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Phenotypic Characterization of Goats Raised under Traditional Husbandry Systems in Bugesera and Nyagatare Districts of Rwanda

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Abstract: Phenotypic characterization is a simple, non-invasive and inexpensive technology that can be utilized in mapping out an inventory of characters peculiar to a group of animals. A random sample of 487 non-descript village goats in Bugesera and Nyagatare districts were characterized according to their phenotypic characteristics. Three age categories (Based on dentition) were examined: milk, young and adults. Parameter assessed included face, back and rump profiles, presence of beards and toggles, horn, tail and ear lengths, coat color and pattern, presence of horns, live weight, heart girth, wither height, body and back lengths. Overall, 77.2% of goats sampled had a flat face while 22.8% had concave faces. About >98.4% had flat backs with 1.6% having a hollow back. All the goats in the study had a sloping rump. Only 6% had beards. About 13.5% had toggles averaging 3.4 cm in length. Average horn length varied from 4.3 (±0.2) in the milk category to 8.0 (±0.1) in the mature goats. Horn diameter varied from 3.3 (±0.1) cm in the kids to 8.6 (±0.2) in adults, respectively. The mean tail length ranged from 9.6 (±0.1)-12.0 (±0.1) for the same age categories. Average mean ear length ranged from 10.3 (±0.1)-11.5 (±0.09) (milk-adults). There was no significant difference ($p>0.05$) from one dentition category to another. The predominant coat color was the uniform multi-colored coat pattern. The mean live weight (kg) recorded were 13.1 (±3.3) (kids), 25.5 (±0.7) (young) and 33.3 (±0.5) (mature goats). Mean heart girth (cm) recorded was 54.4 (±0.5) (milk), 67.0 (±0.5) (young) and 74.0 (±0.4) (mature goats). The results show that goats in the study are predominantly not the East African Small type but rather are an improvement from the typical small East African goats. Implications of the present findings on goat breeding and productivity in Rwanda are discussed.

Key words: Goats, indigenous, phenotypic characterization, Rwanda, Iran

INTRODUCTION

In Rwanda, it has been estimated that there are approximately 1,379,895 goats in the country (MINAGRI, 2006). Goats are a very valuable genetic resource that is suited for low-input agricultural production systems. They require low inputs and are easy to manage making them suitable for the resource poor rural households (Acharya and Battacha, 1992). The abilities to reduce their metabolism, efficiently use water, minimize nitrogen requirements and efficiently digest high-fiber forage are among the desired adaptive features of goats (Gilboa *et al*., 2000; Silanikove, 2000; Morand-Fehr *et al*., 2004; Mengistu, 2007). These characteristics enable them to continue providing milk and meat even when cattle have succumbed to drought (Rege, 1994). On account of their adaptability, goats can survive on woody browses and infrequent watering during droughts and after drought, their high reproductive rate and short generation interval enable their owners to recover quickly and economically (Lebbie, 2004; Peacock, 2005). Other valuable attributes of goats include provision of food (Lebbie, 2004), fibre (Sahlu *et al*., 2004), income generation (Sahlu *et al*., 2004) and creation of employment (Lebbie, 2004) for poor rural families, especially women and children.

They can be sold to attain immediate cash assets for poor goat holders, helping them improve livestock and crop farming and financing social events (Morand-Fehr *et al*., 2004). Last but not least, the value

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of goats for the use of the vast areas of natural mountainous and hilly regions where crop production is less practicable should not be overlooked (Lebbie, 2004).

Despite their multiple roles and economic importance, information collected by the Food and Agriculture Organization (FAO) of the United Nations indicates that approximately 30% of the world's farm animal breeds inclusive of goats are at risk of extinction (FAO, 1999). The major threat has come from animal breeding practices that have emphasized productivity and specialization and by so doing, promoted prevalence of a relatively small number of breeds at the expense of locally adapted but less productive native breeds. Unfortunately, once animal genetic diversity has been lost, it cannot be replaced. Unlike breeds from/in temperate regions, most of the available goat genetic resources in Rwanda have undergone natural selection (Fish and Western, 1977; Hammond, 1994). As a result, the reproduction performance and production of most tropical goat breeds are both low. To improve this situation, native goats should be selected for their abilities to produce and reproduce efficiently and survive in the environments in which they are kept (Bretzlaff, 1995). Breed characterization should thus be prioritized if we are to select superior animals.

Characterization means the distillation of all knowledge which contributes to the reliable prediction of genetic performance of an animal genetic resource in a defined environment and provides a basis for distinguishing between different animal genetic resources and for assessing available diversity. It thus includes a clear definition of the genetic attributes of an animal genetic resource and the environments to which it is adapted or known to be partially or not adapted to at all. It also include the population size of the animal genetic resource, its physical description, adaptations, uses, prevalent breeding systems, population trends, predominant production systems, description of environment in which it is predominantly found, indications of performance levels (milk, meat, growth, reproduction, egg, fibre, traction etc.), genetic parameters of the performance traits and information on genetic distinctiveness of the animal genetic resource and its evolutionary relationship with other genetic resources in the species (Fish and Western, 1977; Hammond, 1994).

Phenotypic breed characterization is an essential, initial step in breed identification. However, very little effort has been made towards characterization of indigenous goat breeds in Rwanda. The lack of information on characterization of a genetic resource may lead to the underutilization of that resource, its replacement and dilution through cross breeding despite their local adaptation to prevailing environmental constraints. Therefore, assessment of genetic variability in domestic animals is an important issue to preserve genetic resources and maintain future breeding options in order to satisfy the demands of changeable markets (Maijala *et al*., 1984). Unplanned and indiscriminate breeding among native stocks is directly or indirectly responsible for the dilution of Rwandan livestock germplasm. Hence, identification and characterization of the goat breeds in Rwanda is a must to identify the genetic resources and also to prioritize breeds for conservation.

Characterization of animal genetic resources promotes continuing use and conservation of indigenous livestock which are usually more productive than exotics under low levels of input. Given that most of the goats in Rwanda are in the resource-poor rural households, promotion of breeds that thrive under low input systems is envisaged to result in increased farmers' incomes and food security. Presently, Rwanda does not have a complete inventory of the indigenous goat breed resources nor a basic description of many of the current species. It is therefore, important to obtain an inventory of domestic animal genetic resources in general and goats in particular and to characterize these resources at the phenotypic and genotypic levels. In this endeavor, physical or morphological characteristics can be particularly useful in the classification of populations, strains or breeds within a species (Winrock International, 1992). The objective of this study was therefore, to make an inventory of phenotypic characteristics of and genetic diversity among indigenous goat breeds in Nyagatare and Bugesera districts of Rwanda. The information so generated will be used in determining their relationships which may thereafter be useful as potential predictors of performance traits.

MATERIALS AND METHODS

Sites of study: The two site chosen for characterization exercise were Tabagwe and Kamabuye sectors in Nyagatare and Bugesera districts, respectively because these sectors are known for keeping purely indigenous breeds. The type of climate experienced in both sites is equatorial and are found in the low altitude zones of the Eastern and South-Eastern parts of the country, respectively. The approximate distance between the two districts is 261 km. The study area is located 30°30-30°25'East and 20°05-20°30'South and an altitude of 1400 m a.s.l) with average temperature 25°C in wet season and 30°C in dry season and relative humidity of 74%. The rainfall received is a moderate bimodal, fairly well

distributed within the year with the short rains (Season A) falling between September and December while the long rains extends from March through may (Season B).

The most popular goat production system is semi-intensive where tethering the goats close to the homesteads or some take them to graze freely in communal areas beginning at about 9:00 am to mid day then they are brought home and either kept in sheds/pens or tethered on pegs and they are supplied with twigs, banana leaves, peels, potato vines, leaves etc., till at about 4:00 pm. They are normally taken back to the grazing area where they are tethered till 6:30-7:00 pm. Banana leaves and pseudo-stems are cut and fed to the animals in the sheds at resting time at mid day when the ambient temperatures are high outside. Supplementation with agro-industrial by-products and other sources of supplements is rather uncommon within the farming systems. The local goats have been adapted to the environment and bear tremendous resistance to a good number of diseases prevalent in the region. Common diseases in the area include helminthiasis and contagious pustular dermatitis. Generally, disease control is done on an *ad hoc* basis. The lack of effective disease control measures has been attributed to inefficient veterinary services and lack of awareness by farmers who rely on use of indigenous technical knowledge. Few farmers keep bucks for breeding. Normally, nearly all born male kids are castrated when <3 months of age for improved meat quality. As result, the farmer keeping a buck whenever, other farmers bring does for mating they pay for that service and the price varies between 200-300 FRw.

Data collection: Data on a random sample of 238 and 249 goats was collected from Nyagatare and Bugesera districts, respectively. The goats were categorized by dentition ranging from young animals with no permanently ruptured teeth (milk teeth) to those with four pairs permanently ruptured teeth (full dentition). This is because farmers seldom keep birth records so, to determine various stages of growth; dentition was found to be the most appropriate. Goats without any permanently ruptured teeth were classified as milk goats while those with one or two permanently ruptured teeth were grouped together and referred to as young and those with three or four permanently ruptured teeth were considered as the mature category. All goats were weighted using a spring balance after ascertaining their dentition. Measurements were recorded using a tape measure in cm. These included heart girth, wither height, body length and back length from the base of the neck to the root of the tail. Tail, ear type and their lengths were also recorded. Horn orientation, its length and diameter at the base were also noted. Presence of toggles, their length and if single which side they occur was also recorded.

Data analysis: Data was analyzed with SAS using the general linear models. ANOVA for live weight and linear measurements was carried out to determine the fixed effects of dentition, coat color, origin and their interactions. Least square means were computed for all the tested factors. Coefficients of correlation between the measured parameters were computed for the various dentition categories in Nyagatare and Bugesera districts to determine linear associations. Stepwise regression models of body weight as the dependent variable with linear measurements as the independent variables for milk, young and mature categories of goats in both districts was determined. This was done to find the most suitable models showing relationships between live weight and linear measurement of heart girth, withers height, back length and body length for various dentition categories. Proportion of live weight to heart girth, withers height, back length and body length was calculated for the various dentition categories to determine the trends of these associations.

Other linear proportion that was considered were heart girth with withers height and back length for various dentition groups.

RESULTS

Three age categories (based on dentition) were examined; milk, young and adults. Parameter assessed included face, back and rump profiles, presence of beards and toggles, horn, tail and ear lengths, coat color and pattern, presence of horns, live weight, heart girth, wither height, body and back lengths. The predominant coat color was the uniform multi-colored coat pattern. Overall, 77.2% of goats sampled had a flat face while 22.8% had concave faces. About >98% (98.4%) had flat backs with 1.6% having a hollow back. All the goats in the study had a sloping rump. Only 6% had beards. About 14% (13.5%) had toggles averaging 3.4 cm in length. Polledness was observed in 8.9 and 4% of goats in Nyagatare and Bugesera districts, respectively. The horn length and diameter varied from 3.4-8.8 and 4.3-8.3 cm, respectively from milk to mature groups. Average horn length varied from 4.3 (±0.2) in the milk category to 8.0 (±0.1) in the mature goats. Horn diameter varied from 3.3 (±0.1) cm in the kids to 8.6 (±0.2) in adults, respectively. About 51% of the horns shape was straight and the orientation of 67.9% being backwards. The mean tail length ranged from 9.6±0.1-12.0±0.1) for the same age categories. Tail length

Table 1: Linear measurement and live weight for the different age-groups of goats in Nyagatare and Bugesera districts, Rwanda

Dentition	Weight (kg)	Heart girth	Wither height	Body length	Back length	Tail length	Ear length	Horn length	Horn diameter	Toggle length
		(cm)								
Milk	13.1±0.3	54.4±0.5	49.3±0.5	46±0.5	44.1±0.4	9.6±0.10	10.3±0.10	3.3±0.15	4.3±0.2	3.30±0.300
Young	25.5±0.7	67.0±0.5	59.6±0.4	57±0.5	55.3±0.4	11.1±0.12	11.0±0.10	6.7±0.10	6.8±0.1	3.36±0.170
Mature	33.3±0.5	74.0±0.4	63.1±0.4	62±0.3	59.2±0.3	12.0±0.10	11.5±0.09	8.6±0.20	8.0±0.1	3.70±0.200

Table 2: Live weight and linear measurements of the different colors of goats in Bugesera and Nyagatare sectors (mean±SE of mean)

Coats color	Live weight	Heart girth	Wither height	Back length	Body length
Black	25.22±0.73	66.20±0.74	57.81±0.59	53.49±0.60	55.42±63.0
Black/White	25.32±0.91	66.07±0.78	58.03±0.60	53.25±0.64	55.12±0.67
Brown	21.50±2.99	65.30±3.05	55.60±2.73	52.90±2.10	53.50±2.51
Black/Brown	28.28±1.70	69.40±1.62	59.80±1.37	55.57±1.20	57.33±1.41
White	21.00±2.60	62.00±2.77	55.11±2.16	49.78±2.48	54.67±3.11
Ikivuzo	21.64±2.20	61.56±2.57	55.40±1.70	52.52±2.10	54.04±2.21
Black/Ikivuzo	24.72±1.97	65.85±2.28	58.63±1.98	54.26±2.14	55.93±2.23

did not differ with age category. Average mean ear length ranged from 10.3±0.1-11.5±0.09 (Milk-adults). There was significant difference ($p<0.05$) in ear length from one dentition category to another. The mean live weight (kg) recorded were 13.1±3.3) (kids), 25.5±0.7 (young) and 33.3±0.5 (Mature goats). Goats with black/brown coat coloration were the heaviest followed by black/white and uniform black (Table 1). Heart girth increased as dentition category increased but the difference between consecutive categories reduced progressively. Mean heart girth (cm) recoded was 54.4±0.5 (milk), 67.0±0.5 (young) and 74.0±0.4 (Mature goats). A similar trend was observed for wither height, back length and body length. Just like weight, black/brown goats had larger linear measurements. Within the dentition groups the proportion of live weight to linear measurements (Heart girth, wither height, body length and back length reduces progressively (Table 2). Live weight was significantly correlated with heart girth ($p<0.01$). There was strong indication that heart girth is a good predictor for live weight as it appears in all dentition categories.

DISCUSSION

The World watch list for domestic animal diversity prepared by the Food and Agriculture Organization of the United Nations (FAO) in 1993 and which has since been revised 2 times (1995 and 2000) has defined a breed as: either a homogenous, sub-specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species or a homogenous group for which geographical separation from phenotypically similar groups has led to general acceptance of its separate identity. The colour ranges recorded in this study is in line with other observations on East African goats which is described as ranging from pure white to pure black with various intermixes of roan and speckled brown. However, horn length in the pure East African goats is reported to range from 2.5-20 cm in length whereas the findings were that horn length ranged from 4-8 cm.

The findings showed great variation in all characteristics studied in relation to those of known breeds hence, little could be said about the breeds under study. However while little is known about the actual breeds of goats in these study sites, differences in their horn shapes indicate that two or more breeds could have been present.

Based on coloration and all other phenotypic characteristics studied, it appears all the indigenous goats under study belong to the small East African goat type. Indigenous goat is the collective term used for all varieties of native East Africa goat breeds. However, it is almost impossible to classify a group of goats into different populations using phenotypic characters commonly used to describe goat breeds (Coat colour, horns, physical body measurements and productive traits) (Banerjee *et al*., 2000) because there is considerable variability within and among the populations. As a result, it is difficult to combine different characters in order to have a useful tool for assigning individuals to their source populations.

Elsewhere, attempts have been made to assign specific breed names according to the geographical areas in which they occur or the names of breeds and types were taken over from the nations or tribes that own them. However, this classification system does not accommodate thousands of indigenous goats found outside these specific locations hence, it has not been well accepted.

Discrimination among individuals is essential for effective and proper management of livestock breeds for conservation especially for Rwandese breeds which are not adequately characterized even at phenotypic level and have no pedigree information. To overcome this, microsatellites can be used to determine the genetic differences between closely related goat populations

thereby paving the way for assignment of anonymous individuals to their source populations. Though, no definite breeds were identified, phenotypic characterization is an essential, initial step in breed identification which should be followed by in-depth genetic characterization of indigenous goat breeds. A lack of information on genetic resource characteristics may lead to the underutilization, replacement and dilution through crossbreeding of local goat breeds, despite their local adaptation to environmental constraints.

The presence of toggles in 13.5% of the goats studied contrasts with observations of Rodero *et al.* (1996) who recorded toggle presence of between 68 and 98% in Spanish goats. Polledness was observed in 8.9 and 4% of goats in Nyagatare and Bugesera districts, respectively. The low prevalence of Polledness can be explained by the fact that the hop allele which is present in both sexes determines the presence of horns and is dominant over the Ho^+ which when homozygous, determines the presence of horns in both male and females (Rodero *et al*., 1996). The Hop^+ allele is generally therefore, of low frequency in East African goats.

Overall, present findings indicate that the indigenous goats of Rwanda vary in horn and coat types, colour, ear length and size and are mostly of medium size. Variation in size between goat types is attributable to environmental extremes. Nevertheless, the local breeds of goats are well adapted to their varied natural environments. This might have influenced the phenotypic characteristics observed herein. Similar observations were reported by Molefe (1986) in Botswana.

Heart girth increased as dentition category increased but the difference between consecutive categories reduced progressively. This was the same for wither height, back length and body length (Table 1). The mean live weights and linear measurements for various coat colors observed (Table 2) shows that goats with black/brown coat coloration were the heaviest followed by black/white and uniform black. Black/brown goats, similarly exhibited larger linear measurements. When we consider live weight as a proportion of linear measurements we find that for all the linear measurements the proportions reduce as the age of goats increases for each measurement. This could be due to morphological changes as result of tissue accumulation relative to linear growth as the animal gets older.

It was also observed that within the dentition groups the proportion of live weight to heart girth, wither height, body length and back length reduces progressively. However, when we consider wither height as proportion of heart girth measurements, constant proportions for all dentition categories for heart girth with wither height and back length are observed. This indicates that there is a proportionate increase of linear measurements as the goats' age. As has been observed by various researchers live weight associates significantly ($p<0.01$) with heart girth and therefore, heart girth could be a reliable indicator for live weight, particularly in circumstances where a weighing balance is unavailable. The association reduces as the animals get older. Similar trends are also observed for other linear measurements exhibiting stronger association. These observations are in agreement with those of Skea (1990).

CONCLUSION

Goats from the two regions of Rwanda differ in various linear measurements and live weights. Thus, there is need to plan to harmonize the classification criteria such that the various strains, landraces and breeds of goats can clearly be identified to plan for an appropriate selection, methodology leading to improvement and thereafter conservation of some of these unique indigenous genetic materials. The characterization exercise forms the beginning of identifying the different heterogeneous goat strains located in the various localities nationwide that constitute previously uncharacterized populations.

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