CURRENT ISSUES AND INITIATIVES IN THE CONSERVATION AND MANAGEMENT OF SHEEP GENETIC RESOURCES[1]

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ABSTRACT

Sheep are less prone to genetic erosion than many other major domestic animal species. A brief overview of the status of sheep genetic resources indicates 1,313 living breeds according to the FAO database with 20 percent at risk and a further 30 percent of unknown status. There are problems with breed definition which should be widened to include populations defined by geography or social system. It is also necessary to have clearer guidelines as to what breeds should be included by countries in the database. It is hoped that the current State of the World's Animal Genetic Resources reporting initiatives will help clarify the situation. While it is desirable to describe the sheep genome and look for Quantitative Trait Loci and their associated markers, the current interest is in readily available packages of genes as defined by breeds. There is likely to remain a satisfactory reservoir of breeds to draw on to construct new designer sheep. This is happening in response to changing requirements for products or production systems but these remain unpredictable. In many situations the conservation of sheep genetic resources is related to the conservation of pastoral or social systems and if or when these change, the sheep will need to change with them. Rational management and utilization of sheep genetic resources requires on-going genetic improvement within breeds. Sensible communal agreement on breeding objectives will enable the owners of breeds to avoid unnecessary genetic erosion and maintain breed utility at the highest possible level.

Keywords: *Sheep, Genetic Resources, Conservation and Management.*

STATUS OF SHEEP GENETIC RESOURCES

Many authors have commented on the trends in commercial livestock production to concentrate on a few highly selected breeds or hybrids (eg. Hall 1996). The examples usually given are the black and white (Holstein-Friesian) dairy cattle, the Landrace and Large White pigs and hybrid chickens. This has resulted in the marginalisation of large numbers of local breeds or landraces and genetic erosion. This tendency has been less dramatic with sheep because of less pressure towards specialization and intensification. Sheep are suited to a wide range of marginal environments and to nomadic or transhumance systems. They are kept to produce a diversity of products from within a single flock. They have a long history of domestication, a world-wide geographic spread and utility for smallholder, family husbandry. While there has been widespread dissemination and use for crossbreeding in developing countries of exotic fine-wool sheep, highly productive in their own environments, sheep (and goats) have retained a greater genetic diversity than the other major mammalian domestic species. The proportion of breeds at risk out of the total existing recorded breeds, according to the FAO-UN Domestic Animal Diversity Information System database (Scherf 2000), is 18 percent for goats, 20 percent for sheep, 24 percent for cattle and 33 percent for pigs.

Table 1 gives the numbers of sheep and breeds, and breed risk status, by region as classified by FAO. The Asia-Pacific region has only 18 percent of the world's breeds in spite of having 39 percent of the sheep. Of the Asia-Pacific breeds, only nine percent are classified as at risk with a further 29 percent of unknown status. Table 2 gives the numbers of breeds and breeds at risk for the countries of Asia and Pacific region. This grouping is not the same as the FAO Asia-Pacific grouping. It is clear where most of the genetic diversity can be found. However, the number of listed breeds alone does not give a clear indication of the existing genetic diversity in any one country or region because more breeds are present than are listed in the database. For example, I have counted a total of 51 breeds as actually present in New Zealand (NZ) of which only

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Table 1. Numbers of sheep, breeds and risk status by region

Region	Sheep		Breeds		Critical	Crit. Maint.	Endangered	Endang. Maint.	Total at risk	Unknown Status
	No. '000	%	No.	%						
Africa	127,440	12.0	147	11.2	10		9		19	53
Asia/Pacific	408,098	38.5	233	17.7	5		15	1	21	68
Europe	185,035	17.4	629	47.9	36	6	108	42	192	115
LatinA./Carib.	89,372	8.4	42	3.2	1		3		4	13
Near East	242,770	22.9	201	15.3			5		5	114
N. America	7,891	0.7	61	4.6	10		16		26	28
Total	1,060,606		1313		62	6	156	43	267	391

Source: Scherf (2000)

Table 2. Breeds in the FAO database by country – Asia and Pacific

	Breeds	Breeds at risk		Breeds	Breeds at risk
Afganistan	12	1	Myanmar	1	
Australia	34	6	Nepal	6	
Bangladesh	1		New Zealand	21	5
China	40		Pakistan	39	5
India	60	1	Papua New Guinea	1	
Indonesia	8	3	Philippines	1	
Iran	26		Sri Lanka	1	
Kazakhstan	17		Tajikistan	10	1
Kyrgyzstan	10	1	Turkmenistan	8	
Laos	1	1	Uzbekistan	8	
Malaysia	6		Vietnam	1	
Mongolia	19				

Source: Scherf (2000)

21 (41 percent) are in the database. Also there is less breed differentiation in Asia compared to Europe or North America because of historical mobility of people and sheep, and lack of breed societies, formal recording and organized breed improvement.

Many of the breeds listed as at risk are rescued feral populations, relatively recent synthetics or country specific sub-populations representing a more widely dispersed multi-country genotype. The five breeds at risk in NZ are all derived from isolated populations of Merino or Merino x Longwool sheep that have been feral for some 150 years. Four of the Australian breeds are two or three breed composites, one is a Border Leicester derivative and one a maintained early Merino type. Marco Polo's sheep is described as a variety of the Argali (*Ovis ammon polii*) and is listed for Pakistan, Afghanistan, Kyrgyzstan and Tajikistan. The other four Pakistani breeds are two or three breed composites as is the Laotian breed. The Indian breed is described as a variety of the Urial. One of the Indonesian breeds is a recently (1994) imported crossbred and there is no information on the other two breeds.

BREED DEFINITION

It seems that for NZ, and similarly for Australia, breeds included in the database are those breeds actually formed in NZ as composites, by crossing or from special selection, plus the rescued ferals, the NZ Romney and the Australian Merino. Not included are all the British and more recent introductions. It is clear that the Romney and the

Merino, and similarly the various Merinos in Australia, are different now from their European ancestors and are rightly listed as distinct. However, the assumption has been made that other breeds, even those of long-standing residence such as the Southdown and Cheviot, are not sufficiently different from their British ancestors to merit stand-alone status. Some of the minor breeds in NZ, if they were actually distinct, would fall into the at risk classes, eg. Shropshire (about 260 ewes), Dorset Horn (380 ewes), Ryeland (315 ewes) and Wiltshire Horn (270 ewes). Similarly for Papua New Guinea (PNG) I submitted the listed data on the PNG Priangan but did not submit anything on the newly formed PNG Highlands Halfbred nor on the Corriedale and Perendale breeds that, together with the Priangan, went into its formation.

From these considerations it would appear that there is a need for clearer guidelines as to what breeds or breed types should be listed in the FAO database. Better guidelines may also be needed for the assessment of the relative importance of the breeds at risk. The main problem areas would appear to be as follows:

1. Breeds having the same name, origins and purposes, but resident in different countries, not necessarily in clearly different ecosystems.
2. Breeds which are probably essentially of the same genotype but with listing in different country lists. Perhaps some cross-referencing is required here.
3. Composites or stabilised derivatives from crossbreeding – at what stage do these warrant separate new breed status and can they be considered as at risk if relatively recent in origin?
4. Exotic breeds – at what stage do breeds imported and then isolated, whether recently or long ago and subjected to more or less intense natural or artificial selection, become different from their source populations?
5. Rescued feral breeds – how do we assess and put a value on 100-200 years of natural selection in isolation, usually in a harsh environment?
6. Isolated populations, perhaps lacking apparent phenotypic uniformity but shepherded by people with common purposes in a definable ecosystem – do such populations warrant the status of distinct landrace or breed? There is clearly a need in such cases for better production characterization and evaluation.

It is to be hoped that the current State of the World's Animal Genetic Resources reporting initiatives will help in clarifying these issues and improving our knowledge of the world's sheep genetic resources.

GENETIC RESOURCE MANAGEMENT

There are four components to the process of management of a nation's sheep genetic resources – documentation, evaluation, conservation and utilization. Documentation is being undertaken as discussed above. Evaluation is more difficult but at least the first step of adequate production characterization must be done as a matter of urgency. It is less urgent to compare breeds in a common environment unless there are pressures to introduce, cross or change breeds. The evaluation process should attempt to determine the reasons for superior performance or fitness if these are indeed present. Breed differentiation has often taken place within an apparently homogeneous environment and we have to try to understand why this has happened. The differences may be more superficial than fundamental to production. However, if it proves possible to identify superior local breeds then the possibility opens up to use these in the development of synthetics rather than looking to import exotics (Turner 1991). It is absolutely essential both for evaluation and subsequently for formulation of breeding objectives to get the best possible understanding of all facets of the environment with their constraints and opportunities and the reasons, both biological and environmental, for the low productivity so often observed or perceived as present in local sheep flocks.

Effective utilization is the incentive for conservation. There has been some interesting debate on the necessity or justification for the conservation of breeds as such in order to ensure sufficient genetic variation for conceivable utilization in the future. Barker (1997) has put the conventional case for conservation which is that breeds have unique sets of genes and present unique genotypes. Franklin (1997) however argues that there is little evidence that breeds contain sets of unique genes that might be needed for the future. Most important genetic differences are polygenic in origin and genetic variation for quantitative traits is renewed each generation at a staggering rate and hence the ongoing response to selection. The argument is that there is ample variation in commercial populations and the major landraces in developing countries which is being constantly renewed and is available to meet any future requirements. There is therefore no need to keep a wide range of obscure breeds for insurance purposes. Clearly many of the minor breeds at risk, conscientiously conserved by a range of voluntary organizations, by small or hobby farmers, in parks and zoos for heritage and educational reasons or in remaining feral populations, will never be needed for production by the wider farming community. As Barker (1997) points out, the breeds at risk have presumably been tested over time and found wanting or unable to adapt to changing circumstances. However, how is it possible to know what will be needed and how quickly it may be necessary to access traits?

GENETIC IMPROVEMENT

Useful genes at single loci have been found and used. These include the polled gene, the carpet wool genes as in the Drysdale, the fecundity genes (Booroola and Inverdale) and the recent Callipyge gene. The search for Quantitative Trait Loci goes on (Crawford 2001) with the possibility of Marker Assisted Selection (MAS) to increase rates of genetic progress or introgress desired alleles into existing breeds (Piper 1999). It is likely that the major advantage of MAS will come with traits that are hard to measure such as disease resistance and meat quality. Gene insertion to produce transgenic sheep for enhanced production, while of limited success so far, may yet prove possible to improve existing breeds (Rexroad 1995). None of this, therefore, diminishes the utility of having available a range of breeds with identifiable qualities for immediate use, generally through the creation of synthetics, to meet changing environmental challenges and market opportunities.

Utilisation of genetic resources or genetic improvement in sheep will most likely continue to involve within breed selection and the formation of composites. Systematic crossbreeding is not usually an option because of the problems of maintaining the different components in situations where the utility of the sheep is multi-purpose and such systems are rare. Even the simple use of terminal sires across base ewes, as in NZ, requires an effective production and marketing structure for the sires. The development of the Landcorp Lamb Supreme terminal sires in NZ (Nicoll *et al.* 1997) is an example of how the development of a new composite can be combined with systematic crossbreeding in the favorable circumstances of very large flocks under unitary control and established markets.

Banks (1997) has argued that little thought has been given as to how to optimize the portfolio of genetic variation in the form of breeds or types of breed necessary to enable continuing improvement and flexibility. He suggests that the development of composites, while apparently widening the choice for farmers, is an attempt at rationalization and there is likely to be, at least for the Australian sheep industry, an ongoing tendency for one breed or composite to dominate each sector of the industry. He raises a series of questions about how best to choose and manage the genetic variability to minimize costs (actual costs and lost production) and maximize potential benefits (current use and flexibility for change). There would appear to have been little progress over the last five years in answering these questions. No doubt eventually the measurement and analysis of genetic distance through microsatellite polymorphism (Crawford and Littlejohn 1998) and the FAO initiatives under the project for the measurement of domestic animal diversity (MoDAD) may help to eliminate some breeds, at least from public investment, but yet it will remain necessary to identify and maintain reservoirs of distinctive breeds with defined traits that may prove useful and easily accessed. However, breeds in their places of origin or major use are always locally adapted so their utility needs to be adequately tested for any new circumstances. Clarke and Banks (1995) have documented the developments in breed introduction and development in Australia and NZ over the last 20 years. These have come from new introductions, synthetics or new strains resulting from selection. Issues that arise here are industry acceptance, levels of investment, competition, adequate genetic information systems and the dangers of overlooking minor traits.

New technology appears to have opened up new freedoms for the safer movement of breeding stock across what were quarantine barriers. This has resulted in the re-examination of the utility of European breeds in NZ and African breeds for the dry tropics of Australia. Breeds showing particular promise in NZ are the Finn, East Friesian and Texel. These are being used along with existing breeds for example to develop composites for new market opportunities in wool (Growbulk sheep – Clarke *et al.* 1999) and sheep milk (Newman and Stieffel 1999). Market forces favouring lamb over wool have also resulted in serious efforts to find the best ways to use Finn and East Friesian sheep to raise reproduction rates (Garrick *et al.* 2000). The Australians are now experimenting with the use of Damara, Dorper and South African Meat Merino sheep in west Queensland (Kleeman *et al.* 2000). The breaking of quarantine barriers however remains expensive as the Pacific countries strive to maintain their enviable epizootic disease free status. The Fijians have managed a breakthrough in developing a wool free composite from Barbados Blackbelly, Wiltshire and Corriedale sheep.

SHEEP BREEDING AND FARMING SYSTEMS

The general trend in livestock production as a response to increased demand for animal products has been towards intensification and industrialization of production with uniformity of breeding objectives. With sheep there is a clear differentiation of systems. On the one hand there are continuing efforts to make use of the fibre digestion abilities of small ruminants in sustainable intensive systems as seen in the traditional cut-and-carry systems in Asia (eg Java) or being developed as components of sugar cane production (Preston and Murgueitio 1992/3). On the other hand there is a reverse trend as sheep are increasingly marginalized into less productive environments by increased arable cropping, plantation forestry, irrigated agriculture, intensive cattle (dairy) production and horticultural techniques or intercropping excluding sheep from orchards and plantations. These trends have clear implications for breed utility assessment and very careful definition of breeding objectives for divergent requirements. An extension of the "easy care" concept, as discussed by Scobie *et al.* (1997), assumes greater and greater importance as sheep production is expected to increase but in low cost, sustainable systems. Pressures to pay more attention to extensive systems come from concerns about the value of maintaining traditional social systems and concerns over human and animal health, animal welfare and protection of the environment. However, as social or pastoral systems change, the sheep will need to change with them.

The main options for sheep breeding would therefore appear to be the development of new composites using existing breeds and selection for genetic improvement within breeds. Both options put value on the qualities, well defined or not, of the existing breeds. Putting value on a genetic resource through intellectual property rights may give a needed impetus to conservation and increased within breed local improvement programmes. The concept of Farmers' Rights is being developed for plant genetic resource management (Kambuou 2000) and is the subject of current debate. Rights may be invoked to assist farmers to take pride in their breeding achievements, or even recognize that there are achievements, and seek adequate compensation when selling breeding stock. It is not in anyone's interest, however, to seek commercial exclusivity, as recognized by Australian Merino breeders when they lifted a ban on export of breeding stock, but pre-agreement on access may benefit everyone.

BREEDING OBJECTIVES AND PLANS

Barker (1997) has pointed out the problem that planned genetic change could cause loss of adaptability to future environmental challenges or changes to production systems. This emphasizes the need to understand the systems as they exist and realistically anticipate likely changes. The unique qualities of different breeds need study for the more we know about the physiological reasons for trait expression for traits associated with adaptability, the more clearly can we define our breeding objectives and the less likely we are to lose qualities through oversight or conflicting objectives. Qualities heretofore unappreciated in so-called unimproved sheep will be recognized and sought. Examples are the breed variations found for helminth resistance in Africa (Baker 1996) which should likewise be sought in Asia. In any case it is essential that selection be done within the marginal environments so often associated with the pastoral or social systems using sheep.

In considering breeding objectives it is necessary to appreciate that we are dealing with whole animals in systems. There have been trade-offs in traits as animals have been subjected to both farmer directed and natural selection and care must be taken not to lose some attributes while selecting for others. The traditional sheep farmer's main aim is optimal use of feed and other resources rather than production per animal although, as now recognized in NZ, there is a need to balance production per hectare against production per animal. Hence it is necessary to consider the following questions:

1. What should the animals look like?
2. What products do we expect them to produce?
3. What production output should they be able to sustain?
4. What sorts of environment are they likely to have to thrive in?
5. What variety of production systems is present now or likely to develop?

We can then set breeding objectives and develop sensible breeding plans. However, note the problem highlighted by Ponzoni (1999) of an increasing complexity of breeding objectives, in his case for the Australian Merino, with a multiplicity of traits and increasing sophistication of the markets. The need for professional advice and access to adequate genetic evaluation schemes increases. That most of us are working at a more elementary level does not relieve us of the obligation to rigorously define objectives.

It seems that little attention has been given to the needs for really good techniques for genetic improvement by selection in systems with small, scattered, individually owned flocks, even if agreement could be reached on objectives, since Turner (1991) drew attention to this need over 10 years ago. Only sensible, communal cooperation will enable progress with the avoidance of unnecessary genetic erosion or loss of adaptation. There are good examples of cooperative schemes, notably the open nucleus group breeding schemes as developed in NZ and the Scandanavian schemes involving the rotation of rams identified as superior by field recording and testing as in the ram circles in Norway. Factors aiding the success of the Scandanavian schemes include a long tradition of cooperation and an absence of commercial competition in the sale of elite breeding stock. All schemes require recording but this may not need to be complicated nor expensive. Effectiveness will be increased if there are cooperatives to enlarge effective flock sizes and non-seasonal breeding to enable continuous ram rotation.

SUMMARY AND CONCLUSIONS

There is a wealth of breeds and genetic resources in sheep worldwide to satisfy the requirements of pastoralists and farmers to adapt to changing circumstances and meet future needs. On-going genetic improvement will require very clear definition of breeding objectives, the development of new composites and the utilization of new technologies for gene manipulation. At the same time, the array of existing breeds or breeding populations must be maintained and adapted to changing social and production systems. Cooperation will be essential for the implementation of sheep genetic improvement plans.

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