Swedish University of Agricultural Sciences
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Abstract

Livestock plays a major role in the livelihood of poor rural communities, being the source of tangible and intangible benefits. The objective of this study was to analyse the production objectives and selection criteria for cattle (N'Dama) and small ruminants (Djallonké sheep and West African Dwarf goat) in The Gambia and Senegal. A Participatory Rural Appraisal (PRA) survey was conducted in 18 villages in both countries. A total of 412 livestock owners and contract herders participated in the survey. The results showed that benefits such as manure production, income, savings and insurance, were the most important reasons for keeping ruminants. Furthermore, cows were important for milk sale and domestic milk consumption, and bulls were kept for draught. Intangible benefits, such as ceremonial and dowry were some of the main reasons for keeping small ruminants. In The Gambia body size was the most important selection criterion for all species. Trypanosomiasis resistance was essential when selecting cattle. Other important selection criterion traits were milk yield in cows, growth in bulls, and fertility and disease resistance in goats. In Senegal, cattle selection was based mainly on morphological characteristics, i.e. body size, conformation and growth. Trypanosomiasis resistance in cattle was rated lower than in The Gambia. In both countries, body size, fertility and growth were the main traits when selecting small ruminants. Generally, most of the farmer's production objectives were in harmony with the selection criteria. However, a number of differences were noted. In The Gambia sheep were selected for milk yield, but this was not an essential production objective. In addition, milk yield was an important selection criterion for cows but not for bulls. Inbreeding was the least important selection criterion in both countries. This divergence in production objectives with selection criteria, and the negative effects of inbreeding need to be addressed in breeding programmes in order to conserve, improve and sustainably utilise these three endemic ruminant species.

Introduction

Livestock plays a major role in the livelihood of poor rural communities, being the source of tangible and intangible benefits (Jaitner et al., 2001; Kosgey et al., 2004). Tangible benefits include milk, skins and meat, while insurance, dowry, and social status are examples of intangible benefits. Livestock can also be a way of overcoming poverty through increase and diversification of income, and being a catalyst to transform subsistence farming into income-generating enterprises (Kristjanson et al., 2004).

This study is part of the Regional Project on Sustainable Management of Endemic Ruminant Livestock in West Africa (PROGEBE). The objectives of the PROGEBE include; ensuring long-term viability of endemic ruminant species, improving livelihoods of the livestock keepers and increasing the productivity of livestock, while contributing to food security and poverty reduction in Guinea, Mali, Senegal and The Gambia (PROGEBE, 2009). This specific study focuses only on The Gambia and Senegal.

The Gambia has a total population of 1.66 million, of which 44% live in rural areas (Rural Poverty, 2010). About 90% of the rural population is poor, a situation that is evenly distributed throughout the country. In addition, 70% of the poor rural population in this

country depends on agriculture (IFAD, 2010). Senegal has a total population of 12.21 million of which 30% live under the poverty line and 75% of the poor households live in rural areas (IIED, 2007).

In 2008, The Gambia had a total of 420,000 heads of cattle, 374,000 goats and 200,000 sheep. Senegal had a total of 3.2 million heads of cattle, 4.4 million goats and 5.2 million sheep (FAOSTAT, 2010). In this context, both countries have high numbers of livestock heads relative to the total rural population size. However, majority of rural households are still below the poverty line. Agricultural development specifically improvements on livestock production provides an opportunity to overcome poverty.

The most important constraint to the agricultural development in the sub-humid and humid zones of Africa is the tsetse-transmitted disease of trypanosomiasis. This disease can cause anaemia, weight loss, decreased milk yields, abortions, testicular damage and ultimately the death of the animals (CFSPH, 2009). One of the direct impacts that trypanosomiasis has on livestock management is the breed composition of the herds, since livestock keepers would prefer trypanotolerant breeds (Swallow, 1999; Stein et al., 2009). Some of these endemic trypanotolerant breeds are the N'Dama cattle (Murray et al., 1981), the Djallonké sheep and the West African Dwarf goats (Murray et al., 1981; Osaer et al., 1994). The importance of this resistance to trypanosomiasis can be reflected on the cattle numbers. For instance, in 1983 about 98% of the total Gambian and 29% of total Senegalese cattle were from the trypanotolerant indigenous N'Dama breed (FAO, 1987; Jaitner et al., 2003). The northern part of Senegal is not affected by Tsetse species, which partly explains the big difference in population dynamics of the trypanotolerant cattle breeds between these two countries (FAO, 2000).

Disease resistance is one of the most important traits influencing selection decisions in Africa (Tano et al., 2003; Stein et al., 2009). Other traits such as fertility and milk performance are also of great significance (Ndumu et al., 2008). Similarly, some species are bred for social purposes, such as ceremonies and dowry. Consequently, it is necessary to understand the production objectives and selection criteria used by livestock owners in order to design and implement practical and sustainable breeding programmes.

Production objective is a concept that constitutes what is the best animal and the purpose for which the animal is bred or kept. Selection criteria are the phenotypic values or other information considered when conducting selection for breeding animals (Northwest University, 2010).The main purpose of this study was to analyse the production objectives and selection criteria for the three endemic livestock species; N'Dama cattle, Djallonké sheep and West Africa Dwarf goat in The Gambia and Senegal. Three specific objectives were considered for this study:

1. To analyse the livestock production objectives of poor livestock keepers for three endemic ruminant species in The Gambia and Senegal, with comparisons across species and countries.
2. To analyse the criterions used by these livestock keepers in animal selection, and to establish relations between their selection criteria and livestock production objectives.

3. Identify the criterions by which livestock keepers can do a better selection of their breeding animals, based on their own production objectives.

Materials and methods

Study site and sample procedures

Data was collected through Participatory Rural Appraisal (PRA) surveys conducted in June and August 2009, respectively, in The Gambia and Senegal. Three districts, Nianija, Nianina East and Kiang West were selected in The Gambia. In Senegal, Bandafassi, Tenghory and Wassadou districts were considered. Three villages were selected in each of the 3 districts of each country, resulting in a total number of 18 villages (Table 1). Only three species were considered in the PRA; N'Dama cattle, Djallonke sheep and West African Dwarf goat. However, cows and bulls were treated as different species in the PRA (Annex 1). Cows and bulls play different roles in African societies, and it is expected that livestock keepers will select and breed them for different reasons (Schneider, 1957; Barret, 1991; Jaitner et al., 2003).

In each village, the PRA was done in a two day period that included several PRA activities. Only results of PRA activity denoted 10b-1&2 are presented (Annex 1). Between 30 and 35 individuals including livestock owners, herders and non-livestock owners were invited to participate. All participants were adults of an age range between 18 and 65 years. Participants were divided into 4 groups according to the number of cattle and ownership: Group 1 from 0 to 10 cattle; Group 2 from 11 to 50 cattle; Group 3 more than 50 cattle and Group 4 only contract herders.

First, participants were asked to rank in order of importance eleven different production objectives for each species of domestic livestock (Annex 1, 10b-1). Production objectives listed were: draught; domestic meat consumption; domestic milk consumption; milk sale; income; savings and/or insurance; transport; manure; ceremonial or dowry; hides or skins; sale of breeding animals or their services (sale of breeding animals); and other parameters. Production objectives were listed in the rows of the matrix, whilst the different ruminant species; cows, bulls, sheep and goats appeared in columns (Annex 1, 10b-1).

Each group specified the relative importance of a specie/trait combination by placing between zero and ten stones, or equivalent (e.g. shells, beans) within each cell of the matrix. Groups were explained that zero stones indicated no importance and one stone the least importance. Additional stones signified an increase in importance, with ten stones being the most important. In addition, participants were informed that:

- If "domestic milk consumption" was given a rating of 10, and "manure" was given a rating of 5, it indicated that keeping animals for domestic milk consumption was twice as important as keeping them for manure production.
- If the ratings given to "saving and insurance" were 10 for cows, 0 for bulls, 8 for sheep and 8 for goats, it meant that bulls had no importance as saving and insurance, and that sheep and goats were equally important but not as important as cows.

Participants within each group only responded for livestock species which contributed to their livelihoods.

Next, the same groups were asked to think about the traits of importance when selecting breeding animals (Annex 1, 10b-2). The traits considered were: high growth rate (growth); high resistance to trypanosomiasis (trypanosomiasis resistance); high resistance to other diseases (disease resistance); high milk yield or in the case of males high milk of dams (milk yield); high fertility (fertility); good longevity (longevity); coat colour (colour); good temperament or behaviour (behaviour); short interval between calving, lambing or kidding (calving interval); large body size (body size); lack of conformation problems (conformation); low feed intake (low feed intake); good drought tolerance or hardiness (drought resistance); not a relative of breeding animals that are currently being used (low inbreeding); and others. The selection criterion traits were listed in the rows of the matrix and the different ruminant species on the columns (Annex 1, 10b-2). Groups had to agree on giving each cell a rating of 0 for never or rarely used, 1 for sometimes used, 2 for often used and 3 for always used.

Sample size and characteristics

The PRA resulted in 90 completed matrixes, 45 for production objectives and 45 for selection criteria, with a total of 412 participants for both countries. The number of participants and percentage for each of the four groups is presented in Table 1. About 62% of the interviewees were smallholders owning 1 to 10 cattle heads, while only 10% of them owned more than 50 animals. About 48% of the participants were living in The Gambia. The other 52% lived in Senegal, showing an even distribution in the total number of participants per country.

Table 1. Detailed distribution of interviewees per country, site, village and group

	Site	Village	Number of Participants[1]				
			Group 1	Group 2	Group 3	Group 4	Total
The Gambia	Kiang West	Manduar	14	4	2	-	20
		Sankadi	16	-	-	1	17
		Wudeba	15	2	2	-	19
	Niamina East	Fadia Kunda	14	1	1	-	16
		Mamut Fana	17	6	3	1	27
		Sambel Kunda	25	3	-	3	31
	Nianija	Chamen	11	6	10	7	34
		Palelleh	16	-	-	10	26
		Sichu Demba	8	-	-	-	8
Total Participants			136	22	18	22	198
Total Groups			9	6	5	5	25
Senegal	Bandafassi	Nianghe	7	-	-	-	7
		Pellel Kendessa	3	9	-	-	12
		Sagaridie Badiary	10	-	-	-	10
	Tenghory	Djimakakor	11	4	-	4	19
		Nghoniam	21	20	-	-	41
		Tendimane	14	-	2	-	16
	Wassadou	Boya	23	-	9	15	47
		Kaone	18	-	11	6	35
		Nianao	14	7	-	6	27
Total Participants			121	40	22	31	214
Total Groups			9	4	3	4	20
Total Participants			257	62	40	53	412
Total Participants (%)			62	15	10	13	100
Total Groups			18	10	8	9	45

[1] Group 1; 0 to 10 cattle, Group 2; 11 to 50 cattle, Group 3; more than 50 cattle and Group 4; contract herders.

Data analysis

Data was analysed using Statistical Analysis Software (SAS version 9.2, SAS Institute Inc, Cary, NC) and SPSS (version 11.5, SPSS, Inc., Chicago, IL). The data obtained was nonparametric and derived from different groups. Similarly, the data was unbalanced between cattle groups, selection traits, production objectives, species and countries. Groups were initially compared with a rank sum test for more than two groups i.e., the Kruskal-Wallis exact test. This procedure calculates a single value for all groups without showing any specific differences among groups. A post hoc analysis (i.e., Bonferroni post-hoc test) was performed for groups found to be significantly different at $P < 0.05$ to compare the various group pairs.

The Kruskall-Wallis exact test, like other non-parametric tests, is performed on ranked data. Consequently, all observations in each data set are transformed into ranks; zero values are also assigned a rank. This means that the output values can only be compared within the same table and data set, and not across tables. Rank positions can be compared across tables.

Three different comparisons were performed: (i) comparison of production objectives and selection criteria for each species, (ii) comparison of selection criteria and production objectives across species, and (iii) comparison of production objectives and selection criteria across groups. Contract herders were omitted in all comparisons of production objectives and selections criterions that were not across groups because they are not the owners of the animals.

Participants were asked to allocate 10 stones (or equivalent) in the specie/production objective combination that they considered the most important in each matrix. However, some groups of interviewees, for example, assigned a maximum value of 7 as the highest value on a matrix. In this case, the data for each matrix (Annex 1, 10b-1) was transformed using the following formula:

$$V_{adj} = V_{org} * 10/V_h$$

Where V_{adj} is the adjusted value for that cell, V_{org} is the original value for that cell, and V_h is the highest value found in that specific matrix.

Results

Production objectives

Production objectives for each of the four ruminant species are summarised in order of importance, in Tables 2 to 10. Values in the diagonals correspond to the mean rank value given to that production objective by the Kruskal-Wallis exact test, while the off-diagonal cells are the absolute values of the mean differences between production objectives calculated by the Post Hoc Bonferroni test.

Production objectives in The Gambia

The Gambian livestock owners primarily reckon their livestock as a source of saving and insurance, and manure, regardless of the specie (Tables 2 to 5). The rank scores place these two production objectives among the four most important priorities for keeping livestock. In all species, except cows, income also appears among the most important production objectives.

Milk sale and domestic milk consumption from cows were also considered important. However, they show no significant differences with the most important production objectives. In contrast, milk sale and domestic milk consumption in bulls were ranked lower, together with use of animals for breeding and hides (Table 3). Probably due to their size and strength, bulls were bred for draught and transport.

Small ruminants were mainly kept for income purposes, savings and insurance, and ceremonial or dowry purposes. However, keeping these species for breeding and milk for sale was ranked lower. Both, the Djallonké sheep and the West African Dwarf goats were not bred for transport or draught purposes (Tables 4 and 5).

Table 2. Ranked production objectives for N'Dama cows in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Savings or insurance	Manure	Milk sale	Domestic milk consumption	Draught	Income	Ceremonial or dowry	Transport	Domestic meat consumption	Sale of breeding animals	Hides or skins
Savings or insurance	194.2										
Manure	0.3	191.7									
Milk sale	0.4	0.1	187.1								
Domestic milk consumption	0.7	0.4	0.3	181.8							
Draught	2.8*	2.5	2.4	2.2	144.3						
Income	3.4*	3.1*	3.0*	2.7*	0.6	134.9					
Ceremonial or dowry	3.9*	3.5*	3.4*	3.2*	1.0	0.5	121.4				
Transport	5.3*	5.0*	4.9*	4.6*	2.4	1.9	1.4	91.3			
Domestic meat consumption	5.3*	5.0*	4.9*	4.7*	2.5	1.9	1.4	0.0	87.3		
Sale of breeding animals	6.2*	5.9*	5.8*	5.5*	3.3*	2.8*	2.3	0.9	0.8	66.0	
Hides or skins	6.4*	6.2*	6.0*	5.7*	3.6*	3.0*	2.6	1.1	1.1	0.2	57.7

*Mean differences between traits are significantly different at $P < 0.05$.

Table 3. Ranked production objectives for N'Dama bulls in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Manure	Savings or insurance	Draught	Income	Transport	Ceremonial or dowry	Domestic meat consumption	Sale of breeding animals	Hides or skins	Milk sale	Domestic milk consumption
Manure	199.2										
Savings or insurance	0	198									
Draught	0.7	0.6	182.8								
Income	2.5	2.5	1.8	162							
Transport	1.9	1.9	1.3	0.6	159						
Ceremonial or dowry	2.5	2.4	1.8	0	0.6	157.9					
Domestic meat consumption	4.5*	4.4*	3.8*	2	2.6	2	109.9				
Sale of breeding animals	5.7*	5.6*	5.0*	3.1*	3.7*	3.2*	1.2	82.6			
Hides or skins	6.0*	5.9*	5.3*	3.5*	4.1*	3.5*	1.5	0.3	72		
Milk sale	5.9*	5.9*	5.3*	3.4*	4.0*	3.4*	1.4	0.3	0.7	70.9	
Domestic milk consumption	6.3*	6.2*	5.6*	3.8*	4.3*	3.8*	1.8	0.6	0.3	0.4	63.4

*Mean differences between traits are significantly different at $P < 0.05$.

Table 4. Ranked production objectives for Djallonké sheep in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Income	Ceremonial or dowry	Savings or insurance	Manure	Domestic meat consumption	Hides or skins	Sale of breeding animals	Domestic milk consumption	Milk sale	Draught	Transport
Income	131.0										
Ceremonial or dowry	0.2	127.8									
Savings or insurance	0.3	0	126.3								
Manure	1.6	1.4	1.3	116.5							
Domestic meat consumption	3.1*	2.9*	2.8	1.5	102.0						
Hides or skins	4.6*	4.4*	4.4*	3.0*	1.5	66.2					
Sale of breeding animals	5.1*	4.8*	4.8*	3.5*	2	0.5	61.8				
Domestic milk consumption	5.6*	5.4*	5.4*	4.0*	2.5	1	0.5	56.6			
Milk sale	6.3*	6.1*	6.1*	4.8*	3.2*	1.7	1.3	0.7	43.8		
Draught	6.5*	6.2*	6.2*	4.9*	3.4*	1.9	1.4	0.9	0.1	40.5	
Transport	6.5*	6.2*	6.2*	4.9*	3.4*	1.9	1.4	0.9	0.1	0	40.5

*Mean differences between traits are significantly different at $P < 0.05$.

Table 5. Ranked production objectives for West African Dwarf goats in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production objectives										
Production Objectives	Income	Savings or insurance	Ceremonial or dowry	Manure	Domestic meat consumption	Domestic milk consumption	Hides or skins	Sale of breeding animals	Draught	Milk sale	Transport
Income	139.8										
Savings or insurance	0.1	137.4									
Ceremonial or dowry	0.4	0.4	134								
Manure	1	0.9	0.6	130.7							
Domestic meat consumption	3.2*	3.1*	2.8*	2.2	109.3						
Domestic milk consumption	6.1*	6.0*	5.6*	5.1*	2.8*	63.8					
Hides or skins	6.0*	5.9*	5.6*	5.0*	2.8*	0	61.9				
Sale of breeding animals	6.5*	6.4*	6.1*	5.5*	3.3*	0.5	0.5	57.1			
Draught	7.3*	7.2*	6.8*	6.3*	4.1*	1.2	1.3	0.8	46.5		
Milk sale	7.3*	7.2*	6.8*	6.3*	4.1*	1.2	1.3	0.8	0	46.5	
Transport	7.3*	7.2*	6.8*	6.3*	4.1*	1.2	1.3	0.8	0	0	46.5

*Mean differences between traits are significantly different at $P < 0.05$.

Across species comparison for different production objectives are presented in Table 6. A number of differences were noted. Small ruminants and bulls were considered more important than cows for ceremonial or dowry purposes. Production objectives such as domestic milk consumption and milk sales are statistically more important for cows than in any other specie.

Manure, and savings and insurance were important, but their means were not statistically different across species (Table 6). In addition, transport and draught were statistically more important in bulls than in any other specie. Breeding animals for domestic meat consumption, breeding and hides or skin were rated lower and not statistically different across species.

Table 6. Comparison of mean rank values across species within production objective, for The Gambia

	Mean rank values per specie			
Production Objective	Cows	Bulls	Sheep	Goats
Ceremonial or dowry	27.9^{bsg}	37.5^{c}	49.3^{c}	53.2^{c}
Domestic meat consumption	30.7	35.1	50.2	51.8
Domestic milk consumption	45.7^{bsg}	16.5^{c}	22.1^{c}	22.8^{c}
Draught	48.2^{bsg}	59.0^{csg}	19.0^{bc}	19.0^{cb}
Hides or skins	38.52	40.5	43.5	38.2
Income	28.6^{gs}	35.6^{g}	49.4^{c}	55.0^{bc}
Manure	42.5	44,0	29.2	41,0
Milk sale	62.5^{bsg}	33.2^{c}	28.9^{c}	27.0^{c}
Sale of breeding animals	40.4	42.5	40.6	35,0
Savings or insurance	41.3	41.4	34,0	41.6
Transport	42.6^{b}	57.4^{csg}	24.5^{b}	24.5^{b}

Superscripts represent significant differences at $p < 0.05$ for that specific production objective when compared to another specie; ^{b,} bulls, ^{c} cows, ^{g} goats, ^{s} sheep.

Production objectives in Senegal

The importance given to the different production objectives differed between The Gambia and Senegal. Income, manure, and savings and insurance were considered among the most important objectives by the Senegalese farmers. These reflect a few similarities among the two countries.

Table 7. Ranked production objectives for N'Dama cows in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Manure	Savings or insurance	Domestic milk consumption	Ceremonial or dowry	Milk sale	Income	Domestic meat consumption	Sale of breeding animals	Draught	Hides or skins	Transport
Manure	170.9										
Savings or insurance	0.9	156.3									
Domestic milk consumption	1.9	1.0	136.2								
Ceremonial or dowry	3.5*	2.6	1.6	130.3							
Milk sale	3.5*	2.6	1.6	0.0	126.7						
Income	3.9*	3.0*	2.0	0.4	0.4	126.1					
Domestic meat consumption	6.0*	5.1*	4.1*	2.5	2.5	2.1	92.6				
Sale of breeding animals	6.5*	5.7*	4.7*	3.1*	3.0	2.6	0.5	68.7			
Draught	7.5*	6.6*	5.6*	4.0*	4.0*	3.6*	1.5	1.0	52.7		
Hides or skins	7.6*	6.7*	5.7*	4.1*	4.1*	3.7*	1.6	1.0	0.1	50.0	
Transport	7.7*	6.8*	5.8*	4.2*	4.2*	3.8*	1.7	1.1	0.2	0.1	44.5

*Mean differences between traits are significantly different at $P < 0.05$.

Table 8. Ranked production objectives for N'Dama bulls in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Income	Savings or insurance	Manure	Ceremonial or dowry	Draught	Domestic meat consumption	Sale of breeding animals	Transport	Domestic milk consumption	Hides or skins	Milk sale
Income	163.7										
Savings or insurance	0.5	157.0									
Manure	0.6	0.0	154.2								
Ceremonial or dowry	1.6	1.1	1.1	147.6							
Draught	2.3	1.7	1.7	0.7	125.4						
Domestic meat consumption	5.2*	4.6*	4.6*	3.6*	2.9	96.4					
Sale of breeding animals	5.6*	5.0*	5.0*	3.9*	3.3*	0.4	77.6				
Transport	6.2*	5.7*	5.7*	4.6*	4.0*	1.1	0.7	67.1			
Domestic milk consumption	6.8*	6.2*	6.2*	5.1*	4.5*	1.6	1.2	0.5	61.8		
Hides or skins	7.2*	6.7*	6.7*	5.6*	5.0*	2.1	1.7	1.0	0.5	52.4	
Milk sale	7.3*	6.8*	6.7*	5.7*	5.0*	2.1	1.7	1.1	0.5	0.1	52.0

*Mean differences between traits are significantly different at $P < 0.05$.

Table 9. Ranked production objectives for Djallonké sheep in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Income	Savings or insurance	Ceremonial or dowry	Manure	Domestic meat consumption	Sale of breeding animals	Hides or skins	Domestic milk consumption	Draught	Milk sale	Transport
Income	146.3										
Savings or insurance	0.5	141.7									
Ceremonial or dowry	1.6	1.1	134.6								
Manure	2.3	1.8	0.7	116.6							
Domestic meat consumption	3.0*	2.5*	1.5	0.7	112.1						
Sale of breeding animals	2.5*	2.0	0.9	0.2	0.6	103.1					
Hides or skins	4.9*	4.4*	3.4*	2.7*	1.9	2.5*	60.9				
Domestic milk consumption	5.3*	4.8*	3.7*	3.0*	2.3	2.9*	0.4	46.5			
Draught	5.3*	4.8*	3.7*	3.0*	2.3	2.9*	0.4	0.0	46.5		
Milk sale	5.3*	4.8*	3.7*	3.0*	2.3	2.9*	0.4	0.0	0.0	46.5	
Transport	5.3*	4.8*	3.7*	3.0*	2.3	2.9*	0.4	0.0	0.0	0.0	46.5

*Mean differences between traits are significantly different at $P < 0.05$.

Table 10. Ranked production objectives for West African Dwarf goats in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Production Objectives										
Production Objectives	Income	Savings or insurance	Ceremonial or dowry	Manure	Domestic meat consumption	Sale of breeding animals	Hides or skins	Domestic milk consumption	Draught	Milk sale	Transport
Income	202.7										
Savings or insurance	1.8	181.3									
Ceremonial or dowry	3.1*	1.3	163.7								
Manure	4.1*	2.3*	1.0	144.3							
Domestic meat consumption	4.1*	2.3*	1.0	0.0	142.1						
Sale of breeding animals	5.6*	3.8*	2.5*	1.5	1.5	100.2					
Hides or skins	6.8*	5.0*	3.7*	2.7*	2.7*	1.2	77.6				
Domestic milk consumption	7.0*	5.3*	4.0*	3.0*	2.9*	1.5	0.3	66.0			
Draught	7.0*	5.3*	4.0*	3.0*	2.9*	1.5	0.3	0.0	66.0		
Milk sale	7.0*	5.3*	4.0*	3.0*	2.9*	1.5	0.3	0.0	0.0	66.0	
Transport	7.0*	5.3*	4.0*	3.0*	2.9*	1.5	0.3	0.0	0.0	0.0	66.0

*Mean differences between traits are significantly different at $P < 0.05$.

Breeding cows for draught purposes lost its importance in Senegal when compared to The Gambia and other breeding objectives. However, the purpose of keeping cows for domestic milk consumption and milk sales remained important among the production objectives (Table 7.) Manure production and saving and insurance were also ranked highly. Production objectives such as draught, hides and skins and transportation were rated the lowest (Table 7).

The most important production objectives for bulls were; income, saving and insurance, manure, ceremonial or dowry and drought, in that order. More priority was given for ceremonial and dowry purposes and less for transportation, when compared to The Gambia (Table 3).

A common trend was observed on the production objectives for small ruminants in both countries. However, in Senegal these animals were not bred for both milk sale and domestic milk consumption. The same rank values were also estimated for draught and transport. This reflects the irrelevance of these production objectives for the livestock owners.

Across species comparisons for production objectives are presented in Table 11. Unlike The Gambia (Table 6), ceremonial and dowry purposes do not show any significant difference across species. Similarly, all four species show no differences for saving and insurances. Breeding for income purposes was considered more important for bulls and goats than for cows and sheep.

Table 11. Comparison of mean rank values across species within production objective, for Senegal

	Mean rank values per specie			
Production Objective	Cows	Bulls	Sheep	Goats
Ceremonial or dowry	38.0	45.2	35.3	35.5
Domestic meat consumption	32.5	38.0	39.5	43.6
Domestic milk consumption	57.2^{bsg}	36.8^{c}	30.0^{c}	30.0^{c}
Draught	36.1^{b}	56.0^{csg}	31.0^{b}	31.0^{b}
Hides or skins	36.8	37.0	42.1	38.6
Income	23.4^{bg}	49.1^{c}	33.4	46.6^{c}
Manure	54.1^{sg}	49.0^{sg}	25.8^{cb}	25.2^{cb}
Milk sale	62.3^{bsg}	32.7^{c}	29.5^{c}	29.5^{c}
Sale of breeding animals	34.2	38.0	46.8	36.1
Savings or insurance	46.1	44.4	30.2	33.0
Transport	36.5	44.5	36.5	36.5

Superscripts represent significant differences at $p < 0.05$ for that specific production objective when compared to another specie; ^{b,} bulls, ^{c} cows, ^{g} goats, ^{s} sheep.

Similar to The Gambia (Table 6), bulls are significantly more important than any other species for draught. Manure production was rated higher for both cows and bulls than for sheep and goats.

Production Objectives, group comparisons in The Gambia and Senegal

The number of participants in each group was not evenly distributed (see Table 1). About 64% of the participants belonged to group 1 (1 to 10 cattle heads), 14% to group 2 (11 to 50 cattle heads), 10% to group 3 (more than 50 cattle) and 12% to group 4 (contract herders). This disparity and the low number of participants in most groups made differences between groups difficult to estimate. Group comparisons for small ruminants were not possible because groups were created based on the number of cattle heads and ownership. Tables 12 and 13 present production objectives compared across groups. Values can only be compared within the same row and specie.

In The Gambia, livestock keepers with more than 50 animals (group 3) had a higher preference for domestic meat consumption in cows, than in any other group (Table 20). Domestic meat consumption, income and manure production in cows was more important for participants in group 3 than for contract herders (group 4). Savings and insurance was statistically more important for the livestock owners in group 1 than in group 4. The rest of the selection criteria were not significantly different across groups. Unlike cows, ceremony and dowry, and income were different for bulls.

Table 12. Comparison of mean rank values across herd groups within production objective, for cows and bulls in The Gambia

	Cows				Bulls			
	Animal owners (herd size)			Contract herders	Animal owners (herd size)			Contract herders
	0-10	11-50	>50		0-10	11-50	>50	
Ceremonial or dowry	16.5	13.4	12.5	7.1	13.1	12.2	22.2^{d}	8.0^{c}
Domestic meat consumption	9.9^{c}	13.6	22.0^{ad}	10.5^{c}	8.9^{c}	13.5	22.0^{ad}	11.7^{c}
Domestic milk consumption	10.9	11.2	20.3	12.1	12.6	12.8	15.0	11.0
Draught	17.2	10.6	6.3	11.4	16.2	9.67	6.5	13.3
Hides or skins	12.2	14.3	10.5	12.2	11.5	13.8	10.0	13.6
Income	13.4	17.4^{d}	18.3^{d}	4.7^{bc}	11.8	16.1	18.8	7.5
Manure	12.4	15.8^{d}	21.5^{d}	5.9^{bc}	11.8	15.2	21.0^{d}	7.4^{c}
Milk sale	9.8	13.7	9.2	16.0	11.9	12.3	10.5	14.2
Sale of breeding animals	9.0	12.6	17.0	14.5	8.5	12.5	16.5	15.4
Savings or insurance	18.9^{d}	11.5	8.3	7.8^{a}	18.8^{bd}	7.0^{a}	12.0	10.2^{a}
Transport	13.1	11.5	14.7	11.8	8.4	11.4	14.5	17.2

Superscripts represent significant differences at $p < 0.05$ for that specific production objective when compared to another herd group. ^{a} group 1, ^{b} group 2, ^{c} group 3 and ^{d} group 4.

In Senegal, no significant differences were found when groups were compared (Table 21). However, trends were similar to the ones observed in The Gambia.

Table 13. Comparison of mean rank values across herd groups within production objective, for cows and bulls in Senegal

	Cows				Bulls			
	Animal owners (herd size)			Contract	Animal owners (herd size)			Contract
	0-10	11-50	>50	herders	0-10	11-50	>50	herders
Ceremonial or dowry	8.8	12.9	10.5	8.5	9.1	10.1	12.8	11.5
Domestic meat consumption	9.9	9.5	10.5	11.3	10.3	9.0	10.3	10.8
Domestic milk consumption	10.4	9.5	9.75	9.8	10.9	9.8	8.0	8.0
Draught	11.4	8.5	8.5	8.5	10.5	10.5	10.3	6.0
Hides or skins	11.4	8.5	8.5	8.5	9.9	9.0	9.0	14.0
Income	9.3	10.4	10.0	12.8	9.2	9.0	17.0	9.5
Manure	8.3	10.5	16.0	11.3	7.8	11.5	16.0	11.3
Milk sale	9.3	10.3	6.0	16.8	10.9	9.0	9.0	9.0
Sale of breeding animals	11.1	7.5	13.3	7.5	9.4	10.6	9.5	12.0
Savings or insurance	10.2	9.7	9.5	10.5	9.4	10.6	9.5	12.0
Transport	10.0	10.0	10.0	10.0	11.8	8.0	8.0	8.0

Superscripts represent significant differences at $p < 0.05$ for that specific production objective when compared to another herd group. [a] group 1, [b] group 2, [c] group 3 and [d] group 4.

Selection criteria

Fourteen different selection criteria were presented to the livestock owners for evaluation. Results are presented separately for each specie and country (Tables 14 to 21), due to the reasons explained earlier (Data analysis section). Diagonal values represent the mean rank values for each trait (Kruskal-Wallis exact test), while the off-diagonal values correspond to the absolute values of the mean differences between traits (Post Hoc Bonferroni test).

Selection criteria in The Gambia

Selection criteria used by farmers for each species are shown in Tables 14 to 17. Body size was the most important trait when selecting ruminants in The Gambia. However, this trait was only significantly different to longevity, inbreeding and feed intake, the least important selection criteria.

Trypanosomiasis and disease resistance were also considered important traits when selecting cattle (Tables 14 and 15). The two traits were only significantly different to inbreeding. Milk yield ranks highly among the selection criterion traits for bulls (Table 15). However, milk sale and domestic milk consumption were the least important purposes for breeding bulls. In small ruminants, trypanosomiasis resistance shows a lower mean rank value, when compared to cattle, but this criterion shows no significant difference with any other selection criterion (Tables 16 and 17).

The most important selection criteria traits for sheep were body size, growth, milk yield, fertility and disease resistance, in that order (Table 16). However, these traits were significantly different only to longevity, inbreeding and feed intake. Unexpectedly, milk yield appears among the most important traits when selecting sheep, yet these animals were not bred for domestic milk consumption and milk sale.

Body size, disease resistance, growth and fertility were considered the most important selection criteria in goats. These traits were significantly different with longevity, feed intake and inbreeding (Table 17). This is consistent to other animal species (Tables 14, 15 and 16).

The distribution of rankings for the different selection criterion traits varied among the species (Tables 14 to 17). However, no significant differences were found for any of the 14 criterions when across species comparison was conducted.

Table 14. Ranked selection criteria for N'Dama cows in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Body size	Trypanosomiasis resistance	Milk yield	Disease resistance	Fertility	Growth	Short calving interval	Conformation	Behaviour and temperament	Drought resistance	Colour	Longevity	Low inbreeding	Low feed intake
Body size	168.6													
Trypanosomiasis resistance	0.2	160.1												
Milk yield	0.2	0,0	160.1											
Disease resistance	0.2	0,0	0,0	155.2										
Fertility	0.2	0.1	0.1	0.1	154.1									
Growth	0.3	0.1	0.1	0.1	0.1	152.1								
Short calving interval	0.2	0.1	0.1	0.1	0,0	0.1	149.3							
Conformation	0.3	0.2	0.2	0.2	0.1	0.1	0.1	146.7						
Behaviour and temperament	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	123,0					
Drought resistance	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.2	108.6				
Colour	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.2	0.2	107.7			
Longevity	1.1*	0.9	0.9	0.9	0.8	0.7	0.8	0.7	0.5	0.3	0.1	105.1		
Low inbreeding	1.2*	1.1*	1.1*	1.1*	1,0	0.9	1,0	0.9	0.7	0.5	0.3	0.2	92.2	
Low feed intake	1.1*	0.89	0.9	0.9	0.8	0.8	0.8	0.7	0.5	0.3	0.1	0,0	0.0	86.2

Mean differences between traits are significantly different at $P < 0.05$.

Table 15. Ranked selection criteria for N'Dama bulls in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Body size	Trypanosomiasis resistance	Growth	Disease resistance	Milk yield	Fertility	Conformation	Short calving interval	Behaviour and temperament	Drought resistance	Colour	Longevity	Low inbreeding	Low feed intake
Body size	168.6													
Trypanosomiasis resistance	0.2	160.2												
Growth	0.2	0,0	159.8											
Disease resistance	0.2	0,0	0,0	155.4										
Milk yield	0.3	0.1	0.1	0.1	152.8									
Fertility	0.3	0.2	0.2	0.2	0.1	151.8								
Conformation	0.3	0.2	0.2	0.2	0.1	0,0	147.0							
Short calving interval	0.3	0.2	0.2	0.2	0.1	0,0	0,0	147.0						
Behaviour and temperament	0.5	0.4	0.4	0.4	0.3	0.2	0.2	0.2	123.5					
Drought resistance	0.7	0.6	0.6	0.6	0.5	0.4	0.4	0.4	0.2	109.1				
Colour	0.9	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.4	0.2	108.3			
Longevity	1.1*	0.9	0.9	0.9	0.8	0.7	0.7	0.7	0.5	0.3	0.1	105.7		
Low inbreeding	1.2*	1.1*	1.1*	1.1*	0.9	1.0	0.9	0.9	0.7	0.5	0.3	0.2	92.8	
Low feed intake	1.1*	0.	0.9	0.8	0.8	0.7	0.7	0.7	0.5	0.3	0.1	0,0	0.5	87.1

Mean differences between traits are significantly different at $P < 0.05$

Table 16. Ranked selection Criteria for Djallonké sheep in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Body size	Growth	Milk yield	Fertility	Disease resistance	Conformation	Short calving interval	Trypanosomiasis resistance	Behaviour and temperament	Drought resistance	Colour	Low inbreeding	Longevity	Low feed intake
Body size	185.9													
Growth	0.1	184.3												
Milk yield	0,0	0.1	181.7											
Fertility	0.1	0,0	0.1	180.3										
Disease resistance	0.1	0,0	0.1	0,0	176.1									
Conformation	0.3	0.2	0.3	0.2	0.2	164.6								
Short calving interval	0.2	0.2	0.2	0.2	0.2	0.1	162,0							
Trypanosomiasis resistance	0.4	0.4	0.4	0.4	0.4	0.1	0.0	160.1						
Behaviour and temperament	0.5	0.5	0.5	0.5	0.5	0.2	0.3	0.1	136.7					
Drought resistance	0.7	0.7	0.7	0.7	0.7	0.4	0.5	0.3	0.2	122.6				
Colour	0.9	0.9	0.9	0.9	0.9	0.6	0.7	0.5	0.4	0.2	120.4			
Low inbreeding	1.3*	1.2*	1.3*	1.2*	1.2*	1,0	1.0	0.9	0.8	0.6	0.4	100.4		
Longevity	1.3*	1.2*	1.3*	1.2*	1.2*	1,0	1.0	0.9	0.8	0.6	0.4	0,0	100.3	
Low feed intake	1.2*	1.2*	1.2*	1.2*	1.2*	0.95	1,0	0.8	0.7	0.5	0.3	0.1	0.1	89.6

Mean differences between traits are significantly different at $P < 0.05$

Table 17. Ranked selection criteria for West African Dwarf goats in The Gambia
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Body size	Growth	Disease resistance	Fertility	Milk yield	Conformation	Short calving interval	Trypanosomiasis resistance	Behaviour and temperament	Drought resistance	Colour	Longevity	Low feed intake	Low inbreeding
Body size	193.9													
Growth	0,0	193.7												
Disease resistance	0,0	0,0	189.6											
Fertility	0.0	0.1	0.1	188.3										
Milk yield	0.1	0.1	0.1	0.1	181.1									
Conformation	0.2	0.2	0.2	0.2	0.1	178.2								
Short calving interval	0.2	0.2	0.2	0.2	0.1	0,0	169.9							
Trypanosomiasis resistance	0.4	0.4	0.4	0.4	0.3	0.2	0.2	168.3						
Behaviour and temperament	0.6	0.6	0.6	0.6	0.5	0.4	0.4	0.2	136,0					
Drought resistance	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.3	0.1	130.4				
Colour	0.9	0.9	0.9	0.9	0.8	0.7	0.7	0.5	0.3	0.2	122.9			
Longevity	1.1*	1.1*	1.1*	1.1*	1,0	0.9	0.9	0.7	0.5	0.5	0.2	115.7		
Low feed intake	1.1*	1.1*	1.1*	1.1*	1,0	0.9	0.9	0.7	0.5	0.5	0.2	0,0	99.1	
Low inbreeding	1.4*	1.4*	1.4*	1.3*	1.2*	1.1*	1.1*	1.0	0.7	0.7	0.5	0.2	0.2	96.0

Mean differences between traits are significantly different at $P < 0.05$

Table 18. Ranked selection criteria for N'Dama cows in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Fertility	Conformation	Body size	Growth	Milk yield	Trypanosomiasis resistance	Behaviour and temperament	Short calving interval	Colour	Longevity	Disease resistance	Drought resistance	Low inbreeding	Low feed intake
Fertility	168.6													
Conformation	0.1	168.4												
Body size	0.1	0.1	168.2											
Growth	0.1	0.1	0,00	164.1										
Milk yield	0.2	0.1	0.2	0.1	164.1									
Trypanosomiasis resistance	0.3	0.2	0.2	0.2	0.1	159.6								
Behaviour and temperament	0.4	0.3	0.4	0.4	0.2	0.2	149.3							
Short calving interval	0.4	0.3	0.4	0.4	0.2	0.2	0,0	146.6						
Colour	0.6	0.5	0.5	0.5	0.4	0.3	0.2	0.2	141.9					
Longevity	0.9	0.8	0.9	0.9	0.7	0.7	0.5	0.5	0.4	114.8				
Disease resistance	0.9	0.8	0.8	0.8	0.7	0.6	0.5	0.5	0.3	0.1	110,0			
Drought resistance	1.3*	1.2	1.3*	1.3*	1.1	1.1	0.9	0.9	0.7	0.4	0.4	100.2		
Low inbreeding	2.0*	1.9*	1.9*	1.9*	1.8*	1.7*	1.6*	1.6*	1.4*	1.1	1.1	0.7	63.0	
Low feed intake	2.2*	2.1*	2.2*	2.2*	2.0*	1.9*	1.8*	1.8*	1.6*	1.3*	1.3*	0.9	0.2	50.21

Mean differences between traits are significantly different at $P < 0.05$

Table 19. Ranked selection criteria for N'Dama bulls in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Growth	Body size	Conformation	Behaviour and temperament	Trypanosomiasis resistance	Fertility	Colour	Disease resistance	Longevity	Drought resistance	Short calving interval	Milk yield	Low inbreeding	Low feed intake
Growth	192.8													
Body size	0.3	179.1												
Conformation	0.4	0.2	172.4											
Behaviour and temperament	0.6	0.3	0.2	162.8										
Trypanosomiasis resistance	0.8	0.5	0.4	0.2	153.7									
Fertility	0.9	0.6	0.5	0.3	0.1	145.3								
Colour	0.9	0.7	0.5	0.4	0.2	0.1	142.9							
Disease resistance	1.1	0.8	0.6	0.5	0.3	0.2	0.1	134.4						
Longevity	1.2	0.9	0.8	0.6	0.4	0.3	0.3	0.2	128.3					
Drought resistance	1.5*	1.2	1.1	0.9	0.7	0.6	0.5	0.4	0.3	114.7				
Short calving interval	1.6*	1.3*	1.2	1,0	0.8	0.7	0.6	0.5	0.4	0.1	107.7			
Milk yield	1.9*	1.7*	1.5*	1.4*	1.2	1.1	1,0	0.9	0.7	0.5	0.4	87.6		
Low inbreeding	2.2*	1.9*	1.7*	1.6*	1.4*	1.3	1.2	1.1	0.9	0.7	0.6	0.2	77.8	
Low feed intake	2.3*	2.1*	1.9*	1.7*	1.5*	1.4*	1.4*	1.3	1.1	0.8	0.7	0.4	0.2	69.6

Mean differences between traits are significantly different at $P < 0.05$

Table 20. Ranked selection Criteria for Djallonké sheep in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Body size	Fertility	Growth	Short calving interval	Conformation	Disease resistance	Colour	Trypanosomiasis resistance	Behaviour and temperament	Longevity	Drought resistance	Low inbreeding	Low feed intake	Milk yield
Body size	188.0													
Fertility	0.3	172.9												
Growth	0.5	0.2	161.2											
Short calving interval	0.6	0.3	0.1	153.4										
Conformation	0.8	0.6	0.3	0.2	142.7									
Disease resistance	0.9	0.6	0.4	0.3	0.1	139.1								
Colour	0.9	0.6	0.4	0.3	0.1	0.0	139.1							
Trypanosomiasis resistance	0.9	0.7	0.4	0.3	0.1	0.1	0.1	136.6						
Behaviour and temperament	1.2	0.9	0.7	0.6	0.4	0.3	0.3	0.3	112.2					
Longevity	1.6*	1.3	1.1	0.9	0.7	0.7	0.7	0.6	0.3	104.5				
Drought resistance	1.7*	1.4*	1.2	1.1	0.9	0.8	0.8	0.8	0.5	0.2	92.4			
Low inbreeding	1.9*	1.7*	1.4*	1.3*	1.1	1.1	1.1	1.0	0.7	0.4	0.2	82.1		
Low feed intake	2.2*	1.9*	1.7*	1.6*	1.3*	1.3	1.3	1.2	0.9	0.6	0.4	0.2	70.3	
Milk yield	2.2*	1.9*	1.7*	1.6*	1.4*	1.3*	1.3*	1.3	1.00	0.7	0.5	0.3	0.1	66.3

Mean differences between traits are significantly different at $P < 0.05$

Table 21. Ranked selection criteria for West African Dwarf goats in Senegal
(Diagonal = Kruskall Wallis mean rank value; off-diagonal = absolute value of Bonferroni's mean differences)

	Selection Criteria													
Selection Criteria	Body size	Fertility	Growth	Conformation	Short calving interval	Disease resistance	Colour	Trypanosomiasis resistance	Behaviour and temperament	Longevity	Drought resistance	Low inbreeding	Low feed intake	Milk yield
Body size	202.9													
Fertility	0.2	192.6												
Growth	0.4	0.3	179.8											
Conformation	0.5	0.3	0.1	174.6										
Short calving interval	0.5	0.3	0.1	0.0	174.5									
Disease resistance	0.9	0.7	0.5	0.4	0.4	153.0								
Colour	1.1	0.9	0.7	0.6	0.6	0.2	142.0							
Trypanosomiasis resistance	1.1	0.9	0.7	0.6	0.6	0.2	0.0	140.4						
Behaviour and temperament	1.2	1.0	0.8	0.7	0.7	0.3	0.1	0.1	135.2					
Longevity	1.5*	1.4*	1.1	1.1	1.1	0.7	0.5	0.5	0.4	117.1				
Drought resistance	1.7*	1.5*	1.3	1.2	1.2	0.8	0.6	0.6	0.5	0.2	103.2			
Low inbreeding	1.9*	1.8*	1.5*	1.5*	1.5*	1.1	0.9	0.9	0.8	0.4	0.3	90.5		
Low feed intake	2.1*	1.9*	1.7*	1.6*	1.6*	1.2	1.0	1.0	0.9	0.6	0.4	0.2	83.3	
Milk yield	2.1*	2.0*	1.7*	1.7*	1.7*	1.3	1.1	1.1	1.0	0.6	0.5	0.2	0.1	78.0

Mean differences between traits are significantly different at $P < 0.05$

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Selection criteria in Senegal

Morphological characteristics such as body size, conformation and growth were considered important traits when selecting cattle in Senegal. Feed intake and inbreeding were rated lower. This is consistent to the trends found in The Gambia.

Fertility was the most important trait when selecting cows. However this trait was only significantly different with the lowest ranked selection criteria (Table 18). Conformation, body size and growth also showed significant differences with lower ranked criterions. Trypanosomiasis resistance maintained its importance for Senegalese farmers when selecting cattle, but this trait was ranked lower than in The Gambia. In bulls, growth and body size were the main selection criteria. Conformation and behaviour were also considered important traits. These four traits were significantly different with milk yield, inbreeding and feed intake, the lowest ranked traits (Table 19).

The most important selection criterion traits for small ruminants were body size, fertility and growth, in that order (Tables 20 and 21). These three traits along with conformation and calving interval were significantly higher than drought tolerance, inbreeding, feed intake and milk yield. The main differences observed in selection criterion traits, between the two countries, was the importance given to milk yield in small ruminants. The latter was the least important trait for Senegalese farmers.

Group comparison of selection criteria in The Gambia and Senegal

Across group comparisons for selection criterion traits were not significantly different for both cattle species and countries. The results are presented in Tables 22 and 23 (Annex 2).

Discussions

This study shows that cattle owners in The Gambia and Senegal consider income generation, saving and insurance, and manure production as the main purposes for breeding their animals. Farmers keeping small ruminants particularly give higher importance to ceremonial and dowry purposes, saving and insurance, and income over potential food production, such as meat or dairy products. The importance given to these production objectives confirm what has been observed in preceding studies (Bennison et al., 1997; Jaitner et al., 2001; Mwacharo and Drucker, 2005). Tangible products such as milk, meat, hides and skins are not necessarily among the most important reasons for keeping livestock.

Gambian and Senegalese farmers consider milk sale and domestic milk consumption among the most important production objectives when breeding cows. However, they consistently agree that these two objectives are the least important reasons for keeping bulls. Further, farmers in Senegal consider milk yield as an important selection criterion in cows, but not in bulls. This divergence in objectives could be attributed to lack of awareness by farmers on the significance of sire and dam selection in genetic improvement. Improvement for important traits in dams can be accomplished at a much higher rate when an equivalent selection criterion is applied in sires (Groen, 1999). This situation becomes more complicated in

traditional farming systems when selecting for sex limited traits such as milk yield and calving interval. Performance testing for bulls is seldom done in these systems, mainly due to lack of technology and infrastructure to perform these evaluations. However, we cannot overrule the possibility that farmers subjectively select their animals based on the performance of their relatives. Studies elsewhere indicate that pastoralists give high importance to the ancestry of the animals, and consider it in selection (Galaty, 1989; Köhler-Rollefson, 1995). Another possible reason for this disparity is the role given to oxen in the African societies. In the current study, bulls and oxen were not considered separately. Previous studies indicate that oxen are kept as a source of income, meat and animal traction, and are essential for cultural and ceremonial purposes (Evans-Pritchard, 1953; Schneider, 1957; Adesina, 1991). It is therefore necessary to first identify production objectives for bulls and oxen separately before drawing any firm conclusions on the trend of farmer's selection decisions. Oxen do not contribute any genes to the next generation and consequently, do not directly influence future production objectives.

Livestock owners consider intangible benefits such as ceremonies and dowry, and saving and insurance as important reasons for keeping livestock. Previous studies have discussed these roles in cattle (Evans-Pritchard, 1953) and small ruminants in the tropics (Bennison et al., 1997; Lebbie, 2004; Kosgey et al., 2004), which are in agreement with the findings of this study. Small ruminants are important for social roles such as bride price payments, sacrificial rites, and as a link between societies (Kosgey et al., 2004; Lebbie, 2004). In the Gambia, Bennison et al. (1997) revealed that savings and insurance, sacrificial rituals, naming ceremonies, and weddings were among the major reasons for keeping small ruminants.

Manure, income and draught were important reasons for keeping livestock in The Gambia and Senegal. The importance of manure as a valuable input for crop production among Gambian farmers has been previously discussed (Bennison et al., 1997). One limitation about manure production is that it is difficult to measure in most production systems. However, farmers can breed their animals for manure production indirectly by selecting for body size. This is because of the direct relationship between body size and the amount of manure produced by an animal (Wilkerson et al., 1997). In addition, body size can be used as an indicator for draught power. Animals with a larger body size are preferred for work in many countries (Matthewman, 1986). For example, in Thailand, breeding programmes have been implemented with draught power and meat production as the main production objectives (Chantalakhana, 1999). Selection for draught power was based on body weight and size of the animal. These conclusions justify the inclusion of body size as the most important selection criterion for Gambian and Senegalese livestock keepers.

Resistance to trypanosomiasis, milk yield and growth rate were essential selection criteria for cattle in The Gambia. In Senegal priority was given to fertility, growth rate and conformation traits when selecting cattle. Farmers in The Gambia mainly keep N'Dama cattle, which belongs to a trypanotolerant breed (Murray et al., 1981). However, livestock keepers in this region still consider trypanotolerance as an important selection criterion. These findings coincide with Jaitner et al. (2003). The reason is that resistance to trypanosomiasis is not an absolute trait and it varies between individuals of the same breed (Naessens et al., 2002).

Trypanosomiasis is also one of the main limitations for cattle production in the tropics (Rowlands et al., 1994; Naessens, 2002; Stein et al., 2009). This disease causes anaemia, decreased milk yields, weight loss and high mortalities, among others, in animals (CFSPH, 2009). In Senegal, some areas are not affected by the Tsetse flies that transmit the trypanosomiasis disease (FAO, 2000). In addition, trypanosomiasis resistance was ranked lower than other criterions in small ruminants in both countries. This could be partially explained by Tsetse flies feeding habits and habitat (Snow and Boreham, 1979; Snow et al., 1996). Small ruminants generally graze closer to human settlements further from Tsetse infested areas, and the flies seldom feed on goats (Snow and Boreham, 1979; Snow et al., 1996).

Fertility and calving interval are important functional traits for livestock production and improvement. Calving interval can be a consistent selection criterion for fertility when service records are missing (Pryce, et al.2002). In Senegal, fertility was the most important selection criterion, while calving interval was ranked lower. Studies indicate that long calving intervals can be related to poor reproductive characteristics (Pryce, et al., 2002; Stein et al., 2009). It is not clear why farmers did not consider calving interval as an important selection criterion. Selection against poor reproduction in cattle is desirable in order to reduce hidden losses and costs of production (Groen et al., 2007)

Small ruminants were selected primarily based on body size and growth rate in both countries. The importance given to these traits is consistent to what was previously reported for Kenyan smallholders and pastoralists (Kosgey et al., 2008; Bett et al., 2009). Higher body weight in sheep can be related to larger lambs, better pre-natal and post-natal environments, and higher meat yields and manure production (Morley, 1954; Wilkerson et al., 1997), which are desirable to the livestock keepers. In addition, milk yield is an important trait when selecting sheep only in The Gambia. Unfortunately, milk is not an important production objective for these farmers. This is a good example where selection criteria do not meet the production objectives. This mismatch was not observed in Senegal. Similar findings have been previously documented in The Gambia (Bennison et al., 1997) and Senegal (Lesnoff, 1999). Farmers in Senegal do not consider small ruminant milk production as an essential trait. Generally, a correct selection criterion is necessary in order to achieve the desired production objectives.

Feed intake is an important trait that should be considered when selecting animals in the tropics. However, this trait was disregarded by most farmers in both Senegal and The Gambia when selecting their livestock. Livestock keepers in the study area mainly belong to the two ethnic groups; Peul and Mande. The Peul specialize in pastoralism and agropastoralism while the Mande are farmers. Some of these agro-pastoral groups are sedentary and they graze their livestock along river courses. Others are nomadic herders that continuously migrate to water sources and occupy communal lands for feeding their animals (Schoonmaker and Schoonmaker, 1993; Fratkin and Mearns, 2003). Feed for livestock keepers therefore remains an irrelevant selection criterion provided that these grazing practises continue to exist. Unfortunately, governments along the world are continuously threatening this mobility by privatizing communal lands and demarcation of boundaries (Fratkin, 1997). All these

measures represent threats to these migrating pastoralists and agro-pastoralists. A change in selection criteria for livestock in future is inevitable.

Inbreeding presented in the PRA as "not relative of breeding animals that are currently being used" was among the least important selection criteria for livestock. Inbreeding has several negative effects in livestock. It has been related to reduced survival and milk production in cows (Thompson et al., 2000), reduced body size at birth and wither height in sheep (Mandal et al., 2006) and affects body size and conformation on goats (Webb, 2003). Inbreeding also negatively affects productivity, vigour and fecundity in cattle and small ruminants (FAO/UNEP, 1981; Taberlet et al., 2008). These traits, which are negatively affected by high rates of inbreeding, consistently appeared among the most important production objectives and selection criteria. Previous studies suggest that herders are able to distinguish individual animals and their genetic relationships to the herd (Köhler-Rollefson, 1995). Livestock owners consider ancestry relations when making breeding decisions to avoid inbreeding (Galaty, 1989; FAO, 2009). Conversely, around 20% of male animals in West Africa are kept in the herd after the age of two, staying in their original herd and breeding in it (Amanor, 1995). These two inconsistent situations should be further examined, and inbreeding needs to be considered in the breeding programme.

Conclusions

A sustainable breeding programme contributing to food production and poverty reduction requires a better understanding of the production objectives and selection criteria used by the local livestock owners. Livestock were principally bred as source of income, saving and insurance and for the production of manure, irrespective of the number of animals owned, specie or country. Selection of animals was mainly done based on morphological appearances such as body size, conformation and growth. Trypanosomiasis resistance and fertility were important functional traits for cattle selection. Generally, most of the farmer's production objectives were in harmony with the selection criteria. However, breeding schemes should emphasize on aligning sire and dam selection strategies to facilitate faster genetic improvement, in the desired direction.

Feed intake and inbreeding were not considered important when selecting livestock. Breeding programmes need to consider the future availability of feed sources and the national policies regarding communal grazing areas in the traditional production systems. The programmes should also emphasize on the negative effects of inbreeding and the importance of mating unrelated animals in order to conserve, improve and sustainably utilise the three endemic ruminant species in The Gambia and Senegal.

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Annexes

Annex 1. Tables from PRA activity 10b.

PRA activity 10b-1: Production objectives of livestock keepers

	Cows	Bulls	Sheep	Goats
Draught				
Domestic meat consumption				
Domestic milk consumption				
Milk sale				
Income				
Savings / insurance				
Transport				
Manure				
Ceremonial (but not sold) or dowry				
Hides / skin				
Sale of breeding animals or their services				
Low feed intake				
Other (specify)				

PRA activity 10b-2. Criteria used to select breeding animals

	Cows	Bulls	Sheep	Goats
High growth rate				
High resistance to trypanosomiasis				
High resistance to other diseases				
High milk yield, or in the case of males high milk yield of dams				
High fertility				
Good longevity				
Coat colour (if a non-zero rating is given, please indicate preference for coat colour and why in notes)				
Good temperament / behaviour				
Short interval between calving / lambing / kidding				
Large body size				
Lack of confirmation problems				
Low feed intake				
Good drought tolerance / hardiness				
Not a relative of breeding animals that are currently being used				
Other (specify)				

Annex 2. Across groups comparison of selection criteria

Table 22. Group comparison of selection criteria, for cows and bulls,The Gambia.

	Cows				Bulls			
	Private owners (herd size)			Contract	Private owners (herd size)			Contract
Selection criteria	0-10	11-50	>50	herders	0-10	11-50	>50	herders
Behaviour	11.4	11.1	15.3	13.1	11.4	11.1	15.3	13.1
Body size	13.0	13,0	10.6	13,0	13,0	13,0	10.6	13,0
Calving interval	15,0	10.8	10.4	12.7	15,0	10.5	10.6	12.8
Colour	16,0	7.8	12.9	12.1	16,0	7.8	12.9	12.1
Conformation	13.1	10.4	12,0	14.5	13.1	10.4	12,0	14.5
Disease resistance	14.5	8.4	14.5	12.2	14.5	8.4	14.5	12.2
Drought resistance	9.9	12.8	12.9	15.9	9.94	12.8	12.9	15.9
Low feed intake	12,0	14.7	15.6	7.6	12,0	14.7	15.6	7.6
Fertility	14,0	10.0	11.4	14,0	14,0	10.1	11.5	14,0
Growth	14,0	10,0	11.6	14,0	13.5	9.5	13.5	13.5
Low inbreeding	15.2	11.8	11,0	10.5	15.19	11.8	11,0	10.5
Longevity	13.1	11.1	15.9	9.9	13.1	11.1	15.9	9.9
Milk Yield	12.6	14,0	11.4	11.6	10,0	14.5	14.5	12.1
Trypanosomiasis resistance	11.9	11.6	13.5	13.5	12.7	14.8	4,0	10.4

Table 23. Group comparison of selection criteria, for cows and bulls, Senegal.

	Cows				Bulls			
	Private owners (herd size)			Contract	Private owners (herd size)			Contract
Selection criteria	0-10	11-50	>50	herders	0-10	11-50	>50	herders
Behaviour	12.1	12.2	9.5	12.8	12.8	12.0	10.0	10.5
Body Size	13.0	11.8	8.8	10.8	12.6	12.3	9.0	11.3
Calving interval	12.6	9.9	9.5	14.0	12.9	8.7	13.8	12.5
Colour	12.8	12.1	10.8	10.1	13.0	11.8	11.8	9.4
Conformation	12.0	16.0	9.0	8.5	11.0	17.0	9.5	9.9
Disease resistance	12.3	13.1	8.5	11.4	12.2	14.8	3.5	12.3
Drought resistance	12.3	13.8	6.0	12.0	12.3	13.8	6.0	12.0
Low feed intake	11.8	10.1	8.0	17.0	12.2	9.6	7.5	16.6
Fertility	11.8	11.4	16.5	11.3	12.0	11.8	11.0	12.9
Growth	13.1	10.7	9.3	11.8	12.1	8.1	15.0	15.0
Low inbreeding	11.1	14.1	8.5	13.9	11.0	13.9	8.5	14.3
Longevity	13.3	11.8	12.8	7.9	13.0	12.1	9.8	9.9
Milk Yield	12.4	13.0	11.0	10.1	10.4	12.2	12.5	16.3
Trypanosomiasis resistance	12.8	13.8	9.8	8.6	12.7	14.8	4.0	10.4