Vol.2, No.2, 127-131 (2012)
http://dx.doi.org/10.4236/ojas.2012.22018

Open Journal of Animal Sciences

Impact of environmental and social factors on genotypic and phenotypic diversity of some local Sudanese sheep breeds

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Received 8 March 2012; revised 29 March 2012; accepted 5 April 2012

ABSTRACT

This mini review aimed to discuss and compare the findings of a genotypic study done by Gornas *et al.*, 2011 and some environmental and social factors discussed previously in Sudan. The main conclusion was the agreement of the genotypic analysis with the previous observations done on the phenotypic part. The important recommendation was to support the nomadic system so as to preserve the biodiversity of livestock in Sudan.

Keywords: Sheep Breeds

1. INTRODUCTION

Sheep are highly adaptable and versatile domestic species, which has made them a critically important resource in human societies around the world. The beginning of livestock domestication, some 10000 - 11000 years ago in the fertile crescent, was a crucial event in human history. The earliest zoo-archaeological evidence for domestic sheep comes from sites in present day Iran, Turkey, and Cyprus [1-4].

Following Mesolithic man's domestication of sheep approximately 8000 - 9000 years ago [2], selection has proceeded on traits such as coat color, environmental tolerance, wool characteristics, and milk and meat production. The result was a spectrum of phenotypic differences between breeds.

Molecular genetics has proven to be highly informative for investigating the relationships between animal populations as well as for documenting the levels of genetic variation resident within breeds. Variation within autosomal microsatellites has been used successfully to make inferences about population history [5], and to examine the relationship between sheep breeds from Europe [6-8] and Asia [9]. In most cases, analysis of the observed variation returned results broadly consistent with both historical and geographic knowledge for the breeds investigated.

Managing genetic diversity is one of the primary goals in a conservation program. In recent years there has been a growing interest not only in the implementation of methods for optimizing the election of the breeding individuals and the mating system but also in developing techniques for the analysis of genealogies and to monitor the changes in genetic diversity that has occurred in a conservation program [10]. All these tools are mainly based on genealogical information but with the development of molecular markers more direct measures of genetic diversity are possible and recommended.

The use of different statistical methods for analysis offered much information on relationships of genetic back ground of the breeds investigated. One of these valuable statistical tools is F_{IS} (inbreeding coefficient).

F_{IS} is one of three interrelated parameters to describe the genetic structure of diploid populations. These parameters are F_{IT}, the correlation between gametes within an individual relative to the entire population; F_{IS} the correlation between gametes within an individual relative to the sub-population to which that individual belongs; and F_{ST} the correlation between gametes chosen randomly from within the same subpopulation relative to the entire population [11]. In practice, F_{IS} is a measure of heterozygosity compared with that expected when genotypes are in Hardy-Weinberg equlibrium. In breeding leads to a deficiency of heterozygotes relative to Hardy-Weinberg expectations, so when there is inbreeding, F_{IS} will have positive values. But if individuals avoid inbreeding or there is heterozygotes advantage, then heterozygotes will be more common than expected under Hardy-Weinberg expectations, and F_{IS} will be negative [11].

In this review we aim to look for the effect of environment and human action on the phenotypic and genetic structure of some local Sudanese sheep breeds.

2. DISCUSSION

Sudan desert sheep are reared strictly within the semi-desert belt of Sudan, in association with camels. They are owned exclusively by nomadic tribes of Arab origin or others closely related to them in the region. Because of their nomadic existence their origin is difficult to trace.

However, it is well established that nomadic Arab tribes entered Sudan through the West and north-western borders via northern Chad or southern Libya, reaching their ultimate destination at the river Nile [12]. Although some individual tribes might have remained for many years in the Sultanate of Waddai, Gimir, Masalat, Borno and Fur, their sheep do not resemble the Asian or North African types. This Arab type of sheep, presumably owned by these tribes, with its woolly coat and short legs, could not have endured the stress of intensive solar radiation and prolonged migration in search of grazing and water or sudden attacks by the predators. To obtain an animal which would satisfy these requirements, while retaining the desirable characteristics of their original sheep, these Arab tribes might have decided to cross-breed their sheep with other types which possessed the required traits [13].

Desert sheep homeland is roughly bound in the south by latitude 12˚N. The western border is marked by the range of rocky hills from Jebel Marra in the south to Zaghwa plateau in the north. To the east, the area extends to the Red sea hills. To the north it fades away with the undulating border in the Nubian desert [13]. Topographically, this area is dominated by sandy plains and stabilized sand dunes in the west, extensive plains of dark cracked soil in the centre and a strip of sandy plains with stabilized sand dunes in the east. This area undergoes very intensive solar radiation from March to the end of June and has a mild, moist temperature from July to the end of October. The vegetation varies from a mixture of grasses and herbs with no woody vegetation whatsoever, to a scattering of scurb bush interspersed with bare areas.

This area is the main habitat of the most of Desert sheep breeds under nomadic system including Ashgar and Dubasi in Gezira scheme and Kabashi and Hamry in Kurdufan area. It also includes the Arid upland and West African breeds in Darfur area.

Sudan desert sheep, like other range sheep, do not tolerate prolonged confinement. Frequent shiftings of the camp and night bedding ground are always practiced for the animal's well-being. The herder carries a few articles on his donkey, such as bag of grain flour, a water-skin, cooking and eating utensils and a netting bag. He keeps one or more dogs to protect the sheep from predatory animals at night [13].

The time of grazing varies between seasons. In dry seasons most of the grazing is done at night. The herders are aware of the benefit of night grazing in lessening water requirements and avoiding the stress of solar heat. In the rainy season the availability of drinking water and succulent grazing enables sheep to ingest their daily requirements in a few hours. Because of the mild temperature and frequent cloud, the sheep will continue to graze and lie down in the open air until late in the afternoon. Rainy season grazing is restricted to the period from 09:00 hours to about 16:00 hours when the plants are without dew. Diseases such as foot-rot and nematode infestation are known to result from grazing at night or early morning while the grasses are cold and damp [13].

The only desert member which is raised under semi-residential system is Dongla sheep, which is reared in the north by farmers in households. Dongla sheep was the only desert population found to have a high value of inbreeding coefficient (0.107) and also deviated from Hardy-Weinberg equation in the ILSTS011 locus [14]. Dongla sheep is restricted by the Nubian desert to be approached by other members of desert breed in the centre of Sudan. Therefore, Dongla sheep kept their old shape of horns and heavy wool which almost disappeared from other sheep populations in Sudan mainly due to hot weather in apparent adaptation to the environment. The high inbreeding coefficient and the movement restriction may impose a direct effect in this population and result in low genetic diversity and decrease in population numbers which may lead to an endangered population.

Under tropical environmental conditions, sheep are raised primarily for meat, although milk is also of importance. The value of the breeding ewe is determined by the quantity and the quality of lamb or mutton produced and the length of its productive life.

Field collected data on the lambing rate of Sudan Desert sheep indicate wide range of difference between localities presumably attributable to climatic, nutritional and management factors [13].

Wide difference in lambing rates exist among individual flocks under semi-residential system maintained in irrigated areas [13]. Tanmia, an independant consultant group [15], carried a feasiblility study in the year 1977 for ALWaha Animal production project situated about 50 kilometers South of Khartoum, Tanmia reported that the ewes in irrigated areas under an open breeding system could lamb three times in 2 years at a rate of 150% each time and they could, therefore, achieve a lambing rate of about 225%. Under a residential system at EL Huda sheep research station, Suleiman and Eisawi (1984) [16] reported an overall lambing rate of 119%.

The report of (SSMO, 2007) [17] stated that for every 100 ewe there were 70 - 85 mothers, and for every 100 mother there were 115 - 133 off springs in one season.

This high percentage of production may indicate the good environment for those populations under nomadic system.

In an investigation done by Gornas *et al*., 2011 [14], five of the six populations (those were D/Muslami, D/Ashgar, D/Rezegat, D/Hamary, D/Kababesh) of Desert sheep raised under nomadic system showed high values of genetic diversity expressed in high values of expected heterozygosity ranging from 0.737 - 0.811, and very low values of inbreeding coefficients. This reflects directly the effect of nomadic system on preserving the biodiversity.

The locality and tribal origin of Desert sheep are identified in local market by their colours. In the central and south-eastern part of irrigated Gezira and Rahad, the sheep population is dominated by the Dubasi (Muslami) variety. They carry a black patch on the back (saddle), the muzzle and legs. The rest of the coat is white with coarse hairy fibres. Gornas *et al.* 2011, [14] stated that Muslami population has a low inbreeding coefficient (0.047) and the whole population was in hardy Weinberg equilibrium. The other population which share the same area of grazing is the Shugar or (Ashgar) population. This population is uniformly yellowish brown and predominates in the eastern part towards Khartoum, on the eastern bank of the Blue Nile and the Nile. Gornas *et al*. 2011 [14], stated that this population also showed a low value of inbreeding coefficient (0.037) and was in the hardy Weinberg equilibrium.

Vast areas of traditional grazing land of Dubasi and Ashgar have been converted into crop farms, where many nomadic families have settled. Their sheep spend dry season within or around the cropping areas and sustain themselves on crop residues. Encroachment on farms and damage to crops has caused a series of clashes between farmers and herdsmen and security forces have been frequently called to drive livestock away from the vicinity of farms [13]. Once harvesting is completed, nomadic and residential livestock are allowed to graze crop residues, thus alleviating the feed situation. However, these residues are only able to sustain this large amount of livestock for about three to five weeks. The animals are then forced out so that the land can be prepared for the next cultivation. Most nomadic and semi-nomadic herds move to remote ranges and are sustained on the remnants and stubble of dry vegetation until rains arrive. This movement in the vicinity of farms and to remote areas resulted in high observed and expected heterozygosity (Ashgar H_O: 0.731, H_E: 0.758; Mus H_O: 0.702, H_E: 0.737) [14] It was also reflected in the phenotypic adaptation such as light body, hairy coat instead of woolly one, long legs that enables animals to walk for long distances searching for food and water, deviating from the old shape of Arab sheep of woolly coat, short legs and heavy body.

The Hamary population in south-western Kordofan and south-eastern Darfur are predominately brown and dark brown. Whereas, the Kababesh of Northern Kordofan and Northern Darfur are multicoloured. The sheep in these areas have shorter legs and a heavy body, for here range grazing and drinking water are abundant, grazing distance is small and the seasonal migration is relatively small [13]. The different colours varieties might have been brought about through prolonged selection towards colours preferred by particular groups or tribes because it is doubtful these experienced herdsman would have been aware of any possible relation between colour and productivity. As the sheep fibres are utilized in nomadic home industry for weaving carpets and nomadic tents, the colour preference of the weaver might have played a vital role in this respect [13]. However, obviously they followed a very safe way of cross breeding with different groups which resulted in a very low inbreeding coefficient for both populations (Hamary 0.047 and 0.049 for kababesh) which were documented by Gornas *et al.* (2011) [14].

The lowest value of inbreeding coefficient was recorded in ND/Baggara (–0.009). This population is a crossbred between Nilotics and Desert breeds and owned by Baggara tribe nomads who move along Kurdufan area from south to north in specific time every year. This nomadic system give bigger chance for livestock to cross bred with other breeds and opportunity to look for better places of pasture which resulted in keeping the biodiversity of this population [14].

In the lake Chad basin and further north, live the northern Fulani tribes, the Balami, whose sheep are uniformly white, and the Auda, whose sheep are white with a brown or black neck and front body. Both breeds have a large frame, long legs and long thin tails. [14]. Compared the West African population in Darfur and Auda breed which was characterized by Adebambo *et al.* (2003) [18]. The comparison revealed great resemblances in the phenotypic structure and the values of observed and expected heterozygosity indicating the relation of these tribes in Western Sudan with their relatives in West Africa. West African population registered a high inbreeding coefficient in (F_{IS} 0.204) and deviated from Hardy Weinberg equilibrium in different loci [14]. In spite of the nomadic route which connect between the Fulani tribe in Western Sudan and their relatives in West Africa, the West African population scored a high inbreeding coefficient and was completely demarcated from other population studied by Gornas *et al.* (2011) [14]. The most plausible explanation is the effect of drought period that occurred in early eighties which displaced people from their natural habitat and ended in loss of thousands of animal populations owned by some tribes in Western

Sudan. Also the civil unrest in Darfur may have direct effect on the connection of the nomadic route and the total number of animals in that area. The effect of the civil unrest in Darfur extended to affect almost all other populations in Darfur, for example the population of D/ Rezegat member of Desert breed which is connected to the other Desert members in principal component analysis of the study of (Gornas *et al.*, 2011) [14] tend to get a high inbreeding coefficient (0.093) compared to other members of Desert populations mentioned in the same study. The same observation is also applicable for Arid upland population which share the same area and live under nomadic system but also recorded a relatively high inbreeding coefficient (0.064) [14].

It is worth mentioning that Sudan Desert sheep and West African sheep undergo similar methods of management and exist in a similar ecological habitat. Many of their body features, such as the shape of the head and face, length of the body and texture of coat, are similar. Sudan Desert sheep, however, possess a thicker tail and fuller rump. These valuable characteristics might have been attributed to partial inheritance from their Asian ancestors [13]. This was confirmed by Gornas *et al.* (2011) [14] who studied the mitochondrial haplotypes and stated that A haplotype is found mainly within the Desert populations located in central Sudan and attributed that to the partial inheritance from a remote Asian ancestor. The A haplotype was not found in the West African population [14].

Going South, the Nilotics population kept also the phenotypic structure of their relatives in west Africa , the Yankassa breed which was studied by Aebambo *et al.* (2003) [18]. Similar to Dongla ecotype in the North part of Sudan, the semi conservative system which is held in Southern Sudan for keeping animals resulted mainly in the high inbreeding coefficient (0.207) stated in Gornas *et al.*, 2011 [14]. These results indicate that the Nilotics population is not exposed to other populations in Sudan because of different breeding system of house hold raising practised in South.

3. CONCLUSION

As a conclusion of this mini-review, the genetic analysis of Sudanese sheep breeds stated in (Gornas *et al.*, 2011) [14] was in agreement with ecological and environmental effects discussed in the study of (Mufarrih, 1991). The main conclusion was the effect of social (nomadic system) and environmental factors in keeping the biodiversity of livestock which may lead us to start supportive programs for nomadic system, e.g. establishing stop points for nomads in desert, educating them about different ways of breeding and how to avoid inbreeding to keep the biodiversity and at last attention should be paid to some populations like Dongla population in the North and West African population in the West. This review recommends to conserve Dongla population so as to keep the old shape of Egyptian sheep formerly raised by Nubians in early decades in Sudan, also there is a raising concern about the population numbers of breeds in the West due to the displacement according the unrest of Darfur conflict.

4. ACKNOWLEDGEMENTS

This work was supported by Central Laboratory, Ministry of Science and Technology, Khartoum, Sudan. The authors wish to thank the D.G, Animal Resources Research Corporation, Khartoum, Sudan for permission to publish this work.

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