79)*	(70)	(75)	(43)*	(54)	(75)*	(43)
Disease tolerance	131	37	26	19	157	163	27	99
	(75)	(65)	(73)	(53)	(62)	(83)	(67)	(68)*
Drought tolerance	131	39	27	20	152	165	28	91
	(81)	(69)	(56)**	(45)***	(70)	(88)	(68)*	(77)
Growth	127	38	28	20	153	162	28	102
	(56)	(92)***	(89)**	(80)*	(44)**	(57)	(93)**	(40)*
Fertility	132	35	26	19	149	161	26	93
	(62)	(94)**	(73)	(95)*	(48)	(59)	(96)**	(52)
Heat tolerance	126	36	27	18	138	157	23	83
	(79)	(56)**	(63)	(39)***	(59)**	(79)	(74)	(70)
Shape	121	37	27	20	126	153	26	91
	(62)	(89)**	(81)*	(65)	(44)	(69)	(73)	(41)***
Prolificacy[c]	126	32	26	17	136	155	25	59
	(29)	(47)	(46)	(41)	(17)	(34)	(80)***	(34)

Table 3.8. (*continued*)

Trait	Sheep					Goats		
	Red Maasai	Dorper	Merino	Other pure[a]	Crosses	Small East African	Other pure[b]	Crosses
Temperament	114	30	27	18	127	138	28	83
	(66)	(60)	(78)	(94)*	(60)	(54)	(54)	(43)***
Meat quality	103	34	24	19	96	152	24	60
	(81)	(100)	(79)	(100)	(70)	(88)	(96)	(70)*
Colour[c]	78	31	21	13	72	86	23	42
	(71)	(81)	(81)	(92)	(46)	(80)	(91)	(60)
Horns[c]	43	10	8	1	25	67	19	32
	(56)	(70)	(50)	(0)	(36)	(55)	(63)	(25)*
Milk	33	12	16	13	19	105	23	63
	(27)	(92)**	(56)*	(38)	(63)*	(27)	(65)*	(27)
Wool	0	0	13	8	31	-	-	-
	(0)	(0)	(77)	(75)	(39)			
Fat	2	1	0	0	2	-	-	-
	(0)	(100)	(0)	(0)	(0)			

*** P<0.001; **P<0.01; *P<0.05 when compared with Red Maasai (sheep) or Small East African (goats) as the reference breed in a logistic regression analysis of r/n, where n = number of farmers rating a trait important and r = number of farmers rating a trait good. Individual breed X farming system r/n values (10 for sheep and 6 for goats) were used in the analysis with terms for breed and farming system in the model.

[a] Breeds: Corriedale, Hampshire Down, Romney Marsh.

[b] Breeds: Alpine, Boer, Dual Purpose, Galla, Saanen, Toggenburg.

[c] Responses for sheep for smallholder and pastoral/extensive farmers were not consistent for prolificacy, colour and horns and so no overall significance values are given for sheep.

Table 3.9. Odds ratios and 95% confidence limits (in parentheses) of farmers' perceptions of 'good' for seven of the traits considered to be 'important' (see Table 3.8), comparing each breed with Red Maasai (for sheep) and Small East African (for goats) as reference breeds

Trait	Sheep				Goats	
	Dorper	Merino	Other pure	Crosses	Other pure	Crosses
Size	2.74	1.70	2.11	0.57	2.60	0.66
	(1.16, 6.48)	(0.69, 4.17)	(0.73, 6.16)	(0.35, 0.95)	(1.04, 6.46)	(0.39, 1.13)
Disease tolerance	0.65	0.91	0.37	0.62	0.44	0.52
	(0.29, 1.42)	(0.35, 2.37)	(0.14, 1.0)	(0.36, 1.07)	(0.18, 1.09)	(0.28, 0.97)
Drought tolerance	0.57	0.30	0.19	0.65	0.32	0.63
	(0.25, 1.29)	(0.12, 0.72)	(0.07, 0.51)	(0.36, 1.19)	(0.12, 0.82)	(0.30, 1.31)
Growth	8.56	6.56	3.24	0.50	9.57	0.49
	(2.50, 29.29)	(1.88, 22.86)	(1.02, 10.28)	(0.29, 0.84)	(2.19, 41.81)	(0.29, 0.84)
Fertility	11.64	1.67	10.86	0.71	21.11	1.01
	(2.65, 51.19)	(0.65, 4.29)	(1.41, 83.53)	(0.42, 1.20)	(2.76, 161.65)	(0.58, 1.78)
Heat tolerance	0.35	0.47	0.17	0.42	0.77	0.71
	(0.16, 0.77)	(0.19, 1.14)	(0.06, 0.49)	(0.23, 0.76)	(0.28, 2.12)	(0.37, 1.35)
Shape	6.01	2.86	1.16	0.67	1.28	0.32
	(1.96, 18.41)	(1.00, 8.16)	(0.43, 3.14)	(0.38, 1.18)	(0.50, 3.29)	(0.18, 0.58)

Table 3.10. Ranking of traits when choosing breeding rams/bucks by species and farming system in the two farming systems[a]

Trait	Sheep				Goats			
	Smallholder (n=178)		Pastoral/extensive (n=198)		Smallholder (n=113)		Pastoral/extensive (n=188)	
	House-holds[b]	Ranking	House-holds[b]	Ranking	House-holds[b]	Ranking	House-holds[b]	Ranking
Size	109	0.25	164	0.35	71	0.26	156	0.35
Performance	96	0.21	137	0.21	67	0.26	136	0.23
True to breed	80	0.20	79	0.13	47	0.18	60	0.11
Shape	72	0.11	111	0.13	43	0.10	104	0.13
Availability	56	0.13	28	0.04	29	0.09	23	0.03
Temperament	47	0.07	72	0.07	28	0.06	64	0.07
Colour	21	0.03	63	0.06	18	0.03	53	0.06
Horns	5	0.00	17	0.01	12	0.02	20	0.02
Other[c]	1	0.00	1	0.00	1	0.00	1	0.00

[a]Index = sum of [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for tick] divided by sum [4 for rank 1 + 3 for rank 2 + 2 for rank 3 + 1 for tick] for all traits.

[b]Households ranking trait important (i.e., 1, 2, 3 or just a tick).

[c]Health status and adaptability to climatic conditions.

The importance of different traits when choosing a breeding ram or buck is shown in Table 3.10. Size and performance ranked as the most important traits in the choice of breeding males. 'True to breed' and availability featured more prominently among smallholder than pastoral/extensive farmers.

3.3.3.2. Type of mating, average age at first mating, average flock sizes and flock structures

Uncontrolled mating within the household's flock was predominant (on average 46% for smallholder and 58% for pastoral/extensive farmers for sheep; 42 and 54% for goats). Group mating, in which a group of ewes or does is left with one or more rams or bucks to mate for a predetermined period, was the other main system practised by pastoral/extensive farmers (42% for sheep; 36% for goats). Smallholder households practised hand mating (25% for sheep; 37% for goats), more so than the pastoral/extensive households. Smallholder farmers mated animals for the first time at about 10-11 months of age both for males and females. A slightly wider age range of 9-12 months was reported in pastoral/extensive farming. Smallholders owned an average of 2.3±2.5 (SD) lambs, 1.7±2.7 weaners and 4.4±4.7 ewes and rams with a maximum flock size of 18 lambs, 18 weaners and 30 adults. The corresponding numbers for pastoral/extensive farmers were much larger: 14.5±24.3, 13.6±24.8 and 36.6±74.6, respectively with a maximum flock size reported of 150 lambs, 170 weaners and 594 adults. For goats the smallholders owned an average of 2.6±3.5 kids, 2.8±4.8 weaners and 5.7±7.9 adults (maximum 16 kids, 21 weaners and 33 adults). The corresponding figures for the pastoral/extensive systems were 9.2±12.2, 8.5±11.4 and 23.1±31.5, respectively (maximum 100 kids, 70 weaners and 200 adults). There were no overall significant differences between flock sizes for the two species within the two farming systems. However, by paired t-test comparison of means, farmers with both sheep and goats owned more of the latter than the former (young animals and weaners ($P<0.001$); adults ($P<0.01$)).

3.3.4. Animal health and feeding management

Over 98% of the households reported incidences of diseases in smallholder and pastoral/extensive farming systems (Table 3.11). Pneumonia, helminthosis, tick-borne diseases, diarrhoea and foot-rot were the most commonly reported. All these diseases were very prevalent among pastoral/extensive systems, but, except for pneumonia and, to a lesser extent, helminthosis, they did not assume the same importance among smallholders ($P<0.001$ by χ^2 tests). Most farmers sought veterinary help, mainly from the government veterinary service, private veterinarians and drug suppliers, with drug suppliers featuring predominantly among pastoral/extensive farmers (Table 3.11). Anthelmintics and antibiotics were the most common forms of treatment applied. Thirty three and fifty eight percent of smallholder and pastoral/extensive farmers reported use of anthelmintics for sheep. Corresponding figures for goats were 27% and 35%, respectively. Uses of antibiotics were reported by 29% and 92% of smallholder and pastoral/extensive farmers for sheep and by 26% and 85%, respectively for goats. Acaricide was mostly used to control ecto-parasites, applied to sheep virtually always by dipping but to goats mainly by spraying. Farmers keeping sheep reported visits from extension agents with an average of 3 (smallholder) and 4 (pastoral/extensive) visits per household within the last 12 months. On average 9% of the farmers attended one or more courses given by an extension agent on issues pertaining to small ruminants.

Over 95% of the farmers (on average across species and farming systems) fed supplements during both dry and wet seasons. Most supplementation in smallholder farming systems was in the form of roughage (in dry season: sheep – 64% of farmers; goats – 85%; sheep and goats – 73%; in wet season: sheep – 53%; goats – 59%; sheep and goats – 56%) and minerals (in dry season: sheep – 97%; goats – 90%; sheep and goats – 95%; in wet season: sheep – 94%; goats – 82%; sheep and goats – 89%). A smaller percentage of pastoral/extensive than smallholder farmers fed supplement roughage (on average 33% in the dry season and 23% in the wet season). They also largely fed mineral supplements (on average

Table 3.11. Number of households reporting prevalent disease and source of veterinary services by species and farming system

Disease	Sheep		Goats	
	Smallholder (n=178)	Pastoral/extensive (n=198)	Smallholder (n=113)	Pastoral/extensive (n=188)
Pneumonia	74 (42)[a]	56 (28)	34 (30)	77 (41)
Helminthosis	34 (19)	73 (37)	17 (15)	46 (25)
Tick-borne	14 (8)	75 (38)	7 (6)	61 (33)
Diarrhoea	13 (7)	58 (29)	8 (7)	46 (25)
Foot-rot	14 (8)	37 (19)	3 (3)	26 (14)
Skin diseases	4 (2)	16 (8)	1 (1)	8 (4)
Others[b]	16 (9)	66 (33)	14 (12)	55 (29)
Households reporting diseases	175 (98)	195 (99)	113 (100)	182 (97)
Veterinary service				
Government veterinarian	77 (43)	88 (44)	62 (55)	94 (50)
Private	94 (53)	40 (20)	58 (51)	*2 (15)9*
Drug supplier	71 (40)	143 (72)	50 (44)	131 (70)
Government extension officers	39 (22)	39 (20)	36 (32)	40 (21)
Other[c]	13 (7)	31 (16)	7 (6)	31 (17)

[a]Percentage of households presented in parentheses.

[b]Includes abnormal births, anthrax, bloat, blue tongue, eye infections, fever, flukes, foot and mouth disease, mastitis, nasal discharge, orf, plant poisoning, pox, pulpy kidney, rinderpest, salmonellosis, staggers gid, tetanus, trypanosomosis, wounds and abscess, and yellow fever.

[c]Includes non-governmental organisations (NGO's), community-based animal health workers and other animal health providers.

94% of farmers in the dry season and 85% in the wet season). Concentrate feed was also purchased by smallholders (in dry season: sheep – 13%; goats – 44%; sheep and goats – 25%; in wet season: sheep – 10%; goats – 36%; sheep and goats – 16%). Pastoral/extensive farmers, however, rarely purchased concentrates (on average 7% of farmers over both seasons).

3.3.5. Marketing and prices

Farmers sold their stock primarily to butchers, secondly to other farmers, thirdly at auctions, but hardly ever directly to abattoirs or through other routes. Respectively 74% and 76% of smallholder and pastoral/extensive sheep farmers did not have a preference for a particular season for selling their animals. Corresponding percentages for goats averaged 84%. The remainder either sold animals in the wet or dry seasons only. Farmers selling during the dry season slightly outnumbered those selling in the wet season. Pure exotic and indigenous X exotic genotypes, in that order, fetched higher prices than indigenous genotypes for both species ($P<0.001$) (Table 3.12) but prices varied significantly across districts, especially for sheep (all genotypes) and indigenous goats. The average price ratios for indigenous to indigenous X exotic and exotic genotypes were 1:1.3:1.4 for male and female weaner sheep, and 1:1.2:1.5 and 1:1.3:1.4 for male and female adult sheep, respectively. Corresponding ratios for goats were 1:1.2:1.3 for weaners and 1:1.1:1.3 and 1:1.2:1.3 for male and female adults, respectively. Generally, farmers preferred meat from exotic sheep and their crosses to that from indigenous breeds. In contrast, most farmers preferred indigenous goat meat to that from exotics and their crosses.

Table 3.12. Average prices (US$)[a] and their standard errors for different categories of animals by small ruminant species

Species	Genotype	Animal category						
		Weaner			Adult			
		n[b]	Male	Female	n	Male	n	Female
Sheep	Indigenous	80	11.55±0.49	11.99±0.48	82	23.16±1.40	83	20.35±1.03
	Indigenous X Exotic	84	15.23±0.48	15.72±0.48	82	28.49±1.36	83	25.39±1.00
	Exotic	82	16.60±0.47	16.91±0.51	81	33.53±1.32	81	29.09±1.03
Goats	Indigenous	90	11.88±0.45	12.29±0.44	95	25.23±0.99	95	21.24±0.75
	Indigenous X Exotic	75	14.25±0.47	14.87±0.49	75	27.43±1.12	75	24.93±0.92
	Exotic	61	15.47±0.49	16.04±0.52	60	32.13±1.31	61	28.20±1.13

[a]US$1.00 ≈ Kshs. 75.00 (Kenya shillings) at the time. [b]Applies to both male and female.

3.4. Discussion

3.4.1. Overview

It is important to have good understanding of a production system and the relative importance of the different constraints prior to initiating any genetic improvement programme (Baker and Gray, 2003). The purpose of the present survey was to provide a better understanding of smallholder and pastoral/extensive production systems in the tropics, by taking Kenya as an example. Smallholder farmers are found mainly in the medium- to high-potential areas (Rege, 1994). Smallholder farmers tend to keep animals for family needs, rather than purely as an economic enterprise. In this system, livestock may provide agricultural inputs, such as manure, and render the enterprise more secure by using residual capacities of production factors with low opportunity cost such as non-arable land, excess labour, by converting crops and crop residues into high value animal products and by balancing production and market risks (Jahnke, 1982). The importance of livestock to the production system is indicated in the present study in which 46% of the smallholders put livestock as their primary activity compared with 33% who put crops first. Pastoralist farmers rely even more on livestock as their main source of livelihood (58% in the present study) and usually own relatively large numbers of animals under extensive or communal grazing and management. They are found mainly in the medium- to low-potential areas. In recent times, pastoralist communities, especially in the medium potential areas, have been changing from purely keeping livestock towards agro-pastoral systems. This change is seen in the present study where 25% of the pastoral/extensive farmers put crop production as their main activity. Encroachment of crop farmers from other communities and adoption of crop-based food by the pastoral communities are now common features in the districts surveyed.

The results of the survey revealed a number of pertinent issues (i.e., opportunities and constraints) that, if addressed adequately, could help in developing effective small ruminant breeding programmes and in increasing the general

productivity of the animals. Small ruminant production was seen not only to be important by both smallholder and pastoral/extensive farmers, ranking closely behind cattle, but also to provide a variety of benefits ranging from tangible to intangible ones. This agrees with other observations (Field, 1985; Okello, 1985; Jaitner et al., 2001; Seleka, 2001). This knowledge of the reasons for keeping small ruminants is a prerequisite for deriving operational breeding goals (Jaitner et al., 2001). Indeed, ignorance of this aspect has been a major constraint in the lack of success in genetic improvement programmes attempted in the tropics (Sölkner et al., 1998; Rewe et al., 2002). The importance that farmers attach to the income that can be generated from small ruminants and the variety of ways in which they use it, however, suggest that genetic improvement programmes could, if carefully planned, have good chances of success. One interesting purpose of sheep production observed by some farmers in this survey, and one rarely reported, is a requirement for milk, especially by the pastoral communities.

3.4.2. Biological aspects

3.4.2.1. Breeds and breeding management

Availability of animals with good genetic potential, a point raised by farmers at report-back meetings at the end of the survey, is a constraint to productivity of small ruminants in the tropics. However, the large percentage of pastoral/extensive farmers with flocks of indigenous breeds (e.g., Red Maasai sheep and Small East African goats) provides a potential for good genetic material. Farmers in the current survey either inherited their males and reared them themselves for breeding purposes or bought or borrowed them. Keeping of small ruminants for breeding purposes was lowly ranked. The predominance of uncontrolled mating in both farming systems and the small flock sizes in smallholder production, as discussed by Seleka (2001), increases the level of inbreeding. Communal herding, which allows breeding females to mix with breeding males from other flocks, can minimise inbreeding (Jaitner et al., 2001), but this appears to have been rarely practised

among the farmers in this survey. Some males were kept up to 6-8 years of age which may not be sound production practice, especially if males are allowed to mate their own daughters. Size, performance and true to breed type ranked as the most important traits in the choice of breeding males. Whereas introduced pure breeds were generally considered better in size, growth rate, shape and fertility than the indigenous Red Maasai sheep and, the Small East African goat, they were rated poor in terms of drought and heat tolerance (Table 3.8 and 3.9), traits that are important in the harsh feed and temperature conditions of the tropics. The crosses, compared to the indigenous genotypes, were disadvantaged throughout most traits (Table 3.9). This is in agreement with previous observations that crossbreds are poorly adapted to the low-input traditional production systems of the tropics (Mason and Buvanendran, 1982; Iñiguez, 1998; Rewe et al., 2002; Wollny et al., 2002; Ayalew et al., 2003). From the findings in the current study, it would to be possible to select for faster growth rate, good size and conformation within indigenous breeds whilst at the same time maintaining the superiority of their adaptability traits.

3.4.2.2. Parasites and diseases

Poor health is the key limiting factor to productivity of sheep and goats in the tropics and the extent of the problem is demonstrated in this study. Most smallholders appeared to use government or private veterinarians, but a significant proportion of pastoral/extensive farmers appeared to depend on drug suppliers; this raises some doubts about the accurate diagnosis of disease. The number of extension visits to address the problems pertaining to the farming of small ruminants, however, was found to be minimal. Maximum productivity in a given system of production emerges when disease control is optimal (Gatenby, 1986). Thus, healthcare is an important problem to consider before genetic programmes can be seriously contemplated. Community-based animal health programmes may be one way forward (Njoro, 2001), and wider utilisation of indigenous breeds tolerant to disease another (Baker and Gray, 2003). Farmers did not discriminate between breeds in terms of disease tolerance (Table 3.8). This appears to contradict recent

studies that unequivocally showed the Red Maasai sheep and the Small East African goat to be more tolerant than the introduced breeds in coastal Kenya (Baker et al., 1998; 1999; 2003a and b). However, this could be due to the different environments in which the study was done (see Baker et al., 2003a), or to the fact that disease prevalence was so high that it overrode any breed preferences detectable by farmers.

3.4.3. Ecological aspects

Inadequate feeding and poor quality feed are often regarded to be major factors limiting sheep and goat production. Climate and season greatly influences feed supply and quality of the feed. Unreliability of roughage production, especially during drought periods, is also a problem. The current survey revealed, however, that a high percentage of both smallholder and pastoral/extensive farmers fed supplements during both dry and wet seasons, especially minerals. Roughage was fed by many farmers in both production systems, but pastoral/extensive farmers rarely purchased concentrates confirming that small ruminants tend to be kept in low-input systems. Although the feed quality and quantity of many tropical grasses is often inadequate (e.g., Carles, 1983; Gatenby, 1986; Charray et al., 1992), it would appear from this survey that farmers are doing their best to attend to the nutrition of their stock from their limited means. Use of genotypes that are adapted to efficiently utilise poor quality feed (Baker and Rege, 1994) may be one option but this trait was not included amongst those used to characterise breeds in this survey.

3.4.4. Socio-economic aspects

Although not studied in the present survey the different socio-cultural ways of different communities (e.g., the Maasai of Narok and Trans-Mara districts and their Samburu counterparts in Laikipia compared with Kikuyu smallholders of Nyeri) will be important to consider in the adoption of any breeding programme. Previous improvement programmes of small ruminants ignored this fact and ended up

unsatisfactorily (e.g., Sölkner et al., 1998; Rewe et al., 2002). The difficulty, however, is that the infrastructure necessary for collection of reliable pedigree and performance data does not exist (Kiwuwa, 1992) and, furthermore, it is unlikely that performance recording is logistically feasible in large numbers of smallholder flocks (Baker and Gray, 2003).

Farmers sold their stock primarily to butchers, and also to individual farmers and at auctions, but hardly ever to abattoirs, suggesting possibilities of none-competitive prices. Animals were often sold throughout the year, presumably often when prices were low, and this supports the results of other reports indicating that *ad hoc* sales of animals to meet emergencies prevail (e.g., Seleka, 2001). Farmers would likely not adopt improved management practices whilst proceeds from sale of animals are low (Seleka, 2001). Some farmers, however, only sold in dry or wet seasons, indicating a necessity to explore the possibilities of organised marketing of animals so that farmers can reap maximum benefit from sales. Current marketing information in the tropics is largely informal and obtained by talking to buyers or sellers who have conducted transactions. The fact that most butchers/traders were paying premium prices for pure exotic and indigenous X exotic crosses of both sheep and goats could influence the type of genotypes adopted by the farmers. However, the relative sheep prices found in the current study are very similar to the 40-60% advantages observed by Baker et al. (2003a) in live weight for Dorper versus Red Maasai sheep in a semi-arid environment in Kenya. Therefore, it is possible that butchers or traders were paying more for heavier exotic animals or exotic crosses (and not, for example, for any improved conformation) with the price per kg probably constant across stock classes.

3.5. Conclusion

The results from the present survey reveal several constraints that need to be taken into consideration when designing and implementing genetic improvement programmes for sheep and goats. It is thus necessary to look at the production system in a holistic way and involve target groups in devising effective small

ruminant breeding programmes. An integrated systems approach to small ruminant improvement is likely to be the best option. For example, in a study of adoption of indigenous X exotic crossbred goats in smallholder production systems in Ethiopian highlands, Ayalew et al. (2003) found that the non-genetic improvement strategies – better feeding practices and greater attention to basic healthcare - were more successful than genetic strategies alone. The ultimate beneficiary in that study was the indigenous goat and not the exotic genotype that had been originally planned. If any genetic improvement is appropriate in the smallholder or pastoral/extensive environment in this study in Kenya, then emphasis of genetic improvement of the indigenous genotype may prove to be the best option.

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