GENETIC RESOURCES FOR LIVESTOCK PRODUCTION

Luis Iniguez
Natural Resource Management Program, International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

J. Stuart F. Barker
School of Rural Science and Agriculture, University of New England, New South Wales, Australia

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Summary

The subject of genetic resources for livestock production is viewed within the context of appropriate management of animal germplasm for its better use and towards its conservation, particularly when the integrity of these valuable resources is threatened. Animal diversity and variability is first visited with examples of small ruminants, including sheep and camelids, which serve a large population of small-scale resource-poor farmers in developing countries. Sheep were selected as an example of a species that is widely distributed with a range of adaptations and breeds. On the contrary, the

Andean camelids (llama and alpaca) illustrate the case of a species with limited availability of breeds or subpopulations. Within the existing diversity, cases involving gene prolificacy and breeding seasonality are also discussed, to reflect the important effect of genetic x environment interactions on animal productivity. Threats to the integrity of animal diversity, involving a number of forces of change, which are an integral part of the world trend of deterioration of natural resources, are then visited. Human population trends, transitional economic crises and wars, and agricultural modernization and development have been shown to impact animal diversity. Threats affecting both developed and developing countries determine that some 30% of all breeds of domestic animals are estimated as being at risk of loss. There is then a need to consider the integrity of genetic resources on a global scale. The urgency of reducing risks is unquestionable, as it involves the economic security of many farmers and the stability and integrity of valuable germplasm. Furthermore, trends of global warming and scarcity of water resources will require the use of this variability for conditions that are yet to emerge, for instance tolerance to drought and heat. These traits and adaptations are present in many populations of domestic animals, and may well be crucial for an expansion of animal production into dry and marginal areas, and under new conditions of global reduction of oil products that will affect productivity in highly industrialized economies. Basic steps towards the appropriate management of animal germplasm, including the characterization of breeds, are finally discussed. The need of farmers to intervene in this process, particularly in developing countries, is fundamental.

1. Introduction

Since their domestication, animals have played a fundamental role in the stability and development of human societies. With their ability to convert very low quality forages into animal products, ruminant livestock contribute critical nutrients to the diet of humans, materials for clothing and working instruments, draft and transportation power, manure as fertilizer and fuel, and a large variety of other resources. The genetic variability of domesticated animals allowed them to colonize and succeed in a variety of environments through development of specific adaptations. Both ruminants and non-ruminants are found in contrasting ecosystems. For example, domestic sheep are widely distributed in all agroecosystems of the world. Breeds of sheep are in fact found in nearly arctic climates such as Iceland in the north, in the Falkland Islands and Tierra del Fuego in the Southern Hemisphere, in the humid tropics of Southeast Asia, in the high altitude areas of the Pamir and Andean ranges, and in the deserts and steppes of Central and West Asia.

Livestock still play a key role in the economies of both industrialized and developing countries. In highly industrialized countries, livestock breeds are exploited in market-driven enterprises, often managed with supporting machinery, specialized infrastructure, well suited feeding systems, and high input levels that result in high yields. In contrast, in developing regions, livestock is mainly owned by resource-poor small-scale producers, and often managed under extensive range conditions subject to extreme environmental fluctuations and with minimal inputs. The livelihood of these producers depends largely, if not exclusively, on domestic animals, with strong economic and social implications melded in the cultural heritage of the people.

In this paper, the existing variability of genetic resources for animal production is briefly introduced along with a discussion of potential threats to their integrity, in particular within the production context of smallholder systems. The basis of the management for conservation of domestic animals to reduce threats and risks is then discussed. A section that summarizes global steps towards the conservation and management of genetic resources is also presented.

Examples in this paper were selected specifically to highlight the value of animal diversity in marginal and fluctuating environments. Moreover, with a production focus, the examples are related to traits that have an economic significance to resource-poor smallholders in harsh environments, where the genetic base is not only subjected to increased risk, but also contributes substantially to sustaining the livelihood of rural families.

2. Animal Variability and Diversity

Ample variation of genetic resources exists to suit agricultural purposes. This reflects natural evolutionary forces interacting with human interventions that changed the genetic structure of populations through selection and cross-breeding. In some cases, the distribution of a given species, such as sheep or cattle, covers a wide range of environments, with also a wide range of differentiated populations known conventionally as breeds. In the process of colonizing new environments, these populations adapted to local conditions and developed specific traits and adaptations determining the emergence of new breeds. In other cases, the distribution of species was confined to particular ecosystems with few differentiated populations or breeds, but still exhibiting large intra-populational variation. Both cases are considered in detail and illustrated with examples below.

In the case of sheep and cattle, the result was the emergence of a large number of specialized breeds suitable for a wide range of environments. In the Mediterranean region alone, about 200 breeds of sheep and 68 breeds of goats are known. In many cases, similar populations within neighboring countries or regions within a country may have different names. The dilemma as to whether these populations differ or are really the same is now being clarified with the precision of modern molecular biology techniques.

2.1 Widely Distributed Species with a Range of Adaptations and Breeds for Specific Environments: The Case of Hair Sheep

Sheep are usually depicted as a woolly animal. In fact, most of the sheep breeds of the world are specialized to produce wool, particularly in temperate and cold climates. However, a number of breeds from tropical regions, known generically as hair sheep, are wool-less or have a rather hairy fleece somewhat similar to that of goats or cattle. Pelibuey hair sheep from Mexico, as an example, derived this name from the similarity of their coat to that of cattle—the name Pelibuey meaning oxen's hair.

There are over 100 million hair sheep in the tropics, which is about 50 % of the world's sheep population. Hair sheep are distributed throughout Africa, India and Southeast

Asia, the Caribbean, and South America. Nearly 90 % of hair sheep are raised in Africa.

It is assumed that hair sheep emerged as the product of natural selection and adaptation rather than human directed selection. It is likely that in hot, humid environments, the presence of wool could be disadvantageous and reduce fitness. In Dorper ewes in Kenya, a negative correlation between the wool coat cover and the weaning weights of their lambs suggest that this presumption could be true. There are also many other examples of the introduction of wool sheep into the humid tropics that failed because of high mortality rates of lambs (Table 1). Notice in Table 1 that the Caribbean Criollo sheep introduced in the Americas during colonial times is a wool breed adapted to the Caribbean tropics for about 400 years.

Under the auspices of the Small Ruminant-Collaborative Research Project (SR-CRSP), E. Bradford from UCDavis and H. Fitzhugh from Winrock International compiled in 1983 a comprehensive set of information on hair sheep from the Americas, highlighting the potential of these breeds not only for sheep production in the tropics, but also for other non-tropical regions. In addition to adaptation to tropical environments, hair sheep are an important source of genetic variability for breeding year-round and, in the case of some breeds, for prolificacy (Table 2). This variability contributed significantly to the development of out-of-season and accelerated lambing breeding programs in the USA.

Breed	Lamb mortality %
Wool breeds	64.9
West African and crosses	15.8–18.7
Blackhead Persian and crosses	14.0–21.0
Caribbean Criollo	10.8–14.0

Source: Thomas D. L. (1991). *Hair Sheep Genetic Resources of the Americas*. In Stephan Wildeus, ed. Proceedings of a symposium, June 28–29, 1991, St. Croix, US Virgin Islands. pp. 3–20.

Table 1. Lamb mortality rates of sheep raised under a humid tropical environment

Traits	**Barbados Blackbelly**	**Saint Croix**
Single births, %	30.0[1]	85.0[1] and 33.3–46.7[3]
Twin birth, %	49.0[1]	13.0[1] and 43.3–57.1[3]
Triplets, %	18.0[1]	2.0[1] and 1.6–10.4[3]
> 3 lambs, %	3.0[1]	0[1]
Mean litter size	1.95[1]	1.17[1]
Weaning, %	65.1[2]	68.6[2] and 85.1[3]
No. lambings involved	366[1], 81[2]	45[1], 203[2] and 392[3]
Inter-lambing interval, days	256[1]	258[1]

Sources:
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[2]Patterson H. C. (1991). *Performance of four breeds of hair sheep and their crossbreed at Blenheim Station, Tobago, West Indies*. In Stephan Wildeus, ed. Proceedings of a symposium, June 28–29, 1991, St. Croix, US Virgin Islands. pp. 33–40.
[3]Wildeus S., Maciulis A., and Foote W. C. (1991). *Lambing performance of Saint Croix Hair Sheep in two different climatic environments*. In Stephan Wildeus, ed. Proceedings of a symposium, June 28–29, 1991, St. Croix, US Virgin Islands. pp. 142-152.

Table 2. Reproduction performance of Barbados Blackbelly and Saint Croix sheep in tropical Trinidad Tobago[1,2] and SaintCroix[3], US Virgin Islands

The findings of Bradford and Fitzhugh promoted the utilization of hair sheep to improve productivity in different regions of the world. An example of a well designed breeding program is that of the Small Ruminant Collaborative Research Program (SR-CRSP), through the University of California-Davis, in Sumatra, Indonesia, in which the adaptation and high reproduction rates of the local Sumatran sheep were combined with the larger size and better growth rates of the Saint Croix and Barbados Blackbelly sheep.

Barbados Blackbelly and Saint Croix sheep have been utilized in the development of various new composite breeds, containing the desired mix of hair breed and local genes to improve sheep productivity in tropical environments and in areas where the environmental and feeding conditions favor lack of seasonality in breeding capacity, prolificacy, and short post-partum resumption of breeding activity.

Some breeds of hair sheep also perform well in temperate environments. In a performance comparison of Saint Croix under standardized management in their native tropical environment (Saint Croix, US Virgin Islands) and in a temperate area (Logan, Utah), no differences in fitness traits such as fertility, prolificacy, and lamb survival were found.

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Biographical Sketches

Luis Iniguez, PhD animal breeding, is a specialist in small ruminant breeding and production, and senior scientist manager of the Small Ruminant Project, Natural Resource Management Program, at the International Center for Agricultural Research in the Dry Areas (ICARDA), ICARDA, Aleppo, Syria.

Research activities involve small ruminant production and characterization of small ruminant breeds in the dry areas of the regions of West Asia and North Africa (WANA) and Central Asia and the Caucasus (CAC).

Stuart Barker is Emeritus Professor, School of Rural Science and Natural Resources, University of New England, Armidale NSW 2351, Australia.

He was previously head of the Department of Animal Science (1979–1993) and ARC Senior Research Fellow (1993–1998). Honours include in 1983, Fellow of the Australian Academy of Technological Sciences and Engineering; 1997, Fellow of the Association for Animal Genetics and Breeding; 1998, Helen Newton Turner Medal; 1996–1999, chair of FAO Panel of Experts on the Development of the Global Strategy for Animal Genetic Resources.

His research has been in the following areas: (a) basic population/evolutionary genetics—factors affecting amounts of genetic variation in natural populations, and phylogenetic analyses of geographic variation, and (b) conservation of animal genetic resources—identification of genetic diversity.