The Wool-Less Canary Sheep and their relationship with the present breeds in America

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Summary

When the Spaniards discovered and conquered the Canary Islands in the 15th Century, they found a type of hair sheep, a breed described by the colonists as "white in colour, large in size and with horns in the males". This discovery provokes the question: from where did these sheep originate? All other breeds of wool-less sheep in the world in that period were located in the sub-Saharan regions, far away from the Canary Islands and with no possible connection.

Archaeologists claim that Northwest Africa was populated by wool sheep from 4000-3000 BC. Northwest Africa is the nearest geographical point of the African continent to the Canary Archipelago. It was also there that the native pre-Hispanic human population is thought to have originated. Did the wool-less sheep breed arrive with these people? The answer is probably yes. It is likely that the population of hair sheep arrived between 3000-2000 BC in a northern expansion of these animals, accompanying the first inhabitants of the islands.

After the Spanish conquest, the Canary Islands provided a necessary stop for the explorers of the New World. Various testimonies exist describing the arrival of the first sheep to the Caribbean Islands. This process of animal introduction started with Columbus´ second voyage, after which domestic animals formed a usual part of the shipment arrangements. This raises a third question: what role did the Canary Island sheep play in the origin and evolution of the present Caribbean and Latin-American hair breeds? The majority of researchers working with these animals in America and the Caribbean think that the origin of their wool-less sheep breeds is related to the traffic of black slaves during the 17th and 18th centuries. It may be claimed that this influence of sub-Saharan animals exists as an additional influence of other wool-less sheep breeds, which arrived in the Caribbean from the Canary Islands two centuries earlier. Today, the ancient native hair sheep breed is extinct in the Canary Islands although some wool-less sheep have recently been introduced from Venezuela.

All these questions and ideas are investigated in this paper, through historical references and current research.

Resumen

En el siglo XV tras el descubrimiento y conquista de las Islas Canarias los españoles encontraron un tipo de oveja sin lana (oveja de pelo), una raza descrita por los colonos como de color blanco, de gran formato y los machos con cuernos.

Este descubrimiento provoca la siguiente cuestión: ¿Dónde se originó esta oveja? Todas las otras razas de ovejas de pelo en el mundo en esa época estaban localizadas en la región

subsahariana, muy alejadas de la latitud de las Islas Canarias y sin posibilidad de conexión. Los arqueólogos postulan que el noroeste de Africa estuvo poblado por ovejas de lana entre los 4000 a 3000 años AC. El noroeste de Africa es el punto geográfico más cercano del continente con el Archipiélago Canario. ¿Arribaron las poblaciones de ovejas de pelo con el hombre? La respuesta para esta cuestión es probablemente, sí. Igualmente que las poblaciones de ovejas de pelo llegaron entre 3000 y 2000 años AC en una expansión al norte de estas razas acompañando a los primeros habitantes de las islas.

Después de la conquista española, las Islas Canarias constituían una parada necesaria para los exploradores del Nuevo Mundo. Existen diversos testimonios que describen la llegada de las primeras ovejas a las islas caribeñas. Este proceso de introducción de animales se inició en el segundo viaje de Colón, continuando los animales domésticos como parte habitual de los embarques. Este hecho suscita una tercera cuestión: ¿Qué papel jugaron las ovejas de las Islas Canarias en el origen y evolución de las actuales razas ovinas de pelo del Caribe e Iberoamérica?.

La mayoría de los investigadores que trabajan con estos animales en América y en el Caribe piensan que estas razas ovinas de pelo se relacionan con el tráfico de esclavos negros durante los siglos XVII y XVIII. Se puede postular que esta influencia de animales subsaharianos es absolutamente real, pero como una influencia adicional de otras poblaciones de ovejas de pelo, que arribaron al Caribe procedentes de las Islas Canarias dos siglos antes. Hoy, los ancestros, poblaciones nativas de ovejas de pelo están en extinción en las Islas Canarias. Sin embargo, algunos animales pelibuey han sido introducidos desde Venezuela.

En el presente trabajo investigamos todas estas ideas y cuestiones, soportadas profundamente en referencias históricas y en investigaciones recientes.

***Key words**: Discovery and colonization of America, Origin of wool-less sheep, Spain, Canary Islands*

Introduction

The Canary Islands are an Atlantic archipelago located off the northwest coast of Africa. Before Spanish colonization in the 15th Century, the human population of these islands comprised of at least three ethnic groups, negro, cromagnoids and Mediterraneans. The third formed both the majority and the dominant group. Cuscoi (1968) reports that they showed morphological, cultural and linguistic relationships with the ancient Berber tribes of North Africa.

An interesting and important fact that must be brought to the reader's attention at this point is that the human population of these islands was completely isolated from the continent before the 15th Century. This is supported by the fact that:

- the early Canary Island inhabitants did not know how to navigate. People of the seven islands maintained the same racial types, although with different (but related) languages, religion, social organization, etc.;
- the early Canary Island inhabitants were culturally located in the Neolithic era, while the North African population was in the middle ages.

When the Spaniards began the conquest and colonization of these islands, they found an agricultural system based on pigs, sheep and goats and a large number of dogs (Canary, coming from "*canis*" the Latin word for dog). Surprisingly, the sheep discovered did not correspond to the wool sheep type spreading across the north of Africa and Europe in those days. In the Canaries, sheep were wool-less, similar to the breeds which inhabited sub-Saharan Africa during the 15th Century. This fact is of great importance to historians and evolutionists and all those interested in animal production. It sheds new light on the controversy concerning when, where and how the Canary Islands were colonized by man in the first place. A further point of interest regarding the Canary hair sheep is its possible influence on the origin and evolution of the currently

widely-distributed hair sheep breed population of the Caribbean Islands, South, Central and North America.

The conquest of the Canary Archipelago was not concluded during Columbus´ first visit to the Caribbean and he returned to the archipelago many times. The chronicles of his second voyage state that domestic animals were on board and species which were present in the Canary Islands (pigs, sheep and goats) were always loaded there rather than the Spanish mainland. The long journeys to the New World started from the southwest coast of Spain, especially the ports of Seville and Sanlucar. From there they sailed to the Canary Islands where the crew finalized arrangements before crossing the Atlantic Ocean. From the Canaries, the ship followed a southward direction to waters near the Cabo Verde Archipelago, where they met the Alisius winds which would take them directly to the Caribbean Sea islands.

This journey took around two months and sometimes the journey from the Spanish coast to the Canaries was as rough as that from the Canaries of the Caribbean Sea. For this reason, live animals were shipped as far as possible in the journey and then pigs, sheep and goats were shipped from the Canary Islands to the Antilles.

The animals left on the Caribbean Islands adapted extraordinarily well to the tropical climate. Their number increased rapidly. These species were then distributed to the American continent. All this historical information has been documented in depth by Morales Padrón (1968, 1977).

Figure 1. Present distribution of Hair Sheep breeds in Africa.

Present Distribution of the Wool-Less Sheep

At present, hair sheep are widely distributed in the world, usually located in the tropics and sub-tropics where they are very well adapted. Most hair breeds have been found in Africa and Latin-America. According to DAD-IS (http://www.fao.org/dad-is), all breeds of this type are found in Africa in a meridian position south of the Sahara desert (Figure 1). In America several breeds are found in the Caribbean Islands and similar genetic resources in Central, North and South America as shown in figure 2.

The relationship among all these resources is clear. After the discovery and conquest of America, the same genetic type arrived on the continent, rapidly increasing in number in tropical and sub-tropical areas. In this paper we examine the role played by the extinct ancient wool-less Canary sheep in the livestock colonization of the American continent.

Brief description of the ancient Canary Wool-Less Sheep

According to Meco Cabrera (1992) the paleo-canary sheep were large (approximately 60-80 cm in height), with hair and had a tendency to carry a large amount of fat. They were characterized by white skin and the rams were mostly horned and the ewes polled. This description coincides with several modern hair sheep breeds present in the Americas, such as the Tabasco white of Mexico (Figures 3 and 4). These animals were not milked, but usually raised for meat production; their skin was used for clothing (Abreu Galindo, 1977). Their management system consisted of seasonal movements between the mountains (summer), midlands (autumn and spring) and the coast (winter), following available pastures. Reports of some feral stock are frequent (Cioranescu, 1980).

Figure 2. Present distribution of Hair-Sheep breeds in America

Where Did These Sheep Come from? When did They Arrive in the Canary Islands?

The arrival of humans in the Canary Islands is still shrouded in mystery. Consequently the arrival of domestic mammals is also difficult to explain. Several arguments exist that suggest the origin of the human population of the Canary Islands to be the nearby African coast. It can be claimed that domestic animals arrived along with humans. However, further investigation of this theory raises several inexplicable questions. Based on archaeological data, scientists date the first arrival of humans to the Canary Islands around 5thC BC (Tejera, 1993). However, this is difficult to believe because of the demonstrated isolation between the Canary dwellers and the African population: how does one explain their Neolithic culture and their lack of navigation skills? Moreover, how does one explain the arrival of wool-less sheep from a latitude populated by breeds of sheep with wool from approximately 4000-2000 BC (Sierra, 1992)?

The only logical explanation is that the human populations arrived on these islands, with the hair sheep before this date (5000 BC). It is likely that during a period of favourable weather at that time, the wool-less sheep moved northwards in Africa from southern areas of the continent. It can be theorised that in later times they were displaced and forced southwards by dry weather, which established the Saharan desert as a frontier between wool - (Northern) and wool-less - (Southern) sheep (Figure 5). Furthermore, this claim supports the hypothesis of the early arrival of humans in the Canary Islands. It explains the Neolithic

Figure 3. Example of modern hair sheep: Tabasco White of Mexico.

cultural presence, sounds more logical than admitting a cultural regression from 5000 to 4000 BC.

Domestic animals are a human patrimony. They can be used to determine some events in history. This investigation of the evolution of the hair sheep provokes the formation of a new hypothesis surrounding the origin of the ancient Canary Islands' human population and their animals.

The Role of the Animals of the Canary Islands in the Animal Colonization of America

During his second trip, Columbus stopped at La Gomera (one of the Canary Islands), where he loaded pigs, goats, sheep, cattle, chickens and horses (Rodero *et al*., 1992). This journey took place in 1493 when the colonization of this island by the Spaniards was in its early stages. Thus, these pigs, sheep and goats were probably of pre-Hispanic origin. Other animals, such as horses, cattle and chickens, may have belonged to Canary Creole populations or may have been loaded in Spain.

The destination of this second trip was the Antilles. These islands are where it is believed that the present American population of hair sheep originated. It is thought that from this point their population expanded to several destinations in South, Central and North America, during different periods and via various routes (González-Stagnaro, 1997; Wildeus, 1997).

It is known that a combination of wind and navigation conditions forced the Spanish sailors to use the route Spain-Canary Islands-Sea of Cabo Verde-Antilles-New World. This allowed them to make full use of the Alisius winds (Primo, 1992). Space on board was very limited. A sailor required around 180 kg of food and water for a trip of about two months. A large animal (cattle or horse)

Figure 4. Tabasco White of Mexico.

needed around 780 kg and small animals (sheep, pig or goat) between 120 and 180 kg of food and water. For this reason, live animals were loaded at the latest possible point. Thus, the animals that could be loaded in the Canary Islands were not carried from Spain. When the Antilles were inhabited with domestic animals, these animals originated from both Spain and the Canary Islands. Therefore, the Antilles became the point from which the hair sheep sprang to the American continent (Rodero *et al.*, 1992) (Figure 6).

This account of history makes it easier to believe that the first sheep arriving in America were wool-less sheep coming from the Canary Islands. These animals were well adapted to tropical conditions. They rapidly expanded to form a widely distributed population, despite the fact that during later phases of colonization, Merino sheep were introduced from Spain in basin areas of Mexico and South America. Other sheep belonging to the Churro branch were introduced into wet mountain areas where they were and still are being raised by the local people forming the foundation of new breeds, Chiapas sheep, Navajo-Churro and other creole breeds (Pedraza *et al.*, 1992; Sponenberg, 1992).

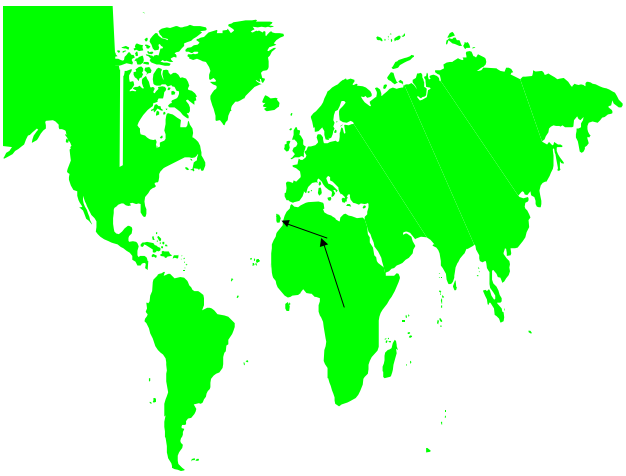

Figure 5. Where did these sheep come from? When did they arrive in the Canary Islands?

Alongside the traffic of black slaves from sub-Saharan Africa to the tropical areas of America some other wool-less sheep were introduced to America. These have also contributed to the evolution of breeds of sheep found in America today. Furthermore, even today, recent introduction of these animals from Africa are being reported (Wildeus, 1997). The aim of this paper is to bring to attention the often forgotten role-played by the ancient Canary hair sheep in the evolution of sheep throughout the Americas.

The Extinction of the Canary Hair Sheep

The conquest of the Canary Islands was difficult for the native population where they were forced to undergo a cultural evolution of 3 000-3 500 years in a very short time. They changed their language, their religion and their political systems, absorbing the European middle-ages culture. Livestock production systems were also altered, the main changes being:

- new species introduced from Europe, Spain (cattle, horses, chickens) and Africa (camels, donkeys) soon became Creole breeds;
- introduction of intensive agriculture;
- new distribution of the productive lands with an increase in areas devoted to agriculture. New species were farmed. The ancient extensive goat, sheep and pig production decreased;
- demand for new products arose: clothes made from leather were substituted by clothes made from textiles (primarily wool);
- the milking of sheep was introduced; and
- the introduction of European and African breeds of pigs, goats and sheep to improve production and therefore the ability of the system to meet the demands of the new cultural system (wool-less sheep, milk-sheep, for instance).

All these factors resulted in a massive cross-breeding of the Canary hair sheep and the creation of the present Canary sheep breed for dairy and wool (Delgado et al. 1990). Genes were mainly introduced from the Churro branch of sheep, a breed having close relations with most of the Creole sheep breeds of Latin-America.

It is likely that in the 16th-17th centuries, the Canary hair sheep became completely extinct. It must be noted, however, that some authors have mentioned the existence of these animals in the Archipelago as late as the 18th and 19th centuries (for example, Tejera, 1993).

Today, some stock of West African wool-less sheep (Pelibuey) are being introduced

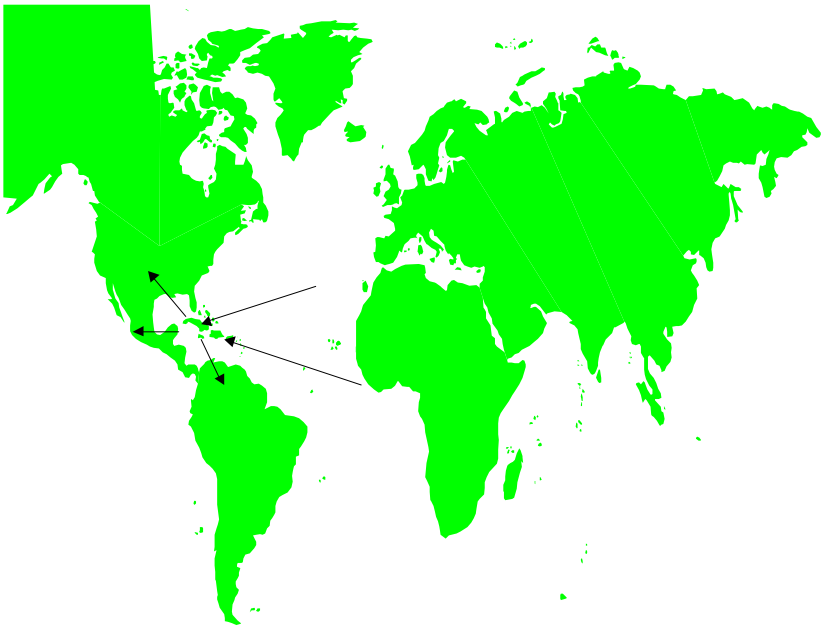

Figure 6. The role of the Canary Islands Hair-less sheep in the animal colonization of America.

back into Tenerife and La Palma islands from Venezuela. These flocks are increasing rapidly.

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Marwari goat of Indian desert

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Summary

Marwari is a desert goat breed of India and is found in the western part of the country. It is well known for its tolerance of hot and cold climates, disease resistance and thriving in very harsh nutritional conditions. It is a hairy black coloured goat. The means of the body length, body weight and ear length were estimated as 54 cm, 83 cm and 20 cm in males and 49 cm, 72 cm and 16 cm in females. Males have larger and stronger horns than females. The average adult body weight in males and females is 46 and 30 kg, respectively. The overall milk yield at 200 days is 98 kg. The kidding percentage in field conditions is 79.3 percent and multiple birth is about 19 percent. The Marwari is an early maturing breed as the average age of puberty is 306 days. The mortality in kid is 3.3 percent and in adults 3.5 percent in field conditions. The marketing and production economics of goats in its home tract have been analysed to ascertain viability of goat enterprise. The breed improvement programme was started in 1990-91 in its home tract involving farmers' flocks.

Résumé

La race Marwari est une race des Indes qui se trouve dans le désert à l'Ouest du pays. Cette race est très connue pour sa tolérance aux températures élevées et basses, sa résistance aux maladies et adaptation aux conditions nutritionnelles très difficiles. Il s'agit d'une chèvre à poils noir avec une hauteur de 54 cm, un poids corporel de 83 kg et longueur d'oreilles de 20 cm pour les mâles et 49 cm, 72 kg et 16 cm pour les femelles. Les mâles présentent des cornes plus grandes et dures que les femelles. Le poids moyen adulte est de 46 kg chez les mâles et 30 kg chez les femelles. Le rendement moyen en lait à 200 jours est de 98 kg. Le pourcentage de mise-bas en conditions de terrain est de 79,3 et les mises-bas multiples représentent 19%. La race Marwari est une race précoce avec l'âge moyen de puberté à 306 jours. La mortalité à la naissance est de 3,3% et de 3,5% chez les adultes en conditions de terrain. On a analysé la commercialisation et la production économique dans son milieu pour s'assurer de la viabilité des entreprises dans ce domaine. Le programme d'amélioration de cette race a commencé en 1990-91 dans son milieu avec la participation des éleveurs qui possèdent des troupeaux.

***Key words**: Genetic profile, Breed characteristics, Management practices, Production economics.*

Introduction

Marwari is an important goat breed from the hot-arid region of India, aptly called "Pride of the Desert" and is mainly distributed over the western part of the Rajasthan State (Khan, 1993). The typical characteristics of this breed is its long hairy coat and black colour and it seems that through natural selection over the years, it has evolved to thrive in harsh habitats. These goats contribute significantly to the economy of people inhabiting the vast arid and semi-arid region in India. The information on different aspects of Marwari goats is very limited. This paper presents information on the breed characteristics related to demographical distribution, morphological characteristics, management and production parameters recorded in field conditions.

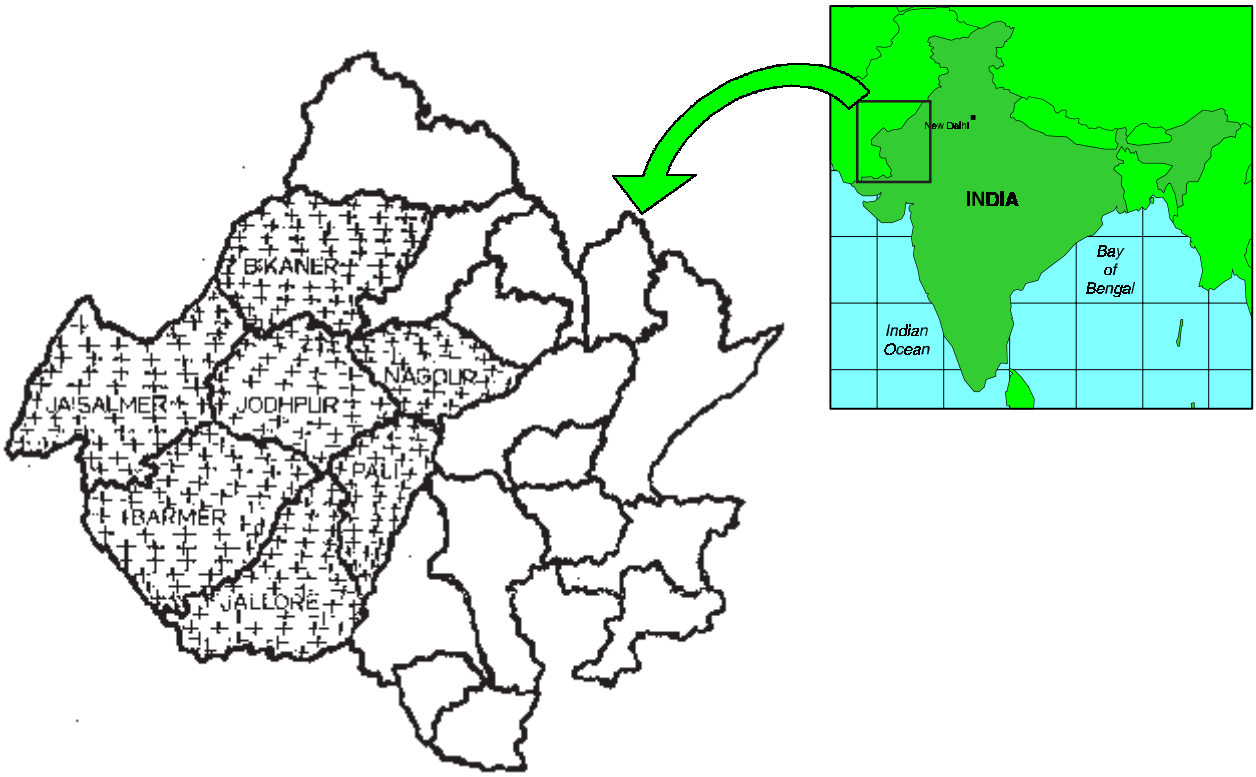

Figure 1. Distribution and home tract of Marwari goat.

Habitat and Distribution

The breed derives its name from the region "*Marwar*" which is the natural habitat of the breed and extends over an extensive area of western Rajasthan comprising of Barmer, Bikaner, Jaisalmer, Jalore, Jodhpur, Nagaur and Pali districts (Figure 1) covering an area of 157 626 km² which is 46 percent of the total geographical area of the state. Due to harsh climatic conditions and poor unproductive land, the human population is rather thin (49 heads / km²). The breed can also be found in the adjoining areas of northern Gujrat.

Climatic conditions

The climatic conditions of this region are extremely harsh. The temperature drops below 2°C in winter and shoots up to 48°C in summer. The rainfall is very scanty and averages about 264 mm in a year but it is very erratic forcing intermittent droughts and dry spells in the region. The land is qualitatively of low grade and agricultural production is low due to poor quality of land, lack of irrigation facilities and other inputs. The rangelands are very poor and the programme for improving the available grazing lands is almost non-existent.

The climatological data (Table 1) of the Marwari tract indicate that this region has large variations in rainfall, temperature and humidity. The mean maximum monthly rainfall was recorded as 163.3 mm during the month of October which is a winter month. The mean maximum temperature was 43.5°C in the month of May and the mean minimum was 2.6°C in the month of December.

The humidity pattern was higher (81-91 percent) during winter months. The drastic variability in the environmental condition showed that the Marwari goats found in this region had better adapted to its surroundings since their productivity was least affected.

Table 1. Environmental conditions in the home tract of Marwari goats (Pooled monthly means) 1997-98. (Anonymous, 1998).

Months	Rainfall	Temperature (°C)		Humidity (%)	
	(mm)	Maximumum	Minimum	Mamixum	Minimum
April	44.6	41.8	15.0	59	19
May	37.6	43.5	19.8	56	19
June	109.8	43.4	19.2	73	34
July	41.6	42.5	25.4	72	40
August	71.1	41.0	24.2	79	43
September	5.9	40.0	19.2	71	37
October	163.3	34.5	14.7	89	15
November	0.6	31.6	8.6	81	36
December	2.3	27.4	2.6	91	51
January	0.0	23.1	8.0	69	30
February	14.8	26.3	12.0	67	28
March	6.8	31.1	16.7	66	24

Population

The total goat population of this region is 3.53 million and this breed accounts for 28 percent of the total goat population in the state (Livestock census, 1988). The density of Marwari goat is about 22.4 goats per km². The flock sizes vary from a few goats (2-5) to larger sizes (100-500) but the migratory flocks are always larger (100-500). The flock holding also depends on the resources available to the owners besides their financial conditions. Normally flocks are maintained by the family members but sometimes the graziers are engaged on a payment basis.

Migration and trade

The goat breeders of this region are forced to migrate from the home tract along with their flocks and herds, due to paucity of pasture and shortage of water in this area. Migration is a routine practice in this region. Migration starts during the months of March and April and extends in many directions through their well-established routes year after year and they return back to their dwellings in the month of July. During the course of migration, the surplus stock and milk are sold en route. They get remuneration from the landholder by keeping the flocks in the agricultural land for manuring. All of these things happen at the cost of genetic adulteration of the breed, since the intermixing with the local animals is an unpreventable malady.

Breed Characteristics

External features

The Marwari is a medium-sized breed with compact body (Figures 2 and 3). The coat colour is predominantly black but animals with brown and white markings are also found. The coat is shaggy and dull in appearance and contains long hairs. A mixture of colours in a large proportion of goats (27.8 percent) is a result of indiscriminate breeding.

The ears are long and floppy hanging downwards. The horns are of medium length, pointed at the tip and are directed upwards and backwards. An estimated 92% of males and females have horns. Males have longer and stronger horns than females. Wattles are present in a small proportion of animals (11.1 percent) and about one-third of the

Figure 2. Marwari buck.

population (29.9 percent) possesses beards. Males possess thicker and longer beards than females.

Body size

Body weight and size of adult Marwari goats (male/female) are presented in table 2. The males are heavier (46.6±0.63 kg) than the females (30.0±0.25 kg). Males also have higher body size with respect to body length, body height, ear length and horn length as compared to females (Anonymous, 1993). However, Mittal (1988) reported lower body weights of Marwari goats which were maintained in farm conditions.

Body weights

The growth of Marwari male and female kids at different ages is given in table 3. Males were significantly heavier than females at all ages from birth to 12 months of age except

Table 2. Body weight and size of adult Marwari goats (Anonymous, 1993).

Traits	Male	Female
Body weight (kg)	46.6±2.63	30.0±0.25
	(11)	(375)
Body length (cm)	54.0±1.40	49.7±0.20
	(11)	(401)
Body height (cm)	83.2±1.80	72.5±0.20
	(11)	(401)
Ear length (cm)	20.1±1.30	16.7±0.20
	(11)	(390)
Horn length (cm)	20.4±1.30	13.4±0.20
	(9)	(323)

Figures in parenthesis indicate the number of observation.

Table 3. Mean body weight (kg) of Marwari kids at different ages (Anonymous, 1993).

Body Weights	Male	Female
Birth	2.3±0.01	2.2±0.01
	(480)	(619)
3 months	11.2±0.06	12.6±0.26
	(385)	(518)
6 months	15.2±0.34	12.1±0.25
	(167)	(168)
9 months	19.5±0.03	17.8±0.26
	(113)	(104)
12 months	25.6±0.53	22.5±0.29
	(66)	(123)

Figures in parenthesis indicate the number of observation.

Figure 3. Marwari flock.

females at three months. The body weight at one year of age was 25.6 kg and 22.5 kg in males and females, respectively. Mittal (1988) reported lower body weights at all ages in Marwari goats maintained in farm conditions.

Milk production

Milk yield in 150 days ranged between 84±5.7 kg to 113±7.0 kg during first to third lactations. The overall milk yield during 1st lactation was 98±7.0 kg in 201 days of lactation period. Milk yield during 150 days as well as total lactation yield indicated an increasing trend during the first to third lactations (Table 4) Anonymous, 1992. Barhat and Chaudhary (1978), however, reported lower values of milk production traits in Rajasthani goat breeds.

Table 4. Milk production performance of Marwari goats (Anonymous, 1992).

Lactation Order	Milk production traits		
	150 days (kg)	Lactation Yield (kg)	Lactation Period (days)
I	84±5.7 (19)	98±7.0 (19)	201±3.8 (19)
II	91±4.8 (27)	108±5.5 (28)	205±2.5 (28)
III	113±7.0 (17)	131±7.8 (17)	205±3.1 (17)

Figures in parenthesis indicate the number of observation.

Table 5. Reproduction performance of Marwari goats (Anonymous, 1993).

Traits	Pooled average
Age at Puberty (day)	306.0±1.5 (659)
Age at 1st Kidding (day)	471.1±2.0 (635)
Kidding interval (day)	313.4±0.7 (635)
Kidding Percent (No. kidded / No. available)	79.3 (10 265)
Birth Status :	
Single (%)	81.5 (2 061)
Twin (%)	17.5 (429)
Triplet (%)	1.5 (39)
Average litter size	1.2 (2 529)

Figures in parenthesis indicate the number of observation.

Table 6. Mortality rate (%) of Marwari goats in different age groups in field conditions. (Anonymous 1993).

Age Group	Male	Female	Total
1. 0-3 months	3.1	3.5	3.3
	(1 147)	(1 286)	(2 433)
2. 3-12 months	3.7	4.5	4.1
	(604)	(853)	(1 457)
3. Adult	7.0	2.9	3.5
(Above 12 months)	(530)	(3 125)	(3 655)

Figures in parenthesis indicate the number of animals available.

Reproduction

Reproductive performance of Marwari goats in field conditions is described in table 5. The average age at puberty and age at first kidding were 306±1.5 days and 471±2.0 days, respectively. The kidding interval in farmers' flocks was 313±0.7 days. The observation indicated that it is an early maturing breed. The reproductive efficiency in terms of kidding percent (number of does kidded / number of does available) was 79.3 percent. The prolificacy was found to be moderate with 17 percent twins and 1.5 percent triplets (average litter size 1.2). All these factors indicate that Marwari is a meat breed and there is scope for further improvement.

Disease pattern/Survivability

Marwari goat is considered as a hardy breed from the desert and the overall mortality in field conditions was extremely low (1.1 percent) in spite of poor feed resources (Anonymous, 1993). The kid mortality during 0-3 and 3-12 months was 3.3 percent and 4.1 percent, respectively. The adult mortality was 3.5 percent in field conditions (Table 6). The morbidity pattern in field conditions was 35.1 percent due to affliction of the alimentary system. The incidence of pneumonia was relatively less (9.8 percent). Among specific diseases, contagious ecthyma was a major ailment with an infection rate of 11.4 percent. An ecto-parasitic (ticks and lice) problem was reported to be very high in this breed due to the presence of long hairs on the body which provide shelter to ecto-parasites.

Management Practices

Housing system

Marwari goats are usually kept in open ranges throughout the day for browsing, except when there is intense heat waves or dust storms. They are usually kept in open corrals, fenced by thorny twigs. In some places, the kids are kept away from their dams in "*Kuccha*" houses made of mud. During the winter, night protection from the cold is provided.

Feeding practices

The goats by and large are reared under an extensive system in open ranges. Concentrate feed is given occasionally to lactating does by progressive farmers. The period of grazing extends from sunrise to sunset. During summer, when grazing becomes difficult due to intense heat during the day time, late evening and early morning grazing is practised.

Production economics

Studies on production economics of the flocks maintained in field conditions revealed that a revenue of rupees 494 per adult unit per annum after meeting all expenses is obtained. The major income comes from sale of livestock (53.7 percent) followed by sale of milk (41 percent). Labour charges for grazing was less then 52.1 percent of the total expenditure. Therefore, utilisation of family members for grazing will reduce the cost of goat rearing and may enhance the profit which is the normal practices (Anonymous, 1993).

Marketing

It was found that there was no difficulty in selling the goats, this was also supported by a survey conducted by Ahuja and Rathore (1987) in some areas of Rajesthan. Sale is mostly accomplished at the door of the farmers or in the local markets held weekly. The purchasers visit the farmers who keep flocks of goats almost daily or weekly and sales are made as per the need of the farmer. A large number of sales are made between December to April i.e. three to six months after kidding. The selling cost of young male / female goats varies from Rs. 500 to 600 per goat.

Improvement Programme

A breed improvement programme for Marwari goats was started in the year 1990-91 with the aim of surveying, characterizing and improving the productivity of Marwari goats involving the farmers' flock in the natural habitat of the breed. The programme in vogue continued under the All India Coordinated Research Project on Goat Improvement and progressed well with the cooperation and participation of the farmers. The selection of young bucks was made based on their own body weights and dam's milk yield. The selected bucks from the farmers' flock were tested and made available to farmers for improvement of their existing flock. It was evident from the studies that farmers' participation in a breed improvement programme was commendable.

Conclusion

Marwari goats are an integral part of the agrarian economy in the desert region of Rajasthan. This breed has the potential to meet the nutritional as well as economic needs of the farmers living in this region. The breed is well adapted to the harsh environmental conditions and therefore, it is necessary to start a planned breeding programme in proper feeding, housing and management practices for exploiting production potential. Moreover, this breed is facing a serious threat in its genetic architecture as intermixing of this breed with other animals occurs during migrations. Hence, a breed conservation programme has to be started for overall improvement of this breed in the desert region.

Acknowledgement

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Phenotypic characterization of three strains of indigenous goats in Tanzania

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Summary

Characterization of three strains of indigenous goats found in three regions of Tanzania was undertaken on the basis of their phenotypes viz: body weight and measurements, colour pattern, ears and horns.

The three strains differed in the body weights and in the frequencies of the different coat colours. The Dodoma and Mtwara strains had similar body measurements, whereas the Kigoma strain was significantly smaller.

Resumé

Une caratérisation de trois lignées de chèvres indigènes trouvées dans trois régions de la Tanzanie a été entreprise sur la base de leurs caractères phénotypiques à savoir le poids, les dimensions du corps, la configuration de couleurs, et la forme des oreilles et des cornes.

Les trois lignées ont différé par leur poids et dimensions corporelles ainsi que par les fréquences des différentes couleurs de la robe. Les lignées de Dodoma et de Mtwara ont eu des tailles similaires tandis que la lignée de Kigoma présentait une taille significativement plus petite.

***Key words**: Dodoma goat, Mtwara goat, Kigoma goat,*

Introduction

The largest proportion of goat population in Tanzania is constituted of indigenous goat breeds which are of great genetic diversity (Rege, 1994). Though these local genetic resources play an important role in the socio-economic life of the people of Tanzania, it is unfortunate that little is known about them in terms of how many strains there are and the degree to which they are genetically adapted to diseases, parasites and nutritional stress and how these qualities have evolved. It is through characterization that this shortcoming can be overcome and much of their diversity in genetic makeup can be known (ILCA, 1992).

Animals are often characterized based on their phenotypic and / or genetic constitution traits. The commonly used phenotypic characters include coat colour, horns (shape and size), hair and / or wool, adult size in terms of liveweight and body measurements such as withers height (Meghen *et al.*, 1994).

Based on mature body weight and height at withers, Devendra and McLeroy (1982) distinguished three breed categories in the tropics, namely: large breeds with body weight between 20 and 65 kg and height at withers above 65 cm, small breeds between 19 and 37 kg and height at withers between

Figure 1. Map of Tanzania.

51 and 65 cm and dwarf breeds weighing 10 to 25 kg and below 50 cm height at withers.

Mason and Maule (1960) characterized the Tanzania goat as a small, very hardy animal with fine, short and smooth coat which may be of any colour, including brown black, brown, white, bi-coloured or multi-coloured. Nowhere in the country do specific colour patterns seem to have been classified, as all colour patterns are seen. Kyomo (1978) reported the variation of horns among Tanzanian goats in both sexes and classified them as very short (2.5 to 5.0 cm only), medium (about 15 cm) and long (about 25 cm). Wilson (1991) classified the ears of Masai goats (Small East African type) as slightly erect and rarely pricked with medium length (12-16 cm).

The aim of this study was to describe phenotypic body characteristics of three strains of indigenous goats found in three different regions, viz; Mtwara (Southeastern region), Dodoma (Central region) and Kigoma (Northwestern region).

Materials and Methods

Ecological zones and management systems

Dodoma is situated in the central semi-arid zone of Tanzania (Figure 1), with annual rainfall ranging from 427 to 836 mm, whereas Mtwara and Kigoma lie in the southern coastal and western sub-humid zones with annual rainfall varying from 856 to 1 417 mm and 773 to 1 121 mm, respectively. The monthly mean temperatures in the respective regions of Dodoma, Mtwara and Kigoma range from 20 to 24.5°C, 24-27.5°C and 22 to

Figure 2. A Kigoma stran male goat.

25.5°C, respectively and the ranges of relative humidity are 37-56 percent, 55-76 percent and 48-78 percent, respectively.

Herded grazing on natural vegetation (grasses and shrubs) with little or no external inputs like supplementation and treatment is practiced in all three regions. Tethering is commonly practiced in Kigoma especially during the cropping season. Water shortage in the dry season is often experienced in Dodoma and Mtawa and farmers supply water to goats every one to three days. In Mtawa farmers are trying to use harvested rainwater to counteract the problem.

In Dodoma, goats are kept singly or in a mixture with cattle and / or donkeys in an open corral of a construction of thorns, whereas sheds constructed from non-baked earth bricks or mud roofed with iron sheets or grasses are used in Mtawa and Kigoma.

A survey was conducted in three regions to obtain information on body characteristics, i.e. body weight and linear body measurements attributed to the three strains of local goats. These regions were selected on the basis that Mtwara and Kigoma goats are reputed for the high twinning rate and they are well known strains in the literature, while Dodoma goats are assumed to have special features adaptable to the semi-arid zone of Central Tanzania.

A total of 597 goats, constituted of 212, 180 and 205 goats from Kigoma (Figures 2 and 3), Dodoma (Figures 4 and 5) and Mtwara (Figures 6 and 7), respectively, had their body weights, heart girths, body trunks, body lengths and height at withers measured as described by Kyomo (1978). The age records obtained from the farmers' memory on the individual animals were classified into four categories, i.e. less than three months kids, four to six months weaners, 7-18 months growers and 19 months, adult goats. It is worth noting that when taking linear body measurements, it was ensured that goats were standing still, relaxed and were on as level a ground as possible. For the accuracy of the data, two records were taken for height at withers, body trunk and body length and the average used as a datum.

Identification and description of coat colour and hair pattern, horns and ears were done by enumerators through visual observation.

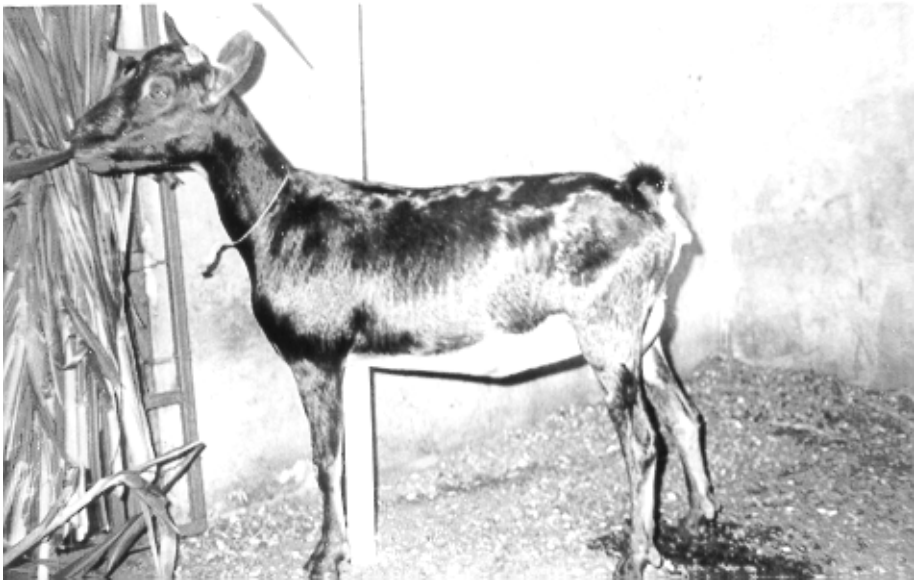

Figure 3. A Kigoma stran female goat.

Statistical analyses

Statistical analyses for various carcass and body measurements were performed separately for the four age groups used by the General Linear Models (GLM) procedure (SAS, 1988). The model for the body measurements included sex, strain / region and the interaction between them.

Results and Discussion

Body weight

There was a significant difference in adult body weights between strains (Table 1). The overall adult mean weights were 31.8, 29.2

Figure 4. Dodoma starin male goats.

Table 1. Comparison of least squares means (±S.E.) for body weights (kg) by strain/region and sex.

		Strain / Region					
		Dodoma		Mtwara		Kigoma	
Age	Sex	M	F	M	F	M	F
Adults	Means	34.2±1.63 (20)	29.3±1.10 (44)	28.5±2.02 (13)	29.9±0.90 (66)	22.4±2.43 (9)	25.4±0.84 (76)
	Overall	31.8^{a} ± 0.98 (64)		29.2^{a} ± 1.10 (79)		23.9^{b} ± 1.28 (85)	
Growers	Means	18.3±1.01 (30)	18.0±0.99 (31)	16.4±1.24 (20)	17.8±0.96 (33)	16.4±1.21 (21)	16.3±0.88 (40)
	Overall	18.1±0.71 (61)		17.1±0.78 (53)		16.3±0.75 (61)	
Weaners	Means	11.0±1.10 (10)	10.7±0.96 (13)	13.8±1.05 (11)	11.7±1.00 (12)	12.0±1.23 (8)	7.9±1.23 (8)
	Overall	10.9^{b}±0.73 (23)		12.7^{a}±0.72 (23)		10.0^{b}±0.87 (16)	
Kids	Means	6.3±0.67 (18)	6.1±0.75 (14)	6.6±0.63 (20)	6.1±0.51 (30)	5.4±0.60 (22)	4.6±0.53 (28)
	Overall	6.2±0.50 (32)		6.4±0.41 (50)		5.0±0.40 (50)	

1. Within row least squares means with the same superscript are not significantly (P>0.05) different
2. Number of observations are shown in brackets

Table 2. Least squares means (±S.E.) of linear body measurements of adult goats by strain/region, cm.

Variable	Strain / Region		
	Dodoma	Mtwara	Kigoma
Body length	89.4[a]±1.19 (64)	91.0[a]±1.34 (79)	77.1[b]±1.14 (85)
Body trunk	62.0[a]±0.87 (64)	62.0[a]±0.98 (79)	52.4[b]±1.14 (85)
Heart girth	75.9[a]±0.79 (64)	71.6[b]±0.89 (79)	68.3[c]±1.04 (85)
Height at withers	61.5[a]±0.76 (64)	59.2[a]±0.86 (79)	53.7[c]±0.99 (85)

1. Within row means with the same superscripts are not significantly (P>0.05) different.
2. Number of observations are shown in brackets.

and 23.9 kg for Dodoma, Mtwara and Kigoma goats, respectively. These figures were higher than the range of 14 to 22 kg mature liveweights of West African dwarf goats (Foulta Djallon) found by Devendra and Burns (1970) as cited by Awah *et al.* (1984), indicating that neither of the three strains fits to be classified in the 'very small breed' (dwarf) category. Nevertheless, they are within the small breed category classified by Devendra and McLeroy (1982).

Linear body measurements

The linear body measurement seems similar for the Dodoma and Mtwara strains whereas the Kigoma goats are consistently smaller (Table 2). Previous studies (Searle *et al.*, 1989;

Figure 5. Dodoma starin female goat with her newly born male kid.

Table 3. Percentage distribution of goats' coat colours by region.

Coat colour	Dodoma	Mtwara	Kigoma
Brown	19.5	33.2	17.3
White	31.1	6.9	0.5
Black	6.7	16.3	40.1
White brown	14.4	7.9	6.9
White black	15.6	9.9	9.4
Black brown	3.3	5.9	17.3
Multicoloured	9.4	19.9	8.5

Hall, 1991) indicate that some of the linear body measurements like height at withers and body length, are more genetically determined while others (for example, heart girth), are more subject to environmental influences. The means obtained for the Kigoma strain which fall within the range were reported by Mason and Maule (1960) for SEA goats. Similar figures to those of Mtwara and Dodoma goats have been reported by Kyomo (1978) on SEA goats.

Coat colours and hair structures

Coat colour varied from one plain to bi-colours of brown, black and white (Table 3). Although multi-colours of these basic colours were also observed in the field, they constituted a small proportion of all goats. The three strains were clearly distinctive with white, brown and black being the most common coat colours found in Dodoma,

Figure 6. Mtawara strain male goats.

Figure 7. Mtawara strain female goats.

Mtwara and Kigoma, respectively. These observations agree with the findings of Mason and Maule (1960) on Tanzanian goats. On the other hand, all three strains had more or less coat hair characteristics which were predominantly smooth, short, fine and generally sweeping backwards. In addition adult males and the minority of females were bearded. Males were observed to have more pronounced ridges of hair (mane) along the length of the back which is consistent with Kyomo's (1978) findings.

Horns and ears

In all strains both sexes were horned, though a few polled goats could be found. Although no measurements were taken on horns, they varied extremely and could possibly fall within the previous classification given by Kyomo (1978). The observation revealed that horns were thicker at the base (roots) and narrowed towards the extreme tips. In most cases horns were straight and pointed backwards with the exception of some horns which curved upwards or forwards at the apex in the Dodoma strain.

In all strains ears were observed to be generally pricked erect with flexibility to move either forward or side-ways, depending on the state of the animal. A similar observation was made by Osterhoff *et al.* (1987) on goats close to the equator and Wilson (1991) on Masai goats.

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Characterization of Mehsana Buffaloes in India

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Summary

Mehsana buffalo is distributed in Mehsana, Banaskantha and Sabarkantha districts of North Gujarat in India. The animals are reared for milk production. The management practices in the breeding tract were studied. The physical, production and reproductive characters were recorded. The Dudhsagar Research and Development Association located in Mehsana district has undertaken breed improvement programmes in farmers' herds by running field progeny testing and providing other animal husbandry services like artificial insemination, health coverage, etc. This has resulted in the improvement in the reproductive performance as is evident from the decrease in the average first service period by 74 days and the average first calving interval by 103 days from 1989 to 1997. Microsatellite DNA marker analysis was carried out on 25 Mehsana buffalo DNA samples using seven markers for genetic characterization of the breed. Number of alleles at different loci ranged from four to seven and heterozygosity ranged from 0.40 to 0.92.

Resumen

La raza Mehsana de búfalos se encuentra en los distritos de Mehsana, Banaskantha y Sabarkantha en el norte de Gujarat en la India. Estos animales se crían para la producción de leche. Se han estudiado las prácticas de cría de esta raza en su entorno. Se han registrado los caracteres físicos, de producción y de reproducción. La Asociación de Investigación y Desarrollo Dudhsagar, en el distrito de Mehsana, ha empezado programas de mejora de la raza con los rebaños a través de pruebas de descendencia sobre el terreno y proporcionando otros servicios tales como la inseminación artificial, la copertura sanitaria, etc. Todo ello ha llevado a un incremento del rendimiento reproductivo ya que se ha disminuido en media de 74 días la primera monta y el intervalo entre partos de 103 días entre 1989 y 1997. Se han llevado a cabo análisis de los marcadores ADN microsatélites con 25 búfalos Mehsana con muestras de ADN, utilizando siete marcadores para la caracterización de la raza. El número de alelos en los distintos loci iban de cuatro a siete y la heterocigosis de 0,40 a 0,92.

Key words*: Mehsana buffaloes, Buffalo genetic resources, Breed characterization.*

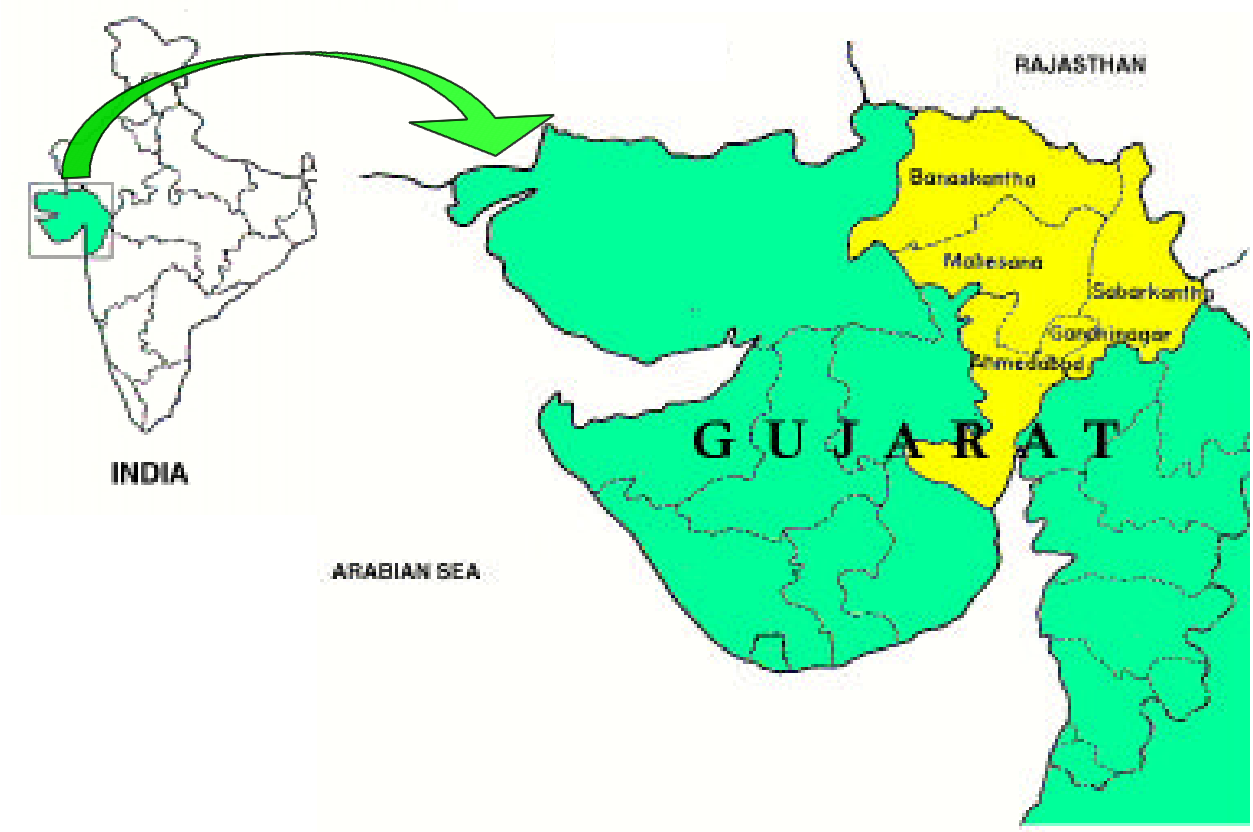

Figure 1. Breeding tract of Mehsana buffaloes.

Introduction

Buffaloes occupy an important place in the agricultural economy of India because of their adaptability to harsh climatic conditions, tolerance to tropical diseases and survival under poor feeding and management practices. The genetic diversity in buffaloes of the country is represented by ten recognized breeds of buffaloes besides several lesser-known breeds / strains comprising about 27 percent of the total bovine population in India (Gupta, 1997) . Buffaloes contribute about 48 percent of the total milk production of the country (Gupta, 1997). The organized dairy sector in India is largely dependent on buffalo milk because of their contribution to total milk production, rich fat and total solid content. Mehsana buffaloes are one of the best milk breeds of buffalo in India (Gupta, 1997) and are spread in the northern part of the Gujarat State (Figure 1). The name of Mehsana buffalo was derived from the town “Mehsana” in the North Gujarat State. Oliver (1938) described the breed for the first time. He pointed out that the characteristics of this breed are intermediate of two buffalo breeds namely Murrah and Surti. It was postulated that the Mehsana buffalo originated from the crossing of Murrah and Surti buffaloes. The skin colour is black. The body colour is not as dark as that of the Murrah and the horns are shorter and less curved. Mehsana buffaloes are well reputed for regularity in breeding, persistence in milk

and efficient milk production which is evident from the lactation length and short dry period (Singh, 1992).

To characterize Mehsana buffaloes in farmer herds phenotypically and genetically, a detailed project was jointly undertaken by the National Bureau of Animal Genetic Resources (NBAGR), Karnal and the Dudhsagar Research and Development Association (DURA), Mehsana to study the breed under farmers' herd conditions. The objectives of the study were to investigate the breed distribution, management practices under field conditions, breed performance and development of breed descriptor. Seven microsatellite markers were analysed in Mehsana buffalo to study the DNA sequence polymorphism in these marker loci.

Distribution of the Breed

The Mehsana buffaloes are concentrated in the Mehsana, Banaskantha and Sabarkantha districts of the northern part of Gujarat State (Figure 1). Animals true to the breed characteristics are observed in Mehsana, Patan, Sidhpur, Vijapur, Kodi, Kalel and Radhanpur areas. The areas experience extreme climates. The temperature in summer goes up to 40°C and in winter it is as low as 9-10°C. Rainfall is uncertain. Soil in these areas is sandy alluvial and porous, which in the southern parts merges into the black cotton soil.

Population Dynamics

The buffalo population in Gujarat State increased by 0.26 million to 1.83 million from 1983-84 to 1993-94. During this period the increase in the buffalo population in Gujarat State was 16.3 percent in comparison to 1.1 percent in indigenous cattle population. Livestock population in the districts where survey work was undertaken and in the whole Gujarat State are presented in table 1. All the three districts had higher livestock density than the average of the Gujarat State.

The Animal Husbandry Department, Government of Gujarat, conducted an integrated sample survey on livestock population and animal production and reported that the percentages of different buffalo breed populations in the whole Gujarat State were 42 percent Surti, 24 percent Mehsana, 24 percent Jafarabadi, 6 percent Murrah and 4 percent non-descript in the year 1993-94 (Report, 1985). In the Mehsana district lactating buffaloes of the Mehsana breed increased from 87.5 to 95.6 percent, while in the other two districts the population of the Mehsana breed declined from 81 to 45 percent in Banaskantha and 57 to 42 percent in Sabarkantha from 1983-84 to 1993-94. In Gujarat State lactating and breedable Mehsana buffaloes declined by 1.1 and 2.8 percent respectively, during this period.

Table 1. Livestock population ('000) and their density in 1992.

District	Cattle	Buffalo	Sheep	Goat	Livestock density per 1 000 hectare
Mehsana	295	630	36	189	1 409
Banaskantha	438	452	215	456	1 326
Sabarkantha	436	459	47	306	1 773
Gujarat State	6 786	5 241	2 025	4 228	1 000

Table 2. Population of total breedable and lactating Mehsana buffaloes in the native tract.

Districts	1983-84		1993-94		Trend (%)	
	Lactating	Breedable	Lactating	Breedable	Lactating	Breedable
Banaskantha	97 485	159 595	49 996	100 053	-38.5	-37.3
Mehsana	189 941	298 553	224 660	329 820	18.7	10.7
Sabarkantha	70 745	111 125	58 245	91 667	-17.6	17.9
Whole Gujarat State	440 006	689 380	435 157	670 170	-1.1	-2.8

Figure 2. Mehsana female buffalo.

Physical Characteristics of the Breed

The Mehsana buffalo is a medium-sized docile animal with a low set deep body. The forehead is wide with a slight depression in the middle sloping towards the base of the horns. The horns are generally sickle shaped and curved upwards and then bend downwards. The neck is long and well set on the shoulders. It is massive and dewlap is almost absent in males. The chest is deep with broad brisket. The legs are medium to short length with clean and broad bones. The barrel is long and deep, with well-sprung ribs. In females, the fore quarters are light while the hind quarters are wide and heavy giving a wedge shaped appearance. The back is straight and strong with pelvic joints higher than the withers. The navel flap is very small. The tail is of medium thickness and long with black or brown switch. The skin is thin, pliable and soft and generally black. The hair is rough and scanty. The average adult body weight varies from 365 to 455 kg in females and about 500 kg in males.

The udder is well developed and well set and in good milking animals it is carried well behind. The teats are fairly thick, long and

Figure 3. Mehsana bull.

pliable. The milk vein is prominent. The photographs of a female-buffalo and bull are presented in figures 2 and 3, respectively.

Management Practices

To characterize the management practices in the breeding tract 1 097 farmers from 144 villages were contacted and information was recorded on a questionnaire developed jointly by NBAGR, Karnal and DURA, Mehsana. It was observed that 25 percent of the farmers rearing Mehsana buffaloes were landless and about 33 percent of the farmers were illiterate. The survey conducted revealed that most of the men and women spent about two hours a day in animal husbandry works like grazing, chaffing, cleaning, feeding and milking. Both male and female family members spent equal time in animal rearing activities. Eighty percent of farmers usually cleaned the udder and teats of the buffalo and 18 percent of farmers cleaned the animals completely.

Utility of the Breed

About 7.5 percent of farmers reared buffaloes for milk production and 44 percent for both milk and breeding purposes and only one percent of farmers reared buffaloes for both milk and ploughing. Farmers who kept buffaloes for breeding represented only 1.5 percent of the total surveyed. About 65 percent of farmers sold Mehsana buffaloes to businessmen who took the animals to Mumbai and Ahemadabad for milk production. These businessmen sent them for slaughtering after completion of lactation. This factor may be one of the reasons for the decrease in the Mehsana breed population in Gujarat State (Table 2).

Animal Housing

The majority of farmers (87 percent) tied their animals throughout the day and night. Forty-eight percent of farmers used open houses and 42 percent of farmers preferred both the open and closed type of sheds for their animals. In about 75 percent of cases, the farmers' and animal houses were separate

Table 2. Population of total breedable and lactating Mehsana buffaloes in the native tract.

Districts	1983-84		1993-94		Trend (%)	
	Lactating	Breedable	Lactating	Breedable	Lactating	Breedable
Banaskantha	97 485	159 595	49 996	100 053	-38.5	-37.3
Mehsana	189 941	298 553	224 660	329 820	18.7	10.7
Sabarkantha	70 745	111 125	58 245	91 667	-17.6	17.9
Whole Gujarat State	440 006	689 380	435 157	670 170	-1.1	-2.8

and in the rest of the cases the animal houses were part of the farmers' own house. About 96 percent of animal houses were well ventilated, however, proper drainage facilities were available in only 23 percent of byres.

Calf Management

More than 93 percent of farmers allow female calves to suckle milk throughout the lactation period, however, the male calves were generally weaned within a week of calving. Dehorning was practiced by only 6 percent of farmers and 87 percent of farmers dewormed.

Wallowing once a day was followed by the majority of farmers. Photographs of Mehsana buffalo calf and the unique milking practice followed in the breeding tract are presented in figures 4 and 5 respectively.

Feeding

More than half (58 percent) of farmers did not take animals for grazing. Out of those who took their animals for grazing, the majority (84 percent) adopted seasonal grazing. Stall-feeding was practiced by 75 percent of farmers and both stall feeding and grazing by

Figure 4. Mehsana buffalo calf.

22 percent. Concentrate feed was provided separately by 83 percent of farmers while 17 percent of farmers provided it along with fodder. The concentrate was fed at the time of milking by 88 percent of farmers and the rest of the farmers fed concentrate at anytime. Green fodder is available mostly during the rainy season. Dry fodder includes mainly bajra (*Pennisetum typhoides*), jowar (*Sorghum vulgare*) and wheat (*Triticum aestivum*) straw.

Breeding

Out of the farmers surveyed, 98 percent were maintaining Mehsana buffaloes, one percent Murrah and one percent other breed or non-descript buffaloes. About 51 percent of farmers adopted artificial insemination (AI), 9 percent natural service (NS) and 40 percent both. Frozen semen was used in 96 percent of cases for AI. It was observed that about 75 percent of buffaloes conceived after two services. The high rate of adoption of AI with frozen semen and good conception rates was due to the service provided by DURA, Mehsana in the breeding tract.

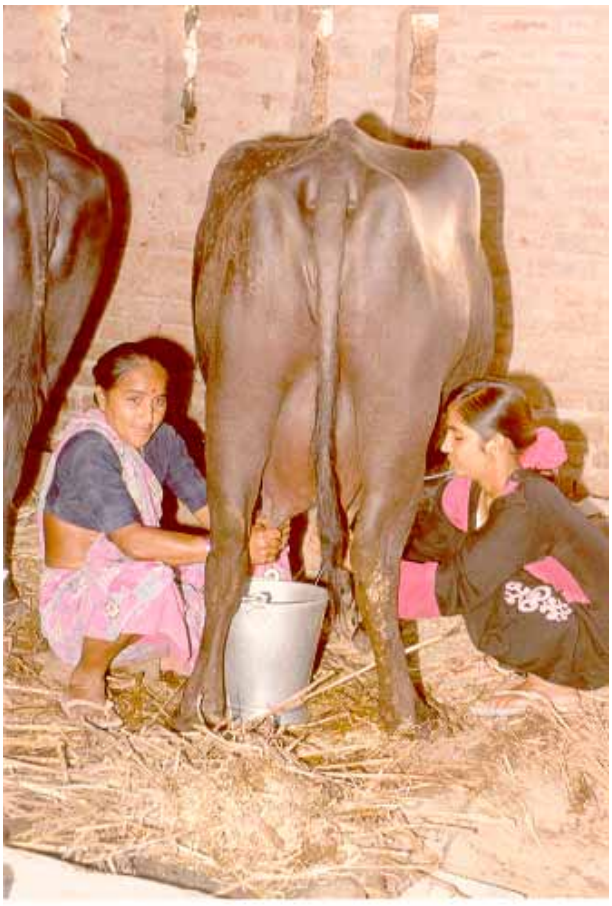

Figure 5. Unique milking practice in breeding the tract

Productive and Reproductive Performance of Mehsana Buffaloes

Production and reproductive performance of Mehsana buffaloes from 1989 to 1997 maintained at DURA, Mehsana are presented in table 3. Progeny testing in Mehsana buffaloes in field conditions has been conducted by DURA since April 1985. A total of 107 bulls in eight batches was tested. The results of five batches are available. The maximum sire indices in terms of daughters' 305-day milk yield was 2 297 kg. The performance over different years (Table 3) showed significant improvement in reproductive traits, i.e. service period and calving interval.

Genetic Characterization of Mehsana buffaloes Using Microsatellite Markers

Microsatellite DNA markers are extensively being used for animal biodiversity typing worldwide. Microsatellites or simple sequence repeats are the tandem iterations of DNA which are two to six bases in length. Due to their levels of variability, ease and reliability of scoring, neutrality with regard to selection, co-dominant inheritance and short length, microsatellite DNA markers are being widely used for genetic diversity analysis, genome mapping, QTL identifications, genetic distancing, etc. Moreover, these can be easily typed using PCR. At present no microsatellite DNA markers have been reported specifically for buffaloes. A battery of cattle microsatellite DNA markers was identified at NBAGR,

Karnal which showed polymorphism in bubaline genome (Navani *et al.*, 1999). These selected markers are being utilized for the characterization of the Mehsana buffalo breed. Blood samples were collected from unrelated animals from different villages in the breeding tract. A male cattle sample from the Haryana breed was used as a positive control. The DNA was isolated using phenol:choloform extraction and the ethanol precipitation method (Sambrook *et al.* 1989).

PCR was carried out on 100 ng of genomic DNA in a 50 ml reaction for 25 animals. The reaction mixture consisted of 200 mM of dNTPs, *Taq* polymerase buffer, 1 unit of *Taq* DNA polymerase and 4 ng / ml of each primer. PCRs were carried out using a PTC-200 PCR machine (MJ Research). The PCR protocol involved an initial denaturation at 95°C for two minutes, followed by 30 cycles of 92°C (one minute), 55°C (45 sec) and 72°C (one minute). A final elongation step of ten minutes was carried out at 72°C. The annealing conditions were similar to those reported for cattle (Kemp *et al.*, 1995). At the end of the reaction, 5 ml of stop dye (95 percent formamide, 0.25 percent bromophenol blue and 0.25 percent xylene cyanol) was added and 10 ml of PCR products were loaded onto a two percent agarose gel, electrophoresed and stained with ethidium bromide. The gel was visualised over UV light after ethidium bromide staining. The positive loci were loaded on

Table 3. Average year-wise production and reproductive performance of Mehsana buffaloes.

Traits	1989	1991	1993	1995	1996	1997
Age at first service (months)	22.20±0.26 (235)	23.18±0.17 (526)	24.54±0.17 (418)	25.49±0.20 (204)	24.87±0.20 (247)	24.70±0.24 (216)
Age at first conception (months)	29.1±0.53 (162)	29.0±0.34 (335)	33.1±0.27 (521)	34.2±0.35 (289)	32.2±0.38 (284)	34.3±0.36 (281)
Age at first calving (months)	36.0±0.59 (58)	40.7±0.43 (244)	42.0±0.28 (467)	44.0±0.37 (248)	44.4±0.39 (246)	42.8±0.37 (298)
First service period (days)	254±29 (47)	268±15 (171)	250±10 (351)	271±11 (222)	232±10 (259)	180±7 (272)
Overall service period (days)	254±29 (47)	265±12 (231)	243±8 (504)	220±8 (443)	215±7 (481)	173±5 (497)
First calving interval (days)	521±20 (41)	545±13 (136)	517±9 (241)	501±10 (171)	490±9 (188)	418±6 (112)
Overall calving interval (days)	521±20 (41)	545±12 (180)	521±6 (636)	499±8 (315)	477±6 (331)	420±5 (180)
First lactation length (days)	305±2 (56)	308±1 (217)	299±2 (442)	301±1 (205)	300±1 (264)	300±2 (275)
Overall lactation length (days)	304±2 (57)	307±1 (289)	300±1 (606)	303±2 (424)	300±1 (504)	297±1 (491)
First 305-day milk yield (kg)	2 093±52 (57)	1 892±23 (225)	1 914±19 (457)	1 951±23 (259)	2 004±21 (323)	1 972±23 (333)
Overall 305-day milk yield (kg)	2 096±51 (58)	1 964±23 (302)	1 988±17 (628)	2 128±20 (522)	2 153±18 (615)	2 147±20 (605)
First lactation fat %	609±0.1 (56)	6.9±0.1 (216)	6.9±0.1 (442)	7.0±0.1 (205)	7.1±0.1 (264)	7.1±0.1 (275)

Figures in the parenthesis are number of observations.

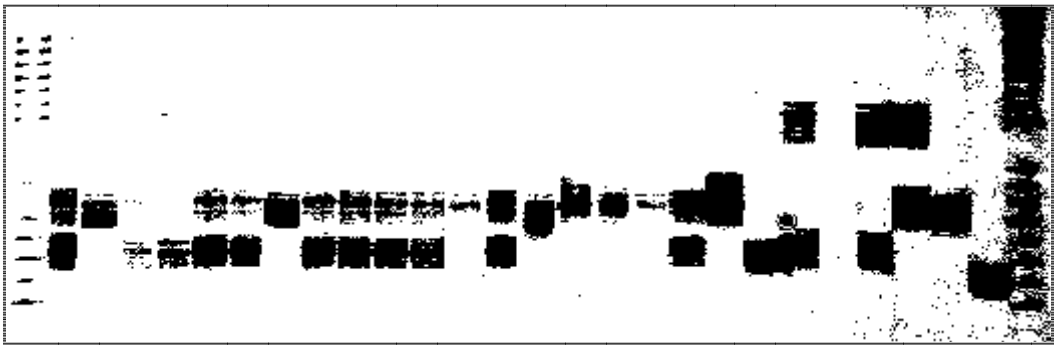

Figure 6. Silver stained representative gel of locus ILSTS052 'M'- marker, 'C'- cattle control

Table 4. Number of alleles, heterozygisity and allelic ranges of seven microsatellite loci in Mehsana buffaloes.

Sl. No.	Locus	Primers (5'-3')	No. of Alleles	Hetero-zygosity	Allelic Range
1	ILSTS017	F-GTCCCTAAAATCGAAATGCC R-GCATCTCTATAACCTGTTCC	6	0.92	104-124 bp
2	ILSTS019	F-AAGGGACCTCATGTAGAAGC R-ACTTTTGGACCCTGTAGTGC	4	0.40	160-170 bp
3	ILSTS025	F-GTTACCTTTATATAAGACTCCC R-AATTTCTGGCTGACTTGGACC	4	0.48	116-130 bp
4	ILSTS052	F-CTGTCCTTTAAGAACAAACC R-TGCAACTTAGGCTATTGACG	7	0.84	145-180 bp
5	ILSTS056	F-GCTACTGAGTGATGGTAAGGG R-AATATAGCCCTGGAGGATGG	6	0.64	140-172 bp
6	ILSTS058	F-GCCTTACTACCATTTCCAGC R-CATCCTGACTTTGGCTGTGG	6	0.88	142-174 bp
7	ILSTS061	F-AAATTATAGGGCCATACGG R-TGGCCTACCCTACCATTTCC	8	0.80	136-170 bp

6 percent denaturing polyacrylamide sequencing gels (Sequi-GT system, BioRad). pGEM DNA marker and allelic ladder of GenePrint™ STR Systems (Promega) were used as a size standard. After the run was over the gel was stained with silver nitrate using a silver staining kit (Promega). The gels were documented by drying between the sheets of cellophane papers and kept for records. The allele numbers were counted manually. The results are presented in table 4. A representative gel picture showing a polymorphic locus (ILSTS052) is illustrated in figure 6. The results revealed that cattle microsatellite markers, to start with, may be used for molecular characterization studies in Mehsana buffaloes.

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