ANIMAL GENETIC RESOURCES IN THE DEVELOPING WORLD: GOALS, STRATEGIES, MANAGEMENT AND CURRENT STATUS

JOHN HODGES, ITALY
Animal Production Officer
(Animal Breeding and Genetic Resources)
Food and Agriculture Organization of the United Nations
Rome, Italy

SUMMARY

The present position of animal genetic resources in developing countries is reviewed. There are many genotypes adapted to various environmental challenges, including extremes of climate, endemic disease and parasitic infections, and specific local conditions for use and production. The long historic processes of adaptation have resulted in relatively low individual animal performance. The current need for increased animal production is resulting in the use of higher producing temperate breeds. Two dangers arise; the possibility of failure to adapt, reproduce, produce and survive; and the risk of loss of the local breeds.

The paper reviews the infrastructure needed to support planned development of improvement projects and the preservation of unique germplasm. It describes recent activities by FAO and UNEP. It lists some desirable steps to advance the effective and rational use of the animal genetic resources of the third world. It concludes that the provision of the needed infrastructures for improved production and for effective preservation should not be organized nationally or left to the operation of market forces, but should be initiated internationally and should be operated regionally.

INTRODUCTION

Twentieth century man has inherited a profusion of domestic animals. They are the legacy of several thousands of years of interaction between man and animals in countless different climatic, topographical, nutritional, social and economic environments. Although the number of species which man has chosen to domesticate for food, fibre and work is scarcely more than 15, there is, within each, an abundance of breeds (strains or races) each of which was evidently suited originally to specific agro-economic niches.

This long-term process of domestication has been greatly influenced over the centuries by the slow migration of animals in the company of human exploration and settlement. In this way, adaptation to gradually changing environments has been tested and crosses with different races have produced new combinations of animal genotypes, thus contributing to the extensive genetic variation which exists today in domestic livestock. An interesting example is the introduction of Bos taurus and Bos indicus cattle to West Africa from the European/Near East and Asian regions respectively in company of human migrations. Neither were challenged by african trypanosomiasis in their regions of origin, but Bos taurus, having been in West Africa much longer then Bos indicus, has under selection, developed much higher levels of trypanotolerance.

Today, some localities have specific constraints which render ineffective the rapid introduction of breeds from elsewhere. On the other hand, some breeds exhibit tolerance of a wide range of natural environments and have adapted successfully to different physical constraints and economic expectations. The domestication of food animals during the last 10 thousand years has thus produced a paradoxical combination of few species, each having many locally adapted breeds, which are characterized by diversity of appearance and performance. The fact that different breeds within a species can mate, offers scope for the creation of a myriad of new combinations of genetic material within each species. The effect of human selection and improved management is seen in the case of the range in milk production per cow per lactation, the average of which in the most high yielding strain of Black and White cattle is 30 times more than in the lowest level unimproved breeds.

Thus mankind today has an enormous wealth of domestic animal genetic resources, arranged in a complex matrix of relationships between breeds which are variously adapted to specific or more general environments. There is considerable genetic variation between breeds, for adaptability to climatic stress, tolerance of some diseases, and resistance to some parasites. For example, some cattle breeds are adapted to semi-arctic conditions and others are adapted to the hot tropics. Whereas among most wild animals from such diverse environments (say bears), inter-mating would not be possible, domestic breeds from totally alien environments can inter-mate and thus multiply the genetic variation available to man. In earlier days, the barriers of space and time effectively limited such dramatic changes and ensured that any new and successful genetic combinations were challenged by only small changes in the environment. These were usually limited to features of physical geography, vegetation, disease and climate, and they occurred very gradually as animals moved on foot with human migrations. Rarely were there dramatic changes of human management systems such as those now brought about by transfer technology. Today, we are changing this traditional picture. We can now compress space and time by moving animal genetic resources rapidly around the globe and producing, for example, several hundred thousand calves in different regions from one bull; and we can extend generation intervals indefinitely with frozen semen and embryos. Additionally, new management techniques with improved feed resources aimed at higher productivity are often introduced. All of this means that today animal production in developing countries can be increased. However, the pace of change is often faster than the pace experienced earlier in the developed countries when they were changing breeds and improving management systems. Breed substitution in developed countries as a response to market pressures nearly always meant simply the use of another temperate breed. The problem of adaptation to new environments has never been experienced in the developed world as it is today in developing countries. This highlights the need for ease of access to accurate information for successful planning.

Economic and survival pressures are forcing old established communities in developing countries to consider giving up their earlier, fierce national or local pride in native breeds, and are tempting them to risk sweeping changes in animal genetic resources by the introduction of exotic germplasm. Whether this is by breed substitution, by structured or indiscriminate cross breeding, or by the creation of new composite breeds, the possible benefits are unfortunately accompanied by considerable dangers due to incomplete knowledge at the present time.

The most fearsome prospects flowing from such changes are twin possibilities: first, that the newly introduced animal genetic resources combination is unadapted for local conditions; and second, that the animal genetic resource being replaced may be lost for all time. Such losses of old established breeds simply because they happen not to fit today's market demands can represent a sudden action to end the accumulated benefits of millenia of natural and human selection. Man's selection has been slow and directed to a variety of ends including not only milk, meat, fibre and draught animal power but also ceremonial use, status and the accumulation of wealth. Today the former items comprise the main interest of mankind in animals. The environment with its challenges of adverse climates and endemic diseases often remains untamed. Even if disease is controlled and climate modified, there is still the possibility of change in the future, in different economic, political or social circumstances when the adapted animal genetic resource will again be needed. An interesting historic example of changed demand which was not foreseen, but which was fortunately satisfied by animal genetic resources retained for other purposes, can be seen in the European beef breeds. Some cattle breeds were selected for centuries primarily for work. Consequently they developed strong muscles. During the early part of the industrial revolution when many people worked manually in the United Kingdom, there was an increased demand for fat animals, with the result that the British beef breeds were selected for the ability to deposit body fat. In the twentieth century with the decrease in manual labour, fat became less popular and the British beef breeds were unsuited to market demand. However, some of the cattle breeds of continental Europe had retained their extensive muscle development for work, were exploited for lean beef production, and quickly became popular in a new market away from their traditional locality, and for reasons different from those for which they had been earlier selected. So today breeds in many developing countries which appear today to have no economic value, which have been kept in the past for cultural or social reasons in a non-market economy, may nevertheless carry unique genes for adaptability to specific or general hazards of the environment. Their contribution to future crossbreeding programmes could be irreplaceable.

THE PRESENT POSITION

Leaving aside the animal genetic resources of the developed world, which is not the subject of this paper, we find today in the developing world of Africa and Asia that the multitude of local types of domestic food animals of a given species have diffuse territorial boundaries which run almost imperceptibly into each other. A gradual change of phenotype is not necessarily accompanied by a change in name. On the other hand sometimes because of traditional tribal or other more recent political boundaries, name changes can occur without any apparent differences in phenotype. The knowledge needed for recognizing these local breeds or races is complex and incomplete, so that Mason's World Dictionary of Breed Types and Varieties of Livestock, first published in 1951, has already been revised and is now in desperate need of another edition which is in preparation. So if we are still struggling to classify names and synonyms correctly, how much further are we from understanding the genetic characterization of many local breeds? Of course knowledge varies from one country and region to another. Some of the most advanced developing nations have excellent documentation of indigenous breeds and of their performance. Others do not yet have adequate recording systems nor even the infrastructure to provide reliable censuses of the numbers of animals of a given type. Still others have never had a tradition of keeping certain domestic species of animals, and are therefore experimenting with importations. An example is the recent introduction of cattle for milk production in some arab countries. Some introductions have been successful, where the environment has been matched or changed to suit the adaptability of the imported genotypes. In other cases there has been failure. It is unfortunately true that the countries having the greatest need for higher production of animal products are often the ones with the less complete knowledge of their own and also of exotic animal genetic resources.

Several important historic events have a bearing upon the present position. The first was the introduction of breeds of domestic animals by explorers, and later during the colonial era, to the countries now described as developing. An example of great importance was the movement of cattle from Europe to Latin America and the Caribbean. These original introductions had great impact since there were no indigenous cattle, and the natural environment was, on the whole, well suited to the species. Nevertheless some adaptation was necesary. So the cattle originally brought from the Iberian peninsular have developed some features similar to the Zebu, thus enabling them to survive in tropical conditions. These Criollo animals have become in effect the indigenous cattle of the region. Today they are viewed as less than ideal for modern production levels and are being crossed with improved temperate breeds to gain more milk and meat. During colonial times introductions of European domestic animals took place also in Africa and Asia. Some were unsuccessful due to lack of adaptability; others were successful, especially in highland areas with a more temperate environment; others succeeded when a systematic method of crossing was devised to maintain the halfbred animals in genetic equilibrium. Some colonial authorities introduced domestic animals from one tropical region to another, especially where the breed had relatively high productivity and could adapt without complex crossbreeding programmes. A well-known example is the introduction of the Sahiwal from Pakistan to Kenya where it is now well established and successful.

A second historic event which has greatly affected livestock in developing countries is the availability of artificial insemination and the cryogenic storage of semen. This technique was first widely used after the second world war. During the last 25 years many developing countries have established a service for cattle, often using frozen semen. Developed countries, having established their domestic artificial insemination services a decade earlier, began to ship frozen semen to the tropics. This has been done both as part of nationally approved development projects and also as commercial business. The knowledge needed to make ideal decisions on which temperate breed to match with which indigenous breed was scanty at first. An understanding of the environment and its challenge to the introduced genotypes was also inadequately understood. Yet the pressure to increase productivity by the use of high potential temperate breeds has been so great that much semen has been imported and not a few live animals. The situation has been described as indiscriminate crossbreeding. It has resulted in both success and failure. Examples of the latter are not difficult to find, though there is reluctance to record them, which is unfortunate for the same mistakes tend to be repeated elsewhere. The success stories are usually associated with the introduction of more than simply semen. The provision of improved management, feeding, vaccinations, methods of harvesting and processing the product, feed production, recording services and general extension seem to be essential. This is true in the case of a totally new turnkey package offering a new environment separate from the natural conditions, and also in the case of the improvement of village herds. To artificial insemination has now been added the technique of embryo transfer. In the not too distant future, some of the many possibilities resulting from biotechnology will become available. These will be considered in more detail towards the end of this paper.

The present situation can be summarized in the following way. There is considerable pressure from valid needs to increase the yields of domestic animals in developing countries, where levels of animal protein are low on average, and in some cases so low as to be the cause of malnutrition due to unbalanced diets. The attractions of breed substitution have led to the extensive use of temperate breeds, which are replacing the tropical breeds completely wherever possible under suitable environments. Where temperate breeds cannot survive, then partial breed substitution is occurring by the use of cross breeding. There are a few outstanding examples of well planned and successful crossbreeding projects. But during the last 2 decades this has often happened without the necessary planning to ensure the permanent survival of either the stabilized crossbred population or of the indigenous population which is often needed to maintain the supply of further crosses. There has also been inadequate characterization of the production and adaptation of indigenous breeds and crosses.

As a consequence recently some animal geneticists have urged the improvement of indigenous breeds themselves without the use of alternative temperate breeds. This judgement is premature in the absence of adequate documentation of what can be achieved by judicious crossbreeding. Another difficulty with attempting to improve indigenous breeds is the fact that many generations are needed to improve economically important characteristics. Change is extremely slow. Another problem with the attempted selection of indigenous breeds is the absence of adequate recording systems, an infrastructure suitable for artificial insemination and the other resources needed for both controlling and measuring the environment in order to separate genetic and management effects in statistical analysis. FAO is attempting some work of an exploratory nature in the improvement of indigenous breeds using a nucleus herd technique in the Sudan with the Kenana breed and in Guinea with the N'Dama cattle breed.

RECENT INTERNATIONAL ACTIVITIES IN ANIMAL GENETIC RESOURCES

One of the main tasks of FAO in the field of animal production is the genetic improvement of animals to achieve higher levels of milk, meat, fibre and to enhance the ability of draught animals. These activities are carried out in many countries at national level in response to requests from member governments of FAO. They cover all the species of domestic mammals and poultry, and have been progressing since FAO was founded 40 years ago. They continue as the main activity of FAO in the field of animal genetic resources today, with technical inputs in the areas of animal genetics and artificial insemination. FAO's semen donation scheme is part of this programme and ensures that semen is used in a planned way.

Nevertheless, as a result of the position described so far in this paper, it became apparent a few years ago that additional organizational resources are needed to make national projects in animal breeding and genetics more effective. A brief description of these activities is given.

In the 1960s FAO originated a series of Expert Consultations on the evaluation, conservation and use of animal genetic resources. Between 1966 and 1973 these covered general problems and also individual species resulting in several publications describing livestock breeds in different parts of the world. In 1973 FAO and the United Nations Environment Programme (UNEP) joined together to launch a pilot project on the Conservation of Animal Genetic Resources. The first task was to prepare a preliminary list of endangered breeds. This was done by surveying the literature and by correspondence. It succeeded in drawing attention to breeds in some tropical areas which were endangered, and also highlighting other breeds with economic potential and results were issued in FAO/UNEP publications. However, it also became clear that the survey method by correspondence was not yielding the information needed either for improved use or for preservation of breeds. In 1980 FAO/UNEP therefore convened a Technical Consultation at which all member countries were invited to participate (FAO, 1981). The results of this Consultation were more specific guidelines on the items of infrastructure needed for the successful implementation of animal breeding and genetic improvement in developing countries by FAO, other UN bodies, national governments and private consultants and businesses. These items include data banks for animal genetic resources, gene banks to store semen and embryos of endangered breeds, training of scientists and administrators in animal genetic resources conservation and use, documentation of the experiences with crossbreeding of temperate and tropical breeds in developing countries, testing and evaluation of methods for the improvement of indigenous breeds having potential for higher production, specialized information in a newsletter for those working with animal genetic resources, and an expert panel to advise on the international aspects of animal genetic resources work. It was also requested that FAO/UNEP should seek agreement to document the extensive but little known animal genetic resources of the USSR and the People's Republic of China. Following the Technical Consultation, FAO and UNEP entered a second phase of their joint project in these areas.

It is appropriate to describe progress in these different ideas to create supranational infrastructure resources for animal breeding and genetics.

Data Banks for Animal Genetic Resources

a. Objectives

The purpose of the data banks is to provide a comprehensive and accessible description of the genetic characteristics of each breed and established crossbred populations of livestock and birds, together with characterizations of the environments to which they are adapted. The characteristics include all the production traits for the food, fibre or work products of the animals concerned. Separate values for genetic and phenotypic parameters would be given. Reproductive performance would be also characterized. Estimates of the numbers of animals and their distribution would be given, in addition to the distinguishing physical features of the breed. Facility would be provided to include information on blood and biochemical traits, karyotyping, immunological characteristics and any newly developed traits. The data banks would document the suitability of breeds for crossing and the known performances of the crosses. They must remain open ended for the addition of new information and for updating.

b. Uses

The data banks are to be used for providing easy access to all the known genetic information on a breed or cross, and thus avoid the user having to make an individual search and analysis. Information is then available to all potential users on breeds able to make contributions to human welfare in present circumstances and for which genetic improvement programmes could be formulated. If appropriate, these could be on an intercountry cooperative basis, so that the national sub-populations of a breed are managed and improved with knowledge of what others are doing with other sub-populations of the same breed. Data banks also will be of value for research, for extension and for the promotion of breeds and crosses to other parts of the region and world to which they may be adapted, but where they are unknown. Endangered breeds can be identified to permit action to avoid extinction. The data bank organized on a regional basis will enable populations of similar genotype in adjacent countries to be compared to ensure that duplicate preservations are avoided.

Data banks will not be simply repositories of all the existing reports and research publications on a breed. Such a system already exists in the Animal Breeding Abstracts of the Commonwealth Bureau of Animal Breeding and Genetics, which are held in the Lockheed data base in California. A similar system is maintained for Africa by the International Livestock Centre for Africa (ILCA). Output from those data bases consist of the abstract of the publication or a microfiche of the original. Using these data bases the user still has to prepare his own genetic characterization for a breed of interest. Similarly, publications, though of great value, are limited in their value for project planning. Each publication has specific objectives, its own format and requires the user to become aware of its existence and then to search, compare and interpret for himself the appropriate information on animal genetic resources. Regional data banks for animal genetic resources are an advance to a higher level of information service, offering a comprehensive statement of the characteristics of the breed under specific conditions of management and of the environment. These are arranged in an orderly format within the data bank, so that comparisons can be made relatively easily between different breeds, and rapid search and access be carried out. It will be possible for example to seek those breeds which are adapted to a certain climate, with specific disease tolerance and to obtain full descriptive characterizations of the known performance levels in specified environments of the breeds fitting these categories.

c. Experience to date with Data Bank Trials

FAO/UNEP operated pilot trials on data banks in a number of countries of Asia, Africa and Latin America in the 2 years 1983-85. As a result a method of extracting data has been developed, descriptor lists have been designed for each main species of domestic mammal and poultry, and studies have been made on the optimum method and the costs of entering, storing and accessing the data in Regional Data Banks. These findings have been published by FAO/UNEP in the Animal Production and Health series, and may be obtained by writing to FAO. At the present time funding is needed for implementation.

One of the most valuable discoveries in the trials was the finding that in each country, of all the original source documents which were read in national and international journals, government livestock stations, files, theses and articles in local language, only 25-30 percent had been previously abstracted by the Commonwealth Bureau of Animal Breeding and Genetics. The remainder were therefore inaccessible to scientists outside the country, and also to many later generations of scientists in the country. This shows that the Animal Breeding Abstract System is mainly serving the needs of the developed world. This means that research and development projects in third world countries are often duplicated in another country. Such duplication was discovered in the pilot trials. The same mistakes in the choice of animal genetic resources for specific environments also are being made repeatedly in project design, even though experience may have already been gained in a neighbouring country.

There is a real need for the creation of Regional Data Banks primarily to meet the needs of those engaged in planning and implementing livestock production projects in developing countries. They will also aid research, extension, teaching and planning of livestock development.

Gene Banks

These are broadly viewed as means of preserving endangered breeds for future use. In many developed countries the methods used include both live animals and cryogenic storage of semen and embryos. Often, in Europe, the endangered breeds and species are kept in semi-wild conditions in parks, where the public is willing to pay to view and give financially to support the activity. Wildlife parks have also been developed successfully in some developing countries but the possibility of doing the same with domestic animals in developing countries is unlikely to succeed. There are two options to maintain endangered breeds. One is to provide some encouragement or incentives for live animals to be maintained **in situ**, in their traditional herd system. The second is cryogenic storage (**ex situ**). The latter is probably the only feasible long term prospect for success in the developing world. Preliminary studies by FAO/UNEP show that there are serious difficulties yet to be overcome in the creation of cryogenic gene banks for developing countries.

First, the breeds from which semen is to be collected and stored are often in a rather isolated place with poor facilities for handling males who have not been used for semen collection before. This may best be overcome by storing embryos, since the harvesting process is less violent with females than with males.

Second is the problem of disease control in the semen or embryos. This is not only a matter of difficulty in arranging the appropriate tests in a remote location but also the need to ship the semen and embryos to another country for storage. Animal health controls at international borders are often, rightly strict.

Third is the issue of ensuring that there is constant supply of liquid nitrogen, or alternatively the provision of a power supply to operate a liquid nitrogen plant to produce it on the spot. The failure of a liquid nitrogen supply would of course jeopardize the value of the stored material.

Fourth is the decision of where cryogenic gene banks are to be located. Obviously they should serve a region or perhaps a sub-region. The questions of ownership of the germplasm and access to it are issues needing resolution.

Fifthly, and associated with point 4 is the question of who is to pay for the long term storage of germplasm for which there is no foreseeable use in the future. Some of these problems continue to be the subject of an FAO/UNEP study on a pilot trial basis. Probably the location of cryogenic gene banks could be in association with existing liquid nitrogen storage of semen for commercial use, thus providing the technical control and resources for operating the gene bank without starting from scratch.

Many countries are aware of their breeds which are endangered. More precise identification of the breeds and similar breeds in adjacent countries could result as a secondary benefit from the data banks where genetic characterization of the local breeds are held, before freezing germplasm.

Other Current International Activities

The publication of a Newsletter (Animal Genetic Resources Information) by FAO/UNEP started in 1983, and serves as a means of spreading information among all who are interested and concerned with animal breeding and genetics. It is available free of charge from FAO, Rome. A book was published in English recently by FAO on the Livestock Breeds of China. It is available in English (FAO, 1985) and it is being translated into French and Spanish. It was originally published in China in Chinese by Professor Cheng Peilieu and Chinese Academic Press. FAO/UNEP are cooperating on a large scale survey and documentation of the Animal Genetic Resources of the USSR, together with the Centre for International Projects in Moscow and the All Union Academy of Agricultural Sciences. It is expected in 1987. Other volumes on animal genetic resources are in preparation. It is vizualized that if Regional Data Banks are established the data from these publications would also be entered into the electronic system.

THE WAY FORWARD

Although most projects to increase animal productivity are implemented at the national level in developing countries, there is clearly a need for increased international cooperation and organization at the regional level to supply the necessary infrastructure resources for animal breeding and genetics.

1. The genetic improvement of livestock populations is generally positively correlated with the size of the animal population. Small populations are not usually able to make significant genetic improvements in economically important traits. It is therefore desirable that local indigenous populations should be linked together in genetically similar groups regardless of their local names or country distribution.

2. The creation of an effective animal breeding population is dependent upon the provision of competent product recording services (like milk recording in the case of dairy animals) and, for some species, of artificial insemination services. The records generated by such services have value for genetic selection when they are in common format, with centralized computer processing facilities. Such services are most competently offered by a large centre. Many relatively small developing countries do not have the resources or records to justify such a centre, and a sub-regional location serving several countries would be valuable.

3. As described earlier, there is within most developing countries a large body of literature based upon research over many years which is unfortunately inacessible. This means that policy makers, project planners, extension workers, researchers and teachers are not informed and are likely to duplicate work already done, and to replicate mistakes in the design of breeding programmes. Access to this information becomes all the more important as germplasm is moved from one country and environment to another. It is desirable that a system of

accessing such information be available through four regional centres in Africa, Asia, Latin America and the Near East. The techniques for doing this have now been formulated and costed and funds are needed.

4. Regional organization of gene banks is desirable for the storage of germplasm.

5. Intercountry cooperation in the testing of high potential breeds under several environments should be organized. This could utilize some of the principles set in the FAO International Black and White Strain Comparison in Poland. The objectives would be the comparative evaluation of indigenous breeds, indigenous x exotic tropical breeds and indigenous x exotic temperate breeds. It could be organised regionally with the use of reference breeds. Alternative management/nutritional systems could be employed in different centres to reflect regional or national practices and to look for genotype-environmental interactions. The provision of data banks will not be a substitute for such trials, although they would provide information that might be extrapolated. The first step in such evaluation trials should be the careful design of scientific and logistic aspects and the identification of centres to provide a cost/benefit evaluation which can then be submitted for international financial support.

6. It is important for projects in animal breeding and genetics in developing countries that adequate characterization of the temperate breeds should be available. This must be based not simply upon general knowledge and opinion, but upon documented experiences, particularly on the subject of adaptability. Those designing projects which involve the use of temperate breeds, and this is a very high percentage of all projects nowadays, should have available the information on how temperate breeds have performed in the past in developing country environments. There are many experiences in different parts of the tropics in the last 20-30 years, but few have been adequately recorded for posterity. The European Association of Animal Production (EAAP) have discussed the possibilities of establishing a centre for documenting the genetic status of breeds in Europe. The idea originated in the wish to identify the endangered breeds of Europe. If such a centre is established it would be highly desirable that it should also hold genetic characterizations of the temperate breeds of Europe, and of their adaptability in the tropics and semi-tropics based upon all experiences to date, both successes and failures. The EAAP have indicated their interest in using the recommended FAO/UNEP format for such characterizations. This would have the advantage that information could be transferred using floppy discs between the proposed regional data bank centres for the four developing regions of the world, and the centre in Europe. Thus new experiences from crosses in developing countries could be entered easily and also summary characterizations accessed by users in any of the developing regions. It is particularly important that in such a centre for temperate breeds, the system should be sufficiently flexible to accommodate characterizations of all the recognized combinations of crossbred animals derived from the use of a temperate breed, and to characterize the environments in which their adaptability and performance has been tested.

It is also desirable to address the question of whether a separate regional data bank for genetic characterizations of temperate breeds and their crosses should be established for data from North America. Since so many North American breeds of domestic food animals have their origin in Europe, it is reasonable to propose only one such centre covering all temperate breeds wherever they are located.

7. One must consider the possibilities being opened for animal breeding and genetics by biotechnology, and its possible application to the developing world. It is likely that the high levels of expertise needed will preclude the widespread application of biotechnology in many parts of the developing world for some years. On the other hand, if a breakthrough occurs for creating new superbreeds by cloning of embryos already implanted with appropriate DNA for disease resistance, and other adaptability traits, it could change the whole picture. If such a breakthrough offered the possibility of avoiding all the current difficult problems of combining the high production of one breed with the adaptability of another breed, it would have great attractions. It would probably depend upon designing the superbreed in the hightech laboratories of the developed world, and carrying out the multiplication in the commercial environment of the developing countries with normal reproduction processes supplemented with artificial insemination and embryo transfer. These latter techniques are already available in some developing countries as field tools. If such superbreed options ever arise, then they will surely be quickly implemented, as demonstrated already by the poultry industry with its specialist breeders and separate commercial production units throughout the world, and operating satisfactorily in both developed and developing countries. If identification of DNA coding segments ever reaches the stage for the creation of such a superbreed of cloned animals, then an associated possibility for the preservation of endangered genetic variation also will arise, namely the preservation of gene segments in isolation from both the live animal and the germplasm.

CONCLUSION

It is clear that the acceleration of rational use of animal genetic resources in the developing world is now dependent upon the creation of additional tools which can only be organized internationally. It would not be wise, in the author's view, to depend upon the economic forces of the market place to provide the essential infrastructure for the genetic characterization of indigenous breeds, nor for the preservation of those with unique traits when they become endangered, nor for the provision of information services to maximize effective animal improvement and project design.

In developed countries the period of rapid animal genetic improvement, has been accompanied by supporting government services for research, extension, information and preservation. Only in the relatively recent past, after the basic genetic information is available, and services like AI and recording of individual animal performance have been established, has it become fashionable to ask the industry to take the financial and moral responsibility for operating the improvement system, and for managing and conserving its own animal genetic resources. Governments or paragovernment agencies have been **in loco parentis** in most developed countries during the period of establishing national genetic improvement programmes.

In the third world today, dependence upon market forces to develop animal genetic improvement where survival and subsistence remain strong features of life is not a rational view. National financial resources are often very limited, and there are sound technical and scientific reasons deriving from first world experiences, for organizing animal genetic support services, research, breed evaluation, AI, performance recording, preservation and information access on regional bases.

SELECTED REFERENCES

Epstein, H., 1969. Domestic animals of China. C.A.B., Farnham Royal (Bucks), 166 pp.

Epstein, H., 1971. The origin of the domestic animals of Africa. Africana Publishing Corporation, New York, NY, 2 Vols., 573 pp and 719 pp.

FAO, 1966. Report of the FAO Study Group on the evaluation, utilization and conservation of animal genetic resources. FAO, Rome 31 pp.

FAO/UNEP, 1975. Pilot study on conservation of animal genetic resources, FAO, Rome, 60 pp.

FAO/ILCA/UNEP 1980 Trypanotolerant Livestock in West and Central Africa (2 Vols). Animal Production and Health Paper Nos 20/1 and 20/2. FAO, Rome 146 pp and 303 pp.

FAO/UNEP 1981. Animal Genetic Resources Conservation and Management. Animal Production and Health Paper No. 24. FAO, Rome 388 pp.

FAO/UNEP 1984 Animal Genetic Resources: Conservation by management, data banks and training. Animal Production and Health Paper No. 44/1. FAO, Rome 186 pp.

FAO/UNEP 1984 Animal Genetic Resources: Cryogenic storage of germplasm and molecular engineering. Animal Production and Health Paper 44/2. FAO, Rome 114 pp.

FAO 1985 Livestock breeds of China. Animal Production and Health paper No. 46. FAO, Rome 217 pp.

FAO/UNEP 1986 Animal Genetic Resource Data Banks: 4 Vols. on Computer System Study; Preparation of Data from Source Documents; Descriptor Lists for Mammals; Descriptor Lists for Poultry. FAO Rome (In Press).

Mason I.L., 1969 A world dictionary of livestock breeds, types and varieties. C.A.B. Farnham Royal (Bucks) 272 pp.

Mason I.L., 1984 Evolution of domesticated animals. Longman, London. 452 pp.