The management of global animal genetic resources

Proceedings of an FAO Expert Consultation
Rome, Italy, April 1992

Edited by
John Hodges
INTRODUCTION

This Expert Consultation was called at the end of a decade in which animal genetic resources moved from relative obscurity to centre stage of interest in development agriculture. During the 1980s, it was increasingly realized that the use and preservation of animal genetic resources are inseparable.

Today animal genetic resources are seen as an integral part of global biological diversity and of the natural environment; they are also an important component of the modified natural environments which are introduced by mankind in development activities and which are now rightly subject to careful scrutiny, appropriate limitation and planned conservation.

During the decade of the 1980s, FAO was very active, jointly with the United Nations Environment Programme (UNEP), in developing a new approach to the management of global animal genetic resources. These activities were carried out in full consultation and cooperation with the member governments of FAO. Thorough studies were made of the underlying rationale and of the needs, opportunities, difficulties and benefits of a new approach to the conservation of animal genetic resources. Extensive consultations took place with all interested organizations; several Expert Consultations were held to sharpen specific aspects of the work as they were brought to fruition; and some preliminary operational infrastructures were set up.

The FAO Committee on Agriculture and the FAO Council have reviewed these activities in recent times and have both expressed their support and wish to see a global programme in place as quickly as possible. They pointed out that new funding sources are needed for this global programme, and they expressed the wish to see the programme integrated as closely as possible with other global programmes in biodiversity and sustainable agriculture.

This Expert Consultation was called both to assist in making a judgement on the desirability of a separate forum for Animal Genetic Resources and to consider the proposed global programme on Animal Genetic Resources. The Expert Consultation was asked to look at the organisation of such a programme, to recommend practices, where needed, and to identify priorities within a global programme.

The participants, although invited in their personal capacities, represented all regions of the world and included experts in all domestic animals species of mammals and poultry. Several were from organizations with close involvement and responsibilities for animal genetic resources. Dr. L. Ollivier of France and Dr. C. Chantalakhana of Thailand were unanimously elected Chairman and Vice-Chairman respectively.

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ABSTRACT

The subject of this publication is the global management of animal genetic resources, namely of the domesticated livestock and poultry species and breeds. Attention is focussed upon the genetic resources themselves, upon the need to identify and to give priority to those which are threatened and to regular monitoring mechanisms for discerning changes in the status of animal populations. Practical issues of conservation are evaluated and the need to combine both preservation and improved use is emphasized. Biotechnology prospects for use with animal genetic resources are described. Attention is given to the institutional, financial and administrative structures needed for a global programme and for its regional and national components. The papers presented in this publication were prepared and studied at the Expert Consultation by the authors and others. Participants attended in their personal capacities and covered all areas of the world and all the domestic species. The recommendations are given in full and are directed towards Institutional Infrastructures, Monitoring Practices, Breed Development and Conservation Programmes, Biotechnology and Legal Aspects.

KEY WORDS

Cattle, buffalo, sheep, goats, camilidae, pigs, equines, fowl, poultry, chicken, ducks, geese, wild animals, breeds, genetics, breeding, breed improvement, nucleus breeding, germplasm, conservation, preservation, biotechnology, rare breeds, endangered and threatened status, small populations, environment, adaptation, World watch, gene bank, animal genetic data bank, institutional, legal, finance.

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RECOMMENDATIONS OF THE FAO EXPERT CONSULTATION ON THE MANAGEMENT OF GLOBAL ANIMAL GENETIC RESOURCES

A. GENERAL

1. In reviewing the past, the Expert Consultation noted the definitions used by FAO which are repeated in Appendix 1. The Expert Consultation noted the recommendations of the FAO Expert Consultation on Animal Genetic Resources in September 1989 in Rome, Italy, particularly recommendations numbered 4, 5 and 9 in the Institutional, Legal and Financial section which stated, inter alia:

   para 4 “that governments should establish as a matter of urgency an appropriate national infrastructure for animal genetic resources.”

   para 5 “that regional cooperation among countries be established to facilitate effective action. The cooperating countries should aim at developing self-sustaining regional organizational structures with the support from member governments.”

   para 9 “that the FAO programme has a sound technical base, is organized effectively and should be expanded and further developed into a global programme.”

2. The Expert Consultation noted the recommendation of the 98th Session of the Council of FAO, meeting in Rome, Italy on 19–30 November 1990, which stated, inter alia: “that FAO prepare a detailed programme for sustainable development of animal genetic resources on a global level for consideration by the next session of the Committee on Agriculture, …that the programme include projects for interested countries and regions to be implemented by their respective governments and should be financed primarily in the form of trust fund projects, …that donor countries as well as international and regional banks assign due priority to sustainable development of animal genetic resources, and …that proposals for the development of an appropriate legal framework for the conservation and rational use of animal genetic resources be referred to the next session of the Committee on Agriculture”.

3. The Expert Consultation noted and approved the continued activities of the FAO and the United Nations Environment Programme (UNEP) in the conservation of animal genetic resources, particularly including the FAO’s cooperation with UNEP in the negotiations for an International Convention on Biological Diversity; in preparation for the United Nations Conference on Environment and Development; and in the FAO's collaboration with a variety of other international organizations in these fields.

4. The Expert Consultation strongly recommended that the FAO, as a matter of urgency, accelerate the design, preparation, search for funding and implementation of a detailed global action plan for the sustainable development and management of animal genetic resources, noting that this programme would assist in the maintenance of biological diversity and development of sustainability of agriculture, emphasizing that this programme be designed in a
fashion that contributes to both the near-term production needs and the long-term conservation needs of the farmers of the developing world, and emphasizing that this programme should combine the conservation of traditional breeds, the preservation of a variety of genetic material, and breed improvement.

5. The Expert Consultation noted the important role of the FAO and other organizations in encouraging training and technology transfer and in fostering the research and development capabilities of developing countries for the conservation of animal genetic resources and recommended that the FAO give extremely high priority to such activities.

**B. INSTITUTIONAL STRUCTURES**

6. The Expert Consultation recognized the urgent and critical need for leadership to coordinate, foster, and organize broad-based national, regional, and international activities to preserve, conserve, manage, and use animal genetic resources. To this end, it recommended designation and establishment of a clearly defined management entity to promote consultation and contractual processes; to coordinate activities at the national, regional, and international levels; and to secure necessary funding.

7. At its outset, the management entity should develop close consultation processes with intergovernmental and non-governmental organizations, including U.N. bodies, conservation groups, international and national agricultural research centres and universities concerned with the management of animal genetic resources. It should be able to enter into contractual agreements with appropriate scientific and technical institutions or other organizations to accomplish activities relevant to the conservation, management and use of animal genetic resources.

8. The institution designated to provide the management entity should prepare an action plan with clearly defined scientific methods, goals, a funding plan, and expected national and international benefits. This action plan should emphasize the consultation processes and contractual relationships necessary to execute the programme. It should make specific proposals for an accountable system which should be transparent. The action plan should recognize as essential the task of creating greater public awareness of the conservation of animal genetic resources; of the need for urgent action; and of the benefits of such practices.

9. The Expert consultation envisaged a progressive programme in animal genetic resources, the first action being designation of the institution responsible for providing the management entity and for developing an action plan. This should include organizing a secretariat, developing a funding mechanism, and designing appropriate technical support groups. In the future, when experience has been gained in operating a global programme for animal genetic resources, the appropriateness of establishing an intergovernmental commission could be considered and, ultimately, a new institution could evolve.

10. The Expert Consultation recommended that the management entity should be accountable for technical and operational programmes to a consultative council comprising representatives of organizations, associations and institutions with interests in the management, conservation, and use of animal genetic resources and of those providing financial support to the programme. This consultative council should be responsible for technical review and oversight of the activities of the management entity and, as such, the membership should include several scientists acquainted with relevant fields; such as, genetics, breeding, conservation technologies, biotechnology, and environmental sciences. The consultative council should meet
no less than twice yearly for review and oversight of the activities of the animal genetic resources programmes and for reporting to the donors.

11. The Expert Consultation **recommended** that at an early stage the established programme should, through its consultative council, consider with scientific, technical, and legal advice the development of an appropriate legal framework for animal genetic resources activities, taking into consideration relevant agreements in the field, such as the Global Convention on Biological Diversity currently being negotiated.

12. In the absence of a legal framework, the Expert Consultation **recommended** that ownership and access rights of any genetic materials collected and maintained by the programme should be determined by the parties concerned before materials are collected.

13. The Expert Consultation **proposed** that the Executive Secretary of the management entity should be a senior animal scientist, who is operationally involved in the management of the animal genetic resources global programme. The individual should have experience with and understanding of the scientific and technical issues relevant to the conservation, management, and use of animal genetic resources.

14. The Expert Consultation **recommended** that the management entity should promote and encourage the formation of national and, where appropriate, regional programmes. National programmes should, at a minimum, monitor the status of indigenous livestock populations and develop plans for conservation at the national or regional level, as needed. Existing regional centres could accommodate new regional programmes. Where resources and needs require, national programmes could encompass a greater range of activities, including but not limited to cryogenic banks, conservation programmes, or *in situ* management. However, regional centres, such as the EAAP/FAO Animal Genetic Data Bank can provide important economies of scale even for large programmes.

15. The Expert Consultation **considered** that the programme must be fully aware of relevant animal health issues. It should, in close consultation with Office International des Epizooties (OIE), participate in negotiations toward appropriate regional or global quarantine procedures to permit the safe collection, movement, storage and subsequent use of animal germplasm among different countries. These points are particularly important should there be regional gene banks.

16. In consideration of the history of activities relevant to the conservation and management of animal genetic resources, and the need to begin a global effort in an efficient and timely manner, the Expert Consultation **recommended** that the FAO be designated as the institution to provide the management entity.

17. The Expert Consultation **recognized** that, following considerable debate and discussion, the 1989 FAO Expert Consultation on Animal Genetic Resources had recommended that the global animal genetic resources programme be organized independently of plant genetic resources activities. This recommendation was subsequently accepted by the FAO Council. Because the issues, technical expertise, and methodologies for conserving, managing, and using animal germplasm differ from those for plants, this Expert Consultation also **recommended** that the animal programme be organized separately from the plant programme. In the future, if appropriate, merging of one or more elements of the animal and plant programmes may be considered.
C. MONITORING ANIMAL GENETIC RESOURCES AND CRITERIA FOR PRIORITIZATION OF THREATENED BREEDS

18. The Expert Consultation recognized that the monitoring of Animal Genetic Resources must be considered of utmost importance as the basis for any long-term conservation strategy. This task needs full consideration at national as well as international level.

19. Recognizing the importance of documenting any breed at risk, the Expert Consultation welcomed the ongoing, excellent work on design and establishment of the Global Information Network for Animal Genetic Resources and the close cooperation in this endeavour with the EAAP/FAO Animal Genetic Data Bank in Hannover.

20. The Expert Consultation recommended further efforts to set up national/regional data banks as soon as possible to aid the gathering of crucial information about population numbers and important breed characteristics. This information needs to be regularly updated to support the regular publication of the World Watch List of Threatened Breeds and to serve as a tool to detect any changes in levels of endangerment thus allowing timely and appropriate action. The information stored in the Global Information Network for Animal Genetic Resources should be made available to all interested parties.

21. The Expert Consultation recommended uniformity of information type, including the simple form of questionnaire and the standard descriptors for the most pertinent information, which are already being used by FAO, by the EAAP/FAO data bank, and by some national data banks; this uniformity will facilitate the capture of information of maximum value. More detailed questionnaires could be used at later stages. Surveys to monitor population numbers should be made more frequently than efforts to collect breed characterization information. Species with higher reproductive rates and shorter generation intervals should be surveyed most often.

22. Recognizing the existence of some species-specific national or sub-regional data banks, and of the Hannover and FAO data banks, the Expert Consultation recommended that a comprehensive Global Information Network for Animal Genetic Resources be fully established with appropriate links to the existing banks and to the regional data banks which are to be created in Africa, Asia, Latin America and North America. Financial resources should be allocated for this work and for carrying out effective surveys. The Expert Consultation recognized that the distribution of summarized information from the Global Information Network at least once a year to governments and to concerned institutions and people at all levels would be an important incentive to keep the Network up to date.

23. To ensure efficiency in the development and coordination of the Global Information Network for Animal Genetic Resources, the Expert Consultation recommended that a Data Bank Working Group should be set up under the leadership of FAO and include representatives of each regional centre. An important task of the Working Group would be evaluation of the information collected and provision of guidelines for the further development of the Global Network. It also recommended that, at the various centres in the Network, continued use be made of the computer system already developed at the EAAP/FAO data bank in Hannover; this system acts as an interface for information from the various data banks in the Global Network and thus facilitates easier information flow.
24. The Expert Consultation recommended that FAO reaffirms the resolution received from the World Poultry Science Association (WPSA) regarding poultry conservation, already endorsed by the FAO Expert Consultation on Animal Genetic Resources held in September 1989. The WPSA resolution reads:

"Whereas the great majority of economically important poultry stocks are now in the hands of a few multinational corporations and
Whereas under these circumstances, economic concerns will override conservation efforts
Whereas governments are tending to opt out of breeding research and flock development and
Whereas poultry gene conservation by cryogenic means is not currently practicable

Be it Resolved the World Poultry Science Association (WPSA) urge the Food and Agriculture Organization (FAO) to vigorously pursue the preservation of poultry genetic resources, by means of:

1. bringing to the attention of member governments the urgent need to establish national gene pools;
2. promoting research into cryogenics or other means of germplasm preservation as an alternative to maintain live birds;
3. coordinating information on the current state of poultry genetic stocks available in the world;
4. providing support to selected private individuals and institutions, who are in a position to maintain key stocks in adequate numbers. And be it further resolved that the WPSA will actively assist FAO in these initiatives in any way possible".

25. The recent completion of the EAAP/FAO poultry questionnaire was welcomed. It was also recommended that FAO begins immediately a dialogue with WPSA regarding future collaboration.

26. Recognizing the needs to classify breeds, strains or geographic populations according to risk of being threatened, the Expert Consultation thoroughly discussed various criteria which might be suitable for assessing levels of risk experienced by breeds. The aim of such criteria and levels of risk is to aid decisions on the need for and design of preservation/conservation and development programmes. The factors considered include absolute as well as effective population numbers, reproductive rates, generation intervals, extent of crossbreeding, semen and embryo storage, variations in family size, number and type of farms hosting the animals, and management systems. The Expert Consultation concluded that no single factor could be used as an adequate criterion to classify the level of risk; studies of the dynamics of the breeds in question and of the competing populations are of crucial importance when classifying them for level of risk.

27. The Expert Consultation recommended that a plan of action as illustrated in Appendix 2 should be followed for classifying breeds, strains or populations by level of risk. This classification should also be used for publication and regular updating of the World Watch List of Threatened Breeds.
28. The Expert Consultation noted that the Proceedings of the FAO Expert Consultation of 1989 gives lists of threatened breeds: (FAO, 1990, Animal Genetic Resources: A Global Programme for Sustainable Development. FAO Animal Production and Health Paper No.80, pp 185–262). The Expert Consultation recommended that these lists should be used to identify candidate breeds for immediate action; these lists should be further developed to form the first World Watch List of Threatened Breeds.

D. BREED DEVELOPMENT AND CONSERVATION PROGRAMMES

29. While the Expert Consultation fully accepted and supported the importance and urgency of expanding the animal genetic resources programme to a global scale as indicated by the 1989 COAG, it recognized that not all the needed work and activities can be completed in the immediate future. It therefore recommended the following priorities for action on the basis of the classification of risk in Appendix 2:

i. Population statistics be completed for those breeds in the global data bank.
ii. Breeds in a critical state be identified.
iii. Populations found at a critical level be preserved immediately.

It is expected that all three of the above actions will be undertaken concurrently. The Expert Consultation recognized that, where necessary to save a threatened breed, immediate action should be taken to preserve the breed, even in the absence of it being adequately characterized. The Expert Consultation recommended that pilot programmes for conservation by management be initiated for breeds considered of high potential.

30. The Expert Consultation recommended use of certain criteria for deciding which breeds to conserve. A breed should be evaluated for conservation according to whether it is:

- threatened
- not being efficiently utilized
- unique in important characteristics
- likely to have potential impact in a large geographical area
- especially important to a particular region.

The criteria should also include a study of whether adequate infrastructure is available to develop and conserve the breed.

31. The Expert Consultation recommended that even when the number of animals of a particular breed, strain or population is above a critical level, in order to ensure the protection of pure lines when crossbreeding programmes are introduced, the action plan should encourage appropriate conservation activities by countries holding such livestock to avoid genetic erosion.

32. The Expert Consultation recognized that both crossbreeding and pure breeding are important methods for increasing productivity and should be utilized appropriately and with due caution to safeguard the maintenance of the pure breeds. In this context, the Expert Consultation recommended that the action plan promote the design and utilization of sustainable crossbreeding plans for each domestic species.
33. The Expert Consultation recommended that studies of the degree of genetic similarity among populations should be undertaken to avoid duplication of conservation efforts.

34. Where appropriate, wild relatives of domestic animals should be conserved to preserve unique genetic characteristics for possible later incorporation into domesticated breeds, strains and populations. In these activities there should be close coordination with international and national groups concerned with the conservation of such wild species. The Expert Consultation recognized and commended the excellent efforts of the Specialist Groups of the Species Survival Commission of the World Conservation Union (IUCN), the Zoological Gardens and other organizations which are engaged in the development of action plans for the conservation of the wild relatives of domestic livestock.

35. The Expert Consultation recommended particular consideration of the candidate breeds, strains or populations listed in Appendix 3 as having highest priority for pilot conservation/development programmes. It was noted that for some of those listed in Appendix 3 conservation and development programmes are already in progress (for example, the N'Dama cattle); the Expert Consultation commended these activities and urged action for those not yet being given attention.

36. The Expert Consultation also recognized that some important species and populations listed in Appendix 3 are not well identified genetically (for example, the West African pigs and the swamp buffalo) and recommended that genetic distance studies be undertaken to identify the appropriate populations that should form the basis of conservation/development programmes.

37. The Expert Consultation noted that some of the candidate high potential breeds, strains or populations given in Appendix 3 may also be threatened and recommended rapid action to identify their current status.

38. The Consultation recommended the Open Nucleus Breeding System (ONBS), both to facilitate conservation and for use in improving populations, to ensure that they are maintained as a valuable resource for present and future generations. In addition to its genetic advantages, the Expert Consultation considered ONBS an appropriate method as it offers the positive benefit of involving participants.

39. The Expert Consultation recommended that the application of the concept of Open Nucleus Breeding should be made in a manner which is conducive to genetic improvement in practical conditions. In particular, the nucleus animals must be maintained in similar environments and under similar husbandry conditions as the base herds and flocks.

40. The Expert Consultation recommended that guidelines be developed for the establishment of Open Nucleus Breeding Systems and for the conduct of such programmes for each breed or species for which the method is used. Such guidelines already exist for tropical hair sheep (FAO, in press).

E. BIOTECHNOLOGY

41. The Expert Consultation confirmed that FAO should continue closely to monitor the rapid developments in biotechnology in order to identify and make use of newly developed techniques for the preservation, characterization and utilization of animal genetic diversity.
42. The Expert Consultation noted that freezing and storage of semen, ova and embryos will continue to be major techniques and procedures for preservation, but that efficiencies vary considerably between species. Consequently it recommended specific efforts to achieve satisfactory efficiency levels for all species.

43. The Expert Consultation noted that whilst DNA storage is currently not an adequate alternative to the cryopreservation of germplasm, it is complementary and should be an integral component of the global animal genetic resources programme for possible future use and for research. Where possible, DNA should be stored in recognized animal gene banks with appropriate access and security measures.

44. To facilitate the process of DNA collection and storage, the Expert Consultation recommended that the action plan include the preparation and publication of a manual describing the sampling strategies and detailed protocols for the collection, preparation and storage of tissues, DNA and RNA libraries.

45. Further, recognizing that the types of genetic material that should be stored will vary according to the level of risk of the breed, strain or population, the Expert Consultation recommended the following policy:

<table>
<thead>
<tr>
<th>Breed/Population Status (as defined in Appendix 2)</th>
<th>Stored Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>DNA, RNA libraries, tissue</td>
</tr>
<tr>
<td>Endangered or vulnerable</td>
<td>DNA, tissue</td>
</tr>
<tr>
<td>Rare</td>
<td>DNA</td>
</tr>
</tbody>
</table>

46. The Expert Consultation noted that genetic distance studies based on protein and DNA variation are sometimes required both for description of threatened populations and for the choice of breeds, strains and populations for development programmes. It recommended that the action plan include such studies where distinct strains, breeds and populations are not identified and where phenotypically similar populations exist in more than one country or over wide geographical areas.

47. The Expert Consultation recognized that current expertise and facilities for DNA based genome studies are very limited in the developing countries, and recommended that the global action plan should include training programmes, the development of appropriate infrastructure and facilities and the formation of close linkages to established laboratories.

48. Recognizing that gene mapping research will have an important role in future conservation and development programmes, the Expert Consultation recommended that protocols for the identification and collection of appropriate individual and family DNA material should be established and the collection of appropriate materials for future research be initiated.
1. CONSERVATION

The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment.

(This definition of Conservation originates with the World Conservation Strategy, which was prepared by the World Conservation Union (IUCN), and the following collaborative organizations: United Nations Educational, Scientific and Cultural Organization (Unesco), the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), and the World Wide Fund for Nature (WWF)).

2. PRESERVATION

That aspect of Conservation by which a sample of an animal genetic resource population is designated to an isolated process of maintenance, by providing an environment free of the human forces which might bring about genetic change. The process may be in situ, whereby the sample consists of live animals in a natural environment, or it may be ex situ, whereby the sample is placed, for example, in cryogenic storage.

3. CONSERVATION BY MANAGEMENT

That aspect of Conservation by which a sample, or the whole of an animal population is subjected to planned genetic change with the aim of Sustaining, Utilizing, Restoring or Enhancing the quality and/or quantity of the animal genetic resource and its products of food, fibre or draught animal power.

4. THREATENED (Species, breed, strain or population)

A term used to describe an animal genetic resource population which is subject to some force of change, affecting the likelihood of it continuing indefinitely, either to exist, or to retain sufficient numbers to preserve the genetic characteristics which distinguish it from other populations. Threatened is a genetic term embracing more precise descriptions such as Endangered or Vulnerable.

(It is also so used in the context of the World Conservation Strategy).

1 Taken from FAO Animal Production and Health paper No 44/1 “Animal Genetic Resources Conservation by Management, Data Banking and Training”.

5. GENE BANK

A physical repository, in one or more locations, where the samples of animal genetic resources populations which are being preserved are kept. These may include animals, embryos, oocytes, sperm, DNA etc.
6. DATA BANK

The fund of knowledge comprising the Characterization and Census information which describe the genetic attributes of animal species, breeds, strains or populations and the various environments in which they occur; this information being stored both as numerics and words in a data/word processing system which provides for the addition of further information for amendment and for analytical use.

7. CHARACTERIZATION

The numeric/word description of:

i. the genetic attributes of an animal species, breed, strain or population which has a unique genetic identity; and

ii. the environment to which such species, breed, strain or population are adapted or known to be only partially or not adapted.

The Characterization is a succinct statement, being the distillation of all available knowledge both previously published or unpublished, which contributes to the reliable prediction of genetic performance in defined environments. It is different from the mere accumulation of existing reports or individual findings on genetic performance on specific occasions.

8. DESCRIPTORS (of species or environments)

A series of items with defined meanings for a species and its environments, which are universally used to prepare data bank Characterizations of:

i. breeds, strains or populations of a given species, covering the phenotypic and genetic parameters of the breed;

ii. environments in which breeds of a given species are found, covering the natural and artificial features relevant to genetic analysis, including such items as climate, topography, endemic disease risk, feed and water supply, and management systems.

The purpose of Descriptors is to facilitate valid comparison, classification or enumeration of breeds, strains or populations within a species in the context of the environments in different countries and regions of the world.
APPENDIX 2
FRAMEWORK FOR RISK CLASSIFICATION OF BREEDS AND PROGRAMME FOR ACTION

(adapted from Animal Production and Health paper No 99 “In situ conservation of livestock and poultry”, by E.L. Henson).

Table A - Identification of populations/breeds

Has a comprehensive national or regional survey of livestock and poultry used for or of potential use in agriculture been carried out?

Yes

Has a national or regional database been established?

Yes

Establish a mechanism to survey livestock and poultry in your nation/region.
To identify breeds:
- Is there a local breed name?
- Is the type locally recognised as distinct?
- Does the population have distinct production characteristics?
- Does the population have other distinct characteristics?
- Is the population restricted to a distinct local area or region?
- Does the population survive in a specialized environment?
- Does the population provide distinctive or specialized products?

No

Seek FAO assistance to establish a database and link into the global database.

No

Seek assistance to make a link into the global database.

Yes

For each of the identified populations/breeds go to Table B.

No

Has the data been lodged with the FAO/Regional database?

Yes

Seek FAO assistance to establish a database and link into the global database.

No

Establish a mechanism to survey livestock and poultry in your nation/region.
To identify breeds:
- Is there a local breed name?
- Is the type locally recognised as distinct?
- Does the population have distinct production characteristics?
- Does the population have other distinct characteristics?
- Is the population restricted to a distinct local area or region?
- Does the population survive in a specialized environment?
- Does the population provide distinctive or specialized products?

If the answer to any of these questions is YES, the population should be included in a national database and should be described, along with its production environment, using the FAO descriptors (FAO 1986a; FAO 1986b). This data should then be lodged with the FAO/Regional database.
Table B - Identification of stocks in need of preservation
(see section 3.4)

For all breeds identified in table A above and not found in larger numbers in neighbouring countries.

What is the estimated total population size of breeding females?

Are there special considerations with respect to the population that would place it at greater risk than is usual for a population of this size?

<table>
<thead>
<tr>
<th>Number of breeding females.</th>
</tr>
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<tbody>
<tr>
<td>&lt;100</td>
</tr>
<tr>
<td>100 - 1,000</td>
</tr>
<tr>
<td>1,000 - 5,000</td>
</tr>
<tr>
<td>5,000 - 10,000</td>
</tr>
<tr>
<td>&gt;10,000</td>
</tr>
</tbody>
</table>

- Critical: Go to table C
- Endangered: Go to table D
- Vulnerable: Go to table E
- Rare: Go to table F
- To monitor and evaluate

Table B1 - Special Considerations

The specific situation of each population is to be examined. Major considerations are:

- Degree of crossbreeding in the population
- Reproductive rate and generation interval of the population. Populations with low reproductive rates are at relatively greater risk than populations of high reproductive capacity of comparable size.
- Special peculiarities and characteristics of the production system (intensive, extensive, nomadic, etc.)
- Historic and current rates of decline in population numbers.
- Geographic isolation of the population or its concentration in one or a few locations that would place it at risk as a result of climatic, economic or political changes or disease outbreak.

Populations deemed at additional risk with respect to the above considerations, would be placed in the next higher category (Table B).
Once classified, action plans for conservation of the population are to be implemented as per Tables C (Critical), D (Endangered), E (Vulnerable) and F (Rare).

Table C1 - Critical Live Population

A live animal conservation project must be established.

Objectives:

- To increase the size of the breeding herd as rapidly as possible.
- To establish a central breeding nucleus with at least an effective population size \((N_e)^*\) of 50.
- To develop the breed for its qualities.
- To minimize the loss of heterozygosity due to inbreeding and drift.
- To use the conservation herds to monitor and characterize the breed.

Methods:

- A well planned conservation herd should be established and/or a conser programme established to coordinate the farmers and institutions already using the breed.
- Sample as much of the population as possible.
- Breeding groups ideally should be at different locations to reduce the risk of disease.

Footnote: * Effective population size \(N_e = 4Nm Nf/(Nm+Nf)\) where \(Nm = \) no. of br males per generation and \(Nf = \) no. of breeding females per generation.
Table D - Endangered Population
Action to conserve is needed to prevent further erosion of the genetic variation found within the population.

- Is collection and cryogenic storage of material from this species technically possible?
  - No → Go to Table C1
  - Yes
    - Is technology available to collect and store semen, eggs and embryos within the country?
      - No
      - Are there regional facilities, budgets or programmes to collect and store materials into which samples from this population could be included?
        - No → Go to Table C1
        - Yes → Sample as large a number of animals as possible. In particular a large collection of semen from unrelated males for long term storage and immediate use would be beneficial.
      - Yes → Go to Table C1

Table E - Vulnerable Populations
Action is needed to evaluate the breed and prevent substantial loss of genetic variation.

- Has the breed been well characterized?
  - Yes
    - Does the breed have recognisable attributes which are, or could be, of value?
      - No
        - Is collection of cryogenic storage material possible?
          - Yes → Make a cryogenic sample and monitor the live population.
          - No
            - Is the population similar to the other breeds in need of conservation with which it could be pooled?
              - Yes → Form a breed pool and manage as in Table C1.
              - No → Establish conservation herds which may be in association with appropriate organizations.
      - Yes → Establish programmes to monitor the production of the breed and its crosses in its native environment.
    - No → Establish programmes to monitor the production of the breed and its crosses in its native environment.

Table E1 - Vulnerable Livestock Objective
- To promote the attributes of the breed by better monitoring and promotion.

Methods
- Increase research into breed.
- Encourage the formation of broader groups and breed promotion.
- Select within sustainable management techniques for the beneficial characteristics of the breed.
Table F - Rare Populations

Has the breed been well characterized?

No

Establish a programme to monitor the production of the breed and its crosses in its native environment.

Yes

Decline in population numbers is normally due to changes in management techniques and to replacement breeds.

Are the changes affecting this breed sustainable in the long term?

Possibly no

Yes

Does the breed have recognizable attributes which are still beneficial?

No

Is collection and cryogenic storage possible?

No

Monitor population numbers, a live animal conservation programme may be needed in the future.

Yes

Make a cryogenic sample.

Table F1 - Insecure Livestock

Objective
-to develop breeding programmes to make better use of genetic characteristics of the breed.
-research into crossing potential and specialized uses.

Methods
-selection should be for increased production within sustainable management techniques.
-Farmer subsidy and nucleus breeding herds may be used.
## APPENDIX 3
Breeds, strains or populations suggested as those having highest priority for conservation by management

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>ASIA</th>
<th>AFRICA</th>
<th>4 LATIN AMERICA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Sahiwal(1)*</td>
<td>N'Dama(2)</td>
<td>Criollo(3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kenana(4)</td>
<td>Guzera(6)</td>
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<tr>
<td></td>
<td></td>
<td>Boran(5)</td>
<td></td>
</tr>
<tr>
<td>Buffalo</td>
<td>Murrah(1)</td>
<td>Djallonke(1)</td>
<td>Pelibuey(2)</td>
</tr>
<tr>
<td></td>
<td>Nili-Ravi(3)</td>
<td>D'man(4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Swamp(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>Javanese Thin tail(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Awassi(5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Djallonke(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D'man(4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goats</td>
<td>Damascus(2)</td>
<td>Fouta Djallon(1)</td>
<td>Moxoto(4)</td>
</tr>
<tr>
<td></td>
<td>Jamnapari(3)</td>
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<td>Taihu(1)</td>
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<td></td>
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<td>Camelidae</td>
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<td>Huacaya Alpaca(1)</td>
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<td></td>
<td></td>
<td>Suri Alpaca(2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Qara Lama(3)</td>
</tr>
<tr>
<td>Horses</td>
<td>Ahal-Teke(1)</td>
<td></td>
<td>Pantaneiro(2)</td>
</tr>
<tr>
<td>Poultry</td>
<td>Domestic ducks(4)</td>
<td>Guinea fowl(2)</td>
<td>Indigenous Turkeys(1)</td>
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<td>Muscovy ducks(3a)</td>
<td>Chickens(5b)</td>
<td>Muscovy ducks(3b)</td>
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<td></td>
<td>Chickens(5a)</td>
<td></td>
<td>Chickens(5c)</td>
</tr>
</tbody>
</table>

* Numbers in parentheses indicate priority order within species groups
A. OPENING AND GENERAL INTRODUCTION

THE MANAGEMENT OF GLOBAL ANIMAL GENETIC RESOURCES

OPENING STATEMENT

H. de Haen

On behalf of the Director-General and, more specifically the Agriculture Department, I welcome you to the Expert Consultation on the Management of Global Animal Genetic Resources. FAO appreciates the fact that experts from all corners of the world are willing to provide their knowledge to assist it in its task.

The role of livestock production in the achievement of sustainable agriculture is well recognized. The ability of various types of livestock to use roughage, crop residues and various waste feeds and by-products is well known and utilized although not always fully exploited. The ability to survive in and adapt to any array of environments did not always get due consideration either. The contribution to the food diet in terms of milk and meat provides a valuable, albeit in many cases small, addition to protein intake and the animals provide products for use as hides, skins, wool, plus manure either as fertilizer or as fuel and, in some cases, animals provide draught power.

World population continues to grow. While total livestock production has increased, the output per individual livestock unit has not changed significantly. The most pressing need for increased animal efficiency is to feed animals adequately but there is another need which is becoming ever more urgent as the pressure grows for animal production to increase output and that is to ensure that the genetic resource base is maintained.

Increased communication, access and technical options are adding to the pressures to exploit genetic programmes for short term gains. Such pressures, particularly from politicians, are quite understandable and correctly reflect priorities to feed people. While programmes should aim to exploit genetic variability in the optimal manner there is now a much clearer understanding that there should be no loss of genetic resource in achieving gains. For the longer term, it is crucial that such genetic resources as exist should be maintained. Genetic programmes need to be sustainable in their own right. This should be seen not necessarily on a country basis but in the context of the environment in which the animals are required to produce. From the viewpoint of
sustainable agriculture, conservation of animal genetic diversity is an important component of the preserving natural resources base.

The traditional twin approaches of improved use versus maintenance of genetic diversity should no longer be seen as a dilemma since the need is for both and both can be achieved. Indeed it is part of FAO's responsibility to ensure that both occur. FAO has been concerned with this aspect of livestock production virtually since its inception. About 50 percent of FAO publications on animal production and health have been concerned with the subject, with one as early as 1948 on “Breeding livestock adapted to unfavourable environments”.

FAO has been more active on Animal Genetic Resources since the special FAO/UNEP Technical Consultation in 1980. One of the papers at this present Expert Consultation comprehensively reviews the progress over this period. In recent years, the FAO Committee on Agriculture (COAG) and the FAO Council have regularly considered animal genetic resource matters and have supported the increasing development of a long term programme.

At its meeting in April 1991, the COAG stated in its report to the FAO Council the following endorsement of plans for the preservation and improvement of animal genetic resources.

"The Committee welcomed the increased attention and activities aimed at strengthening national capabilities in developing countries for the conservation and utilization of animal genetic resources. It noted that this went a long way in responding to the Council recommendation that FAO prepare a programme for the sustainable development of animal genetic resources on a global level. The Committee supported the idea and, in particular, the activities proposed to initiate the programme, i.e.:

- to procure information for the Global Data Bank on breeds/populations;
- to estimate genetic distances between breeds and to design conservation policies;
- to undertake pilot projects for the genetic improvements of valuable under-utilized breeds and promote their use and conservation;
- to make comparative evaluations of germplasm within and across regions, in order to design breeding strategies for improved livestock economic efficiency;
- to preserve endangered breeds through in situ and cryopreservation schemes; and
- to undertake in-service training and workshops on the above subjects.

"The Committee urged care to ensure that in selecting for one trait, other traits of equal or greater value are not lost. The Committee also urged FAO to include camelides - camels and especially alpaca - in the pilot projects for genetic improvement.

“Following the request of the last session of the Council the Committee examined the possibilities for widening the mandate of the Commission of Plant Genetic Resources to become the Commission for Biodiversity in Food and Agriculture. The Committee could not agree to broaden the mandate at this time and consequently, it recommended calling an expert consultation, provided that funds could be located, to assist in making a more informed judgement about the desirability of establishing a separate forum for animal genetic resources. The expert consultation would also assess the proposed programme on animal genetic resources.”
These paragraphs clearly indicate what the Eleventh Session of the Committee on Agriculture (COAG) had in mind when it proposed the Expert Consultation. The objectives are clearly stated and will be the major areas addressed over the next few days. None of the subjects referred to or as elaborated in the agenda of this meeting is new. The outline programme sent to you last year with the initial indication of this meeting is a useful start but it requires full evaluation and assessment. The recommendations of the 1989 FAO expert consultation on animal genetic resources are contained in the report and proceedings (FAO, 1990) of that meeting. They should be considered alongside the elements of the most recent COAG request which are all contained in the agenda of this expert consultation. It is a wide ranging agenda covering detailed consideration of policy issues, the degree of threat, global evaluation of species and the role of the new biotechnologies as well as legal, structural and institutional matters.

It is clear that there is greater awareness that a framework for the management of global animal genetic resources must be established. It is most appropriate that this Expert Consultation is taking place now in the context and timing of the Earth Summit, the United Nations Conference on Environment and Development (UNCED) to be held in Brazil in about eight weeks time.

It is pleasing to note that the Agenda 21 document at the Earth Summit, which concerns ongoing issues for the next century, includes the FAO proposals on animal genetic resources as a specific section. These are naturally based on the FAO outline programme, which you are further to develop here.

Given the world concern for biological diversity and given the fact that there are about 2,500 identified breeds of farm livestock (500 in Europe and 2000 elsewhere), it is important that the new programme is clearly defined and can be applied with urgency. I note from papers you will consider at this Expert Consultation that some 26 percent of identified breeds in developing countries have census figures on populations and 30 percent have production records; clearly there is more work to be done at this level alone.

This Expert Consultation is meeting as there is greater recognition of the need and increased activity to safeguard the global environment and biological diversity. At the same time, the need to feed the world remains and that problem continues to increase; it is a considerable task but certainly is not insurmountable. This Expert Consultation should, by its deliberations and in its final documents, provide clear guidelines for global activities concerned with the improved use and the conservation of animal genetic resources which is an important component of the ongoing task of feeding the world. It is crucial that activities can be tackled with the urgency required. This expert consultation can provide the considerable weight of its expertise in assisting FAO to achieve that goal.

FAO, and in particular colleagues in the Animal Production and Health Division, is grateful for the time and effort which you are prepared to put into animal genetic resources and, in particular, into this meeting in preparation, in debate and in providing documented recommendations. I wish you well in your deliberations and a successful conclusion to your work.

Reference

1 Introduction

The decade of the 1980s has been one of change and progress for animal genetic resources. The growing world population and expectations of higher living standards are increasing the demand for animal products, especially in developing countries. In response livestock producers seek to increase productivity per animal. This usually involves attempts to change the genotype of traditional livestock types either by breed substitution or, more commonly, by crossbreeding. There is a tendency to focus upon fewer breeds and crosses which are more suited to current production systems and market conditions. Consequently many indigenous breeds with unique traits are threatened and may be lost in the absence of special steps to preserve them. In developing countries local animals are often specially adapted to harsh climates, able to use poor quality feed and to resist endemic disease. It would be tragic if they were lost. There is a growing awareness in the world community that an international approach is needed to preserve biological diversity in its many forms including animal genetic resources.

All possible aspects of animal genetic resources and the need for concerted conservation action have been discussed in a variety of fora over the last ten years. These include national and international gatherings of concerned livestock producers, scientists, administrators and international organizations both inter-governmental (IG) and non-governmental (NGO). Among the international agencies, FAO has taken a lead position, associated in some activities with UNEP. Several other inter-governmental organizations and non-governmental organizations such as Unesco, World Conservation Union (IUCN) and the World Resources Institute (WRI) have indicated their interest.

Studies and/or activities have been undertaken by some CGIAR centres, especially ILCA, ILRAD and CATIE. Regional groups have given time to the topic, including ALPA, ARABIC Groups, DAGENE, EAAP, the NORDIC countries, OAU/IBAR, SABRAO and others. National organizations in many developed countries have effective conservation programmes. Well known successful examples are the Rare Breed Survival Trust (RBST) in the UK and the American Minor Breed Conservancy (AMBC) in the USA. In developing countries, budding programmes are found only in the larger states such as Argentina, Brazil, China, and India. Animal genetic resources are currently on the agenda of UNDP and the World Bank and are included in the major theme of biological diversity at the UN Conference on Environment and Development (UNCED) Brazil in June 1992. The US National Research Council is currently completing a comprehensive review of animal genetic resources. At the 1993 World Conference on Animal Production to be held in Canada the issue is scheduled as a major topic. A new international NGO, Rare Breeds International (RBI), was created in 1991 with founder membership in 30 countries and is exclusively concerned with these issues. And this list is by no means exhaustive.
Despite this enormous interest and concern, programmes to date have been mainly national with the beginnings only of some regional activities. The activities have been most successful in the developed world, where a variety of private organizations has been established to engage in animal genetic conservation. During the years of central planning in countries of Eastern Europe and the former USSR, some governments started and maintained conservation programmes.

Even though there are successful programmes in the developed world, the main result of the widespread discussion and study to date has not been a world wide programme but rather raised awareness of and expectations for such an initiative. It may be recalled that in 1980, when FAO and UNEP called national governments together for a Technical Consultation (FAO, 1981) on animal genetic resources, the issues were low on the priority list for national and international action were poorly understood and were even regarded as a fringe topic compared with increasing animal output. The decade of stimulus from 1980–89 has been particularly valuable in putting animal genetic resources on the agenda of national governments and also of several influential international organizations. A realistic diagnosis of the present activities leads to the conclusion that there are two outstanding issues which call for urgent action.

a. First, there is relative lack of activity on animal genetic resources in most developing countries, (Hodges, 1990a).

b. Second, the issues in animal genetic resources are no longer amenable to national solutions. In the global village people and their domestic animals are inter-woven into common patterns of activity and need. The solutions, though applied locally, must be world wide in concept and design.

The format of this paper is to review the past, assess the present and highlight the issues needing resolution for action. A companion background paper is entitled “Policy Issues and Financial Requirement of the Programmes for the Conservation of Indigenous Livestock Breeds”. This first paper brings into a focussed review, in the next section, the conclusions from the many studies, discussions and reports of the last decade.

2 Need for a global programme for animal genetic resources

2.1 Rationale

Why should efforts be made to conserve threatened breeds? A minority has argued that there is no need to be concerned since market forces will automatically bring about any conservation which is really needed. Others opposed to organized conservation cite costs and the absence of any guaranteed returns as valid reasons to let matters take their own course. On the other hand, there is a substantial majority who feel that the reasons for not instituting programmes are inadequate and also that the loss of unique genetic material from domestic animals is unacceptable. Animal genetic diversity, they point out, is part of the earth's natural heritage and mankind depends upon animals for work, for clothing and for food. A distillation of the reasons to support institutionalized conservation, taken from the wide variety of sources already mentioned, is now given here:

2.1.1 Economic

Livestock are essential elements of the economy at local, national and international levels. These elements include the support of standards of living with livestock products and the contribution of livestock and livestock products to trade and wealth creation. Since genetic
variation is the raw material for animal improvement, its conservation provides options for uncertain and unknown future economic needs. Livestock management systems respond to economic conditions. The livestock industry in the future is likely to use different systems from those used today. Conserved genetic variation will offer the resources to respond quickly and economically to changes in the market. Most countries have animal genetic variation with adaptive and performance traits which are not needed for present management and economic conditions. Future producers and consumers together with all concerned with economics would consider this generation unwise to have failed to conserve this flexibility for future economic changes.

2.1.2 Scientific

Breeds with unique traits are of great interest scientifically in a number of ways. Some obvious examples are the unique DNA sequences of species, breeds, strains and populations, the specialized physiological and adaptive functions and the opportunity to study animals as biological models. At the molecular level science is entering a new era when society will benefit from manipulation of biological material. DNA, which holds the coding for genetic variation, is the key to this breakthrough. DNA combinations are highly important to science, even though their nature and function is not yet understood. Genetic variation will be of increasing interest and importance to science both at the animal and molecular levels in the future. Loss of the full range of animal genetic variation which has been developed over thousands of years of natural and human selection would be a great loss to science.

2.1.3 Human culture

For thousands of years livestock have been intimately associated with human life. They are one of the special characteristics of human culture. They are comparable with many other reminders of man's past civilizations and life styles which, when threatened, are treasured and preserved with little dispute.

2.1.4 Global biodiversity

Animal, plant, forest, fish and wildlife genetic resources are equal major components of biological diversity. The domesticated animal species ought not to be viewed as totally separate from the species of plants, trees and animals still found in natural environments. Domestic animals not only share DNA as the common basis of their genetic nature with all other species, but are also integrated in many management systems with pasture and forest species and with wild animals. The overall approach to the conservation of biological diversity should ideally embrace all these species as well as the animal breeds which provide diversity within the domestic animal species. Although animals, plants and forestry may need separate operational programmes, the linkages should be recognized and the activities planned in relation to each other so that, where possible unity in the conservation of biological diversity is achieved rather than competition.

2.1.5 Development and sustainability

A primary goal of the management of global animal genetic resources is to ensure the sustainable development of animal agriculture in particular and of agriculture in general. This is built upon the premise that conservation and development are parts of one process. Conservation has very reduced meaning if use, however far in the future, is not a basic premise.
Similarly use alone, as practiced by mankind today, automatically leads to loss of genetic diversity.

2.1.6 Environment

The environmental implications of domestic animals are substantial. There are billions of cattle, sheep and goats in human care in developing countries which daily move over huge areas of land, where they graze and browse on natural vegetation and depend upon natural supplies of water. The implications of their interactions with the other components of the environment are enormous. The interactions between domestic animals, wildlife, plants and trees, as well as micro-organisms, mean that any programme concerned with preserving the environment and biological diversity, especially in developing countries, must include animal genetic resources.

2.1.7 Social aspects

Livestock owners in developing countries are increasingly under economic pressure to change their indigenous breeds. In some cases such change can also affect their traditional lifestyle and thus have additional environmental impacts. Whether livestock owners decide for or against such changes, they deserve the support of the best information and the continued availability of animal genetic diversity so that they can make decisions which are valid for them, for their children and grandchildren, for their land - and for the global environment.

2.2 Conclusion on rationale for conservation

The above aspects of the rationale for the conservation of animal genetic resources are based on a recognition that society must use natural resources sustainably. An approach which is solely utilitarian and exploitative fails to anticipate tomorrow. Underlying the financial support for conservation is the concept of insurance. There are available and tried methods of conserving animal genetic resources which are neither costly in absolute terms nor in relation to the costs of preserving plants or forest trees.

2.3 The need for urgent action

The complex issues for and against planned conservation have been debated and evaluated in technical and economic terms in many different fora over the last ten years. Recently they have been formally reviewed by the member governments of FAO through the Committee on Agriculture (COAG), which approved the existing FAO programme without reservation and recognized the need to expand it to a global scale as quickly as possible. A report of this review is given in FAO (1990).

Why then, it may be asked, does such a global programme not already exist? No technical, scientific or philosophical barriers remain. Political approval and intent have been expressed. What are the limitations which have effectively precluded such a programme in the face of the unanimous support of national governments, the stated commitment of several international bodies, the scientific evidence and the expressed enthusiasm on the part of many private groups and individuals ? There are however two realms which, to date, have not been effectively structured and without which no further progress can be expected.

a. organization of a global programme
b. funding for the programme
These are the topics on which this Expert Consultation is asked to provide recommendations. This paper identifies the needed activities and addresses the question of how they should be organized. A second paper by the same author discusses the issues of policy and finance.

### 3 Historic patterns in the use of animal genetic resources

#### 3.1 Long term background

Since conservation involves not only the use of carefully designed practices in the present, but also anticipates the long term future, it is appropriate to pause for a moment and to look back over periods of time past to see how domestic livestock have come to their present position. Such a review highlights the extremely rapid pace of change now affecting animal genetic resources compared with the leisurely rates of change in the past. Time is limited. Options for conservation are reduced by delay. Perspectives on animal genetic variation are sharpened by standing back briefly to absorb the enormous impact of late twentieth century science and economics on domestic animals. Such a moment gives a better time frame against which to plan for the future.

Society has domesticated a limited number of animal species of which about fifteen are used generally for food, fibre and work. Six or seven of these are major species found in almost all communities throughout the world. They are cattle, sheep, goats, pigs, chickens, turkeys and in Asia, the buffalo. Although having centres of origin in specific locations these domesticated species, apart from the buffalo, have spread and are now used throughout the inhabited world. Through the large numbers of breeds and types which they comprise they exhibit great adaptability in the most diverse of climates and eco-systems. Since the breeds and types within a species can inter-breed, they provide an extraordinary and prolific source of genetic variation. Other domestic species - for example, camelidae, elephant and yak - are used by more limited numbers of people.

#### 3.2 Eras of change for animal genetic resources (Hodges, 1990b)

##### 3.2.1 Domestication

Centres of origin: 9,000-5,000 BC.

##### 3.2.2 Migrations of human populations with their domestic animals

Adaptation of animals to hostile environments; isolation; genetic drift, natural and human selection; the result is an enormous number of highly adapted breeds of animals within each domestic animals species. 5,000 BC-1700 AD.

##### 3.2.3 Controlled matings

Herd books; more intensive selection for preferred types. 1,700–1945 AD

##### 3.2.4 Application of science
Artificial insemination; freezing of semen; new quantitative methods for selection of desired traits; computers; selection of inbred populations; crossbreeding; movements of semen and livestock internationally on a large scale. 1945-present.

3.2.5 Era of biotechnology

Started in 1980s, may be decades before widely applied at farm level, but has enormous potential; embryo manipulation including splitting, cloning, sexing; in vitro fertilization; transgenic animals with designer gene mix; new applications of quantitative genetics; hormonal control of reproduction, growth and lactation.

3.3 Evaluation of legacy of the past in animal genetic resources

Because developing countries have a greater range of natural environments than temperate zones, they have a wealth of indigenous animal and poultry breeds and types, which over thousands of years have become adapted to difficult and harsh conditions. Local breeds are frequently associated with characteristic human lifestyles, which have often been shaped around the indigenous animals in many different environments and agro-economic niches. The land resource includes tropical cropland, deserts, arid and sub-arid areas, rain forests, grasslands, cold tundra, high ranges, and a great variety of climates. Some arid areas cannot support large scale crop production and therefore maintain limited populations of specialized ruminant species and breeds which bring the poor natural herbage into the human food chain. Other examples of adaptation to a special environment are the trypanotolerant breeds of Central and West Africa where trypanosomiasis is endemic. There are many others less well known. In regions of higher elevation where insect vectors of some tropical animal diseases cannot live, for example in the highlands of East Africa, large livestock populations are found which consist of many breeds with differing adaptations.

The prevalence of small scale livestock ownership in many parts of the developing world and the isolation of communities over centuries contributes to the integration of animals with human lifestyles, diet, work habits, wealth and traditions. This isolation has resulted in many local breeds, usually easily identifiable by their different appearances. Often, however, it is not known whether these morphological differences are symptomatic of true genetic differences in performance. What is known, however, is the outstanding ability of many indigenous breeds to survive and support human life within specific agro-ecosystems. Until recently human interventions have been introduced only by the local people and have produced a variety of management systems ranging from the nomadic and transhumant to small livestock producers, large range systems and integrated crop/livestock farming.

Relatively little change took place during thousands of years. Although the colonial periods brought new livestock introductions to the Americas where some of the major species did not previously exist, by contrast, in Asia, Africa and the Middle East even the colonial periods brought little change in animal agriculture. Much has changed in the last forty years. In Europe and North America during this period man has changed the genetic make-up of domestic livestock through quantitative genetics allied to the widespread use of artificial insemination (AI) and the long-term storage of semen by freezing. Breed replacement was the first step, followed by constantly improved breeding methods within a few high performance breeds and resulting in massive increases in animal productivity. Though a little late in starting, conservation of the declining breeds has now been established in all countries of the developed world and only relatively few of the old indigenous breeds were totally lost.
The economic and technical orientation of western civilization calls for comparable changes and benefits to improve the livestock of developing countries. So, it has been tempting, both to the leaders of animal production in developing countries and to specialists in the developed world, to try to increase individual animal production in the tropics with similar methods. However, the transfer of these techniques and germplasm to developing countries has, to date, achieved only very limited success with ruminant livestock at the level of the producer. This is due to several reasons. First, temperate breeds of ruminants are largely unable to achieve their normal performance and even to survive for long in tropical environments. Second, the limited social and economic infrastructures have precluded the adequate use of the modern techniques of AI and field breeding programmes.

Nevertheless the increased international movement of genes in semen and increasingly in embryos has affected livestock of the developing world. Since the higher producing temperate breeds cannot survive in pure form, crossbreeding indigenous with temperate breeds is an attractive option. Crossing with exotic tropical breeds having both higher economic value and adaptation is also practiced. Frequently entering through government research or livestock stations, shipments of exotic semen, embryos and animals, as purchases, gifts or aid, have been used to produce crossbred animals which are then released into the community of livestock owners. These animals bring variable mixes of genes from the indigenous and the imported breeds. Success in raising production brings an additional cost; namely, that the indigenous breed, in pure form, faces dilution and possibly extinction. Failed introductions can also have similar effect. Consequently many indigenous breeds with unique adaptive genetic traits are today threatened by new breeding practices and exotic germplasm. Although hard, quantitative information is difficult to obtain, no serious observer of the local scenes doubts that indigenous breeds are at high risk. Some countries have tried to assess the extent of the loss and risk. For example, in Africa, the Organization for African Unity (OAU), through its Inter-African Bureau for Animal Resources (IBAR), has attempted breed surveys from time to time which, though far from complete, reveal significant numbers of breeds which are already threatened and many others whose populations are in decline. These surveys show clearly that breed erosion is mainly due to economic pressures on livestock owners to increase animal output by displacing indigenous breeds or by cross-breeding them with exotic breeds with higher performance. The same story is known in most other parts of the developing world. In all cases, the indigenous breed in pure form is under threat.

It is most important to state clearly at this point that the aim of conservation is not to preserve the indigenous breeds and their owners in developing countries in the status quo, without the benefits of improved animals. As already noted, well designed conservation programmes combine improved use and preservation of indigenous breeds in economically viable, scientifically sound, long term, sustainable programmes. However, such programmes are clearly not being offered to most livestock producers at present. It is not an easy task, as international agencies and national specialists have discovered. Even in optimum circumstances there are considerable organizational difficulties in structuring the crossbreeding of ruminants to obtain the desired gene mix.

It is concluded that in most developing countries where the infrastructures are generally poor, the only certain genetic result has been a decrease in numbers of the purebred indigenous animals. Nevertheless considerable efforts are in progress to assist livestock producers to benefit from improved output per animal. A good livestock development programme which includes a genetic component, should always aim to maintain a pure population of the
indigenous breed. This is necessary for ongoing genetic improvement, otherwise the source of the adaptive genes needed for future generations of crossbred animals is lost.

4 Record of institutional activities

4.1 International activities since 1945

The United Nations has been concerned with animal genetic resources for more than forty years. As early as 1948, FAO published its first study on the subject, entitled “Breeding Livestock Adapted to Unfavourable Environments”. Growing FAO activities in this field are demonstrated by publications over the next twenty-five years, mostly arising from studies or projects on different livestock species. Examples are “Zebu Cattle of India and Pakistan (1953); “Types and Breeds of African Cattle” (1957); and “The Buffaloes of China” (1970). (See Appendix 1 for a full list of FAO and FAO/UNEP publications in this field.) This documentation, while valuable in its day, was often concerned with descriptions of the breeds in the natural environments where they were found. Genetic improvement was largely concerned with selection within the indigenous breed. It was slow and often limited in success. More, animal production was gained by improved health care and nutrition.

4.2 Increasing application of science

In the 1960s, when the technique for freezing semen became possible, interest in the international movement of animal germplasm grew rapidly with the aim of increasing livestock production in developing countries, many of which were newly independent. By that time the displacement of traditional breeds in the developed world was well advanced. No serious adaptation problems were encountered in Europe when temperate breeds replaced other temperate breeds. Consequently genetic improvement methods in developed regions emphasized selection within breeds using quantitative genetic techniques. However breed substitution and quantitative genetic methods were not easily transferred to the tropics where problems of animal adaptation became evident. As a result the focus of livestock improvement in the tropics moved to defining the appropriate mix of exotic and indigenous genes for a given environment, to the genetic effects of crossbreeding and to organizational methods for achieving the desired gene mix.

4.3 Growing interest in the environment

At the same time more thorough studies were started of the environment in which the domestic animal lives. This has resulted in a better understanding of the limiting factors of the environment in animal production and of the interactions between natural habitats and breeds with special adaptation traits. In developing regions other than Africa, these studies have resulted in the introduction of some practices to change the natural environment, thus adjusting a new animal gene mix to a modified environment. In Africa this approach has been very limited. Most African livestock systems for ruminants remain in an essentially unmodified natural environment.

4.4 The creation of United Nations Environment Programme

The growing international awareness of a deteriorating environment in the early 1970s led to the 1973 UN Stockholm Conference and to the creation of the United Nations Environment Programme (UNEP). FAO was one of the first UN Specialized Agencies to join with the newly
established UNEP in formulating joint projects which took account of the need for development and conservation to be practiced together. In the mid 1970s, a joint FAO/UNEP project for the Conservation and Management of Animal Genetic Resources was set up. It soon became clear that activity on a single country basis was inadequate. Many issues and needs were, in principle, common to all developing countries. FAO publications of the period show interest moving to regional activities and to the study of species found in many countries. Examples are “Bibliography on the Criollo Cattle of the Americas” (1977), Mediterranean Cattle and Sheep in Crossbreeding” (1978) and “Dairy Cattle Breeding in the Humid Tropics” (1979).

4.5 FAO/UNEP Technical Consultation and programme

In 1980, FAO and the United Nations Environment Programme (UNEP) held a Technical Consultation on the Conservation and Management of Animal Genetic Resources, the aim of which was to identify priority areas and activities on a global and regional basis. All member governments of FAO and of UNEP were invited. Representatives of more than one hundred member governments participated. It should be noted that at that time the term ‘Management’ was used to include development activities; thus the concepts of improvement and conservation were already seen together. The meeting produced a comprehensive series of recommendations. These covered the reasons for genetic erosion in animal resources, rationale for conservation being linked with improved management, establishment of regional activities, data banks and gene banks, promotion of appropriate research in areas likely to aid conservation and reproduction, training nationals of developing countries, study of health barriers to movements of germplasm, breeding programmes for conservation and for improvement, special studies of the little known animal populations in the USSR and China, publication of a newsletter and the creation of an FAO/UNEP Joint Expert Advisory Panel.

These activities were all completed between 1982 and 1989, being financially supported by UNEP through a renewed joint FAO/UNEP project and by the FAO Regular Programme. FAO was the executing agency. Methodology studies and field trials in many countries were completed, documented and published for characterizing breeds, operating animal genetic data banks, sampling threatened populations, collecting semen, embryos and DNA, health checks and monitoring and establishing cryogenic gene banks.

A close watch was maintained on developments in biotechnology, especially in two areas which might contribute to improved conservation techniques. These are:

- genome mapping, DNA handling and genome libraries,
- reproduction and embryo manipulation.

Training courses were held, a periodic publication - Animal Genetic Resources Information - was issued, the animal genetic resources of the USSR and China were surveyed and published and the FAO/UNEP Joint Expert Panel met several times to monitor progress and make further recommendations. Other Expert Consultations were also held for special subjects; for example, on the final appraisal of the trials to develop new Animal Descriptors.

In addition, the necessary infrastructures for regional cryogenic animal gene banks were negotiated with governments in 7 developing countries (Africa - Ethiopia and Senegal; Asia - China and India; Latin America - Argentine, Brazil, Mexico). Lack of funding has so far restricted the inflow of germplasm from other countries in the regions, although in Latin America a training course for nationals of participating countries has been held. Also an animal genetic data bank
was arranged in 1988 by the European Association of Animal Production (EAAP) and FAO at Hannover, Germany which has a comprehensive set of data on all European breeds, (Simon, 1990). Nationals from the 7 developing country regional animal gene banks were trained at Hannover, (Hodges, 1990c). However, limited data has been flowing from developing countries.

In 1991, FAO set up a matching Data Bank which includes all developing regions. It has been designed to bring together in one system the animal genetic information contained in the large variety of FAO livestock reports, publications and projects. The FAO data base uses software developed at the FAO/EAAP Data Bank in Hannover, Germany. The FAO bank used Mason's “World Dictionary of Livestock Breeds” (Mason, 1988) as a framework. This is the only orderly world list of domestic breeds and although it has little characterization data, it nevertheless offers a unique classification of most breeds. The FAO Data Bank has names of 1608 breeds in Africa, Asia, Central and Latin America. 29% and 21 % have some information on production and population size, respectively (see note on FAO global animal genetic data bank in this publication). This will form the skeleton for a new developing world inventory.

4.6 Review of FAO/UNEP programme

In 1989, the FAO Committee on Agriculture (COAG), which is one of the Governing Bodies of the Organization, reviewed the programme on animal genetic resources. The COAG commended the work and recognized that there is now an urgent need to apply these proven conservation techniques on a global scale. Subsequently, the FAO Council affirmed the recommendations of the COAG and called for the programme to be expanded and further developed. It also recommended that lack of funding should not be the cause of delay in implementation nor lessen the impetus already achieved. Unfortunately, several events have prevented the implementation of the global programme so far. While it is clear that FAO's regular programme could never finance the development of the global programme, restrictions on FAO's budget in recent years have also unfortunately limited any expansion of the small group of FAO staff working on this sub-programme. The need for special funding was recognized by the COAG, which proposed a special trust fund for animal genetic resources and invited individual governments to donated. Apart from one or two significant indications of future support, this appeal has not resulted in any general response. This is due, in part, to the present economic climate and the absence to date of an agreed organizational system for a world wide programme. In the meanwhile, FAO is continuing with some activities supported by the Regular Programme and UNEP is continuing to provide some funds.

5 The present position

A solid decade of work on animal genetic resources conservation has been carried out by FAO and UNEP in cooperation with some other bodies and includes the following: the original consultation in 1980 at the inter-governmental and technical levels; constant monitoring of technical developments; design, trial and documentation of methods; identification of breeds in need of conservation; development of rationale and methods for the integration of development and conservation of animal genetic resources; pilot field programmes with select breeds; experience in training; establishment of needed technical infrastructures for data and gene banks; publications; raising levels of awareness among governments; and cooperation with other bodies having similar interests in animal genetic resources in the developing countries. Techniques are established, tested and ready for application, as listed in the following paragraphs.
6 Work done

6.1 Identification and sampling of threatened breeds

All needed knowledge is available on methods for identification of threatened breeds and populations, estimation of effective populations sizes, analysis of structure, demography and rates of change of populations, sampling techniques to ensure that genetic variation is preserved, avoidance of inbreeding, criteria for selection of animals for preservation, numbers of doses of semen, embryos or oocytes per donor and per breed, collection of blood and extraction of DNA and collection of appropriate records for long term storage and subsequent use of germplasm.

6.2 Animal gene banks

(a) Cryogenic storage of semen of most species and of embryos of some species are available techniques. Long term storage of DNA is a most convenient and practical process.

(b) Techniques for reproductive manipulation are available for collection of germplasm, including screening of male and female donors, evaluation, processing, freezing and labelling of semen and embryos

(c) Regional animal gene banks for the cryogenic storage of germplasm and DNA have been established in principle with key governments in Africa, Asia and Latin America. A training course has been held in the latter region. Such gene banks would provide uniform methodology and split samples for the secure storage of germplasm and DNA. Organizational and legal aspects need more work.

(d) Such regional animal gene banks are well suited to serve the interests of smaller countries whose national resources are limited and for which national animal gene banks would be extravagant. Many developing country governments have indicated their wish to take part in such regional facilities and also for their nationals to receive training in the needed techniques.

6.3 Animal health

Technical aspects of animal health procedures and protocols are well developed, including tests for suspect diseases, appropriate tests for shipment, quarantine and isolation and records to accompany samples.

6.4 Animal genetic data banks

(a) Methods exist for handling passport, characterization, census and other breed data. Software programmes have been prepared, tested and are in use in animal data banks.

(b) An Animal Data Bank is established and fully operational at Hannover in Germany, which has focussed largely mainly on the animal genetic resources of Europe. An Animal Data Bank for developing countries is established at FAO in Rome and is compatible with the German counterpart.

6.5 Preservation of breeding herds or flocks
Considerable experience has been gained in developed countries in establishing and operating breeding herds or flocks for preservation. Some of the larger developing countries have also established herds or flocks of breeding animals.

6.6 Breed development strategies

Experience has been gained on the introduction of genetic improvement programmes which integrate with the indigenous breeds and thus avoid endangering animal genetic resources.

6.7 Indigenous selection conservation programmes

New methods are under trial in both developed and developing countries for the genetic improvement of indigenous breeds. These include Nucleus Breeding, with or without Multiple Ovulation Embryo Transfer (MOET) and Genetic Screening.

6.8 Government approval

The FAO Committee on Agriculture (COAG) approved the work to date without reservation and recommended that it be expanded to an operational global programme as a matter of urgency. The work to be done is listed in outline below. More details are given in Hodges, 1991.

7 Tasks remaining

- There are many breeds of indigenous livestock in developing countries which are declining. The rate of decline, the current numbers of animals, the distribution and likely dates for extinction are generally not known. Mason's Dictionary indicates some indigenous breeds have already been lost.
- The genetic characteristics of many threatened breeds in developing countries are poorly documented. Although their production may be relatively low, resulting in declining economic interest, breeds often have unique adaptive qualities.
- Attempts to document the status of breeds by mail surveys have generally not been successful. It is most difficult to obtain accurate information in many countries and sub-regions where breeds are most at risk.
- National boundaries are poor indicators of breed distribution. Breeds frequently exist in several countries, although known by different names.
- Legal protocols are needed to ensure that the samples in a regional animal gene bank have identified ownership and access to third parties under agreed conditions is guaranteed.
- Animal health protocols which are agreed in principle need to be established for the transfer of germplasm from country to country for storage in regional animal gene banks. The practical procedures must ensure that animal diseases are not spread via regional animal gene banks, that accurate records are established of the health status of the animals from which the samples are taken and that any restrictions are realistic and do not limit activities.
- The existing data on indigenous breeds in developing countries must be brought together, examined and verified if needed, then collated into a useable system. While not necessarily meaning that it must be in one location, it must be uniform and accessible to all users.
- Documentation is needed of breeds for which there is no data on genetic characterizations, population status or productions/ adaptability traits.
- A World Watch List is required to provide governments with early warning.
- Technical and financial support is requested by many developing countries wishing to develop breeding herds or flocks for preservation programmes.
- Training programmes are needed for both national scientists and administrators in the operation and management of national programmes and to provide them with a window on their involvement and connection with the global facilities and programme.
- Studies on genetic distance are needed to establish relationships between breeds having different names or being in different locations. These will also provide clues to preservation needs, and in the longer term will enhance the scientific understanding of adaptive and productive traits.
- Provision of breeding strategies to national governments.
- Creation of appropriate infrastructure and institutions to implement a global programme for animal genetic resources at national and international levels.
- Source of new funding for a global programme.

8 Issues to be included in a global action plan

This comprehensive review of the past offers a harvest of valuable information for deciding where to go from here. Present decision makers also have a heritage of recommendations from earlier Expert Consultations and from the FAO COAG and Council. Combining this distilled experience of the last decade with new visions and rising interest from the world community, it should now be possible to design an Action Plan for the Management of Global Animal Genetic Resources. That is the task of the Expert Consultation in April, 1992. This paper, as an introduction to that Expert Consultation, provides an Agenda for that Action Plan. In other words it identifies the issues which ought to be considered for inclusion in the Action Plan at the national and international levels. This final stage of this paper therefore brings forward issues in an orderly way which must be addressed by the Expert Consultation.

8.1 Information handling

Handling of information includes the rationalization of existing limited amounts of data; the identification of breeds, environments and animal management systems from which additional data is needed; and the analyses of data to support valid decision making on conservation and utilization programmes. Rationalization of existing information and harvesting of new data will permit priority lists of breeds for special attention by country and region. A further output from the data handling activity will be the new World Watch List for Animal Genetic Resources.

8.2 Field programmes for individual breeds

Arising from the World Watch List will be identification of both high potential and high risk breeds. Field programmes will then be designed to the needs of individual breeds and will include development strategy plans and indigenous selection/conservation programmes.

8.3 Preservation

Priority must be given to preservation of breeds which are threatened. Even though their uniqueness may not be clearly documented, preservation action should be taken before they disappear. It is possible that some breeds which are not unique may be preserved. This is part of the price of ensuring that truly threatened breeds are not totally lost. It is a relatively small price.
Breeding herds or flocks for preservation programmes should be encouraged on a national basis, wherever possible, by drawing international attention to the declining and threatened breeds, seeking financial support and emphasizing the opportunity for individuals to contribute. Such in situ preservation is particularly important for poultry, where the cost of keeping individual live birds is modest.

8.4 Creation of appropriate infrastructures

New institutional facilities to support field activities will be needed. They need not be large, but they must be suitable for liaison with national governments, international bodies both governmental and NGO, and with bi-lateral organizations working on animal genetic resources. They should include Cryogenic Animal Gene Bank(s) and Animal Genetic Data Bank(s).

Training

Programmes for training nationals for a variety of tasks will be needed, including aspects of genetics, breed development strategy plans and indigenous selection/conservation programmes, reproduction, data handling, sampling of donor animals, handling of semen and embryos, animal health controls and computer systems. FAO has already designed and used training courses on these topics.

8.6 National management of animal genetic resources

The national management of animal genetic resources will be a key activity. It will involve skills at the technical, personnel, diplomatic and financial levels. It will involve establishment of full cooperation between participating governments and will liaison with qualified agencies concerned with animal genetic resources.

It is considered vital that the programme should be linked nationally and regionally, not only philosophically, but in reality, with other projects concerned with different components of biological diversity and the environment. A major goal is to ensure the sustainable development of animal genetic resources. Conservation and development are parts of one process. The global programme must guarantee that present and future livestock owners, whatever their economic orientation and preferred animal management system, will have available the full range of animal genetic diversity.

Links between animal genetic resources and wildlife are recognized and should be explored and applied with benefit to both groups at national and regional levels. FAO has established good relationships with organizations in this field including UNEP and IUCN.

9 Conclusion

The discussion and experiences of the last decade provide a consensus that a global programme for the conservation and improved use of animal genetic resources is urgently needed. Such a programme has the aim of ensuring that no more animal genetic resources are lost and that those which are threatened by changing livestock and farming practices are secured for posterity. These ends are to be achieved by activities which recognize animal genetic resources, together with plant and forestry genetic resources and wild life as related, major components of biological diversity and of the environment. The needed technology and
methods are available. The political will has been expressed and repeated in urgent terms by the FAO COAG and Council in the last two years.

The task is now to create a management system able to organize the conservation and the improved use of animal genetic resources so that they are linked in reality as well as in concept with the sustainable development of animal agriculture to meet increasing human needs and expectations. Several earlier Expert Consultations have addressed the technical and scientific issues. This Expert Consultation is asked for recommendations on organization, programme priorities and a budget. Both privilege and responsibility rest upon this meeting. In animal genetic terms we stand at an historic moment. Like Yalta or the Congress of Vienna in a different context, the output of the meeting, be it good or bad, will inevitably affect the future of the subject being decided. Expectations for a global programme for animal genetic resources have been raised over many years. Decisions on organization and structure have earlier been postponed. Now they must be made. In the words of Shakespeare “there comes a time in the affairs of men, which taken at the flood leads on to fortune”. For animal genetic resources, after many years, that time is now.

10 References


11 Annex FAO and FAO/UNEP publications on animal genetic resources

APAHP No.

1977  1 Animal breeding: selected articles from World Animal Review

1977  5 Bibliography of the Criollo cattle of the Americas

1977  6 Mediterranean cattle and sheep in crossbreeding
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<td>Buffalo reproduction and artificial insemination</td>
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Vol 1 - General study |
| 1980 | 20/2 | Trypanotolerant livestock in West and Central Africa  
Vol 2 - Country studies |
| 1981 | 22   | Recursos genéticos animales en America Latina |
| 1982 | 23   | Disease control in semen and embryos |
| 1981 | 24   | Animal genetic resources - conservation and management |
| 1982 | 25   | Reproductive efficiency in cattle |
| 1982 | 26   | Camels and camel milk |
| 1982 | 27   | Deer farming |
| 1982 | 30   | Sheep and goat breeds of India |
| 1982 | 34   | Breeding plans for ruminant livestock in the tropics |
| 1983 |      | Animal genetic resources in Africa - high potential and endangered livestock. Published: FAO/UNEP/OAU-IBAR |
| 1984 | 42   | Animal energy in agriculture in Africa and Asia |
| 1984 | 44/1 | Animal genetic resources: conservation by management, data banks and training |
| 1984 | 44/2 | Animal genetic resources: cryogenic storage of germplasm and molecular engineering |
| 1985 | 46   | Livestock breeds of China |
| 1986 | 54   | Small ruminants in the Near East: Vol I |
| 1986 | 55   | Small ruminants in the Near East: Vol II |
| 1985 | 56   | Sheep and goats in Pakistan |
| 1985 | 57   | Awassi sheep |
| 1986 | 59/1 | Animal genetic resources data banks  
1 - Computer systems study for regional data banks |
| 1986 | 59/2 | Animal genetic resources data banks  
2 - Descriptor lists for cattle, buffalo, pigs, sheep and goats |
| 1986 | 59/3 | Animal genetic resources data banks  
3 - Descriptor lists for poultry |
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3 Publications with an APAHP number are in the FAO Animal Production and Health Series.

Publications marked with an asterisk * are joint FAO/UNEP publications.
CONSERVATION AND DEVELOPMENT OF ANIMAL GENETIC RESOURCES FAO OUTLINE PROGRAMME

E.P. Cunningham

1 Introduction

The livestock sector is responsible for over half of the output of agriculture in the developed world. In developing countries as a whole, calculated on a similar basis, it is responsible for a quarter of output. This proportion is growing. In addition, when account is taken of the non-commercial contributions of livestock, such as work, fuel and manure, livestock are responsible for almost half of the output of agriculture (FAO, 1991). Furthermore, in many countries with large pastoral resources, livestock are the mainstay of the economy.

All this is simply to restate the fundamental importance of livestock resources for the future agricultural and economic development of these countries.

In the short evolution of agricultural systems, covering somewhat less than 10,000 years, surprisingly few animal species have been drawn into domestication. Evidence from the earliest human settlements (Ammerman and Cavalli-Sforza, 1984) indicate that the same species have been used from the start: sheep, goats, cattle, pigs, buffaloes. Though other species (camelidae, rabbits) are locally important, practically all of world animal agriculture can be accounted for by less than 20 mammalian and avian species. These are a small subset of the 40,000 known vertebrate species (including 4,000 mammalian and 9,000 avian).

Despite this narrow species range, the animals used in agriculture represent an enormous breadth of biological diversity. Much of this is undoubtedly due to the fact that, with the spread of settled agriculture to all sectors of the globe, specialized and adapted strains from each species have evolved for a very wide range of environmental conditions.

This great pool of diversity is now under threat. As development proceeds, livestock agriculture moves from subsistence into commercial farming systems. Production objectives become more specialized, and competitive pressures increase. The effect of this process can be seen in Europe, where of the surviving 737 distinct breeds of farm livestock, one third are in danger of extinction (Maijala et al, 1984). In these countries, an awareness of the potential value of the threatened breeds has been combined with the necessary resources in most cases to put in place a variety of conservation programmes. In the developing countries, particularly in Asia and Africa, the development process is less far advanced, and a much higher proportion of the historical pool of variability survives. However, here too economic pressures are having the same effect. This is particularly true in some cattle breeds, where artificial insemination permits very rapid change in existing populations. It is also the case in pigs and poultry where easy introduction of developed breeds has facilitated widespread replacement of local stock.

2 Conserve or develop?

It is clear that the depletion of genetic resources is a consequence of economic change and development. Is there therefore an inevitable conflict between the desire to conserve the present variety of genetic resources on one hand, and the need to concentrate increasingly on a
narrow range of genotypes in the interests of more efficient production? To a certain extent there is. Because of the competitive nature of livestock farming, it is clear that, in certain circumstances, more productive individuals, strains or breeds will tend to replace less productive ones. However, this drive is tempered by three main factors. In the first place, production circumstances and market requirements vary so much throughout the world that a variety of breeds and types is needed within any one species. Secondly, in any one set of production and market conditions, requirements change over time. This is well illustrated by dramatic shifts in European dairy cattle objectives in the last 20 years, first from dual purpose to specialized dairy types, and then, in the wake of market saturation and quotas, from milk and butterfat production to protein and management traits. The third element can be called the insurance factor. While short-term trends in livestock farming systems are evident, we cannot accurately envisage requirements more than a few decades into the future. Furthermore, the actual genetic patrimony of most breeds and strains in the world has only been observed at the most superficial level. There may well be genes and gene combinations of great value but at this stage totally unknown. For these reasons, it is no more than prudent to ensure that the breadth of genetic resources which have survived to the present time are conserved against future possible utility.

3 FAO's programmes

Animal genetic resources have been part of the FAO programme since the establishment of the organization, but a significant new approach was taken during the last decade following a Technical Consultation in Rome in June 1980. The approach was further developed by an FAO/UNEP Expert Consultation, held in Lomé. The programme was initiated in 1982, and was supported financially by the FAO Regular Programme and UNEP funds. During the period 1982–90 a large programme of work, based on the recommendations of the 1980 Expert Consultation, has been implemented. The methodologies for a global programme for animal genetic resources have been researched and defined and the necessary infrastructures have been established. The work has been documented in a series of publications in the FAO Animal Production and Health Paper series. In addition, the initiatives taken by the European Association for Animal Production (EAAP) have been supported, and an effective collaboration has been established on the use of their database and associated computer system.

The current programme addresses the needs of both development and conservation in different parts of the world. An example of a former is the nuclear selection scheme in Awassi sheep in Turkey, aimed at increasing productivity of an important Middle Eastern breed in situ. An example of conservation activities is the recently published major inventory of livestock resources of the USSR. More than 30 field projects addressing problems of development or conservation of Animal Genetic Resources throughout the developing world are at present in progress.

In 1989 a major review of the programme in this area was carried out, and the groundwork has now been laid for a new global programme on Animal Genetic Resources. It has the following five main elements.

3.1 Global Inventory of AGR and World Watch List.

Initially the global inventory will be prepared in its simplest form, essentially describing each breed, its effective population size and a limited set of key production parameters. A first edition will be published at end of year 1. Over the life span of the project the data inputs to the
inventory will be expanded such that by the end of the project a comprehensive Global Inventory of AGR will be established and published, and a permanent data base established.

Based on the data collected for the Global Inventory a World Watch List will be published at regular intervals focusing attention on those breed populations considered to be at risk. The attention focussed on particular breeds will enable national governments to take action to preserve threatened breeds and to seek technical assistance where necessary.

3.2 Breed Preservation

As and when threatened breed populations are identified and if, following detailed evaluation, the breed is considered to have genetic uniqueness, preservation plans will be drawn up. The preservation strategy will be country specific, and may involve semen or embryo collection and storage or in-situ preservation. Priority will be given to utilizing in-country facilities such as National AI Centres and Government farms. Regional gene banks will evolve to the extent that they are justified on cost benefit analysis.

Many countries throughout the developing world have placed their indigenous livestock populations at risk through programmes of exotic breed importation and/or crossbreeding. Rarely has adequate attention been given to evaluating and setting realistic and optimum breeding objectives (goals) prior to embarking on breed improvement programmes. Mistaken objectives are sometime then followed by breed improvement schemes which are totally inappropriate to the existing or available infrastructures. It is proposed to assist selected member states in the planning and initiation of realistic breeding strategies so as to avoid inappropriate breed replacement/dilution programmes.

The intention is to link any such activities in developing countries to parallel technical programmes in the developed world.

3.3 Indigenous Breed Development/Conservation Programmes.

The genetic improvement of selected indigenous breeds is a major objective of this programme. In many cases, a local breed which remains static in the face of competition and changing requirements will not survive. Breed improvement programmes, tailored to fit the conditions in which the breeds are farmed, will therefore be planned and implemented. A total of 12 unique populations have been identified for attention in the first phase of what will be a five year programme. These have been selected on the basis of their regional importance and genetic uniqueness and are listed below:

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The breed improvement programmes developed for each of these populations will vary from case to case. However, they will share common methodologies, e.g. based on the Genetic Screening/Open Nucleus Breeding Strategy. Participating country inputs will be substantial, including physical infrastructure, feed inputs and operational costs. In a second phase of this project an additional cohort of indigenous breeds will be singled out for development.

3.4 Gene Technology/Genome Mapping.

The economics of germplasm preservation could be made significantly cheaper if it were demonstrated that many breeds shared a common DNA heritage. DNA level studies may enable geneticists to categorise breeds in terms of ‘genetic distance’ and in this way to sharpen the scientific rigour with which breeds should be selected for preservation. Furthermore, genome mapping may eventually lead to the isolation of DNA segments that code for particular traits, eg., trypanotolerance. This would revolutionise the overall approach to genetic resource preservation. It could also have a dramatic effect on the cost of preservation or use of genetic resources. A venture research fund is being proposed to stimulate, coordinate and guide particular lines of research, which in the longer term, may lead to new and more efficient mechanisms for the conservation of animal biodiversity.

3.5 Legal and International Framework

As in the plant world, but with significant differences, there is a growing need for a framework of internationally agreed conventions to protect legitimate rights and to guide and regulate access to the world's animal genetic resources. As part of the overall programme, the development of the necessary legal and regulatory instruments is being undertaken.

4 References


1 Introduction

1.1 Purpose of paper

This is the second background paper prepared by the same author for the Expert Consultation. The first entitled “Review of past and present activities and prospects for the future” reviews the present situation and the events leading to it; it is found earlier in this volume. It concludes that there is an international consensus on the need to design and rapidly to implement a global programme for the conservation and improved use of animal genetic resources. The paper recognizes that in the developed world national and, in places, sub-regional programmes are already in place. The main objective of the proposed worldwide approach is, in broad terms, to provide support for animal genetic resources in developing countries at the grass roots level. But experience has shown that most national programmes need technical and economic support from regional and global infrastructures.

Linkages between developing and developed regions are greatly advantageous in the use of shared infrastructures like information systems and in the application of the new biotechnologies and breeding methods. There are also common interests in the availability of animal genetic resources from different environments for the improvement of animal agriculture. Such factors are basic to the extensive discussions and trials which have taken place during recent years and which have resulted in a unanimous call by governments of both developing and developed countries in the forum of the FAO Committee on Agriculture (COAG) for a new global programme for animal genetic resources.

1.2 Proposed global conservation programme

The proposed global conservation programme has several objectives:

a. To bring together the urgent need for the development of animal agriculture and the imperative of conserving the biological diversity of indigenous livestock and poultry breeds in developing countries. Pursuit of either alone is unbalanced and in the longer term would not serve humanity well. Together they make sense for the present and the future, both for developing and developed regions.

b. To establish national government policies and local practices which recognize animal genetic resources as an essential and integrated component of biological diversity in the natural environment and as a major resource of sustainable agriculture.

c. To enable national governments in developing countries to work together in those aspects of the conservation and use of animal genetic resources in which they have common interests and which are amenable to joint action.
d. To provide a model of national action in a few countries with critical situations and breeds which are at high risk; then progressively to extend the programme to all developing countries.

e. To provide essential regional and global infrastructures to support national and sub-regional activities.

f. To bring together the common interests and different contributions of developing and developed countries and regions in a worldwide programme for the conservation and improved use of animal genetic resources.

g. To enable international bodies and organizations, NGOs, regional groups and bilateral agencies which have interests in and commitments to the conservation and improved use of animal genetic resources in developing regions to cooperate together in a united, directional programme.

2 Component activities of a global programme

Each of the identified components of the global programme is given a separate section consisting of two paragraphs. The first paragraph provides succinct information to focus the topic; the second paragraph lists the issues for discussion. It may be noted that these are, on the whole, organizational, since technical aspects of these issues are already known in most cases.

2.1 Preservation of germplasm and DNA

(a) Cryogenic preservation of semen and embryos has been recommended as the basic method for use in developing countries, supplemented by DNA storage taken from blood.
(b) It has also been recommended that regional cryogenic gene banks with at least two centres in different countries should be established in each developing region to serve the countries of the region. Agreements have been made with Ethiopia and Senegal (Africa); China and India (Asia); and Argentina, Brazil and Mexico (Latin America and the Caribbean).

(c) The concept of regional facilities for such storage has been shown by FAO during earlier field trials to have many advantages over a larger number of national cryogenic stores. These advantages include technical skills, management, animal health controls, long-term security and finance. Many developing country governments have indicated to FAO during field trials and in inter-governmental discussions that they want cryogenic facilities to be available but do not wish to have their own.

2.1.1 Issues for discussion

• Should cryogenic storage of germplasm be the prime means of preservation in developing countries?

• Should preference be given to semen, ova, embryos or all?

• Are regional animal gene banks for cryogenic storage of semen, ova and embryos the most appropriate way to preserve breeds in the long term?

• Is DNA storage an acceptable alternative to cryogenic storage of germplasm, since it so much cheaper and easier in practice?
2.2 Breeding herds or flocks

(a) Although technically, the maintenance of breeding herds or flocks has been seen as an equally valid method with cryogenic storage under certain circumstances and although technical recommendations seek to encourage both methods, within FAO's programmes live animal populations have so far been given lower priority for technical and financial support.

(b) Some developing countries have live animal populations of threatened breeds. For example, Argentina and Brazil hold special herds of Criollo. China and India have herds of some of their threatened breeds.

(c) It has been recommended that FAO develop a technical manual to aid developing countries in this activity.

(d) It has also been recommended that when countries establish live populations, the cryogenic storage of germplasm should also be practiced for security reasons.

2.2.1 Issues for discussion

• Is the maintenance of breeding herds or flocks an option to be included for financial support to governments in a global programme?

• Are there certain domestic species for which the maintenance of breeding herds or flocks should be the preferred technique?

• Should breeding herds or flocks be maintained in situ, that is in the original site where animals remain in local ownership, or should farm park type facilities be created where animals are brought together?

• Are the minority species and micro livestock special candidates for breeding herds or flocks?

• What recommendations and support for the breeding of captive populations should be offered to governments and other groups maintaining live animal herds?

• Should FAO encourage governments to make live domestic animal populations more available to the public? Or should FAO encourage other organizations to be involved in this type of activity?

• Is a manual needed on techniques and issues for maintenance of domestic breeding herds or flocks? What topics should be included?

• Is there need for a global list of live domestic animals populations, farm parks, preserved herds etc? If so who should prepare it?

2.3 Existing animal genetic data banks
(a) There are several main centres where animal genetic data is held: the major ones which service one or more regions are: EAAP/FAO Hannover, FAO Rome, ILCA Africa and Kasetsart University, Buffalo. The Hannover and FAO banks use compatible software.

(b) The Hannover bank holds mainly European information. The new FAO data bank brings data from FAO publications and reports mainly on developing countries.

(c) The ILCA data base should be a rich source of regional information on Africa. It holds microfilm copies of published and, more important, unpublished reports on all livestock subjects from the files, archives and libraries of many African governments. It will be necessary to extract the animal genetic resources information.

(d) There are other animal data banks; for example, the data base held at Maracay University, Venezuela and the sheep data base at Utah, USA.

(e) A prime task is to make all this data accessible for identification of breeds which need special attention. This will include the rationalization of systems and of the existing data; the identification of breeds, environments and animal management systems from which additional data is needed; and the analyses of data to support valid decision making on conservation and utilization programmes. A further output from the data handling activity will be creation of a World Watch List for animal genetic resources.

(f) Another task will be making the coordinated data available to users throughout the world.

(g) Much of the information scanning, input and analyses must be done by specialists who are competent both in computer systems and in animal genetics.

2.3.1 Issues for discussion

• Is a global animal genetic data bank needed ?

• Should it be a separate entity from the existing data facilities ?

• How should the flow of data be organized taking account of local, national, regional, global and specialist species interests ?

• What assistance, if any, should be given to existing animal genetic data banks which are concerned with regional or species interests ?

2.4 Harvesting new information

(a) After existing data is unified and analyzed, gaps will be revealed and breeds identified that need new or upgraded data on their genetic characterizations and population sizes.

(b) Field collection of new and updated information will be a major task open to nationals of the countries on short-term bases. Students and UN volunteers will also be suitable to make field visits under the supervision of qualified animal geneticists who will verify the data.

2.4.1 Issues for discussion
• How should new information be obtained on breeds which are inadequately documented?

• Is there need for a special mechanism to validate animal genetic data flowing from the field? If so, how should it be organized?

• Are special steps needed to organize the collection of data on certain species or types of animals, for example, draught animals?

• There are broadly two types of pig production in developing countries; the industrialized and the local scavenger systems. Should data from both be collected for animal genetic data banks?

• Is there merit in setting up special data banks for certain species - for example the camelidae species or the domestic rodent species?

• Should recognized crossbred types be included in animal genetic data banks?

2.5 World watch list

(a) An early warning list, to be known as the World Watch List, will be issued to governments warning them of breeds which are already threatened or are moving towards that state. This alert will permit anticipatory action to avoid the loss of the breed. The list will be updated periodically and reissued. Associated with the list will be the recommended means and resources to take preventative action.

(b) Political boundaries rarely coincide with breed distributions. One of the valuable benefits of a World watch List will be the opportunity to study breeds which occur in more than one country. In some cases, the same genetic makeup is known by different breed names in adjacent countries. In such cases it is clearly important to make accurate diagnoses of genotypes and threatened status before launching into the conservation of a national breed which exists in plenty elsewhere.

(c) Another type of inter country cooperation is illustrated by the trypanotolerant breeds of West and Central Africa. They are of great interest because of their genetic ability to tolerate trypanosomiasis. Several distinct breeds and even species exhibit this trait. It is the DNA coding for this trait which is of interest rather than the breeds themselves. It is not yet known whether there is one common DNA sequence across breeds and species which show this trait.

2.5.1 Issues for discussion

• Is there a case for the immediate publication of a World Watch List using available data, even though it would not be complete?

• Should separate species lists be published, following for example the pattern of the IUCN Red Data Books? If so, what priority order of species should be followed?

• What additional information, advice or support should be published with the World Watch List?
• Should special lists be prepared for each government to draw their attention to the breeds and species at risk in their country?

• Should there be a comparable World Watch List of High Potential Indigenous Breeds for developing countries? What type of information should it contain?

• Which categories of risk assessment should be used in a World Watch List for domestic animals?

• Is a World Watch List for minority species and micro livestock species required? If so should FAO undertake it?

2.6 Breed and species development strategies

(a) In the process of attempted improvement programmes through exotic breed importations and crossbreeding, indigenous germplasm has frequently been placed at risk. Rarely has adequate attention been given in advance to the design of the programme and to evaluation of its chances of success within the existing environment and infrastructures. Consequently, in the past, some inappropriate importations, failed or disappointing results and lost animals have resulted.

(b) In these cases the impact on the livestock producers lifestyle and on his animals has been deleterious and in some cases tragic. Support should be provided to assist governments and local communities in planning realistic breeding strategies to avoid inappropriate breed replacement and dilution programmes.

(c) When threatened breeds are identified and recognized as having unique genetic traits, conservation plans will be made available. These will be specific to a breed and will depend upon population size and demographic structure, on the rate of population change and anticipated use or neglect in the current economic situation. Conservation plans will also provide an evaluation of the options of cryogenic storage and the maintenance of breeding herds or flocks in the local circumstances and a long-term conservation plan for operation by the national government(s) concerned.

2.6.1 Issues for discussion

• What issues on Breed Development Strategies should be addressed?

• Should these be published and training courses for governments and nationals of developing countries?

• Should special strategies for conservation and improved use be designed and published for species with special characteristics, for example buffalo, camelidae, or minority species?

• Similarly should special strategies for conservation and improved use be designed and published for breeds suited to certain products; for example milk production? In such a case the target could be breeds like the Sahiwal, the Kenana and the Butana.
2.7 Indigenous breed selection/conservation plans

(a) Most indigenous breeds have the strong qualification that, although they may have more limited production than exotic breeds, they are well adapted to their local environments and management systems. The aims of increasing local animal products is not easily solved by the introduction of germplasm from elsewhere.

(b) Even when the intention is to combine the best qualities of local and introduced breeds into a new crossbred, the practical mechanisms are often formidable. Thus, there are attractions in increasing the performance merit of indigenous breeds by selection within the population.

(c) Once owners of indigenous livestock breeds see increased performance from their own animals, whether as more milk, meat, work, wool or reproductive traits, the attractions of crossbreeding diminishes. In this way also conservation and genetic improvement are combined.

2.7.1 Issues for discussion

• Is it a valid thesis to put before governments and small livestock producers, as a generalization, that indigenous breeds can be improved by pure bred means on a reasonable time frame?

• Or, is this only true in certain cases; for example, when harsh environmental conditions make crossbreeding impossible?

• Would it be desirable to make the situation more clear regarding the circumstances and species and breeds when it can be recommended that indigenous breeds can be kept purebred for over a long time frame and still remain economically viable?

2.8 Methods of genetic improvement

(a) In the last five years new methods of genetic selection have been developed which theoretically offer equal or better rates of progress than the established methods and which also avoid many of the older organizational problems.

(b) They are Nucleus Breeding and Genetic Screening, which are now being tried with some success with purebred indigenous breeds in a number of developing countries cooperatively by FAO and national governments.

(c) Genetic improvement methods and plans need to be designed in ways which are not only friendly to the owner but also contribute to the maintenance of biological diversity and to the issues of sustainable agricultural development.

2.8.1 Issues for discussion

• Should special publicity be given to nucleus breeding and genetic screening for livestock improvement in developing countries?

• Are these techniques applicable to certain species more than others? If so which?
• What are the needed steps for successful development of these techniques for use in developing countries?

• What should be the recommended attitude towards the use of older methods of genetic improvement such as progeny testing and field production recording for use in developing countries?

• Is there a case for preparing manuals on the new genetic improvement methods for different species, systems, environments or traits? If so what is the species priority list?

• Should FAO continue to offer and organize semen donations from developed to developing countries? If so, under which terms?

• Should FAO be involved in the supply of embryos to developing countries? Would it be advantageous to offer a technical and breeding advisory service, even though the embryos are part of a commercial contract between buyer and seller?

• Is there need for organized exchange or supply of semen and embryos between developing countries using the known high potential breeds found in some parts of the tropics?

2.9 Biotechnology

(a) Recommendations have been made regularly since the FAO/UNEP Technical Consultation in 1980, that FAO should keep a close watch on the developments in biotechnology, especially those concerned with molecular genetics and reproduction. This watch has been observed and clearly should be continued.

(b) Biotechnology has been seen as capable of new techniques for both preservation and for genetic improvement. The two are closely linked, for example, in the use of embryos for cryopreservation and for nucleus breeding plans.

(c) Special areas of reproductive technology which have been of special interest in recent times: vitrification as a simple, cheap and effective method for cryopreservation of embryos and oocytes; recovery of sperm and immature oocytes from animals at the end of their lives with subsequent in vitro maturation, fertilization and culture of zygotes; nuclear transfer for cloning of embryos; and sexing of sperm and embryos.

(d) Some areas of molecular genetics have been of special interest in recent times: genome mapping associated with estimation of genetic distance; creation of DNA libraries; collection, extraction and storage of body tissues, blood samples, specific chromosomes or pieces of chromosomes and of DNA for possible later use; techniques for the transfer of DNA with mammals involving embryos; and developments in transgenic animals.

2.9.1 Issues for discussion

• What areas of biotechnology are important for research and development in animal genetic resources in developing countries?
• Which of these should be researched in developed countries and which are better researched and tested in the developing countries?

• Is genome mapping of indigenous breeds an important topic within the long term plan of animal genetic resources?

• If so, at what stage should genome mapping be started?

• How can the global programme best prepare now for the possibility that genome libraries are likely one day to be of value and importance to animal genetic resources?

• Is there merit in FAO developing further regional network projects for animal biotechnology on the Asian model which includes eight countries? If so what should be the order of priority for topics for network research and development in national institutions?

2.10 Training

(a) Programmes for training nationals at a variety of tasks will be needed, including aspects of genetics, reproduction, data handling, sampling of donor animals, handling of semen and embryos, animal health controls and computer systems. FAO has already designed and used training courses on these topics.

2.10.1 Issues for discussion

• What are the topic priorities for training?

2.11 Poultry

(a) The great majority of economically important poultry stocks are now in the hands of a few multinational corporations.

(b) Economic considerations tend to override conservation efforts.

(c) Governments tend to opt out of breeding research and flock development.

(d) Poultry gene conservation by cryogenic means is not available.

2.11.1 Issues for discussion

• Should FAO attempt to establish national or international gene pools?

• Is research into cryogenic preservation for poultry germplasm important?

• Should poultry be included in animal genetic resources data banks systems?

• Should the preservation of indigenous poultry stocks in developing countries be encouraged? If so, how?
2.12 National programmes

(a) It is important to recognize from the start of this new worldwide enterprise that the heart of the enterprise will be the national and local plans which the regional and global infrastructures are to support. The development of national animal genetic resources programmes by governments will be a foundation aspect of the global programme.

(b) National programmes should be developed first in specially chosen countries in each region. These countries should be chosen on the basis of their special needs and opportunities or because they have breeds which are close to extinction or have high potential breeds or both. For example, in Africa it may be appropriate to choose several countries which are representative of widely different environmental zones and have different types of animal genetic resources and management systems and which embrace both anglophone and francophone countries.

(c) A key activity of national programmes will be the design of breed management plans. This will include breed development strategy plans and indigenous selection/conservation programmes designed to the needs of individual breeds. It will involve skills at the technical, personnel, diplomatic and financial levels. For example, advice will be needed on appropriate animal genetic improvement methods which are not only friendly to the owner but also contribute to the maintenance of biological diversity and to the issues of sustainable agricultural development. Training will be necessary.

(d) Breed management plans will need regional coordination in some cases where breeds exist in more than one country.

2.12.1 Issues for discussion

• Which are candidate countries for starting national plans in each regions and for what reasons?

2.13 Minority and micro animal species

(a) Just as the buffalo was long neglected by science and development but is now prominent in project and research programmes, there are other species which are usually overlooked. The Camelidae are often cited as neglected species.

(b) There are also several domesticated bovine species which are overlooked, such as the Banteng, Mithun, Yak, and various established hybrids such as the Yakows.

(c) The pig and associated species such as the Bearded Pig, Sulawesi Warty Pig Pigmy Hog, Javan Warty Pig and Babirusa are all extremely interesting both economically and scientifically.

(d) The rodent species offer a large number of domestic animals including the Agouti, Cabybara, Coypu, Giant Rat, Grasscutter, Guinea Pig, Hutia, Mara, Paca, Vizcacha and others. They are each capable of being proposed as candidates for preservation in view of their special use in minority cultures.
(e) Consideration of the deer and antelope families leads towards the wildlife species which are generally acknowledged to be more within the purview of other international organizations than FAO.

2.13.1 Issues for discussion

• Which minority and micro species should be included in the programme for preservation?

• Should these species be included in the animal genetic data bank system? If so, in specialized banks or generally?

• Should genetic improvement programmes be developed for any of these minority and micro species?

• What order of priority should be given to the Camelidae species for inclusion in the programme?

• Is there need for a special programme to investigate and act in respect of any of these species?

2.14 Wildlife

(a) Although wildlife are important in the FAO Forestry programme, it has not generally been seen as FAO's task to engage in their preservation.

(b) Wild bovine species include the Wild Banteng, Gaur, Kouprey, Tamaraw and Anoas which are also cited as serious candidates for organized preservation. They share much common genome with their domestic relatives and it is expected that they probably carry variants and polymorphisms which, later in the development of molecular genetics, will be of interest scientifically and economically.

(c) However, FAO has agreed with IUCN that the cryogenic gene banks should also be available for the storage of semen and embryos from wildlife.

2.14.1 Issues for discussion

• Should FAO take initiatives for the live preservation of wild animal species which are related to domestic species? If so, should this be organized cooperatively with any other organizations?

2.15 Animal diseases

(a) A principal interest is the transmission of animal disease through germplasm. It is of concern to FAO that germplasm stored in cryogenic gene banks be free of disease and that adequate documentation be available for future users.

(b) The possibilities of washing embryos and of ensuring their freedom from disease is an added attraction over the obvious genetic benefits of using embryos rather than semen.
It is important to note that DNA is a chemical and is not biological tissue. It does not attract the interest of quarantine authorities at national borders.

2.15.1 Issues for discussion

• Are there any special research topics which need attention to overcome problems of animal health in conservation work?

2.16 Research

(a) In general FAO has, in the past, become involved in supporting research only when it is critical for the application of specific development projects.

(b) FAO has nevertheless been highly active in taking research results and transferring them to developing countries.

(c) In addition, FAO provides support for the organization of research capabilities in developing countries. In recent years this has applied to the support of research and development in biotechnology of animal reproduction and molecular genetics.

2.16.1 Issues for discussion

• Are there new research areas or topics which FAO should monitor?

3 National, regional and global levels of activity

The concept of a global programme has its roots and its results in the animal genetic resources of individual countries. Conservation and improved use of animal genetic resources at the livestock and farmer level is the goal. Regional and global levels of activity are called for only because experience shows that at the national level some services and systems would be expensive, fail to provide the needed support or be of limited value. In particular there are specific types of external support to be provided:

- cryogenic stores
- animal genetic data banks
- information and information systems
- technical support services
- training
- finance

The differing activities to be undertaken by differing levels of the programme are outlined here as a basis for discussion.

3.1 National governments

(a) It is anticipated that within countries, governments will wish to establish an appropriate national infrastructure for animal genetic resources, which is capable of providing administrative, technical, financial and organizational support for a national programme. Some countries will need technical, financial, legislative and training assistance in starting and operating such
national programmes. Governments should be encouraged to incorporate into this new structure the existing branches of government or other bodies, institutions, universities or other groups which have had traditional interests and activities in animal genetic resources.

(b) It may be appropriate for governments to establish national animal genetic resources consultative groups to provide support and advice to those responsible for activities.

(c) The national group responsible for the animal genetic resources programme will be expected to forge links with the appropriate regional and global centres for the flow of information, germplasm, participation in training courses, field programme design and breed development strategies.

(d) It is expected that regular lines of communications will be established between those responsible for animal genetic resources and certain government ministries responsible for allied fields. These will include the Ministries concerned with Agriculture, Livestock and Forestry, Ministries concerned with the Environment, Land and Rural Development and, depending upon the national situation, links with the Ministries responsible for Research and for Tourism.

(e) It is expected that national governments wishing to gain the benefits of the global programme will enter into agreements which define their financial and national staff inputs and their long term commitment to their own national animal genetic resources plan.

(f) Governments should be encouraged to review the current uses of their existing livestock centres to take advantage of the new methods of nucleus breeding and genetic screening.

(g) Inter-country cooperation will be needed for a variety of topics, including cryogenic storage, animal genetic resources data, training and research and development. Governments should be active in such regional programmes.

(h) Governments should encourage where possible, public interest and finance in the preservation of indigenous domestic animal breeds as reserves and farm parks.

3.2 Regional organization

(a) Regional activities, though established with external finance should be under the governance of a regional consultative group, which will regularly review the policies and activities of regional infrastructures and provide guidance to national governments.

(b) It is anticipated that regional cryogenic gene banks will be funded and become operative under the new programme.

(c) It is also anticipated that an information network will be created to coordinate the flow of information on animal genetic resources from national origins to various centres. It is possible that existing and newly created regional information centres could be linked electronically with the designated global centre.

3.3 Global organization
(a) Global infrastructures should be concerned with organization and support rather than the creation of new physical facilities.

(b) Nevertheless a recognized centre will be needed for the global planning and organization in support of regional and national activities. In the past this has been provided by FAO as part of the Regular Programme. It has been a very small group of staff, normally only two officers. This is inadequate to take organizational responsibility for a new global programme.

(c) A new approach to the organization of animal genetic resources information is needed. Rationalization of the existing animal genetic data banks and bases is needed to enable them to increase their effectiveness and value. A review of the types of data to be included will be relevant and should include for example, animal genetic and environmental characterizations, passport data, production data and populations structures. Other types of information should be considered, for example records of conserved cryogenic samples of semen and embryos. These records are most important for posterity and include sampling technique, donor animal profile and genetic status, health tests and control procedures, methods used for collection, processing, freezing and storage, and ownership records.

(d) The information associated with DNA libraries for domestic animal species is a new and important topic. Are separate information systems to grow for each species at locations where enthusiastic researchers are working, or should there be an early attempt to coordinate such information on a global basis? This information and system will be particularly important for the animal genetic resources of developing countries.

(e) The facilities to be used as a global centre for animal genetic resources must be sufficient for several important functions. These would include:

- the storage, analyses and use of information
- executing the global programme, including policy and finance
- liaison with national governments and other organizations and bodies wishing to access animal genetic resources information of any type.
- coordination of inputs by the variety of bodies concerned with and contributing to the programme
- provision of advice to governments for example on the appropriate animal genetic improvement methods.

3.4 Roles of FAO and other UN bodies, NGOs and bi-lateral agencies

3.4.1 Major organizations

It is proposed that the major organizations with experience and commitment to animal genetic resources in developing countries should be involved at some level in the project. Organizations with clear involvement include:

- Food and Agriculture Organization of the United Nations
- United Nations Environment Programme
- United Nations Development Programme
- World Bank
- Global Environmental Facility
- World Resources Institute
3.4.2 Rare Breeds International

A new NGO with special interest and ability to contribute is Rare Breeds International (RBI), which brings together the expertise, experience and enthusiasm of private organizations and individuals working with domestic animal conservation in 30 countries.

3.4.3 Global Environment Facility

It is considered vital that the project should be linked, not only philosophically but in reality, with the Global Environmental Facility (GEF) projects concerned with different components of biological diversity and the environment.

3.4.4 Issues for discussion

• Is FAO the appropriate organization to execute the new programme in the Management of Global Animal Genetic Resources? Why?

• If FAO is not to be responsible for this programme, which body should be?

• Are there special tasks which can be identified for specific organizations which have experience or skills?

• What role and activities can Rare Breeds International play in the proposed new global programme?

• Is there a need for a new international consultative group to act in an advisory capacity to the programme somewhat in the same way that the FAO/UNEP Joint Expert Panel served?

• If so what should be included in the Terms of Reference of the consultative group?

4 Finance, accountability and monitoring

(a) The FAO/UNEP programme on animal genetic resources over the last decade was initiated at the request of member governments of FAO and UNEP in 1980. The decade of work was reviewed and commended by member governments of FAO in 1989 in the COAG which is one of the FAO Governing Bodies. COAG also made recommendations for implementation on a global and regional scale in each of the developing regions. The FAO Council later confirmed this proposal. In 1991 the COAG again briefly reviewed animal genetic resources and restated its earlier view that action is both imperative and urgent. While the search for an appropriate pattern of organization and for funds is in progress, FAO and UNEP are meanwhile continuing
to fund some activities in animal genetic resources in the expectation that they will be enlarged in the near future to the scale requested by governments.

(b) The outline of the global programme and its regional and national components have been described in this paper. It is considered that the financial budget needed to initiate this programme and to operate it for five years will amount to US$15 million. It is intended that at the end of the five years, infrastructures will have been established which will facilitate full cooperation between national governments and all other appropriate other organizations concerned with animal genetic resources. The anticipated global financial breakdown is given below:

(c) PROGRAMME COSTS FOR FIVE YEARS

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Amount (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Animal Genetic Data Bank</td>
<td>500,000</td>
</tr>
<tr>
<td>World Watch List</td>
<td>250,000</td>
</tr>
<tr>
<td>Breed Preservation</td>
<td>750,000</td>
</tr>
<tr>
<td>Strategic Breed Development Plans</td>
<td>750,000</td>
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<tr>
<td>Indigenous Breed Selection/Conservation Programmes</td>
<td>12,000,000</td>
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<tr>
<td>Gene Technology/Genome Mapping</td>
<td>750,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15,000,000</strong></td>
</tr>
</tbody>
</table>

(d) It is recognized that the budget will be most appropriately separated into components to serve the global and regional infrastructures and also components to be made available for national programmes within each region.

(e) Contributions of the involved governments are expected to include provision of physical plant, facilities and national personnel when appropriate. Other government contributions will be identified in the Project Document.

(f) It is considered that the Global Environment Facility (GEF) offers an almost unique opportunity to tie this implementation into a comprehensive approach with other aspects of biological diversity conservation, while also engaging the active involvement of the several bodies with experience and ongoing interest in animal genetic resources and sustainable agriculture of which it is part.

(g) Monitoring of the programme will be necessary at two levels. One will be scientific and the other, implementation. Both will be worked out in the agreement between the donor agency or agencies, the executing agency and the national governments involved.

4.0.1 Issues for discussion

• What factors should be taken into account when breaking the global budget into operational components?
Does the outline budget allocation by activities reflect the likely needs and opportunities? If not what adjustments are proposed?

5 Conclusion

This paper was presented at the start of the Expert Consultation, of which this volume is the proceedings. The Issues for Discussion listed in this paper were discussed during the Expert Consultation and the Recommendations which are found at the beginning of this volume may be regarded as the response of the Expert Consultation.
1 Introduction

1.1 Need for information and documentation

The importance of collecting information on animal breeds has been stressed in many meetings and papers concerned with the conservation of animal genetic variation (e.g. 3, 7, 8, 9–11, 13, 18, 22). A record of these meetings and recommendations is given by Hodges in an early paper in these proceedings, entitled "Review of past and present activities and prospects for the future". Details of some information already assembled at the FAO Animal Genetic Data Bank is given in the paper by Ruane in these proceedings; similarly a review of the data in the EAAP/FAO Animal Genetic Data Bank may be found in Simon (25).

1.2 Purposes and kinds of information to be collected

The information should serve decision making for both conservation and for improved use in different production environments. It should be in standard and comparable form making it possible to classify breeds and strains on the basis of the urgency of their conservation, their genetic and phenotypic traits and according to their suitability to given production systems and environments. The Global Animal Genetic Data Banks should serve member countries of FAO by the publication of a World Watch List as an early warning system, which is regularly undated. A critical feature of this list would be the indication of declining or small population sizes.

In earlier discussions because of the large number of breeds and the cost of conservation, the evaluation of breeds was stressed as a first step in the programme. More recently it has been realized, that acquiring sufficient information is so difficult, time-consuming and expensive that it is not possible to evaluate each breed properly before it is lost. The emphasis has shifted to identifying the populations which are threatened and therefore in need of urgent conservation activities. Collections programmes should therefore be restricted initially to the most important and urgent information to permit rapid decisions on the need for conservation.

The different types of information needed for different types of decisions were discussed and evaluated by Maijala (17). There are today several types of questionnaires. The type of information needs further study and discussion which is now addressed in this paper.
The Society for the Advancement of Breeding Research in Asia and Oceania (SABRAO) developed forms for documentation of performance of the breeds of 11 species in Asia and Australia. Eight of these are summarized in Appendix 1. In addition there were forms for guinea fowls, geese and quails.

The forms are divided into two parts: schedule 1 for a general description of each breed, and schedule 2 for actual performance data collected on a particular flock or herd, or from a particular survey or evaluation study. Hence, the forms are rather extensive and not very suited for preliminary and fast mapping of threatened populations.

2.2 FAO Descriptors

The FAO descriptors were developed in trials organized by FAO and UNEP in Africa, Asia and Latin America in 1983–85 (9–11). They are summarized in Appendix 2. They are intended for extracting data from various published or unpublished source documents and entering into a computer system. These lists, too, are divided into two parts: master records about the physical characteristics of each breed/strain, and slave records about the performance characteristics and environments. Since the forms cover all possible traits of interest and occurrence, they are massive and difficult in use by untrained people for identifying threatened populations in need of swift conservation actions.

2.3 EAAP/FAO Questionnaires

The EAAP/FAO-forms were developed gradually by a working party of the European Association for Animal Production (EAAP), for collecting information of European breeds for which conservation might be needed (18, 20, 25). The forms are summarized in Appendix 3.

In planning the questionnaires, the EAAP working party partly utilized the SABRA forms as models; partly its own experiences from the European surveys in 1982 and 1985; those of the Scandinavian Animal Genetic Resources Working Party and those of FAO/UNEP. It tried to standardize the forms for different species and sought an optimum compromise between many-sided, reliable information and on the other hand maintaining the interest of those supplying the information.

Originally, there were five forms (A-E), but when the Hannover Animal Genetic Data Bank was expanded in cooperation with FAO to provide global coverage forms F and G were added for additional information (25, 14) Buffaloes and chicken were added to the species covered. In spite of the attempts to standardize and simplify the forms, they have continued to cause problems of completion, even in Europe. Further simplification may be needed for identifying the breeds needing urgent conservation actions (17). The task of completing the forms can be eased by pre-filling them with the information from previous surveys. In this way only checking is needed for the part of the form.

Care has been taken to provide clear instructions for completing the forms. The use of scientific or popular terms is clarified and those completing the forms are urged to provide only objective information. The language problem has been solved by using only English. This is important for the using the information, although those completing the forms would sometimes prefer their own language for speed. In some parts of the world it may be necessary to accept some other important language simply to get the information.
2.4 Shortened FAO-form

The shortened FAO form (23), summarized in Appendix 3, was developed for collecting central information of non-European and Russian breeds and of all buffalo breeds, listed by Mason (21). It is intended for fast identification of breeds needing immediate conservation action. The intention is to send them out pre-filled with the basic information of breeds names etc. from Mason's World Dictionary of Livestock Breeds (21).

2.5 Selected Parts of EAAP/FAO Questionnaires

An alternative for the shortened FAO forms is to use forms A and B of the EAAP/FAO questionnaires. The former could be pre-filled from Mason's book. Answers should be sought only for paragraph 4 (breeding population numbers). In addition, opportunity should be found for the supply brief information on the outstanding performance traits and special environmental adaptations (Form D, paragraph 4) qualifications.

2.6 Recommendations

The SABRA forms and the FAO descriptors are obviously too massive for getting enough basic information rapidly on a large number of breeds for assessment of threatened status, especially in developing countries. Even the EAAP/FAO forms are too complicated and difficult to fill in for this purpose; but some parts of them (Form A, Form B, para.4, Form D, para.4) could be used, as well as the shortened FAO-forms (23). Experts involved in these matters operationally will have to discuss and decide which to use or whether a new alternative should be developed for the preliminary listing.

In the second round, the complete EAAP/FAO questionnaires might be appropriate in many cases and even the FAO descriptors or SABRA forms could be used for collecting information from different sources and evaluation studies. In the later rounds of surveys, the proportion of populations for which these forms are appropriate will be increased.

3 Suggestions as to the frequency of survey

3.1 Frequency for the EAAP/FAO questionnaire

According to the European experiences, attempts to collect information simultaneously on population sizes and various other characteristics impairs the frequency, completeness and speed of replies. Hence, there is reason to consider separating regular censuses of population sizes from surveys on characteristics of the breeds.

3.1.1 Shortened Forms for Census Data

In view of the urgency of getting basic information for possible conservation actions, it is well-founded strategy to carry out surveys of a shortened form as soon as possible in all developing countries and in those industrial countries in which no survey has been made before. Some information about performance and the existence of specially interesting genetic traits could also be requested. The part of the form concerning animal numbers and the recent trends of these and crossbreeding should be repeated at 3-year intervals. Where numerically minor breeds or breeds being extensively crossed with males of other breeds exist, even more frequent surveys would be desirable. However, advice should be taken from local experts on
whether this is realistic. In the follow-up surveys, attempts should be made to use the more complete forms.

3.1.2 Complete EAAP/FAO Questionnaires

On the subject of repetition of information the complete questionnaires can be divided into two classes:

- The origin of the breed, breed description, qualification of breed, management conditions, environment and socio-management system need not be repeated frequently. On average 10-year intervals suffice, but the contact persons should be encouraged to check and up-date any item, in which essential changes have taken place.

- Some of the performance records and additional information deserve to be checked and up-dated as soon as essential new information becomes available, but at least every fifth year. It would be sensible to repeat the surveys at shorter intervals for species with high reproduction rate and short generation interval. However, maintaining the cooperation of people and organizations responsible for replying to the questionnaires has to be considered. Hence, the question deserves to be discussed in an expert group or to be solved in different ways in different regions and for different species.

3.2 Frequency for Different Regions

It is not possible to give fixed repetition schedules for the frequency of different surveys for different regions or country types, since the situations vary. The situation of many breeds in many developing countries would speak in favour of more frequently surveys than in developed countries, but the difficulty of getting the data may make this unrealistic. On the other hand, the efficient application of A.I. and other techniques in the developed countries can accelerate breed changes increasing the need for frequent up-dating. Thus, it would be desirable to have a competent contact person or organization in each country for assessing the needs of up-dating the surveys for different species and breeds. In this case, relevant information of essential changes could be requested annually from each country. As an example of such a need the change in the breeding policy of the Chinese pig breed Taihu may be cited. Extensive crossbreeding has begun recently and could make it a threatened breed, in spite of large numbers.

Possibilities of getting data on breed performance in developing countries are probably less than in developed countries. However, it may be possible to find positive, encouraging exceptions. On the other hand, getting information from developed countries has become increasingly difficult, due to high labour costs.

3.3 Frequency for Different Species

It is also difficult to give clear rules for different species. In principle, threatened breeds and rapidly reproducing species need more frequent monitoring. However, extensive use of A.I. and crossbreeding can make frequent follow-up important for at least part of the population. The appropriate frequency depends also on the policies of governments and of local organizations working on the species in question.

4 Useful criteria to assess the threat to breeds
4.1 Need for Criteria

A choice for conservation is often necessary because of the great number of breeds in some areas, and of the limited resources available. This calls for making clear the criteria for choosing breeds for conservation. Such criteria have been discussed by several authors (e.g. 26, 2, 18, 24, 16, 17, 4).

4.2 Population Size

Population size and its trends are decisive factors in determining the vulnerability of a given population and the need and kind of special conservation actions. Population size can be expressed as:

a. total number of individuals of a breed alive at a time,
b. total number of animals of breeding age,
c. effective population size \( Ne = 4NmNf/(Nm+Nf) \), where \( Nm = \) no. of breeding males and \( Nf = \) no. of breeding females (30).

Alternative (c) makes it possible to compare the effects of various population sizes and structures on changes in gene frequencies. With \( Nm = Nf \) and random matings, \( Ne = N \) (=alternative B above).

Alternative (c) is preferable, since \( Ne \) largely determines the levels of random genetic drift and inbreeding in a breed both before and after conservation. Heterozygosity per generation starts to decrease at an accelerating rate after \( Ne \) falls below 100. Values below 50 decrease the heterozygosity by more than 1 %/generation. These changes were discussed by Maijala (17) and also illustrated by a figure. It has been calculated that:

- the S.D. of gene frequency due to chance increases with accelerating rate after \( Ne \) falls below 30 or 40 (17),
- ca.18, 10, 4, 1.6, and 0.8 % of genetic diversity is lost in 10 generations, when \( Ne = 25, 50, 125, 250 \) and 500, resp. (15),
- the probability of transferring both alleles at a 2-allelic locus, from the base population to the progeny, decreases with accelerating rate, when the number of founders goes under 30, (27),
- the loss of alleles at a many-allelic locus can be considerable, when the number of founders is less than 20 (27).

4.2.1 Sex ratio

\( Ne \) is also important for understanding the effects of varying numbers of males and females on genetic drift variance and inbreeding. Hence, it is important to know the numbers of breeding animals of each sex. For example, 4 males + 4 females gives the same \( Ne \) as 2 males + 100 females. Even 1000 females give the same result, so the number of males is very decisive. In fact, with large values of \( Nf \) (e.g. > 1000) \( Ne \) = approximately 4 \( Nm \) and is thus simple to calculate.

Assuming there is no variation in family size in a population, \( Ne \) is linearly dependent on the \( Nf/Nm \) ratio and can thus be simply estimated from this ratio. The following regressions can be used:
The Ne for each sex ratio (1st row) can be obtained by multiplying the Nf by the corresponding figures of the 2nd row.

A table giving details of these relationships is given by Maijala (17). Curves for Ne-values can easily be plotted and are available from the author.

### 4.2.2 Recent Trends in Population Size

Changes in population size can be caused by a general decrease or increase of demand for a certain product or by crossbreeding with a breed considered more competitive. The latter cause has increased in importance, because of the generality of A.I., frozen semen and embryos, of improved communications and more effective marketing of genetic material. The changes can be very abrupt and can threat also reasonably large breed populations. They are important to be estimated in assessing degrees of endangerment. Turner (29) has calculated the effects of various annual rates of decreases in population size on the total decreases in different time periods. She calculates, for example, that annual decreases of 5% and 10% lead to total decreases of ca. 18% and 33% in 5 years, respectively. Her paper gives a figure illustrating these trends.

Turner (29) also estimated the percentage decline in the number of females after 5 years in a breed, with varying proportions of females crossed with males of another breed. She shows that the initial number of purebred females can be reduced to 20% in five years, if all females are used for crossbreeding and there are five age groups of females. This can easily happen, when an exotic breed becomes popular in a country with effective A.I. service. In case half-bred males of the foreign breed are used to all females, ca. 87% of the females after five years would have at least ¾ of their genes from the original breed, but the corresponding figure after 10 years would be only 13%. These figures are also illustrated in a figure by Turner (29).

Thus, the recent trends of population can be used for predicting the population size in the future and can be very important in assessing the vulnerability. In the European surveys, the trends were estimated as three alternatives of direction in the last three years, but the speed of change was not recorded (17). It would be desirable to have a crude estimate of the speed, in order to adjust the Ne accordingly for risk assessment. In Germany, a breed is classified as endangered, if more than 10% of matings are performed with males of another breed (6).

### 4.2.3 Variations in family size

In practice, there is considerable variation in fertility and length of life, causing variations in family size and increasing the numbers of males and females needed for a given Ne. Accordingly, the numbers below which a population should be considered threatened are increased. Because there are difficulties in getting exactly enough numbers of breeding animals, it is not sensible to give exact values of Ne for different values of the standard deviation of family size. However, it pays to have some idea about this variation and to apply larger values of Ne in assessing the vulnerability of a breed, including cases with known artificial selection.

### 4.3 Number of Herds
When animals are located only in a few herds or flocks, there is a risk for that accidents, disease outbreaks, disposal of the herd for economic, health or age reasons, etc. will decrease the population size to a dangerous level. In Germany, less than 10 herds is considered to place a breed in a threatened state (6). The risk of dispersing a herd has increased due to over-production and economic depression, and may also affect big herds or flocks, even though small units are at greater risk. The critical number of herds depends on local economic circumstances and has to be assessed independently in different countries.

4.4 Existence of Cryogenic Stores of Genetic Material

The need and urgency of special conservation actions depends on whether frozen semen and/or embryos have already been stored and to what extent (19). In most cases nothing has been done, and in some cases the stores are too small and do not contain large enough numbers of males or matings. According to Smith (28) the numbers needed for securing 98% of the genetic variation would be semen from 25 unrelated sires or by 25 parental pairs with frozen embryos. Some increases in these amounts would be desirable for safety reasons. The number of males or matings stored can be added to the number of breeding males in estimating Ne for assessing vulnerability. In the case of low numbers of females, the number of matings can be added to the number of breeding females.

4.5 Criteria for Different Species

Assuming the above criteria concerning population size are applied, similar criteria can generally be used for different species. The relative importance of trends, variations in family size and number of herds may be somewhat different with small and large animals and should be considered separately by experts of the species in question. In poultry, the availability and utilization of hatching machines have to be considered. They increase the risk of extinction and thus the level of Ne needed for not being considered threatened.

4.6 Criteria for Different Global Regions

The use of Ne, adjusted by the various factors described above, diminishes the need for finding different criteria for different global regions. However, because of the greater uncertainties in the developing countries, the levels of threat (see below) have to be set differently from those in the developed countries. Regional and national expertise is required for considering the specific criteria.

4.7 Type of Information needed/desired

On the basis of paragraphs the above paragraphs, the following kinds of information are necessary:

a. General information: country, species, breed, main location.

b. Numbers of males and females in breeding age.

c. Trends in numbers in last 3 years: decreasing, stable or increasing. Estimates of the percentage annual decrease would be very desirable, if they are possible to obtain.

d. Percentage of females bred pure (or crossed with purebred/half-bred males of an unrelated).

e. Number of males from which frozen semen has been stored.

f. Number of matings, from which embryos have been stored.
g. Number of herds: <5, 5–9, >10
h. Estimate of health and other risks in the herds left.

In addition, it is desirable to get following information:

i. Note about outstanding traits of the breed for possible future utilization.
j. Note about the special environment to which the breed is especially adapted.
k. Note of special products, which the breed can produce.
l. An assessment of endangerment and priority for conservation, based on items a-k and made by a group of local experts.

4.8 Recommendations for Guidelines

It is recommended that the effective population size (Ne) be estimated on the basis of numbers of breeding males (Nm) and females (Nf), by using sex ratio (Nm/Nf) and Nf in small populations, and 4 Nm in case of large numbers of females. The estimates should be adjusted by known trends in population size and extent of crossbreeding (by using Turner's estimates of the effects), and by estimates of variation in family size. In addition, one should consider whether the number of herds is alarmingly small, what kinds of outstanding traits the breed has, and to what kind of special environment it has adapted itself. Finally, an assessment of the degree of threat and priority for conservation should be made by local experts.

5 Proposals on levels of risk

5.1 Earlier classifications of risk status

Previously, different levels of threat, based mainly on the numbers of breeding females, were suggested by some authors or working parties (Table 1).

Table 1. Criteria proposed by some working groups for considering breeds to be threatened.

<table>
<thead>
<tr>
<th>Species</th>
<th>RBST</th>
<th>EAAP</th>
<th>AMBC</th>
<th>Bodó</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No males &gt;20</td>
<td>No males &lt;20</td>
<td>Rare</td>
<td>Minor</td>
</tr>
<tr>
<td>Cattle</td>
<td>&lt;750</td>
<td>&lt;1000</td>
<td>1000–5000</td>
<td>&lt;200</td>
</tr>
<tr>
<td>Sheep</td>
<td>&lt;1500</td>
<td>&lt;500</td>
<td>500–1000</td>
<td></td>
</tr>
<tr>
<td>Goats</td>
<td>&lt;500</td>
<td>&lt;500</td>
<td>500–100</td>
<td></td>
</tr>
<tr>
<td>Pigs</td>
<td>&lt;150</td>
<td>&lt;200</td>
<td>200–500</td>
<td></td>
</tr>
<tr>
<td>Horses</td>
<td>&lt;1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td></td>
<td></td>
<td></td>
<td>100–1000</td>
</tr>
</tbody>
</table>

Notes to table above:

1. * = Ne-values of 0–333 were given for varying sex ratios.
2. RBST required in addition, that:
(a) an official herd book has existed over six generations,
(b) the breed "breeds true to type"
(c) other breeds have contributed less than 20% of the genetic make-up in the last six generations,
(d) the breed has been known for 75 years.

These objectives are mainly cultural-historical, hence the classification does not suit cases where the main motives for conservation are economic-biological. The requirements are especially difficult to fulfil in developing countries, where herd books are rarely kept and where it is difficult to identify even the immediate parents and certainly not six generation of ancestors.

3. The EAAP working party added that steadily decreasing numbers of breeding animals or increasing use of crossbreeding are reasons for increasing the numbers of animals below which a breed is considered threatened. FAO (12) recommended multiplying the EAAP figures by 2 or 3 for developing countries, because of the subdivisions and genetic isolation of nomadic populations, harsh climatic conditions and high risk of disease. It proposed as a working rule that "when a population size approaches 5000 breeding females, the survival risk of the breed should be studied and appropriate actions initiated. Specific recommendations are needed for each circumstance, based upon the local circumstances of the breed, its management system, the extent of crossbreeding, rate of decline in numbers and the certainty of the breed having unique qualities.

4. The AMBC classification is based on the number of registrations per year, and there are three categories. The AMBC system, like the RBST system, cannot be applied in developing countries, since registration of parents is rare.

5. Bodó (4) used five categories (normal, insecure, vulnerable, endangered, critical), of which "endangered" is included in Table 1. He gave also Ne-values for different sex ratios. For the "endangered" category they varied from 4 to 333.

5.2 Suggestion for a classification based on Ne

The RBST and EAAP systems need different criteria levels for different species and try to cover different situations within species. In order to make the classification more systematic, the use of Ne is suggested here. It is proposed that Ne (adjusted by trends in animal numbers, extent of frozen stores and crossbreeding, and variations in family size) be used as the main criterion for setting the threat levels. In addition, too few herds, the existence of outstanding traits and special environmental adaptations should be considered. The suggested levels of threat are presented in Table 2.

<table>
<thead>
<tr>
<th>Risk status category</th>
<th>Ne</th>
<th>No. herds</th>
<th>Outstanding Traits</th>
<th>Special Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>E = Endangered</td>
<td>&lt;50</td>
<td>&lt;10</td>
<td>1 or more</td>
<td>1 or more</td>
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<tr>
<td>V = Vulnerable</td>
<td>&lt;100</td>
<td>&lt;20</td>
<td>1 or more</td>
<td>1 or more</td>
</tr>
<tr>
<td>R = Rare</td>
<td>&lt;200</td>
<td>&lt;40</td>
<td>1 or more</td>
<td>1 or more</td>
</tr>
</tbody>
</table>

The main category to be found at the first stage E, which could be considered the threshold for inclusion in the Early Warning List and the indication of need for urgent conservation action.

Categories V and R indicate need for a close watch, since the speed of changes in the economic, political and commercial life is accelerating and the use of various techniques of reproduction is expanding. They can also be used for indicating breeds in which some selection could be carried out in addition to preservation. However, the question deserves to be discussed and a search for other alternatives should be continued. Since the number of herds is important, evaluation of the limits in Table 2 is needed to determine whether they are appropriate or if some other values would be more effective.

5.3 Recommendation for risk status assessment
It is suggested that a classification of breeds for threat level should be based on the concept of Ne, adjusted by trends in population size, extent of crossbreeding, frozen stores, and variability of family size. In addition, the number of herds and trends in numbers of herds, outstanding traits and environmental adaptations should be considered in assessing the risk status and conservation priority.

6 References


7 Appendix 1. Summary of SABRA documentation of livestock breeds (3).

(B=buffalo, C=cattle, Ch=chicken, D=duck, G=goat, P=pig, S=sheep, T=turkey, v=verbal description)

<table>
<thead>
<tr>
<th></th>
<th>C&amp;B</th>
<th>S&amp;G</th>
<th>P</th>
<th>Ch</th>
<th>D</th>
<th>T</th>
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<td>5</td>
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- incubation  -  -  -  2  2  2
- breeding system  -  -  -  3  3  3
C. Other aspects of performance
- react. to heat & solar radiat.  16  15  11  v  v  v
- resist. to parasites & diseas.  v  v  v  v  v  v
- efficiency in converting feed  -  20  -  -  -  -
D. Housing and management
- type of housing  -  -  -  9  3  3
- artificial lighting  -  -  -  3  -  2
- feed  -  -  -  6  6  6
- feed supplements  -  -  -  3  3  3
E. Conditions of data collect.
- geographic region  1  1  1  1  1  1
- annual rainfall  2  2  2  2  2  2
- type of rainfall  7  7  7  7  7  7
- average maximum temperature  3  3  3  3  3  3
- average minimum temperature  3  3  3  3  3  3
- average maximum humidity  3  3  3  3  3  3
- average minimum humidity  3  3  3  3  3  3
- type of management  28  28  6  -  -  -
F. Place where data obtained  3  -  7  3  3  3
G. References  v  v  v  v  v  v
TOTAL NO. OF PAGES  19  17  10  8  6  8

Appendix 2. Summary of FAO-descriptors (9, 10, 11). (Species symbols as in Appendix 1).

Approximate No. of alternatives

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V. Physiology
- reaction to solar radiation 48 48 48 48 48 (2v) (2v) (2v)
- react. to climate 38 38 38 38 38 (2v) (2v) (2v)
  chamber stress

X. Genetic parameters 900 900 900 900 900 900 900 900

Y. Cytogenetics & heritable abnormalities 20 20 20 20 20 20 20 20

Z. Disease and parasite resistance 10 10 10 10 10 10 10 10

TOTAL NO. OF PAGES 21 24 38 34 18 15 15 14

Appendix 3. Summary of EAAP/FAO-forms (25), and shortened FAO-form

(= X) (23). (Species symbols as in Appendix 1, H=horses).

Approximate No. of alternatives

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  - Country, species, breed names | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
  - Location, organization | 3 | 3 | 5 | 3 | 3 | 3 | 3 | - |
  - Prepared by, date | 5 | 5 | 5 | 5 | 5 | 5 | 5 | - |
| B. Origin and development |   |   |    |   |   |   |   |   |
  - Origin | 18 | 18 | 24 | 18 | 18 | 18 | 18 | - |
  - Breeding popul. nos. & year | 10 | 10 | 8 | 10 | 10 | 10 | 10 | 8 |
  - Aver. age of breeding animals | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - |
  - Storage of semen and embryos | 6 | 6 | - | 6 | 6 | 6 | 6 | - |
| C. Breed description |   |   |    |   |   |   |   |   |
  - Colours (incl. eggs) | 18 | 18 | 29 | 18 | 18 | 18 | 18 | - |
  - Horns (comb type) | 8 | 8 | (5) | 8 | 8 | 8 | 8 | - |
  - Hairs and wool | - | - | - | 5 | - | - | 5 | - |
  - Adult size and weight | 4 | 4 | 5 | 4 | 4 | 4 | 4 | - |
  - Other specific visible traits | 2 | 2 | 6 | 2 | 2 | 2 | 2 | - |
  - Genetic peculiarities | 10 | 10 | 10 | 10 | 10 | 10 | 10 | - |
| D. Qualification of breed |   |   |    |   |   |   |   |   |
  - Present main use | 10 | 10 | 6 | 10 | 10 | 10 | 10 | - |
  - Special qualifications | 12 | 12 | 12 | 12 | 12 | 12 | 12 | - |
E. Management conditions
- Type of housing | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | -
- Housing period  | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | -
- Feeding of adults | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | -
- Special conditions | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | -

F. Summary of performance record
- Standard breed for compar. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -
- Production of standard breed | 4 | 4 | 5 | 5 | 3 | 5 | 5 | 5 | -
- Relative performances | 14 | 14 | 16 | 12 | 10 | 11 | 12 | 12 | -
- Absolute performances (in X) | 8 | 8 | 10 | 8 | 7 | 10 | 10 | 10 | -
- Validity of comparisons | 42 | 42 | 48 | 36 | 30 | 33 | 36 | 36 | -

G. Additional information
- Genetic distance | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | -
- Genet. mater. stored as DNA | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | -
- Live anim. conserv. activit. | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | -

TOTAL NO. OF PAGES | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 1
THE MINIMUM NUMBER OF PRESERVED POPULATIONS

I. Bodó

1 Introduction

Recommendations for a minimum population size for use in preservation programmes throughout the world are important for the following reasons:

- to give a framework to the various technical intervention activities and thus provide means for avoiding genetic drift, which results in the loss of genetic diversity within a population;
- to prevent the reduction in size and possible extinction of populations by increases in inbreeding, which is always a threat in small populations;
- to avoid degeneration due to the absence of selection;
- to aid decision making for financing measures to maintain threatened, non-commercial breeds;
- to provide criteria for the regular publication of a World Watch List for threatened breeds on the basis of internationally accepted “minimum numbers”.

The minimum number is an important parameter for planning both the preservation of isolated non-commercial populations for possible use in the long term future and also for conserving populations which, though having current economic value, are threatened. Conservation by cryogenic storage of genetic material and the maintenance of breeding herds or flocks involve different problems and issues; therefore the problems of ex situ and in situ preservation must be treated separately. Identification of the different types of populations such as breeds, strains, lines etc. for a preservation programme is an associated topic, related to the minimum number question, but it is not appropriate to consider it in detail here.

Many factors influence the recommendations for a minimum number for threatened populations which should be considered when deciding upon recommendations. The danger of extinction is a function of genetic drift and the fixation of homozygous loci relative to the size, dynamics and structure of a population. Some important factors influencing this situation are:

- Initial gene frequency relative to the founder effect (or with the impact of a bottle neck phenomenon);
- Generation interval;
- Reproductive potential, which affects the possible growth rate of inbreeding;
- Planned selection and mating systems;
- Mutation rate;
- Migration;
- Number of herds;
- Future mating system;
- Costs and market, that is to say the economic situation;
- Management factors which can influence many of the above mentioned factors.

1 Department of Animal Breeding, University of Veterinary Science, Budapest, Hungary.
When all these aspects are taken into consideration the inevitable conclusion is that a defined minimum number must be worked out for each individual case. Nevertheless a general framework can be given which then needs to be elaborated in each case. The idea of a World Watch List for threatened breeds, strains and populations needs definition of the minimum numbers for each level of threat. These guidelines must be sensitive to the species, regional and national aspects of programmes.

2 Scientific and experimental calculations and systems

Classical and current calculations of minimum populations size use the concept of effective population size, Ne, which adjusts the actual number of active breeding animals to a sex ratio of 1:1 (Wright 1921, Fisher 1946, Falconer 1964, Fewson 1966, Pirchner 1968, Dohy 1989). With random mating the level of inbreeding increases as the population size decreases. Wright (1931) and Lush (1945) indicate that this effect is very small when the Ne is more than 200. Smith (1982, 1984) calculated the drift of haploid and diploid genes and concluded that 25 non-related animals are theoretically enough for the long term storage of a population. For safety reasons it is often recommended that this figure should be doubled. This figure of 25 is widely cited in the literature in connection with artificial insemination and embryo transfer systems. Wu (1990) calculated that, if the inbreeding coefficient is to increase by no more then 0.1 per 100 years, then a minimum Ne of 100 is needed for horses and cows having a generation interval of five years, whereas for sheep and pigs with a generation interval of two and a half years the Ne would be 200. Brem et al. (1990) are of the opinion that a population is not threatened when the effective population number is over 50 and where there is a minimum of 10 males. For effective selection an Ne of at least 100 is necessary.

Table 1. Population size proposed for preservation (populations size)

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<td>Goat</td>
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<td>Pig</td>
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<td>Horse</td>
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</tbody>
</table>

Rasch and Herrendorfer (1990) based on a literature survey, recommended an Ne of 200 for maintaining a genetically constant population over 50 generations. Based on the results of Latter (1959) and Hill (1972), Rochambeau and Chevalet (1990) offer a new and more sophisticated method for the calculation of the effective population size. Thus, theoretical approaches can be summarized as giving an Ne in the range of 25 to 400 depending upon circumstances. Some authors calculate specific figures for several species, while others do not make distinctions between them and use a single figure for all. For everyday practice, some authors prefer to give simpler population figures rather than Ne for the maintenance of populations. The most frequently cited authors in this respect are Maijala (1982) and Alderson (1981). Their recommendations are summarized in Table 1.
The Rare Breeds Survival Trust considers that when the number of male lines decreases below 4 the population is threatened (Alderson 1980). Draganescu (1975) used different criteria for the domestic animal species and also took into consideration the costs (Table 2).

Table 2. Minimum numbers for different species (Draganescu, 1975)

<table>
<thead>
<tr>
<th>Species</th>
<th>Minimum Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigs:</td>
<td>25 boars + 100 sows</td>
</tr>
<tr>
<td>Sheep:</td>
<td>10–12 rams + 100–250 ewes</td>
</tr>
<tr>
<td>Cattle:</td>
<td>10 bulls + 50–60 cows</td>
</tr>
<tr>
<td>Poultry:</td>
<td>50 cocks + 250 hens</td>
</tr>
</tbody>
</table>

Chen Ruihe (1990) gives a Chinese view of the minimum number as follows: “...it is well known, according to theoretical calculations, that the minimum number must be 12–15 rams and 100–250 ewes, but a better alternative is to extend and enlarge the flock”. Smith (1984) suggests the following minimum numbers (male/female) for several species: cattle 10/26; sheep 32/60; pigs 44/44; chickens 72/72. This recommendation is a synthesis of genetic and financial aspects. Beilharz (1983) recommended 25 males and 25 females per generation each giving one progeny to the next generation. According to Sheldon (1984), 400 animals are necessary in a 1:1 sex ratio. Simon (1991) proposes a breed be regarded as threatened when the effective population size (Ne) is less than 50 and when there are other conditions affecting the populations. The effective population size of 50 can be derived from a variety of sex ratios. For example it can result from the following ratios of males and females - 25/25; 20/35; 15/180; 13/300. Simon adds that the associated conditions which would cause the population to be regarded as threatened include a decrease in the number of breeding animals by more than ten percent per year, the number of herds being less than ten and matings with other breed(s) being greater than ten percent or other economic conditions causing rapid changes in the population.

In France in 1980, breeds numbering no more than a few thousand were considered to be threatened with extinction (Devillard 1981). A general recommendation for the first monitoring in developing countries is a total population size of less than 10,000 animals (Hodges 1989). Ngere (1989) thinks, based upon west African experience, that 7,000 is an appropriate level for action to start. The FAO Committee on Agriculture in 1989 accepted the notion of total population size of 10,000 or the number of females in the population as 5,000 as levels for action to be initiated (reported in FAO, 1990). Another possible approach is to use not only the minimum variable population size (MVP) but also its relationship to the effective population size, Ne (Foose 1988). This relationship is expressed by MVP/Ne. In extreme cases of very small populations, Yamada and Kimura (1984) consider that a founder stock with less than 5 individuals cannot survive when such parameters as fecundity, viability, sex ratio, and their correlation to inbreeding depression are taken into consideration.

A common idea for specifying the minimum number is the creation of categories which largely depend on population size and which indicate differing levels of threat. Rognoni (1981) proposed the categories in Table 3.
Table 3. Different levels of endangering of animal populations (Rognoni, 1981)

<table>
<thead>
<tr>
<th>Category</th>
<th>Mammals</th>
<th>Poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relic populations</td>
<td>less than 100 individuals per breed</td>
<td></td>
</tr>
<tr>
<td>Semi-relic populations</td>
<td>100–4,000 individuals per breed and seriously threatened by extinction</td>
<td></td>
</tr>
<tr>
<td>Small populations</td>
<td>5,000–15,000 individuals per breed and expected to reach an equilibrium</td>
<td></td>
</tr>
<tr>
<td>Large but declining</td>
<td>12,000–500,000 individuals per breed</td>
<td></td>
</tr>
<tr>
<td>Populations in equilibrium</td>
<td>17,000–110,000 individuals per breed</td>
<td></td>
</tr>
</tbody>
</table>

The system of American Minor Breeds Conservancy (1990) is very practical and has been in use for a decade (Table 4):

Table 4. The American Minor Breeds System, (1990)

<table>
<thead>
<tr>
<th>Category</th>
<th>Mammals</th>
<th>Poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watch</td>
<td>breeds whose registration over a 25 year period have shown a steady decline or where registrations are less than 5,000 per year</td>
<td>2,000–20,000 females and less than 10 male lines, decreasing tendency</td>
</tr>
<tr>
<td>Minor</td>
<td>Cattle, sheep, goat, horse, breeds with less than 1,000 registrations per year. Pig breeds with less than 200 registrations per year.</td>
<td>Females less than 2,000, male lines 5 or less. Less than 3 male lines.</td>
</tr>
<tr>
<td>Rare</td>
<td>Cattle and horse breeds with less than 200 registrations per year. Sheep, goat and pig breeds with less than 200 registrations per year.</td>
<td>females less than 500, male lines less than 3.</td>
</tr>
<tr>
<td>Feral</td>
<td>Stocks known to have been running wild for at least 100 years with no known introduction of outside blood.</td>
<td></td>
</tr>
</tbody>
</table>

Another classification is used by the World Conservation Union (IUCN) for wild animals. It is not possible to use it as a normal standard for domestic animals but it has some useful aspects shown in Table 5. (Thornback, 1983).

Table 5. Status of populations according to the Red Data Book System

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of danger</td>
<td>effective conservation measures have been taken and the population is considered relatively secure</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>lack of enough information to say which category is appropriate</td>
</tr>
<tr>
<td>Rare</td>
<td>taxa with small world populations that are not at present threatened or vulnerable, but are at risk</td>
</tr>
<tr>
<td>Vulnerable</td>
<td>taxa believed likely to move into the threatened category in the near future if the causal factors continue operating</td>
</tr>
<tr>
<td>Endangered</td>
<td>taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitat have been so</td>
</tr>
</tbody>
</table>
drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that are possibly already extinct but have definitely been seen in the past 50 years.

Extinct species not definitely located in the wild during the past 50 years (criterion used by CITES)

Results of two trials to make an acceptable system for the categories of risk status of farm animals were published in 1989 simultaneously by Maijala (1990) and Bodó (1990a) in FAO (1990). Maijala (1990) feels it is appropriate to apply the terms endangered, vulnerable and rare from the IUCN classification to domesticated animals; and perhaps in some cases also extinct, indeterminate and insufficiently known might be useful. The recommended categories are in Table 6.

Table 6. Categories based on Ne

<table>
<thead>
<tr>
<th></th>
<th>developed countries</th>
<th>developing countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endangered</td>
<td>Ne &gt;50</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Vulnerable</td>
<td>Ne 50 – 100</td>
<td>100 – 500</td>
</tr>
<tr>
<td>Rare</td>
<td>Ne 100 – 500</td>
<td>500 – 2,000</td>
</tr>
</tbody>
</table>

Bodó (1990a) used the number of breeding females in several categories (normal, insecure, vulnerable, endangered, critical) and also took possible sex ratios into consideration. The comparison of the IUCN system for wild animals and a possible solution to farm animals was published by Bodó (1990b) at the 4th World Conference of Genetics applied to Livestock Production. Other publications touching the same topic are Maijala 1974, Crawford 1981, Campo and Orozco 1982, Sirkkomma 1983.

3 Some examples of the history of preserved small populations

The theoretical considerations and classification systems can be illustrated with some practical examples of animal breeding.

Emperor Napoleon received a flock of Merino sheep from Spain as a gift about 185 years ago. This flock is the famous Rambouillet Merino and it was kept without addition with not more than 100 – 120 ewes from the beginning (Perret 1985).

As a consequence of the activity of Rare Breeds Survival Trust in Great Britain the number of Portland females grew from 85 to 341 and the number of cows and heifers of White Park cattle from 65 to 138 between 1974 and 1986 (Alderson 1989). The stock of Soay sheep which consisted of 20 rams 44 ewes, 22 male lambs and 21 female lambs was left on an uninhabited island in the UK, (Alderson 1989).

The most interesting population of the world from the preservation aspect is the Chillingham cattle in the UK. It has been an inbred population of some dozen head since 1270. After the severe winter of 1974 the herd consisted of 8 cows and 5 bulls without young animals. During the subsequent ten years the population increased to 8 bulls 29 cows and 7 calves. The extreme homogeneity of this herd can be well understood and is demonstrated by biochemical polymorphisms (Wallis 1986).
In Switzerland a small swine population (Wollhaarige Weideschwein) is registered as having only six ancestors of which two were boars and four sows (Marx 1990); the group is however experiencing some reproduction problems.

In the former USSR, as described by Dmitriev and Ernst (1989), five cattle breeds, six chicken breeds, eight goose breeds, seven turkey breeds and one guinea fowl breed did not exceed 1,000 head in population size.

The Murnau-Werdenfelser cattle are preserved in Bavaria with 17 bulls and 250 cows.

The figures concerning the European Braunvieh (without American Brown Swiss) are 11 and 500 respectively. 7,000 doses of semen from 23 bulls are also available. An effective population size of 51 can be calculated, but the situation will become less favourable because of the old age of the cows (Hirsch et al 1990).

Crawford (1989) reported, that he had maintained poultry populations with 18 males and 50 females for many decades.

The number of Hungarian Grey cows was less than 200 before the preservation programme began in the 1960s (Bodó 1985). The Hungarian Cikta breed has been kept in a flock of 250 ewes for 25 years without any problems. The population size of the different Lippizan studs in the neighbouring Danubian countries has not been more than some dozens each and the use of the males from the other countries began only some years ago (Bodó and Pataki 1984).

Ryder (1985) says that all the captive Przewalski Horses trace their ancestry to 13 founder animals. The average of their inbreeding coefficients is about 0.23 (maximum individual value: 0.597).

4 Discussion

When summarizing the data from the literature and from the practice, some contradiction can be observed and it is difficult to make a simple general conclusion on the minimum number to indicate the threatened status of different farms animal populations. From the theoretical statements and estimations, an Ne of between 50 and 200 seems generally to indicate threatened status. Above an Ne of 200 there is generally no danger of genetic drift and below an Ne of 50, the driftless reproduction and even the survival of the population is uncertain. There are some theoretical and practical considerations which leave some uncertainty when using the effective population size (Ne) to define level of threat for use in the World Watch List. The major aspects are now given.

Effective population size is based on the actual number of breeding females and males without taking into account the initial situation (founder effect, bottle neck syndrome). The increased inbreeding coefficient is then uncertain, if Ne alone is used.

The existence or lack of recessive, (damaging or lethal) factors is unknown and can not be estimated in Ne calculation.

The different characteristics of various species are disregarded.
In theoretical calculations the assumption of random mating is made, whereas in practice sophisticated mating systems are sometimes used.

Some practical aspects like the reproduction rate, the generation interval, the different expenses and the maintenance requirements are also important.

The number of males is sometimes unknown due to the unrecorded use of young males.

As a consequence of these aspects it is not realistic to state simply a single figure of effective populations size and to rely solely upon that for decision making. The most appropriate solution, depending upon the various factors for a given population, is to interpret the effective population size according to the particular situation. A general recommendation which will offer commonly accepted limits is needed, however, for use on a large scale approach to preservation programmes as, for example, in the development of the World Watch List using data banks information. Thus, a published category system should be very carefully elaborated for this purpose, within which the special distinctions and circumstances applying to an individual population can be presented.

5 The proposal

Four different levels of risk are proposed plus normality and extinction in Table 7.

5.1 Normal status

This category applies to populations of more than 10,000 females. It seems to pose no genetic problems. However it must be recognized that, even in this status of risk, the effective number can fall below the level needed due, for example, to sex ratio or rapid decreases of the population due to crossbreeding. Some interventions are then required. Generally in the normal status it is obvious when the population is not in danger of extinction, it can reproduce without genetic loss and there are no visible changes in the population size. In the literature the total populations size is used for this category (ie not effective population size). Here however, it is proposed that the number of females is used since this often fluctuates due to the seasonality of birth and disposal. Other factors can also be misleading, for example when oxen are used for draught, when the generation interval and or reproduction rates are deliberately controlled or changed by adverse environmental factors.

Table 7. Risk categories for domestic animals

<table>
<thead>
<tr>
<th>Status</th>
<th>Number of breeding females</th>
<th>Approximate effective population size when the sex ratio is:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5:1</td>
</tr>
<tr>
<td>Normal</td>
<td>&gt; 10,000</td>
<td>6,666</td>
</tr>
<tr>
<td>Insecure</td>
<td>5,000–10,000</td>
<td>3,333–6,665</td>
</tr>
<tr>
<td>Vulnerable</td>
<td>1,000–5,000</td>
<td>667–3,332</td>
</tr>
<tr>
<td>Endangered</td>
<td>100–1,000</td>
<td>67–667</td>
</tr>
<tr>
<td>Critical</td>
<td>&lt;100</td>
<td>&lt;67</td>
</tr>
</tbody>
</table>

Extinct. The resuscitation of the population is impossible, even if after a bottle neck syndrome other genetic variance comes into being.
5.2 Insecure status

With a population size of 5,000 to 10,000 females, some disadvantageous effects can affect the existence of the population. Crossbreeding and the use of semen of exotic males under the pressure of sales promotion organizations can cause large changes in a short time. That is why some preventive measures must be taken into consideration. In developing countries, in transhumance situations for example, risks are even more evident though are usually not predictable or avoidable. In these cases the obligatory activities of the next status level should be introduced.

5.3 Vulnerable status

The population number is typically 1,000 to 5,000 females. Here the level of threat is increasing. Measures for well-directed programmes should be set up for example, the establishment or renewal of breeders associations, publicity, the subsidy of preserved animals and regulation of marketing etc.

5.4 Endangered status

The population size is between 100 and 1,000 females which implies that the breed is in danger of extinction. Without action its effective population size is inadequate in most cases to prevent continuing genetic loss in future generations. An increase in the degree of inbreeding is unavoidable and threatens the vitality of animals. There is a real danger either of spontaneous loss for example by sudden disease, or due to neglect by man. Methods of preservation must be started to save the population in question, for example by cryogenic storage, management of a narrow sex ratio, sophisticated mating system, measurement of biochemical polymorphisms etc, using RLFP, VNTR and finger-print techniques when available. However these electrophoretic studies often show a surprisingly small amount of genetic variability at gene level (Cunningham, 1990). The level of danger is not the same for a populations with 100 and 1,000 breeding females. Therefore the minimum population size must be chosen on an individual basis within the framework of the financial support system made available for example by government or other local or international organizations. Then, the aspects of reproduction, sex ratio, generation interval, system of management, the possible presence of defect genes, mating system used, possible financing etc. should be taken into consideration.

5.5 Critical status

Populations of less than 100 females are an extreme case of the previous level of threat. The population is close to extinction. The first action must be to increase the population size. At this level of threat, the genetic variability is often already reduced so that the population cannot be considered the same as the ancient breed. In spite of this likelihood, there are some exceptional populations which have been maintained at this populations size for many years, as shown by some examples given earlier. However, groups of formerly populous breeds which arrive at this small size should not be maintained at this level of threat and efforts should be made to enlarge the population size.

A domestic animal population should be considered extinct, when resuscitation is impossible. If, after a crucial bottle neck syndrome, another genetic variety comes into being a new name must be given to it.
6 Pros and cons

Some questions must now be faced concerning the system which has been proposed above. It can be argued that in this system the issues of generation interval, reproduction rate, specific characteristics of the species, mating system, sex ratio etc. are not sufficiently involved. It seems probable, that the majority of preserved populations will be kept in at an threatened level as a result of the need to balance between the ideal genetic benefits and available finances. When activities cannot be undertaken for all cases, populations with numbers of females between 100 and 1,000 should be afforded some special consideration for attention. On the effect of inbreeding, some geneticists have recently concluded that there are some mechanisms, such as the phenomenon of non-nuclear inheritance, which act against the depletion of genetic variance and the damage of increasing homozygosity (Cunningham 1990, Ron et al. 1990). Nevertheless, it would not be prudent or useful to recommend lower minimum population size limits for preservation on the basis of these new possibilities until they are fully demonstrated by scientific evidence or by some successful practical examples from the history of animal breeding. The threat of a permanently changed situation through failure to act indicates that the figures proposed in Table 7, which are based upon current proven genetic knowledge, should be the basis of action programmes. These threat categories are proposed for developed country conditions to make doubly sure that extinction does not happen; and for developing country conditions, where control is less certain, the figures could be increased with advantage.

7 Recommendation for A.I. and E.T.

In the literature the generally accepted theoretical basis for the storage of genetic material is a stock of non related 25 individuals (Smith 1982). The collection and storage of semen is not too difficult and that is why storage of some hundreds of doses is recommended as a first step for all cattle breeds (Alderson 1989). For the creation of gene banks of embryos many breeding animals are needed (Springmann et al., 1987), when the following aspects are considered:

- Cooperation of owners;
- Ratio of possible donors animals to recipients;
- Response rate to super-ovulation;
- Proportion of embryos suitable to deep freezing;
- Deep freezing loss;
- Storage loss;
- Pregnancy rate after thawing;
- Loss during pregnancy;
- Perinatal loss;
- Losses during the growing period;
- Sex ratio;
- Intensity of selection of breeding females;
- Security.

Number of embryos needed for a founder stock of 25 heifers is shown in Table 8.
Table 8. Number of embryos needed for preservation (Brem et al., 1990)

<table>
<thead>
<tr>
<th>Embryo survival (%)</th>
<th>pregnancy rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>50</td>
<td>616</td>
</tr>
<tr>
<td>60</td>
<td>513</td>
</tr>
<tr>
<td>70</td>
<td>440</td>
</tr>
<tr>
<td>80</td>
<td>385</td>
</tr>
<tr>
<td>90</td>
<td>342</td>
</tr>
</tbody>
</table>

The criterium of “non related 25 individuals” means that the same animal must not appear again up to the third generation in 25 pedigrees. Therefore embryo collection involves a male population of 175 head (although not at the same time) and a female population of many thousands. It is generally agreed that at least two embryo or semen banks are necessary for safety reasons (Beilharz 1983). Renard (1982) proposed 130 embryos from 30 donors as a basis for the cryogenetic storage of a population. The situation is more complicated when, in addition to the cryogenic storage there is also a preserved breeding population. Published recommendations indicate the following figures as desirable:

- two or three lots of 300 doses of semen from each of 25 non-related males
- sufficient embryos to produce two or three groups of 25 breeding females each.
- if there is a combination of ex situ and in situ preservation the criteria can be combined.

8 Summary

An authoritative programme should be established by FAO which addresses national and regional preservation programmes for domestic animal breeds and which includes the creation and publication of a World Watch List. Associated with this should be a recommended system of risk assessment which is capable of being used in individual cases and adapted to the specific characteristics and problems. Instead of using only the scientifically valuable concept of effective population size it seems more suitable to propose a category system for the different risk-levels of different situations.

The proposed categories are:

Normal status (over 10,000 females); no danger

Insecure status (5,000–10,000 females); a possible danger in the near future

Vulnerable status (1,000–5,000); the problems can be solved by usual measures

Endangered status (100–1,000 females); special methods of needed

Critical status (below 100 females); exceptional methods needed quickly.

Extinct (no animals); too late.
Using these categories it is possible to create the special minimum number for each individual case. This means that within the given category the specificity of the population, the generation interval, the reproduction rate of the species or breed, the mating system used and the management etc. can be taken into consideration when deciding on the minimum number. It is meaningful to study the genetic structure of a population using blood groups and other polymorphisms.

For cryogenic storage of breeding material minimum numbers of doses of semen and of embryos are recommended. The minimum number for \textit{ex situ} and \textit{in situ} methods can be combined.

\textbf{9 References}


SUMMARY OF FAO ACTIVITY ON THE GLOBAL DATA BANK FOR DOMESTIC LIVESTOCK

J. Ruane

1 Introduction

A data bank is a place where information or data can be stored and managed. In modern times, storage is by electronic means and hence requires the use of computers, be they mainframe or portable. The data that are entered can be instantly recalled, examined, rearranged, edited and printed. In turn, they can then be distributed worldwide in diskette form.

To work for the preservation or promotion of animal genetic resources it is essential that we first know what resources exist. The Global Data Bank for Domestic Livestock aims to document and characterize the different populations of domestic livestock found throughout the world.

2 Current Status

The Global Data Bank is now based in Rome and currently includes 2054 breeds (and varieties of breeds) of ass, buffalo, cattle, goat, horse, pig and sheep. Populations from all areas of the world are covered with the exception of Europe but including the former U.S.S.R. (Table 1). The number of breeds is highest in Asia (43% of total) and, among the seven species, is highest for sheep (29%) and cattle (28%). Most populations (92%) are restricted to a single country while only 8% are found in more than one country.

The list of breeds is still in the development phase and is certain to change as information accumulates concerning populations currently entered in the Global Data Bank that no longer exist and populations that do exist but are not currently included in the data bank. In addition, it is planned that the data already collected on European breeds will be added at a future date.

As of April 1992, the regional data bank for Europe (based in Hannover) contained a total of 707 entries comprising 5 ass, 206 cattle, 54 goat, 110 horse, 92 pig and 240 sheep entries (Maijala, 1992). Note that the numbers in the two data banks are not strictly comparable since in the data bank in Rome there is one entry per breed (even if the breed is found in several countries) whereas in the Hannover data bank there is one entry per breed per country.

The Global Data Bank in Rome currently holds information on population size for only 27% of all entries (Table 2). Furthermore, in most cases this information consists of an overall figure for total population size (which may not be up-to-date) or of a description of the breed as rare, disappearing or almost extinct.

1 Animal Production Service, Food and Agriculture Organization, Rome, 00100, Italy.

For 31% of entries in the data bank some information on production characteristics is available (Table 3) while for 20% some information on both population status and production performance is present (Table 4). The production data may consist of data on characteristics such as adult size and weight, milk traits, fleece weight or litter size.

3 Sources of information
The world dictionary of livestock breeds by Mason (1988) was used as the primary source of information on breeds and breed varieties for the data bank. This book provides breed names and synonyms, the geographical location of the population as well as giving a basic description of the origin, physical appearance and main uses of each breed.

Not all entries from Mason (1988) were included in the data bank. For example, those referring to a cross between breeds, a hybrid between two species or to a group or collection of breeds were excluded. On the other hand, all varieties or strains of breeds as well as wild or feral species were included. Of the 2054 entries, 515 (25%) were described by Mason (1988) as a variety, subvariety or strain of a breed and 83 (4%) as wild or primitive species.

Mason (1988) does not provide estimates of population size (other than to occasionally indicate that a breed is nearly extinct, rare or declining in numbers) or of production performance for the breeds cited. To find this information, a wide range of literature sources in FAO Headquarters were consulted:

a. FAO Animal Production and Health Papers (about 20 are relevant)
b. Animal Genetic Resources Information booklets (7 in total)
c. World Animal Review (1972 to date)
d. Reports on individual countries (mainly carried out for FAO) and a selection of books from the library of the Animal Health and Production Division, FAO

Note that at this early stage, greater emphasis was placed on data collection for developing countries. After entering these data it was however obvious that essential information was missing for the majority of breeds (Tables 2 to 4). To rectify this, agreements were made with parties in every part of the world asking them

a. To confirm that the entries in the data bank relating to their country or region are a true representative of the animal genetic resources in their area.
b. To complete short one-page questionnaires (see Appendix) for those breeds for which there is no information on population size in the data bank and, if possible, to do the same for those breeds for which some information on population size is available. For these questionnaires, it was emphasized that information on population numbers was of primary importance.

4 Information that can be stored

For each entry in the Global Data Bank a wide variety of data can be stored (Table 5) ranging from basic features such as the origin, population size, physical characteristics, uses, production performance and management conditions of each breed to rarer features such as genetic distancing studies, DNA analysis and genetic conservation programmes. To give an idea of the amount of information that can be stored, a print-out for a single breed covers seven pages.

5 Computer software

The programmes for the data bank were written with a standardized software package called dBASE III PLUS. The original programmes were written, as part of an initiative by the European Association of Animal Production (EAAP), at the Institute for Animal Breeding and Genetics in Hannover, Germany with European breeds and conditions in mind. Consequently it was
necessary to make some changes to the programmes to make the data bank more suitable for breeds from developing countries. Among the changes made were the simplification of the section on production data and the addition of references for population or production data. These changes were made while ensuring that the data stored in the data banks in Hannover and Rome would remain compatible.

6 Extinct breeds

The 2054 breeds or breed varieties in the Global Data Bank represent populations known or thought to be in existence around the world today. Together with the number of breeds in the European data bank, it can be estimated that at the present time 2500 to 3000 different breeds or breed varieties are found throughout the world. A parallel data bank has also been set up containing information on 208 extinct breeds that Mason (1988) described as being recently extinct or that were important to the origin of certain breeds in the Global Data Bank.

7 Future work

At this stage we have reached the end of the first phase of the project. A first, rough list of animal genetic resources has been drawn up and, following a relatively brief literature survey at FAO Headquarters, information on population numbers and production data has been collected for a small fraction of these genetic resources.

The next phase of the project should have two objectives. Firstly, to update the entries in the data bank, in the sense of confirming the existence of the breeds or breed varieties already in the data bank and the addition of genetic resources not yet documented or included in the data bank. In this way we can work towards producing a final inventory of the populations of domestic animals found throughout the world.

Secondly, population (of primary importance at this early stage) and production data should be collected for those breeds lacking this information and updated for those breeds for which some information already exists. This will then allow us to pinpoint those populations of high merit or production potential that are endangered and/or that should be promoted. The completion of questionnaires described in Section C by individuals throughout the world concerning genetic resources in their own regions will help to fulfil both objectives.

Once the completed questionnaires are received, the data must be thoroughly checked before they can be entered into the data bank. It is especially important that no breed be entered more than once (this is a danger since the same breed may have several names).

Currently, breeds and breed varieties of seven domestic species (ass, buffalo, cattle, goat, horse, pig and sheep) are present in the data bank in Rome. In the future, it is planned to include camelids and poultry as they also represent important animal genetic resources.

8 References

9 Tables

**Table 1.** The number of breeds or breed varieties per geographical region in the Global Data Bank.

<table>
<thead>
<tr>
<th>Group</th>
<th>Ass</th>
<th>Buffalo</th>
<th>Cattle</th>
<th>Goat</th>
<th>Horse</th>
<th>Pig</th>
<th>Sheep</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former USSR</td>
<td>15</td>
<td>1</td>
<td>62</td>
<td>20</td>
<td>59</td>
<td>35</td>
<td>135</td>
<td>327</td>
</tr>
<tr>
<td>Africa</td>
<td>16</td>
<td>8</td>
<td>173</td>
<td>59</td>
<td>35</td>
<td>8</td>
<td>133</td>
<td>432</td>
</tr>
<tr>
<td>N&amp;C America</td>
<td>5</td>
<td>1</td>
<td>67</td>
<td>12</td>
<td>41</td>
<td>35</td>
<td>48</td>
<td>209</td>
</tr>
<tr>
<td>Latin America</td>
<td>5</td>
<td>2</td>
<td>45</td>
<td>11</td>
<td>22</td>
<td>17</td>
<td>17</td>
<td>119</td>
</tr>
<tr>
<td>Asia</td>
<td>22</td>
<td>63</td>
<td>200</td>
<td>147</td>
<td>88</td>
<td>142</td>
<td>231</td>
<td>893</td>
</tr>
<tr>
<td>Oceania</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>39</td>
<td>74</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>63</td>
<td>75</td>
<td>568</td>
<td>255</td>
<td>247</td>
<td>243</td>
<td>603</td>
<td>2054</td>
</tr>
</tbody>
</table>

**Table 2.** The number of breeds or breed varieties for which there is some information on **POPULATION SIZE.** The figures in brackets represent % of all entries in the data bank (Table 1)

<table>
<thead>
<tr>
<th>Group</th>
<th>Ass</th>
<th>Buffalo</th>
<th>Cattle</th>
<th>Goat</th>
<th>Horse</th>
<th>Pig</th>
<th>Sheep</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former USSR</td>
<td>0</td>
<td>1</td>
<td>43</td>
<td>11</td>
<td>48</td>
<td>22</td>
<td>54</td>
<td>179 (55)</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>1</td>
<td>1</td>
<td>50</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>23</td>
<td>89 (21)</td>
<td></td>
</tr>
<tr>
<td>N&amp;C America</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>45 (22)</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>33 (28)</td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>4</td>
<td>4</td>
<td>47</td>
<td>27</td>
<td>16</td>
<td>19</td>
<td>84</td>
<td>201 (23)</td>
<td></td>
</tr>
<tr>
<td>Oceania</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>13 (18)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5</td>
<td>6</td>
<td>175</td>
<td>60</td>
<td>76</td>
<td>53</td>
<td>185</td>
<td>560 (27)</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>(8)</td>
<td>(8)</td>
<td>(31)</td>
<td>(24)</td>
<td>(31)</td>
<td>(22)</td>
<td>(31)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.** The number of breeds or breed varieties for which there is some information on **PRODUCTION.** The figures in brackets represent % of all entries in the data bank (Table 1)

<table>
<thead>
<tr>
<th>Group</th>
<th>Ass</th>
<th>Buffalo</th>
<th>Cattle</th>
<th>Goat</th>
<th>Horse</th>
<th>Pig</th>
<th>Sheep</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former USSR</td>
<td>0</td>
<td>1</td>
<td>40</td>
<td>9</td>
<td>30</td>
<td>21</td>
<td>53</td>
<td>154 (47)</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>0</td>
<td>1</td>
<td>51</td>
<td>21</td>
<td>0</td>
<td>1</td>
<td>46</td>
<td>120 (28)</td>
<td></td>
</tr>
<tr>
<td>N&amp;C America</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>13 (6)</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>29 (24)</td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>0</td>
<td>24</td>
<td>63</td>
<td>68</td>
<td>12</td>
<td>28</td>
<td>118</td>
<td>313 (35)</td>
<td></td>
</tr>
<tr>
<td>Oceania</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5 (7)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0</td>
<td>26</td>
<td>174</td>
<td>106</td>
<td>43</td>
<td>53</td>
<td>232</td>
<td>634 (31)</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>(0)</td>
<td>(35)</td>
<td>(31)</td>
<td>(42)</td>
<td>(17)</td>
<td>(22)</td>
<td>(38)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. The number of breeds or breed varieties for which there is some information on POPULATION SIZE AND PRODUCTION. The figures in brackets represent % of all entries in the data bank (Table 1)

<table>
<thead>
<tr>
<th></th>
<th>Ass</th>
<th>Buffalo</th>
<th>Cattle</th>
<th>Goat</th>
<th>Horse</th>
<th>Pig</th>
<th>Sheep</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former USSR</td>
<td>0</td>
<td>1</td>
<td>38</td>
<td>7</td>
<td>30</td>
<td>21</td>
<td>51</td>
<td>148</td>
<td>(45)</td>
</tr>
<tr>
<td>Africa</td>
<td>0</td>
<td>1</td>
<td>38</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>18</td>
<td>69</td>
<td>(16)</td>
</tr>
<tr>
<td>N&amp;C America</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>(4)</td>
</tr>
<tr>
<td>Latin America</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>21</td>
<td>(18)</td>
</tr>
<tr>
<td>Asia</td>
<td>0</td>
<td>1</td>
<td>36</td>
<td>25</td>
<td>0</td>
<td>12</td>
<td>80</td>
<td>154</td>
<td>(17)</td>
</tr>
<tr>
<td>Oceania</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>(5)</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>3</td>
<td>126</td>
<td>48</td>
<td>30</td>
<td>37</td>
<td>161</td>
<td>405</td>
<td>(20)</td>
</tr>
<tr>
<td>%</td>
<td>(0)</td>
<td>(4)</td>
<td>(22)</td>
<td>(19)</td>
<td>(12)</td>
<td>(15)</td>
<td>(27)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Summary of information that can be stored for each entry in the data bank.

1. **General information**
   - Species (ass, buffalo, cattle, goat, horse, pig, sheep)
   - Whether the entry refers to a breed variety or a breed
   - Geographical location of entry
   - Local names, synonyms and international name (as described by Mason (1988)) of the entry
   - Names of individuals or organizations that provided information on the entry

2. **Origin and development of the breed**
   - Origin of the breed
   - Whether the breed is wild or primitive
   - Whether immigration of animals from other breeds or countries has taken place in recent years
   - Description of population size, in detailed and/or in simple terms (including reference(s)).
   - Degree of usage of artificial insemination and storage of semen and embryos

3. **Description of breed**
   - Coat colour
   - Number and description of horns
   - Hair and/or wool type
   - Adult size and weight
   - Genetic characteristics of the breed e.g. marker genes, chromosomal aberrations

4. **Uses and qualities of the breed**
   - Main uses of breed
   - Special qualities of breed e.g. disease resistance, adaptability to harsh climate or environment

5. **Management conditions**
   - Type of management, housing period, feeding

6. **Production Record**
   - Two ways of describing the performance record are possible a) Giving actual figures for the performance traits described in Table 6 (including reference(s)) or b) comparing the breed to a standard breed (preferably one that is very common) for a range of production traits
7. Additional information
   - Estimates of genetic distances to other breeds
   - Analysis of genetic material of the breed
   - Information on any conservation programme for the breed
   - Contact address for the conservation programme

10 Appendix. Breed questionnaire - population and performance data

NOTES:

1. COMPLETE ONE QUESTIONNAIRE PER BREED
2. QUESTIONS ARE WRITTEN ON BOTH SIDES OF THE PAGE
3. WHEN GIVING DATA, IF IT IS POSSIBLE, PLEASE INDICATE WHETHER THE DATA SOURCE IS VERY RELIABLE (V), RELIABLE (R) OR NOT RELIABLE (N). e.g. If the population size estimate is 10,000 and the data source is very reliable, write 10,000 (V)

GENERAL INFORMATION

1. Country:

2. Species (Buffalo, Cattle, Goat, Sheep, Horse or Pig):

3. Breed name:

4. Local names or synonyms:

POPULATION DATA

5. Year of data collection: ..........................................................

6. Total population size:

7. Total number of females being bred:

8. % females being bred pure (mated to males of own breed):

9. Total number of males used for breeding:

10. Of the above males, the number in AI-service:
11. Is the number of females increasing (1), decreasing (2) or stable (3): .................................................................

12. Additional population information (or any comments on the population data (e.g. source of data)): .................................................................

........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................

PERFORMANCE DATA

1. PERFORMANCE

<table>
<thead>
<tr>
<th></th>
<th>BUFFALO, CATTLE ASS OR HORSE</th>
<th>GOAT OR SHEEP</th>
<th>PIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield per lactation (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactation length (days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk Fat per cent (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk yield per year (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (male) (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (female) (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily gain (male) (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lean meat (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Litter size (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleece weight (female) (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Adult wither height (cm) : Males .................. Females ..................

   Adult live weight (kg) : Males .................. Females ..................

3. Management conditions under which performance was measured:

   a) Type: Stationary (1), Transhumant (2) or Nomadic (3) ........

   b) How many months per year were the animals housed ?: ........

   c) Feeding of adults: Total Grazing (1), Grazing + Fodder (2), Grazing + Concentrate (3), Total Concentrate (4), Other (explain) .........................

   d) Special conditions, e.g. lack of water supply: ....................

........................................................................................................................................................

4. Comments on performance data (e.g. source of data) or additional performance information (e.g. other merits of the breed): ..........................
1 Buffalo types and distributions

The water buffaloes of economic importance consist essentially of three major groups: Riverine, Swamp, and Mediterranean. They are distributed in more than 50 countries around the world. Most of them, especially the riverine and swamp types, are raised by small farmers in developing countries. In 1990 there were approximately 140 million water buffaloes in the world, compared with only 90 million in 1961 (see Table 1). Water buffaloes are being raised in many parts of the world including Asia, Africa, Latin America, as well as Australia and Eastern Europe. During recent years some water buffaloes, mostly of the swamp type, have also been introduced into the USA in order to investigate their adaptability and use for commercial purposes.

During the past three decades (1961–1990) the number of buffaloes in the world steadily and consistently increased in all regions except in Eastern Europe where numbers decreased during 1981–1990. The most striking expansion in numbers has taken place in the Latin American countries, especially Brazil, where some estimates put the buffalo population as high as 1.6 million. Furthermore, buffaloes have spread into more than 13 Latin American countries.

Water buffaloes are raised for milk and meat, as well as draught power and manure. In South Asia, some buffaloes, mainly of the riverine type, are raised for milk and others for both milk and draught power; buffalo meat is also becoming an important source of animal protein.

For small-farm production systems in developing countries, buffaloes serve as an integral part of crop production, providing draught power and manure for fertilizer as well as other uses. The role of buffaloes is socio-economically quite significant, especially in the lowland rain rice production systems prevalent in Asia. Large-scale commercial buffalo production for meat or milk also exists in many countries, for example, in Egypt, Bulgaria, Brazil, India, Pakistan, and Italy.

It is estimated that, of all three major groups of water buffaloes, about 70 % are riverine type, 28 % swamp type, and less than 2 % Mediterranean type. The riverine buffaloes are concentrated mainly in Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka (Soni, 1991), with total population numbers in 1990 including those in Brazil and Egypt, of about 100 million (see Table 2). The swamp buffaloes are raised mainly in Brunei, Myanmar, China, Indonesia, Cambodia, Lao, Malaysia, Philippines, Thailand, and Vietnam, as well as other countries like Australia and USA (see table 3). The total number in 1990 was approximately 40 million. The rest of the water buffaloes in the world (less than 2 million) are mainly Mediterranean type; some of them could be related to the riverine or the swamp buffaloes due to a long history of animal introduction and
interbreeding. The Mediterranean buffaloes are mainly in Italy and countries of the Near East and Eastern Europe.

**Table 1:** Number of buffaloes by continent (source: FAO, 1991).

<table>
<thead>
<tr>
<th>Continents</th>
<th>1961 (In millions)</th>
<th>1971</th>
<th>1981</th>
<th>1990</th>
<th>change per annum (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>88.0</td>
<td>108.4</td>
<td>122.7</td>
<td>136.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Africa</td>
<td>1.1</td>
<td>2.1</td>
<td>2.4</td>
<td>2.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Latin</td>
<td>0.06</td>
<td>0.14</td>
<td>0.54</td>
<td>1.23</td>
<td>6.3</td>
</tr>
<tr>
<td>America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>0.53</td>
<td>0.39</td>
<td>0.44</td>
<td>0.38</td>
<td>-0.9</td>
</tr>
<tr>
<td>World</td>
<td>90.5</td>
<td>111.4</td>
<td>126.4</td>
<td>140.9</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Notes to table 1:**

1. **Africa**: includes only Egypt and Mauritius. Some numbers of buffaloes can be found in Madagascar, Mozambique, S. Africa, Uganda, Zaire and Congo.
2. **Latin America**: includes only Brazil. Some numbers of buffaloes can be found in Venezuela, Trinidad, Peru, Paraguay, Argentina, Ecuador, Colombia, Surinam, Honduras, Costa Rica, Bolivia, and Uruguay.
3. **World**: Australia which has more than 200,000 buffalo is not included.

**2 Buffaloes in Asia**

Two major breed groups of water buffaloes in Asia are the riverine and the swamp buffaloes. Table 2 shows the number of buffaloes in Bangladesh, Bhutan, Sri Lanka, India, Nepal, and Pakistan. The total number of riverine buffaloes in Asia in 1990 was 96 million of which 75 million were in India and 15 million in Pakistan. The indices of growth in buffalo populations in India and Pakistan were positive from 1961 to 1990 being in the range of 1.0 to 1.7% per year in India and 2.1 to 4.2% in Pakistan. Only Bhutan and Nepal had negative growth indices of buffalo number during 1981 to 1990. Soni (1991) indicated that, through a cytogenetic study conducted by the National Dairy Research Institute of Karnal (India), all the animals of recognized breeds of water buffaloes in India had the riverine type chromosome configuration with 2n = 50. A few nondescript animals in Assam and Orissa States had swamp-type or riverine x swamp crossbred type chromosome configurations.

The most important Indian (riverine) breeds of buffaloes are the Murrah, Surti, Mehsana, Jaffarabadi, Bhadawari, Nagpuri, and Toda, while the most important Pakistan breeds are Nili-Ravi and Kundi (Soni, 1991). Detailed descriptions and characteristics of these breeds have been well documented in various publications such as that by Cockrill (1974), Sivarajasingam (1987), Mudgal and Sethi (1990) and Soni (1991). Hence detailed figures on different traits of riverine breeds will not be repeated here.
Table 2: Number of riverine buffaloes in Asia (source: FAO, 1991).

<table>
<thead>
<tr>
<th>Countries</th>
<th>Years (In millions)</th>
<th>1961</th>
<th>1971</th>
<th>1981</th>
<th>1990</th>
<th>change per annum (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>Bangladesh</td>
<td>0.47</td>
<td>0.81</td>
<td>1.60</td>
<td>2.05</td>
<td>11.2</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Bhutan</td>
<td>3,000</td>
<td>3,700</td>
<td>5,500</td>
<td>4,000</td>
<td>1.1</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Sri Lanka</td>
<td>0.77</td>
<td>0.73</td>
<td>0.90</td>
<td>1.02</td>
<td>1.1</td>
</tr>
<tr>
<td>India</td>
<td>India</td>
<td>51.21</td>
<td>56.88</td>
<td>67.50</td>
<td>75.00</td>
<td>1.6</td>
</tr>
<tr>
<td>Nepal</td>
<td>Nepal</td>
<td>2.93</td>
<td>3.66</td>
<td>3.50</td>
<td>2.95</td>
<td>0.0</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Pakistan</td>
<td>6.70</td>
<td>9.55</td>
<td>11.92</td>
<td>15.00</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Note to Table 2: The number for Bhutan is the actual number of animals.

The numbers of swamp buffaloes in Asian countries during 1961 to 1990 are shown in Table 3. In 1990 more than 54% of these swamp buffaloes were in the Chinese People’s Republic, and more than 45% were in Southeast Asian countries. The rest were in small countries like Taiwan and Brunei. During 1981 to 1990, the indices of growth of buffalo populations in quite a few countries in Southeast Asia showed a negative trend, such as those in the Philippines and Malaysia and Thailand. Taiwan, Singapore, Brunei and Guam also showed negative growth in buffalo population, though their populations were very small. Bunyavejchewin and Chantalakhana (1991) summarized the situation of buffalo production in East and Southeast Asia and stressed its economic importance in relation to meat, draught power, and manure utilization especially on small farms in rural areas.

Compared with the riverine breeds such as Murrah or Nili Ravi, the genetic characteristics of the swamp buffaloes have been less well described. The information on different traits of swamp buffaloes has been reviewed by some authors including Sivarajasingam (1987) and Chantalakhana (1992). It is generally recognized that there are no distinctly different breeds among the swamp buffaloes, most of which are confined mainly to countries in East and Southeast Asia and Australia. However, some differences have been observed among populations of swamp buffaloes. For example, animal body weight shows differences. Heavy, medium and small strains of swamp buffaloes have been reported in China (Chantalakhana, 1992), while certain populations of Thai swamp buffaloes are recognized as heavier animals. In general only some traits of outer appearance, such as skin colors or horn shape can be used to differentiate groups of swamp buffaloes. The performance and reproductive traits reported so far do not present any clear evidence to indicate the existence of different breeds in the swamp buffaloes. It should be noted also that almost all the information available in swamp buffaloes is of a phenotypic nature and it can be expected that, to a high degree, the differences reported among animal groups are due to feeding, management and other environmental factors. However, Mukherjee et al. (1991) studied genetic relationships among populations of swamp buffalo in Southeast Asia, using the Nei genetic distance and reported that the distances among these populations are within the range exhibited for distances among breeds of European domestic livestock.
**Table 3**: Number of swamp buffaloes in Asia (source: FAO, 1991).

<table>
<thead>
<tr>
<th>Countries</th>
<th>1961</th>
<th>1971</th>
<th>1981</th>
<th>1990</th>
<th>change per annum (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.0</td>
</tr>
<tr>
<td>Myanmar</td>
<td>1.05</td>
<td>1.60</td>
<td>1.97</td>
<td>2.02</td>
<td>3.1</td>
</tr>
<tr>
<td>China</td>
<td>8.04</td>
<td>16.08</td>
<td>18.52</td>
<td>21.40</td>
<td>5.5</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>2,000</td>
<td>1,350</td>
<td>150</td>
<td>143</td>
<td>-3.1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2.87</td>
<td>2.92</td>
<td>2.49</td>
<td>3.46</td>
<td>0.7</td>
</tr>
<tr>
<td>Cambodia</td>
<td>0.52</td>
<td>0.86</td>
<td>0.40</td>
<td>0.75</td>
<td>1.5</td>
</tr>
<tr>
<td>Laos</td>
<td>0.42</td>
<td>0.74</td>
<td>0.88</td>
<td>1.09</td>
<td>5.3</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.35</td>
<td>0.30</td>
<td>0.26</td>
<td>0.22</td>
<td>-0.7</td>
</tr>
<tr>
<td>Philippines</td>
<td>3.45</td>
<td>4.56</td>
<td>2.85</td>
<td>2.77</td>
<td>-0.2</td>
</tr>
<tr>
<td>Singapore</td>
<td>3,130</td>
<td>3,200</td>
<td>400</td>
<td>150</td>
<td>-3.2</td>
</tr>
<tr>
<td>Thailand</td>
<td>4.96</td>
<td>5.57</td>
<td>6.12</td>
<td>4.72</td>
<td>-0.2</td>
</tr>
<tr>
<td>Vietnam</td>
<td>2.21</td>
<td>2.27</td>
<td>2.32</td>
<td>2.87</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note to Table 3: The numbers for Hong Kong and Singapore are the actual numbers of animals.

### 3 Buffaloes in Africa and the Near East

Buffaloes in Africa are mainly confined to Egypt, where in 1990 the total number was 2.55 million (see Table 4) and the indices of the population growth during 1961 to 1990 were positive, ranging from 0.9 to 3.5. The magnitude of annual population growth, however, appears to be declining in recent years. Buffaloes in Egypt are mainly of the riverine type (El-Serafy, 1991) and belong to one breed (Cockrill, 1974) of two vaguely differentiated local types, the Beheri of the Delta and the Saidi of Upper Egypt.

Buffaloes in Iraq and Iran were described as similar or related to those of Egypt (Cockrill, 1974). The population size of buffaloes in Iraq has been decreasing during recent years, while that of Iran showed a slight increase, with growth index of 0.4 during 1981 to 1990. Buffalo populations in Jordan and Syria are rather small, being 150 and 1200 head in 1990, respectively.

**Table 4**: Number of buffaloes in Africa and Near East (source: FAO, 1991).

<table>
<thead>
<tr>
<th>Countries</th>
<th>1961</th>
<th>1971</th>
<th>1981</th>
<th>1990</th>
<th>change per annum (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>1.50</td>
<td>2.06</td>
<td>2.37</td>
<td>2.55</td>
<td>2.3</td>
</tr>
<tr>
<td>Mauritius</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Near
East

<table>
<thead>
<tr>
<th>Country</th>
<th>1961</th>
<th>1971</th>
<th>1981</th>
<th>1990</th>
<th>change per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>0.25</td>
<td>0.18</td>
<td>0.22</td>
<td>0.23</td>
<td>-0.3</td>
</tr>
<tr>
<td>Iraq</td>
<td>0.25</td>
<td>0.27</td>
<td>0.18</td>
<td>0.15</td>
<td>-1.4</td>
</tr>
<tr>
<td>Jordan</td>
<td>200</td>
<td>200</td>
<td>132</td>
<td>150</td>
<td>-0.8</td>
</tr>
<tr>
<td>Syria</td>
<td>1,400</td>
<td>846</td>
<td>2,200</td>
<td>1,200</td>
<td>-0.5</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.14</td>
<td>1.11</td>
<td>1.03</td>
<td>0.54</td>
<td>-1.8</td>
</tr>
</tbody>
</table>

Note to Table 4: Numbers in Mauritius, Jordan and Syria are the actual numbers of animals.

It was reported that some numbers of water buffaloes were introduced into some Sub-Sahara countries, such as Mozambique, South Africa, Tanzania, Tunisia, Uganda, Zaire, but most of them disappeared due to diseases, war, or simply mismanagement (Cockrill, 1974). Recently, some swamp buffaloes from Thailand have been introduced to Senegal for draught and breeding purposes. So far they are reported to be surviving well.

4 Buffaloes in Latin America

According to the FAO statistics, there were 1.2 million buffaloes in Brazil in 1990, and the annual growth indices ranged from 7.7 to 17.7 per cent during 1961 to 1990 (see Table 5). But Cabrera (1988) reported the number of buffaloes in Brazil of 1.6 million, as well as numbers of buffaloes in twelve other Latin American countries (see footnote of Table 5). Buffaloes in Brazil and other countries in Latin America are mainly related to the riverine or the swamp type, although some may be of the Mediterranean breed. Buffaloes in Brazil are raised for meat or milk, as well as for draught purpose in some regions of the country. It was reported that water buffaloes will become one of the major meat animals in Brazil within a coming decade (Cabrera, 1988). The Brazilian Association of Buffalo Breeders has played a very important role in promoting buffalo development and enterprise in that country.

Buffalo population in other Latin American countries, except Brazil and Venezuela, are still small and on an experimental scale. However, buffalo production performances reported so far have shown promising potential for milk, meat and draught purposes, as well as their high adaptability to adverse environmental conditions.

Table 5: Number of buffaloes in Latin America (source: FAO, 1991).

<table>
<thead>
<tr>
<th>Countries</th>
<th>1961 (In millions)</th>
<th>1971 (In millions)</th>
<th>1981 (In millions)</th>
<th>1990 (In millions)</th>
<th>change per annum (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>0.06</td>
<td>0.13</td>
<td>0.54</td>
<td>1.23</td>
<td>65.0</td>
</tr>
</tbody>
</table>

Note to Table 5: Cabrera (1988) reports the number of buffaloes in other countries as follows.

1. Venezuela 25,000
2. Trinidad 7,000
3. Peru 32,000
4. Paraguay 25,000
5. Argentina 2,000
6. Ecuador 1,100
7. Colombia 500
8. Surinam 500
9. Honduras 120
10. Costa Rica 100
11. Bolivia 40
12. Uruguay 12
13. Brazil 1,600,000

Latin America 1,642,072

5 Priority Breeds of Buffaloes

As shown by Mudgal and Sethi (1990) in Table 6 there are five major breed groups of riverine buffaloes in Asia, some of which have been introduced to other parts of the world such as Africa, Near East, Latin America, and Eastern Europe, including some members of the Commonwealth of Independent States. Of these major breed groups, there are 15 well-defined breeds of the riverine buffaloes in India and Pakistan, as described by Mudgal and Sethi (1990). The priority breeds of riverine buffaloes which should be considered for support in conservation and development in order of priority are: (1) Murrah, and (2) Nili-Ravi. The other breed group of buffaloes which equally deserves support for development and conservation is the swamp buffalo.

Table 6: River buffalo breeds of Asia

<table>
<thead>
<tr>
<th>Group</th>
<th>Name of breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Murrah</td>
<td>Murrah, Nili-Ravi Kundi</td>
</tr>
<tr>
<td>2. Gujarat</td>
<td>Surti, Mehsana, Jaffarakandi</td>
</tr>
<tr>
<td>3. Uttar Pradesh</td>
<td>Bhadawari, Tarai</td>
</tr>
<tr>
<td>4. Central Indian</td>
<td>Nagpuri, Pandharpuri, Manda, Jerangi, Kalahandi, Sambalpur</td>
</tr>
<tr>
<td>5. South Indian</td>
<td>Toda, South Kanara</td>
</tr>
</tbody>
</table>

The swamp and riverine breeds are proposed for development conservation due to their important roles in the rural economy of most developing countries in the world. On the other hand, the Mediterranean buffaloes are mainly confined to Italy and some Eastern European countries, with relatively small population sizes.

5.1 Priority buffalo breeds

- Murrah
- Nili-Ravi
- Swamp buffalo
6 Justification for Conservation of Proposed Breeds

It is generally recognized that buffaloes are the poor man's cows. Almost all riverine and swamp buffaloes in the world belong to small farmers in developing countries. They provide milk, meat, draught power, manure as fertilizer, as well as source of income and employment. Crop yield in most rural small farms, where buffaloes have been integrated into agricultural systems, has been sustained through the use of buffalo manure to maintain soil fertility. Agricultural wastes, such as straws and stubble, as well as by-products which are available in small amounts and not marketable, are used by the buffalo and turned into the value-added products of milk, meat and draught power.

In 1990 there were more than 38.5 million milking buffaloes producing more than 43.7 million metric tons of raw milk. And, approximately 10.7 million buffaloes were slaughtered to provide more than 1.6 million metric of red meat supply in the world. More important, however, about one third to one half of buffaloes in small farm herds in developing countries have been used to provide draught power for crop production, especially in lowland rainfed paddy areas. In addition their social, cultural, and other traditional values, which cannot be measured in economic terms, are very important to rural village farmers.

The Murrah is the most well-known riverine breed and originated in India, while the Nili-Ravi originated in Pakistan. Both breeds are better known for their milking ability, with average lactation milk yield of 1600 to 1700 kg during 300 days, with butterfat of 7 percent. They are among the bigger breeds of the riverine type with average mature weights of 500–550 kg for both the Murrah and Nili-Ravi (Mudgal and Sethi, 1990). Hence, many of them are also being used as draught animals by small farmers throughout the developing world.

Murrah buffaloes are the largest group of the riverine buffaloes to be introduced to various countries, such as the Chinese Peoples Republic and Southeast Asian countries for crossbreeding with the local swamp buffaloes to produce dual or triple purpose offspring. Various reports from China such as that by Xiao Yongzuo (1990), indicated that Murrah x swamp crossbreeds were fertile and promising as animals for milk-and-meat or for milk-meat-draught purpose. The Nili-Ravi were also introduced to several countries, such as The Peoples Republic of China and the Philippines for experimental crossbreeding with local swamp buffaloes in order to increase milk yield, as well as meat and draught abilities, in the crossbreds.

It is well recognized that real genetic potentials of these breeds are much higher than that reflected by their averages. For instance, Soni (1991) indicated that some of the Murrahs in Haryana province could produce up to 5000 kg of milk per lactation. Breeding improvement of these riverine breeds would be of direct benefits to rural farmers in term of raising their nutritional standards, income, and employment. However, lack of well-organized systematic genetic improvement, including genetic testing, data bank facilities, effective gene bank and exchange of germplasm has kept these animals' potential from being efficiently utilized for the well-being of rural farmers in developing countries. As a matter of fact, some riverine populations appeared to be genetically eroded due to loss of superior germplasm through various causes such as inbreeding and disease etc.

Swamp buffaloes are well known for their potential as draught and meat animal. They mostly belong to small farmers in developing countries of East and Southeast Asia. However, a big population also exists in Northern Australia. In spite of their great potentials for meat and draught power, the swamp buffaloes have remained neglected as far as genetic improvement is
concerned. The swamp buffaloes have been regarded as an exceptionally well-adapted to harsh environmental and feeding conditions, and as a result they are taken for granted as a self-sustaining species. Most animal scientists in developing countries do not have a good understanding of this animal.

In many countries, large strong male buffaloes are commonly castrated around the age of 2 to 3 year to be trained for work. As a consequence, larger bulls are being culled or prevented from breeding. It has been evident that, in Thailand, for example, during the last three decades the body weight at slaughter of the Thai swamp buffaloes has been reduced from an average of close to 600 kg to 500 kg or less. There are no genetic testing and selection schemes for swamp buffalo, except a small programme in Thailand where a 300-cow herd has been organized for genetic selection based on body weight and growing ability.

It is quite alarming to take note that almost all small farmers do not maintain any breeding buffalo bull. Mating a young male with its dam or sisters often take place in villages. Smaller bulls not castrated for work also mate their own daughters or genetically related females. Populations of swamp buffaloes in many Southeast Asian countries have been reducing drastically due to growing demand for beef and illegal slaughter. In Thailand, during the last 3 or 4 years the number of swamp buffaloes reduced from more than 6 million to less than 5 million.

It should be noted also that during the past decade crossbreeding of swamp buffaloes with riverine breeds, such as Murrah or Nili-Ravi, has been promoted by government livestock programmes in several countries and has become popular among village farmers. It is anticipated that the rates of crossbreeding between swamp and riverine breeds will increase substantially in the coming decade due to good performances of crossbreds and their acceptance by farmers. It is therefore imperative that germplasm conservation and management for swamp buffaloes should be supported in order to prevent the loss of genetic potential and purity of the swamp buffaloes. Crossbreeding programmes between swamp with riverine buffaloes which have been implemented in various countries should be examined for their long-term impacts and the resulting crossbreds ought to be closely examined for their real suitability to local farming systems conditions, both from genetic and socio-economic aspects.

7 References


A GLOBAL REVIEW OF THE GENETIC RESOURCES OF CATTLE

J. Philipsson

1 Introduction

Effective use of the modern reproduction technologies of frozen semen and embryo transfer has contributed not only to successful genetic programmes with highly productive breeds in developed countries, but also to a wide-spread use of such germplasm around the world. In many parts of developing countries the use of semen of these “exotic” breeds has greatly enhanced the production of milk and beef, mainly by crossbreeding with indigenous cattle breeds. Areas or farms with high management standards and little climatic stress in the tropics have gained good results with pure or high grade exotic breeds, for example in Kenya. However, the more common experience under less favourable tropical conditions has been the use of a temperate breed to crossbreed with the indigenous cattle, thus producing positive results with F1 animals. Grades higher than 5/8 usually give poorer results. This effect is often due to less resistance and adaptability to various climatic, disease and other stress factors which cause health or reproduction problems and result eventually in a higher rate of loss.

Despite these well known facts there is a continuous use of semen of exotic bulls in the tropics for the production of superior crossbreds, while the preconditions for a successful long term breeding strategy are neglected. This type of indiscriminate crossbreeding, which at first sight gives very promising results, has become the greatest threat to some indigenous cattle breeds, especially those which show the highest potential for continuous crossbreeding.

An illustrative example of such a case is the Sahiwal breed in Pakistan and India. Crosses with Holstein and some other exotics have been so successful for milk production that few purebred females were retained. Consequently the pure Sahiwal population very rapidly decreased in numbers. The Kenana breed in Sudan is another example. When AI was introduced, only the imported semen of Holstein bulls was available. When the more progressive farmers joined the AI scheme they were extremely satisfied with the results of their F1 animals. However, they were not so satisfied with the 3/4 or 7/8 Holstein crosses, which were less resistant to diseases and climatic stress. Since the AI service did not offer anything other than imported Holstein semen, the lack of long term breeding strategy at farm level meant that the more progressive farmers had to quit the AI service.

These two examples illustrate the importance of sound long term breeding strategies to make efficient use of modern biotechnology in animal breeding, as well as providing the basis for a sustainable breeding programme using valuable indigenous breed resources. Although some indigenous breeds with unique characteristics for a given environment are threatened with extinction in this way due to their highly competitive F1 progeny, there are other indigenous breeds that retain their competitive position as pure breeds. However to stay competitive in the long run, improvement and conservation schemes need to be applied, whereby different reproductive technologies might prove their usefulness, especially when a breed expansion is desirable.

The objective of this paper is to identify and review a number of cattle breeds, recognized for unique characteristics or proven to be of such importance, whose future survival justifies the use
of improvement and conservation schemes. To some extent also studies supporting the conservation and improvement schemes of the selected breeds are proposed.

First the development of cattle populations and types of cattle breeds in the various regions of the world are briefly reviewed. Criteria for choice of breeds for conservation and improvement programmes are proposed; this is followed by a review of six breeds considered to have high priority.

2 Cattle populations by region

The cattle population of the world amounts to nearly 1,300 million head according to the most recent FAO statistics (FAO, 1991). Of these, nearly 900 million head are found in developing countries. Their distribution by region is given in table 1.

Table 1. Cattle populations of developing or tropical countries by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Number (millions of head)</th>
<th>Developing countries (1)</th>
<th>Tropical countries (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td></td>
<td>151</td>
<td>160</td>
</tr>
<tr>
<td>Latin America</td>
<td></td>
<td>314</td>
<td>260</td>
</tr>
<tr>
<td>Near East</td>
<td></td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Far East</td>
<td></td>
<td>363</td>
<td>272</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>879</td>
<td>740</td>
</tr>
</tbody>
</table>

Source: (1) FAO yearbook, 1990; (2) Maule, 1990

In the last decade the cattle population in the developing countries increased by some 85 million head or 10% (table 2) according to FAO statistics. By contrast cattle numbers in the developed countries decreased about 6%. The increase in the tropics has been most rapid in the Far East. Also Africa has had a continuous growth despite some severe droughts. The highest ratio of cattle to the human population is found in the Americas, where it is twice as high as the ratio in Africa, which in turn has a ratio which is more than twice as high as that of Asia. On the other hand, in relation to land area, Africa has a little less than half the numbers of cattle compared with the other two regions.

Table 2. Development of cattle populations by regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Cattle population (mill.)</th>
<th>Milk animals (mill.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1980  1990  Change %</td>
<td>1980  1990  Change %</td>
</tr>
<tr>
<td>Developing countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>138  151 +9.5</td>
<td>17  23 +30.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>287  314 +9.1</td>
<td>34  37 +9.6</td>
</tr>
<tr>
<td>Near East</td>
<td>52  50 -2.7</td>
<td>14  15 +3.8</td>
</tr>
</tbody>
</table>
Total milk production increased in the last decade by 41% in the developing countries of which those in the Far East show the sharpest increase. This is also true per cow (table 3). Latin America shows the highest annual yield per cow, but a slower total production development (+17%) than the human population growth (+24%), a situation which is even more pronounced for the Near East region (+9% vs. +32%).

Table 3. Development of milk production by region. The corresponding change in human population size is given with brackets

<table>
<thead>
<tr>
<th>Region</th>
<th>1980 Total (millions of tonnes)</th>
<th>1990 Total (millions of tonnes)</th>
<th>% Change</th>
<th>1980 Per cow (kg)</th>
<th>1990 Per cow (kg)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>6.0</td>
<td>8.4</td>
<td>+40.0</td>
<td>(+35.8)</td>
<td>345</td>
<td>370</td>
</tr>
<tr>
<td>Latin America</td>
<td>34.5</td>
<td>40.3</td>
<td>+16.7</td>
<td>(+23.5)</td>
<td>1028</td>
<td>1095</td>
</tr>
<tr>
<td>Near East</td>
<td>8.8</td>
<td>9.7</td>
<td>+9.4</td>
<td>(+32.1)</td>
<td>616</td>
<td>649</td>
</tr>
<tr>
<td>Far East</td>
<td>19.2</td>
<td>38.7</td>
<td>+101.1</td>
<td>(+20.5)</td>
<td>541</td>
<td>881</td>
</tr>
<tr>
<td>Developed countries</td>
<td>384.7</td>
<td>378.5</td>
<td>+8.6</td>
<td>(+6.8)</td>
<td>3101</td>
<td>3605</td>
</tr>
</tbody>
</table>

3 Main types of tropical breeds

The cattle breeds in the tropics may, according to Maule (1990), be divided into three distinct main groups:

3.1 Humped cattle
   a. Zebu (*Bos indicus*)
   b. Sanga (Zebu × Humpless Longhorn)

3.2 Humpless (*Bos taurus*)
   a. West African Humpless
   b. Middle East Shorthorn
   c. Criollo of Latin America
   d. Far East Humpless types

3.3 Humped × Humpless
   a. Zebu × West African Humpless
   b. Zebu × *Bos brachyceros*
   c. Zebu × *Bos taurus*
4 General characteristics of the different breed types

4.1 Humped cattle

The zebu is the dominant tropical cattle breed with its main location in Asia. It has long been well represented in all tropical regions due to its adaptation to hot and harsh environments. The different breeds vary considerably in size and are, with few exceptions, rather low producers of milk. A relatively high resistance to tropical cattle diseases has made the zebu an important part of most crossbreeding programmes in the tropics, as well as a foundation component of many synthetic breeds. A generally slow reproductive rate, including high ages at puberty and calving, is noticeable.

The Sanga type of cattle is unique to the southern and eastern parts of Africa. They are distinguished from the zebras by their long horns and the position of the commonly smaller hump.

4.2 Humpless cattle

Breeds of this type fall mainly into four groups which are of importance for the tropics. Their area of domestication, Asia, is still very important. The West African Longhorn type includes the N'Dama breed, which is known for its tolerance against trypanosomiasis in the tse-tse infested areas of the humid central and western parts of Africa.

The Criollo type breeds have proven to be of specific importance to the Americas. These cattle, originating from the Iberian peninsula, gradually became the dominant type of cattle throughout Latin America. Later, Criollos have to a large extent been replaced in Latin America either by zebras or European breeds or crosses.

4.3 Humped × Humpless

Numerous breeds are the result of crossbreeding *Bos taurus* and *Bos indicus*. These may be divided into three groups. The first include established indigenous breeds of rather ancient origin. These are numerous in Africa and South East Asia.

Breeds of the second group are still at a formative stage and are intermediate, while the third group includes breeds of recent origin resulting from planned crossbreeding to produce synthetic breeds such as the Jamaica Hope and Santa Gertrudis. The characteristics of these crossbreds vary considerably depending on the parental origin. The oldest ones have developed into breeds which are well adapted to their usually harsh environments, while the last group of breeds usually has developed a higher production potential.

In Payne (1990) a detailed classification is given of the tropical breeds, categorized as above, by world region.

5 Criteria for choice of breeds and pilot conservation and improvement schemes

A number of indigenous breeds of ancient as well as more recent origin, is apparently threatened with extinction, despite or just because of, some very good characteristics relating to their adaptation to tropical climate and harsh conditions. Equally well some indigenous breeds
have been identified that possess characteristics needed for long term planned cross-breeding with exotic breeds and which will result in desired and adaptable crosses.

Some indigenous breeds show characteristics that prove themselves to be highly competitive with any crossbreds or exotic breeds, but they are not fully utilized in the tropics, nor is their genetic potential utilized in a breeding programme for further improvements. When choosing 5–6 breeds for global pilot conservation and improvement schemes which will be of the greatest benefit to their users and which will also contribute experience in the management of the pilot schemes, the following criteria are desirable:

a. The breed should have some unique characteristics that are considered to be of specific importance for food production in a large tropical area  
b. The breed is either endangered or is not efficiently utilized  
c. The breeds should be of different types and cover some different needs  
d. The breeds should cover different tropical regions  
e. The infrastructure, some basic resources of the country where the pilot scheme is to be conducted and the personnel competencies should be of an acceptable level to support the anticipated performance of the pilot scheme.

6 Selected breeds and proposed schemes

On the basis of the above criteria the following breeds have been selected in priority order. Reasons for their choice, some more detailed facts about the breeds and features of proposed studies and conservation and improvement schemes will be given.

   A. Sahiwal (Asia, Africa, Humped, very productive, dual purpose)  
   B. N'Dama (West Africa, Humless, trypanotolerant)  
   C. Criollo (Latin America, Humless, dual purpose)  
   D. Kenana (Africa, Humped, milk)  
   E. E. Boran (Africa, Humped, beef)  
   F. F. Guzera (Latin America, Humped, triple purpose)

Due to the fact that Sahiwals cover two continents, and that synthetic breeds with a component of Sahiwal are utilized in two more continents this breed will be given somewhat more consideration than the others in this paper. Ongoing FAO supported research concerning Sahiwal also calls for more evaluation.

7 Sahiwal

7.1 Origin, habitat and distribution

The Sahiwal breed originated in the central and southern parts of Punjab, Pakistan, primarily in the districts of Sahiwal and Okara. This area is characterized by a subtropical and arid climate. According to Hasnain & Shah (1985) there is no authentic record of the early development of the breed but most probably it derived from a mixture of strains that migrated from the south of India and north of Pakistan and the adjoining territory of Afghanistan. There is an apparent similarity with the Gir breed, which has had a great influence on other breeds in India such as the Red Sindhi. This one is also considered to be a possible parental breed of the Sahiwal cattle.
7.1.1 Pakistan and India

Sahiwal cattle were the main livestock in the original habitat in Pakistan throughout the last century. The introduction of a canal irrigation system at the beginning of this century changed the entire ecology and agriculture from pastoral livestock production into intensive crop production. The dairy qualities of the Sahiwals were then challenged by the buffaloes, which produce a higher fat milk. In addition Sahiwal bullocks, being slow workers and lethargic, were found to be inadequate for farm operations in the new production system. Thus, the Sahiwal breed lost its old status and was to a great extent replaced by other better work animals.

The number of pure Sahiwal animals declined drastically and the process was further accelerated by the introduction of AI and crossbreeding with temperate dairy breeds. Crosses with Sahiwal have been extremely successful under the prevailing conditions and much more in demand than the pure breed. To preserve and improve the breed several large governmental and grantee Sahiwal herds have been built up in Pakistan since 1920. These farms, which practice milk recording with registrations of pedigree and performance data, now form the only effective breeding population of the Sahiwal breed in Pakistan. Around 2,000 pure Sahiwal breeding females are found on such farms out of a total of about 10,000 in the whole country (see table 4). The most well known of these farms are the privately run Jehangirabad (nearly 400 cows) and Allahdad farms (about 250 cows), the governmental experimental stations Bahadurnagar (about 500 cows including its tenant farms) and Qadirabad, which has the AI station.

In Pakistan a progeny testing programme started in 1981/82 comprising four farms (Bahadurnagar, Jehangirabad, Allahdad and Fazilpur) with almost 1,000 cows. Around 100–150 cows are considered as elite cows and used for the production of breeding bulls, whereas the remaining cows are used for testing of young bulls. A batch of 5–7 bulls is tested every second year and bulls with a positive breeding value, calculated on a contemporary comparison basis, are used for breeding the elite cows.

In India, the Sahiwal breeding herds are found almost exclusively at various institutions and military farms in the northern parts of the country. The best known being at the National Dairy Research Institute at Karnal. A cooperative progeny testing programme was established in 1982/83 between 9 institutional herds (Bhat & Taneja, 1987). These farms have around 900 cows and according to the plan 6–8 young bulls in each set are progeny tested of which one or two will be selected.

Table 4. Estimated population size, effective breeding population (number of registered cows) and crosses of the Sahiwal breed

<table>
<thead>
<tr>
<th>Country</th>
<th>Population size (1)</th>
<th>Effective breeding population (2)</th>
<th>Crosses (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakistan</td>
<td>10000</td>
<td>2000</td>
<td>100000</td>
</tr>
<tr>
<td>India</td>
<td>2000</td>
<td>1000</td>
<td>?</td>
</tr>
<tr>
<td>Kenya</td>
<td>2500</td>
<td>1000</td>
<td>?</td>
</tr>
</tbody>
</table>

Sources (1) Hodges, 1987; (2) estimation by author; (3) Hodges, 1984
7.1.2 Kenya

Sahiwal cattle were first imported in 1939 from the Pusa herd of India followed by further imports from Pakistan after World War II. A total of 60 bulls and 12 cows were imported following which the Kenya Sahiwal stock was closed for nearly 30 years.

Sahiwal herds are owned both by the government and by a few private breeders. These herds are found mainly in the central and eastern parts of the country at high altitudes but also in the humid coastal areas. In general the Sahiwals and their crosses are kept in grazing areas where the environmental conditions are rather harsh.

To establish an effective national breeding programme a national stud herd was founded at Naivasha in 1962. An intensive selection programme has been applied since then in this herd of some 500 cows of which about 180 are kept in an elite group. These regularly produce some AI bulls, which are selected on pedigree and growth rate followed by a progeny test for milk yield. According to the plan around 10 young bulls are progeny tested each year in the national stud herd and of these, two are later selected as proven bulls for further breeding.

The usefulness of Sahiwal as a dairy breed, with good potential also for beef, for improvement of local stock in tropical and sub tropical regions by crossbreeding is well recognized. As a result the breed has been introduced to many more countries in addition to Kenya including Australia, Tanzania, Thailand and Zambia. The world demand of frozen semen of pure Sahiwal bulls has been larger than the supply.

Several new breeds have developed from crosses between Bos taurus and Sahiwal such as the Jamaica Hope (Jamaica), Karan Swiss (India), AMZ and AFS (both Australia), and a synthetic cross with Ayrshire and Brown Swiss at the Kilifi plantation in the coastal region of Kenya.

7.2 Characteristics

The Sahiwal is considered to be one of the pre-eminent productive zebu breeds for milk production in the tropics. It was first recognized as a potentially useful dairy breed when the Pusa herd was established in 1912 in Bihar State in India. During a period of 20 years the average daily milk yield increased rapidly from 2.6 to 8.5 kg/day.

It is also one of the largest zebu breeds, heavily built with deep body and strong legs. The mature weight of cows is around 340–400 kg and of bulls up to 700 kg. The coat colour is usually reddish but other colours like pale red, dark brown, or almost black with white patches may also occur. The cows have large, sometimes pendulous udders and big teats. The horns are very short and thick and loose horns are common in the female. The bulls have a large, massive hump which frequently falls to one side. The sheath is quite pendulous and the dewlap is also large and heavy. The lethargic temperament has also given bulls of the breed a reputation as slow breeders. This has been reported by Philipsson et al. (1989) to be a problem of the Sahiwal AI service in Kenya.

Some research has been carried out to characterize the Sahiwal breed, mainly in India and Pakistan, but also in Kenya and some other countries. In general most studies have been based on fairly small data sets (less than 1,000 animals) or on data including very long time spans, in some cases more than 50 years.
Two comprehensive reviews on performance and other characteristics of the Sahiwal breed in Pakistan, India and Kenya have been published by Kimenye (1985a) and Hasnain & Shah (1985). Table 5 shows an extract of their findings together with some other results.

According to the literature, average lactation yields are in the range of 1,500 to 2,000 kg. with individual results reaching double this. Lactation lengths are 260 to 300 days. Kenyan data are often at the lower limit for milk yield. However, there is a common belief in Pakistan and India that short lactations (the limit varies between 70 and 200 days) are abnormal and should be rejected from the analysis; this practice may have biased the quoted means upwards. Studies in Pakistan and India show a negative annual genetic trend in milk yield (Chaudhry, 1988; Bhat & Taneja, 1987). This is commonly explained by poor breeding bulls and inbreeding. In Kenya a moderate improvement of 0.28%/year has been observed (-Wakhungu et al., 1991).

Age at first calving and calving intervals are given a high priority in Pakistan. Generally, the calving age is around 37 to 45 months and calving intervals are 390 to 490 days.

**Table 5. Results from the literature characterizing the Sahiwal breed**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean</th>
<th>CV%</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (kg) Male</td>
<td>23.6</td>
<td></td>
<td>Hasnain &amp; Shah, 1985, (P)</td>
</tr>
<tr>
<td>Female</td>
<td>22.7</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>Male</td>
<td>22.5</td>
<td></td>
<td>Bhat &amp; Chandramohan, 1982, (I)</td>
</tr>
<tr>
<td>Female</td>
<td>21.1</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>Male</td>
<td>23.9</td>
<td>11</td>
<td>Meyn &amp; Wilkins, 1974, (K)</td>
</tr>
<tr>
<td>Female</td>
<td>21.4</td>
<td>12</td>
<td>&quot;</td>
</tr>
<tr>
<td>Live weight, (kg) 1 year, male</td>
<td>168</td>
<td></td>
<td>Hasnain &amp; Shah, 1985, (P)</td>
</tr>
<tr>
<td>Female</td>
<td>142</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>Female</td>
<td>154</td>
<td></td>
<td>Taneja et al., 1979, (I)</td>
</tr>
<tr>
<td>Live weight, (kg) 2 years, male</td>
<td>308</td>
<td></td>
<td>Hasnain &amp; Shah, 1985, (P)</td>
</tr>
<tr>
<td>Female</td>
<td>252</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>Weight at first calving, (kg)</td>
<td>331</td>
<td>11</td>
<td>Ishaq &amp; Shah, 1975, (P)</td>
</tr>
<tr>
<td>287</td>
<td>Basu et al., 1979, (I)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at first calving (months)</td>
<td>48.2</td>
<td></td>
<td>Ahmad et al., 1971, (P)</td>
</tr>
<tr>
<td>38.0</td>
<td>Ishaq &amp; Shah, 1975, (P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.8</td>
<td>Reddy &amp; Nagarcenkar, 1988a, (I)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.3</td>
<td>Basu et al., 1979, (I)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.3</td>
<td>Trail &amp; Gregory, 1981, (K)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calving interval (days)</td>
<td>413</td>
<td>19</td>
<td>Ishaq &amp; Shah, 1975, (P)</td>
</tr>
<tr>
<td>481</td>
<td>Muhammad &amp; Ahmad, 1968, (P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>458</td>
<td>Rao &amp; Sundaresan, 1979, (I)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>412</td>
<td>Kimenye, 1981, (K)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A special characteristic reported in Sahiwal cows, compared to most other zebu breeds, is that there are rather few milk let down problems, despite the fact that the calves are reared separated from their dams. This is thought to be a result of selection over many years.

### 7.3 Ongoing research

As a result of an FAO consultancy report by Philipsson (1985) a joint initial programme for the rehabilitation of the Sahiwal breed in Pakistan has been established between FAO, the Pakistan Agricultural Research Council (PARC) and the Swedish University of Agricultural Sciences. The programme started in 1987 and data were collected from 12 governmental/grantee farms of almost 6,000 pure Sahiwal cows born in 1964 and later with more than 20,000 calving records. The material contains information on pedigree, dairy and fertility traits, stillbirths, growth rate, longevity, health problems etc. This data set is unique and constitutes almost all recorded Sahiwal cows in Pakistan during the time period in question. The following analyses are underway (Olsson, 1992):

- Population structure, inbreeding and generation intervals.
b. Estimation of genetic and phenotypic parameters for various traits of milk production, live weight and reproduction.
c. Estimation of breeding values and genetic trends.

In table 6 overall means, standard deviations and coefficients of variation are listed for some traits, based on the data analyzed. Short lactations were not excluded from these data.

Some other main results extracted from the analyses are:

- Generation intervals for the four paths were estimated to roughly 6 years except for the path dam/son which was 8.3 years.
- Most Sahiwal herds have to a great extent been closed and inbreeding coefficients are fairly high, on average 5%; in some small farms they are even more than 10% on average.
- Preliminary REML estimates of the heritability for total yield in first lactation was 0.17 and for 305 day yield 0.20.
- Preliminary breeding values have been estimated for all animals with a BLUP animal model. The estimated genetic trend was slightly positive (+2.5 kg/year) for the population of breeding bulls, but negative (-1 kg/year) for the cows. The majority of all bulls with large progeny groups had negative breeding values indicating the use of inadequate selection criteria.

The results of the analyses will form the basis for:

- development of a procedure (BLUP animal model) for continuous genetic evaluations of Sahiwal cattle in Pakistan
- studies of alternative breeding plans for the Sahiwal breed in Pakistan.

Table 6. Overall means of various traits of Sahiwal cattle in Pakistan recorded during 1964–1987 (Olsson, 1992)

<table>
<thead>
<tr>
<th>Trait</th>
<th>No.</th>
<th>Overall Mean</th>
<th>SD</th>
<th>CV(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactation yield, first lact. (kg)</td>
<td>4,622</td>
<td>1,395</td>
<td>639</td>
<td>46</td>
</tr>
<tr>
<td>305 day yield, first lact. (kg)</td>
<td>4,568</td>
<td>1,356</td>
<td>605</td>
<td>45</td>
</tr>
<tr>
<td>Lactation yield; all lactations (kg.)</td>
<td>17,292</td>
<td>1,522</td>
<td>701</td>
<td>46</td>
</tr>
<tr>
<td>305 day yield all lactations (kg.)</td>
<td>17,104</td>
<td>1,488</td>
<td>674</td>
<td>45</td>
</tr>
<tr>
<td>Fat %</td>
<td>293</td>
<td>4.5</td>
<td>0.5</td>
<td>11</td>
</tr>
<tr>
<td>Lactation length days</td>
<td>17,469</td>
<td>256</td>
<td>78</td>
<td>31</td>
</tr>
<tr>
<td>Calving interval days</td>
<td>13,951</td>
<td>465</td>
<td>130</td>
<td>28</td>
</tr>
<tr>
<td>Gestation length days</td>
<td>16,094</td>
<td>286</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Stillbirth rate %</td>
<td>19,345</td>
<td>4.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Age at first calving months</td>
<td>4,601</td>
<td>44</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Age of cow at disposal years</td>
<td>2,331</td>
<td>8.2</td>
<td>3.2</td>
<td>39</td>
</tr>
<tr>
<td>Birth weight males</td>
<td>7,425</td>
<td>21.8</td>
<td>2.6</td>
<td>12</td>
</tr>
<tr>
<td>(kg.) females</td>
<td>7,064</td>
<td>20.9</td>
<td>2.4</td>
<td>12</td>
</tr>
<tr>
<td>Liveweight females at one year</td>
<td>2,053</td>
<td>129</td>
<td>30</td>
<td>24</td>
</tr>
</tbody>
</table>
7.4 Needs and plans for conservation

According to the results presented here and to several other authors, including Maule, 1990, the Sahiwal breed is one of the best zebu milk breeds in the tropics. Its qualities, not only for dairy but also for beef, have been exploited especially in crossbreeding programmes in developing countries. However, the success in crossbreeding has become a real threat to the breed. The replacement of purebred Sahiwals have been neglected for a long period and the population size has decreased continuously. It is presently estimated at only 10,000 pure Sahiwals in Pakistan or 15,000 in the whole world, of which about 4,000 constitute the active breeding population which is divided into three sub-populations which are genetically isolated from each other. If the decline is not stopped the number will, within a few decades, reach such a low level that the genetic base will be too narrow for any significant improvement of the breed in the future. A strong increase in the inbreeding coefficient could then be anticipated and the breed would certainly be in danger of extinction.

There are several reasons why a long term conservation plan is needed. One is the lack of genetic progress during the last 40 years; another is a deterioration of the Pakistan cow population, most probably caused by inbreeding, and a lack of adequately defined breeding objectives and efficient breeding programmes. The Sahiwal breed with its sub-populations in Pakistan, India and Kenya, meets all the criteria of a breed to be selected for a pilot conservation and improvement scheme with global implications. If successful the Sahiwal breed should be more extensively used in an expanded area of the Near East in order to increase cattle productivity.

It is therefore an urgent matter to complete the studies outlined for the Sahiwal of Pakistan and also to include data from Kenya and India. This will give a basis for a joint analysis of alternative strategies for a global approach to conserve, improve and better utilize this breed resource.

Presently, there is almost no exchange of genetic material (Sahiwal semen or bulls) between Pakistan, India and Kenya. Such an exchange should be facilitated not only as a measure to prevent inbreeding, but also because there is a great demand for Sahiwal semen for crossbreeding, especially in Africa. Sahiwal semen is regularly being produced at Qadirabad in
Pakistan but infrastructural problems seem to hamper the export of semen. In Kenya it seems urgent to try alternative methods of rearing the young bulls and train them for semen collection.

In summary the conservation scheme for the Sahiwal breed should include the following steps:

a. Studies on population structure of the three sub-populations in Pakistan, India and Kenya.
b. Establishment of a procedure to exchange semen regularly between the countries.
c. Development of a BLUP animal model procedure for continuous evaluation of dairy, growth and reproductive traits to be applied in the nucleus populations of all three countries.
d. Definition of the breeding objectives utilizing dairy, growth and reproductive traits into a single index for selection of bull dams and young bulls for AI service and use in the nucleus herds.
e. Studies of alternative selection strategies for sustainable improvement, considering the possibilities of a global breeding programme with a controlled development of inbreeding and relationships.
f. Implementation of the most attractive and realistic breeding plan according to resources available in the nucleus herds and AI schemes of Pakistan, India and Kenya.
g. Production of Sahiwal semen for crossbreeding purposes on a global scale in tropical and subtropical countries.

Results from studies in Kenya and Pakistan, already published or in progress, indicate good possibilities of success with an FAO supported scheme for this breed, given the resources available in recorded herds at governmental and some other farms, as well as developed AI services and research competence.

8 N'Dama

8.1 Origin, habitat and distribution

Around one third of the African continent, mainly West and Central Africa, is infected with tsetse flies which transmit trypanosomiasis disease to domestic animals. This disease severely limits food production from domestic animals in some of the best watered and fertile lands of Africa. However, the N'Dama cattle, introduced to the continent some five to seven thousand years ago, has during this long period of time developed a high degree of resistance to trypanosomiasis. The development of the breed and its characteristics have been reviewed extensively by Starkey (1984).

The N'Dama is a humpless (Bos taurus) breed of the Hamitic Longhorn type. Its ancestors were probably the first domesticated cattle in Africa. According to a recent ILRAD (1989) report, the N'Dama cattle population is thought to number about 4.9 million of which the majority is in Guinea. Other countries with large N'Dama populations are Senegal, Mali and The Gambia. The breed apparently increased in numbers during the last century. The N'Dama constitute about half of all the trypanotolerant cattle in West and Central Africa, that is cattle that are able to resist the pathogenic effects of trypanosomiasis and to remain productive in tsetse infected areas where other breeds cannot survive. Thus, the N'Dama cattle, which is well adapted to conditions of both humid and dry tropical areas, constitute the principal wealth of many West African villagers.
8.2 Characteristics

The typical N'Dama is a small humpless animal with a straight top line, well muscled hindquarters and short, fine limbs. The coat is usually yellow, fawn, light red or dun in colour, although there are black and pied animals with black or fawn on a white background. The head is short and broad. The horns are lyre shaped. The dewlap and umbilical fold are rather small as well as the udder of the females. Cows weigh on average about 230 kg and bulls 370 kg. Withers height is to about 110 cm. Despite its small size the N'Dama is mainly used for beef, producing meat of good quality. Milk production is relatively low. The N'Dama cattle are also used for draft purposes. The normal range of performance of the N'Dama breed is given in table 7 from a thorough FAO study of 1980.

The single most important characteristic of the N'Dama breed is its inherited trypanotolerance which contrasts with the zebu breeds of Africa. Due to this fact much research has been directed towards the N'Dama breed to understand better both the effects of trypanosomiasis and the biology of its resistance (e.g. FAO, 1980; ILRAD, 1989). Studies have also shown that the N'Dama breed, when kept in non tse-tse infected areas, shows much better performance and is quite comparable to common zebu breeds in those areas. Also considerable benefits have been seen from improved management of the cattle in their normal habitats.

8.3 Needs and plans for conservation

The situation of the N'Dama breed is quite different from most of the other breeds proposed for conservation. The population size is large and even increasing. However, its habitat in a densely populated area of Africa that permits few other cattle breeds to survive and produce, is a serious call for effective schemes to guarantee the future existence of the breed and to improve its productivity. Any improvement would be significant to the human food supply. A significantly increased output might also be obtained by improved management.

Table 7. Normal range of N'Dama performance levels under traditional and improved management (FAO, 1980)

<table>
<thead>
<tr>
<th>Management system</th>
<th>Performance trait</th>
<th>Traditional</th>
<th>Ranches and Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age at first calving (months)</td>
<td>48</td>
<td>35–42</td>
</tr>
<tr>
<td></td>
<td>Calving interval (months)</td>
<td>18–24</td>
<td>14–16</td>
</tr>
<tr>
<td></td>
<td>Calving rate (%)</td>
<td>50</td>
<td>75–88</td>
</tr>
<tr>
<td></td>
<td>Mortality calves (%)</td>
<td>12–30</td>
<td>10–23</td>
</tr>
<tr>
<td></td>
<td>1–2 years (%)</td>
<td>12</td>
<td>2–4</td>
</tr>
<tr>
<td></td>
<td>Adults (%)</td>
<td>3</td>
<td>2–4</td>
</tr>
<tr>
<td></td>
<td>Rate of gain</td>
<td>20–40 kg/year</td>
<td>0.3–0.7 kg/day</td>
</tr>
<tr>
<td></td>
<td>Milk yield</td>
<td>0.4–0.8 kg/day (partial milking)</td>
<td>400–600 kg/lact.</td>
</tr>
</tbody>
</table>

The N'Dama was chosen as a prospect for a conservation programme by FAO in 1980. Improvement schemes based on nucleus herds at research or government stations, where performance recording easily can be applied are suggested. Selected bulls from the nucleus herds should regularly be distributed to the villages. Improved management would then ensure
the future development of the breed and its advantages in tse-tse infested areas. It could be an appropriate strategy for ILCA and ILRAD to include these aspects into the research networks already operating for studies of the trypanotolerance of the N'Dama breed in cooperation with governments and research institutes of West and Central Africa.

9 Criollo

9.1 Origin, habitat and distribution

The Criollo cattle of the Americas are defined as descendants of the *Bos taurus* cattle that were brought originally from the Iberian peninsula and the Canary Islands by Christopher Columbus on his second voyage in 1493 and subsequently. Probably less than 1,000 head were landed within a 50 year period in the Caribbean islands and were then rapidly dispersed throughout South and Central America as well as the south western parts of the United States. The cattle originated from different parts of Spain and Portugal. They could certainly not be described as simply one breed but rather comprised various unselected populations of cattle from different parts of a limited geographical area.

In the early parts of the 16th century this cattle population grew very rapidly. The quick multiplication of animals continued over large areas, in a great variety of environments of South and Central America during the next centuries and has been described as a biological wonder (de Alba, 1978). By the beginning of the 19th century the original population had increased to millions.

During the second half of the 19th century Indian zebu cattle were brought to Brazil and *Bos taurus* breeds from North America were introduced to Argentina and Uruguay. Later the American Brahman was introduced as well. A period of crossbreeding these breeds with the various types of Criollos started. In the temperate zones crossing with Holstein and Brown Swiss was successful for dairy production and in tropical areas crosses with zebu led to increased productivity. These results encouraged further massive importations, which resulted in a rapid decline of the pure Criollo types of cattle. A detailed account of the history of Criollo cattle, their development and later decline may be found in Rouse (1977).

The present types and distribution of Criollo cattle in Latin America have been reviewed by Wilkins (1984) and by de Alba (1987). The latter distinguished the following main Criollo types of cattle:

a. Lowland tropical beef Criollos
b. Mountain ecotypes of Criollo
c. Temperate climate or subtropical Criollo ecotypes
d. Blanco Orejinegro, a unique external parasite resistant breed
e. Tropical milking Criollos

Table 8 from de Alba (1987) summarizes the various Criollo type breeds recognized in different countries according to the classification above. Population trends and an indication of some research facts about the breeds are also given. Mariante (1992) has suggested that the Brazilian Criollos Pantaneiro belonging to the first group and Criollo Lageano of the second group are of significant importance, although they now exist only in small numbers.

9.2 Characteristics
The origin of Criollos and their development in various parts of Latin America easily explains the number of distinct breeds found in different ecozones. The typical Criollo is almost of any colour and pattern. However, where selection has been practised within some of the sub-populations for a long time a considerable uniformity is found, for example in colour. Despite some heterogeneity in characteristics between different Criollo breeds it seems that they have several important traits in common. One is the docility of the animals, which has been cited as a great advantage of Criollo cattle compared with the zebus and their crosses. Other typical traits are resistance to ticks and biting flies, good fertility and longevity. They are generally considered as dual purpose cattle, which often produce 1,000–2,000 kg of milk in a lactation. Cows weigh 350–400 kg and bulls up to 700 kg. The present state of knowledge on the characteristics of some 27 Criollo breeds has been well documented by de Alba (1987) in his review paper of the Criollos presented at the second meeting of the FAO/UNEP Expert Panel on Animal Genetic Resources Conservation and Management.

**Table 8.** Locations, population trends and amount of knowledge of Criollo breeds (de Alba, 1987)

<table>
<thead>
<tr>
<th>Name of breed</th>
<th>Country of origin</th>
<th>Present numbers (approx.)</th>
<th>Population trend</th>
<th>Descriptive and research literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOWLAND TROPICAL BEEF CRIOLLOS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Romosinuano</td>
<td>Colombia</td>
<td>9 000</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Senepol</td>
<td>U.S. Virgin Islands</td>
<td>3 000</td>
<td>+</td>
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</tr>
<tr>
<td>San Martinero</td>
<td>Colombia</td>
<td>4 000</td>
<td>+</td>
<td>+</td>
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<tr>
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<td>Cuba</td>
<td>4 000</td>
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<td>0</td>
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<tr>
<td>Mocho Nacional</td>
<td>Brazil</td>
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<td>-</td>
<td>+</td>
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<td>Colombia</td>
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<td>-</td>
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<td><strong>MOUNTAIN AND TEMPERATE CLIMATE CRIOLLOS</strong></td>
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<tr>
<td>Chusos</td>
<td>Ecuador</td>
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<tr>
<td>Serranos</td>
<td>Peru</td>
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<tr>
<td>Criollo de las</td>
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<tr>
<td>Sierras and Highlands</td>
<td>Mexico</td>
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<td></td>
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<td>Highlands</td>
<td>Guatemala</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Venezuela</td>
<td>2 000 000</td>
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<td>0</td>
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<tr>
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<td>USA</td>
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<td>+</td>
</tr>
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<td>Frijollos</td>
<td>Lower California</td>
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<td>-</td>
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</tr>
<tr>
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<td>Argentina</td>
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<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Blanco Orejinegro</td>
<td>Colombia</td>
<td>4 000</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
9.3 Needs and plans for conservation

Indiscriminate crossbreeding has taken place for several reasons. The successful results from crossing Criollos with improved breeds of European origin for milk production and with zebus in the tropical regions mainly for beef production have been principle attractions.

The different Criollo types of cattle, with their common characteristics of docility, productivity and adaptation to a range of ecological zones in Latin America where pure temperate breeds cannot contribute, certainly have certainly played an important strategic role for food production in these areas.

Awareness of the need for specific efforts to conserve a number of Criollo breeds exists in several Latin American countries. There are various projects to preserve or conserve Criollo breeds, for example in Argentina, Bolivia, Brazil, Colombia and Venezuela. The National Research Centre for Genetic Resources and Biotechnology (CENARGEN) in Brazil started in 1981 to document and evaluate information about various Criollo breeds and to identify those in danger of extinction (Mariante & Trovo, 1989). In 1987, when FAO decided to create two Regional Animal Gene Banks in South America, CENARGEN was chosen as the site of one due to the work in this area already started at the Centre. These include reproducing populations as well as freezing of semen and embryos. A data bank is kept for storage and retrieval of information on the threatened breeds.

In Bolivia Wilkins & Rojas (1989) have reported a progressive commercial scheme for the improvement of Criollo cattle for the humid lowlands. The procedure, which could serve as a model for more areas and breeds, involves fairly thorough investigations of the problems in the local livestock industry, the potential role of different genotypes and economics of alternative breeding programmes. These aim at multiplication of the breed under conservation in order to provide the producers with continuously selected bulls. Interest in the breed and its further improvement schemes are gradually taken over by a newly formed breed society.
Conservation programmes of Criollo cattle have two different purposes. The main one is to produce bulls for crossbreeding programmes in a number of different environments, either with temperate breeds for dairy production or with zebus for beef production. The benefits of the latter type of cross, according to Plasse (1989), is clearly increased fertility, reduced calf mortality and heterotic effects for growth rate.

The other purpose, which also seems very important, is to conserve pure Criollo cattle adapted to certain adverse environments for use in remote areas where crossbreeding might have no advantages or be difficult to realize due to small herds and lack of AI service. Such adapted breeds might produce 1,500–2,000 kg of milk per cow for support of both a calf and a family.

It seems important that future efforts of FAO should include conservation and continuous improvement schemes for a number of pure Criollo breeds in Latin America. The Regional Animal Gene Banks that are now to be enlarged seem to offer a logical structure for coordination of these. The work should include detailed evaluations of the different Criollo breeds or strains, and of their potential role as pure breeds as well as sources for crossbreeding; this should be followed by conservation of closely recorded nucleus herds for production and selection of improved bulls.

10 Kenana

10.1 Origin, habitat and distribution

This Sudanese breed is named after the semi-nomadic Kenana tribe who live on the western bank of the Blue Nile. The home land of the breed is mainly between the Blue and White Nile rivers within the savannah ecological region of Sudan south of Khartoum. The area is characterized by low rainfall and high temperatures.

The Kenana breed is a true zebu belonging to the Northern Sudan Shorthorn Zebu group of cattle. The exact origin is not known, although most likely it migrated in early years from Asia. However, the other main type of Sudanese cattle, the Nilotic Sanga cattle in the south, have undoubtedly been native to Sudan for a much longer period according to Osman (1985).

In an FAO study of the population structure and alternative strategies of conserving the Kenana breed, the total population including the White Nile type, was estimated at about 3 million (Cunningham, 1987). The production systems involving the Kenana breed are quite variable and range from pure nomadic in stressful, arid environments to more settled systems producing milk for urban areas. The latter certainly utilize exotic breeds in various degrees of crossbreeding with the Kenana cattle to increase production. Proper crossbreeding ensures the availability of cattle that are well adapted to the environment.

10.2 Characteristics

The Kenana, and the related Butana breed, have the general reputation of being among the better, if not the most productive indigenous African milk breeds. In a small number of herds Kenana cattle have long been selected for milk production. Table 9 summarizes some data of the breed. The results refer only to experimental farms, while field data are scarcely to be found. However, the institutional herds provide much better feed and environmental conditions than can be obtained under nomadic conditions.
Kenana cattle are white or steel gray in colour with shadings on the neck, shoulders and tail. Calves are born reddish brown but turn grey at about 6 months of age. Horns vary greatly in size and direction. Polled animals are common. The Kenana cattle are considered docile and are fairly tall. Mature bulls weigh 500–550 kg and cows around 400 kg (Osman, 1985). Calving intervals, as well as age at first calving, have been reported to be quite variable, indicating a large influence of environment and especially an effect due to nutritional status. As an example the better fed group of heifers in an experiment calved at 32 months of age compared with 47 months for the controls.

Recent genetic studies show a heritability of 0.21 for milk yield, while it was close to zero for lactation length and calving interval (Ageeb & Hillers, 1991).

10.3 Needs and plans for conservation

As a zebu breed the Kenana apparently has an outstanding potential for milk production adapted to arid and semi-arid conditions. Results also indicate that it would respond to selection for milk production and in addition, reproductive traits would respond to environmental improvements.

**Table 9.** Some characteristics of the Kenana breed in Sudan

<table>
<thead>
<tr>
<th>Source</th>
<th>Lact. yield, kg</th>
<th>Lact. length, days</th>
<th>Calving interval, mo.</th>
<th>Age at 1st calving, mo.</th>
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</thead>
<tbody>
<tr>
<td>Ageeb &amp; Hillers (1991)</td>
<td>1344</td>
<td>256</td>
<td>17.6</td>
<td>50</td>
</tr>
<tr>
<td>Wilson et al. (1987)</td>
<td>1597</td>
<td>264</td>
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</tr>
<tr>
<td>Fangaly (1980)</td>
<td>1359</td>
<td>264</td>
<td>14.3</td>
<td>45</td>
</tr>
<tr>
<td>&quot;</td>
<td>763</td>
<td>13.5</td>
<td>51.5</td>
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</tbody>
</table>

The development of more intensive settled production systems near urban areas of Sudan results from a great need to improve the food supply. This calls for the use of exotic breeds in crossbreeding with the Kenana. However, the lack of a long term strategy for crossbreeding might in a relatively short period threaten the breed with extinction. As a result of such a situation the crossbreeding programme will collapse.

Due to its extremely good genetic potential and the importance for milk production in rather variable hot environments, the Kenana breed deserves being conserved and further improved. The related Butana breed has similar potential and characteristics and could also be considered. However, the Kenana breed was deemed more important and given the highest priority in the FAO study earlier reported.

The conservation plan of the Kenana breed should satisfy the two fold objectives:

- to conserve and consistently to improve the pure breed taking into consideration all important traits including milk production, growth, udder conformation, beef and reproductive traits.
- to produce continuously pure and crossbred bulls to be used in long term crossbreeding programmes with exotic breeds applied in semi intensive systems of milk production.
Cunningham (1987) proposed a detailed strategy to utilize the herd of the Umbenein Research Centre as an open nucleus herd. It was suggested that 200 cows should be kept in this herd and that some 20 outstanding cows of village herds in the country should be recruited annually to the nucleus. The best selected cows should produce bulls for both AI and natural service in other herds. Such a scheme could be enhanced by the use of the embryo transfer (ET) technique. However, before investing in such a technique it is essential that effective genetic evaluation techniques are first applied for selection of bull dams and that the nutritional status is such that good technical results of ET could be anticipated.

The conservation plan earlier proposed in the FAO study is highly recommended. It assumes preceding studies for more exact definition of the breeding objectives, the mode of recording the desired traits in a fairly detailed manner in the nucleus herd and in a more extensive way in the village herds. It also assumes application of an appropriate procedure for genetic evaluations of the cattle in the nucleus herd.

By establishing an open nucleus herd as the basis for the conservation plan at an experimental station, sufficient infrastructure and personnel competence to conduct the project with the assistance of FAO should be guaranteed.

Although the Kenana breed is fairly well documented, mainly at the Gezira and the Umbenein research stations, data from the field is still scarce. Various supportive studies to the conservation plan are thus needed, and were also proposed in the FAO study, in order to make the most efficient long term use of the breed and to ensure its existence.

11 Boran

11.1 Origin, habitat and distribution

There are two distinct types of Boran cattle which is an East African Shorthorn Zebu. The indigenous type is found in the Borana Province of southern Ethiopia from where it spread to western Somalia and northern and central Kenya. The other type is the improved Boran developed in Kenya under ranch conditions for beef production.

The Ethiopian Borana cattle are kept under nomadic semi dry conditions by the Borana tribe, known for their high husbandry capabilities and which depend to a large extent upon the milk produced by their cattle. There are large numbers of the indigenous type in Somalia known as Avai cattle, which are similar to the Ethiopian type; in northern Kenya cattle of the same type as the Avai are known as the Tanaland Borana.

The improved type of Boran, bred in the semi arid uplands of Kenya, is the result of six to seven decades of selection for conformation and size, fertility and mothering ability under commercial ranching conditions. Some literature indicate that an early inclusion of imported European cattle in the 1920’s, mainly Hereford, might have occurred. The improved Boran cattle in Kenya today play the role of a predominant beef breed in Eastern Africa and it is now being exported to a number of countries outside the main original areas.

The development of the Kenya Boran cattle has been supported by the improvement programme undertaken by the Borana Cattle Breeders Society founded in 1951 in Kenya. Development in Ethiopia has gained from the research and breeding programmes used at the
Adamitulu and Abernossa pure breeding and crossbreeding ranches (e.g. Kassa-Mersha & Arnason, 1986).

There is no accurate census of the Boran cattle but Kebede (1985) in a breed review indicated a figure of some 820,000 animals.

11.2 Characteristics

The Ethiopian Borana are rather large, long-legged cattle with good body conformation. They are normally white or grey, but brown or pied colours occur. Horns are short and thick at the base. The hump is well defined and the thorax usually large and sometimes folded on one side, especially in bulls.

The improved Kenya Boran cattle are characterized by well developed hind quarters and they produce carcasses that suit the export market. Weights of mature cows are reported to 400–550 kg while adult bulls weigh 550–750 kg. The Ethiopian Borana weigh a little less. Cows and bulls are frequently reported to weigh 300–400 kg and 550–675 kg respectively.

On good grazing Kenya Boran steers are ready for slaughter at three to three and a half years of age giving a carcass of 220–250 kg. In a number of studies Boran cattle have shown a surprisingly good potential also for milk production. In the review by Kimenye (1985b) lactation yields of 1,000–1,600 kg have frequently been found.

The specific characteristics of the Boran cattle that contribute to its leading role as a highly productive, indigenous breed may be summarized from the extensive studies and reports published about the breed. These are according to Maule (1990):

- a. ability to walk long distances in search of grass and water and to do without water for two days, possibly longer;
- b. strong herd instinct and good mothering ability;
- c. adaptability to a wide range of environmental conditions;
- d. high fertility - up to 90 per cent - and low calf mortality (3 per cent);
- e. longevity - cows will breed up to 20 years; seven calves in 10 years is a reasonable expectation.

The good performance of Boran cattle in adverse environments also lies in its generally good resistance to endemic diseases. However, Kenya ranchers usually practice dipping to prevent tick born diseases. Unlike the small East African Zebus the Boran cattle are quite susceptible to East Coast Fever.

11.3 Needs and plans for conservation

The Boran breed has undoubted value, especially beef production but also milk, under quite variable tropical conditions. The breed was chosen in 1980 by FAO as meriting special attention for future conservation and improvement. It certainly is a high potential breed which should be multiplied into more areas and thereby increase food production. There is already a fairly good infrastructure. Research stations and the beef recording scheme established in 1973 in Kenya should provide excellent data for the breeding programme.
An FAO supported conservation and improvement programme for this breed should therefore aim to support the existing activities with emphasis on analyses of records and their use for selection purposes. A further component should aim at increased semen production in Kenya for domestic as well as export purposes. An increased export of live animals of the improved Kenya Borans to neighbouring countries might also be important as part of the programme.

12 Guzera

12.1 Origin, habitat and distribution

The Guzera is a Brazilian selected population of *Bos indicus* cattle originating from India, where it is named Kankrej. The breed has been well known in its home area probably for more than five thousand years. The introduction of the Guzera breed to Brazil, when it was named after its home province Gujerat, started in 1895. Due to its superiority in producing highly productive crossbreds with Holstein Friesian the number of pure Guzera has reduced to some ten thousand registered cows (Madalena, 1983). Annually three to four thousand female calves are registered by the breeder's herd book association, that was formed in 1936.

The Guzera breed has been used as the foundation of several new Brazilian breeds, such as the Pitangueiras (Red Poll cross), Lavinia (Brown Swiss cross), Riopar dense (Holstein Friesian cross) and Indo-Brasil (Guzera, Gir and Nellore synthetic), besides having had a strong influence on the foundation of the Brahman breed.

12.2 Characteristics

The Guzera is a triple purpose breed (draft, milk and meat). It is well recognized by its stature (135 cm withers height of cows) and lyre shaped horns. It is reported to have very good draft power in its country of origin. Milk yield in Brazil has been reported to be between 1,155 kg and 2,134 kg per lactation in the official recording scheme.

The following average weights were, according to Madalena (1992), obtained in the national performance recording scheme, adjusted to ages 205, 365 and 550 days, respectively: 128 kg (n = 7,568), 195 kg (n = 3,951) and 250 kg (n = 1,812). In a study in seven commercial farms, cows of second and higher parities weighed about 440 kg. The range of body weights of bulls in AI studs is 900 to 1,140 kg.

The crosses of Guzera with the Holstein Friesian have very good dairy characteristics. The F1 crosses have outperformed the purebred Holstein Friesians in a wide range of management systems, producing between 1,730 and 2,450 kg milk per lactation.

12.3 Needs and plans for conservation

The Guzera breed has proven its value in Brazil both as a pure breed and in crossbreeding. It certainly deserves serious attention since the population is small and needs to be conserved by management for the future. A nucleus breeding scheme has already been initiated involving 17 private breeders and one experimental farm according to Madalena (1992). The better cows (in the owner’s judgement) are sent to a central farm for milk recording and embryo production for sale. The average production of the first 100 cows with completed lactations was 3,100 kg with 4.1% fat content. Feeding of these cows was based on elephant grass hay, natural pastures, dried whole plant maize, yuca residues and cottonseed meal. The scheme has technical
support from the School of Veterinary Science, Federal University of Minas Gerais, and the Federal and State research organizations (EMBRAPA and EPAMIG). However, extra funds and organization are needed for milk recording and better evaluation of cows and bulls in order to allow full use to be made of the genetic improvement which is potentially available by capitalizing on present activities and infrastructure.

13 Conclusions

A number of very important indigenous cattle breeds in tropical countries show a fairly high production potential combined with adaptability to tropical and often adverse environments. Several of these breeds are endangered due to indiscriminate crossbreeding programmes lacking long term strategies for selection. These indigenous breeds need to be conserved and further improved in order to guarantee possibilities of long term crossbreeding programmes and of more widespread use as pure breeds.

Six priority breeds or breed types are proposed for practical conservation and improvement programmes. They cover different regions of the world and different types of cattle with unique characteristics which are deemed important for either milk or beef production. They are adapted to a range of tropical or subtropical environments. Finally, the conservation and improvement programmes cover different stages of development and, therefore, they may also serve as pilot schemes for other similar cases.

14 References


1 Introduction

There are 1190 and 557 million sheep and goats in the world, respectively. Table 1 shows the break-up by economic class and region according to FAO (1991). Of the total, 53 and 94 per cent of the sheep and goats are kept in developing countries, respectively, where they make an important contribution to the well being of human populations as a source of meat, milk, fibre and hides. Note the disproportionate number of goats in developing countries compared to that in the developed ones.

In the past, developing countries have shown a marked tendency to rely on imported ‘improved’ sheep and goat breeds for genetic improvement. This has sometimes resulted in a reduction in the number of stock of the indigenous breeds, and in extreme cases in a threat to their future existence. There are, of course, other factors that may also put some breeds at risk, such as natural disasters or pressure from other forms of land use. More recently, however, there seems to be a greater awareness of the need to identify, preserve and improve local breeds perceived as possessing attributes that could be valuable now or in the future. This change of attitude can be partly explained by the efforts made by organizations such as FAO in the conservation of global genetic resources, but it is also probably due to the frequent failure of introduced breeds to perform satisfactorily. In harsh environments, which can include special disease risks, the indigenous ‘unimproved’ breeds have often turned out to be better suited to the local conditions.

This paper consists of three main sections. The first section is a review of publications presenting descriptive information about sheep and goat breeds, with special emphasis on those in developing countries. The second section reviews reports that have specifically pointed to indigenous sheep and goat breeds that are worthy of attention. Finally, the third section lists those breeds that available information suggests should be the target of research and development programmes in the immediate future. The overall aim of the paper is to discuss a number of practical issues related to the conservation and improvement of indigenous sheep and goat breeds.

1 Department of Agriculture, Box 1671, G.P.O., Adelaide, S.A., Australia 5001.
Table 1
Sheep and goat numbers (1000 head)

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<thead>
<tr>
<th>Region</th>
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<td>Other developed</td>
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<td>USSR</td>
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<td>All developed</td>
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<td>Developing countries</td>
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<td>525 355</td>
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<td>WORLD</td>
<td>1190 499</td>
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</tbody>
</table>

A Source: FAO 1991

2 Review of publications on sheep and goat breeds

Currently, FAO statistics and most country census do not provide information on breeds. Sometimes information about numbers of a particular breed can be derived indirectly from local statistics when the breed is confined to a restricted area. However, more commonly, information on particular sheep and goat breeds cannot be obtained unless a special effort is made with that purpose.

One of the problems faced when trying to make decisions about priority sheep and goat breeds is the lack of a data base containing an inventory of breeds, with the necessary characterization in terms of productivity, outstanding features, population size, etc. Answering questions about the need for maintenance of various breeds without such an inventory is extremely difficult. Table 2 lists key publications describing sheep and goat breeds. The list is by no means exhaustive and it concentrates mainly on developing nations. In addition to the work cited in the table there have been numerous articles dealing with specific breeds. These will be referred to in the next section, only in case they discuss a breed that is considered worthy of immediate attention for some reason.

In table 2 the studies have been grouped according to their scope, that is, whether they attempt to cover the whole world, a particular country or region, or a specific type of sheep or goat. In some instances the studies are merely of a descriptive nature, with little or no comment regarding the relative worthiness of the breeds or their risk status. Nevertheless, as a whole the information provided is a very good basis for the creation of an inventory of sheep and goat breeds worthy of attention on a global basis. Much of the information called for by the descriptor
lists for sheep and goats (FAO 1986c) can be found in these studies. Computerization of this information would make the search of breeds according to any relevant criterion (e.g. risk status, heat tolerance, etc.) a relatively simple task. At present, any attempt at choosing breeds on the basis of specific criteria is a very difficult and time consuming task, except perhaps for a small number of very knowledgeable people.

Table 2
Key publications describing sheep and goat breeds

<table>
<thead>
<tr>
<th>Scope</th>
<th>Title of study</th>
<th>Species</th>
<th>References</th>
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<td>Wild goats and their domestication</td>
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<td>Bhat et al. 1981</td>
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<td>Small ruminants in the Near East, vols. I, II and III</td>
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<tr>
<td>Type of animal</td>
<td>Trypanotolerant livestock, vols. I and II</td>
<td>✔</td>
<td>FAO 1980a, b</td>
</tr>
<tr>
<td></td>
<td>Prolific tropical sheep</td>
<td>✔</td>
<td>FAO 1980c</td>
</tr>
<tr>
<td></td>
<td>Hair sheep of Western Africa and the Americas</td>
<td>✔</td>
<td>Fitzhugh and Bradford 1983</td>
</tr>
<tr>
<td></td>
<td>The Awassi sheep</td>
<td>✔</td>
<td>FAO 1985c</td>
</tr>
</tbody>
</table>

*For space reasons some titles have been shortened. The complete titles are given in the REFERENCES section.*
3 Review of reports identifying sheep and goat breeds worthy of attention

The reports cited in this section are of three different types. Firstly, there are those that draw attention to particular indigenous breeds, either because they are at risk, or because they possess specific valuable attributes, or for both reasons. Secondly, there are reports on live animal preservation programs currently underway in various parts of the world. It is reasonable to assume that the breeds included in such programs would be at risk and (or) have specific valuable attributes. Thirdly, a number of personal contacts were made during the preparation of this review. The information obtained in this way is quoted as a personal communication.

Table 3 lists sheep and goat breeds that have been identified as worthy of attention. The information is grouped into four regions (Africa, Latin America, Near East and Far East). These correspond with currently accepted FAO regions (FAO 1991) for developing countries. Regions classified by FAO as developed were not included in the review. Two interesting features emerge from table 3. One of them is that the number of sheep breeds listed is about three times greater than the number of goat breeds, even though the number of sheep in developing countries is only 1.2 times greater than the number of goats. This feature is probably a reflection of the difference in the amount of interest in the two species shown by researchers. The other feature revealed by table 3 is that several of the breeds listed are related to each other in some way, and could therefore be considered together as a single population from the point of view of implementation of preservation, research and development programs. A brief discussion of the relationship among some of the breeds follows.

Latin American sheep breeds such as Bahama Native, Barbados Blackbelly, Morada Nova, Pelibuey, Red African, Santa Inés and Virgin Island White are all hair sheep derived from those taken to America from West Africa (Fitzhugh and Bradford 1983) during the seventeenth century (Devendra and McLeroy 1987). Despite the differentiation that has taken place over time (e.g. Bahama Native, Barbados Blackbelly and Virgin Island White are more prolific than the other breeds) there are still some remarkable phenotypic similarities among them, and also with West African sheep. For example, Santa Inés are larger than the rest of American hair sheep, and said to be derived from crosses between Morada Nova and Bergamasca. Nevertheless, Fitzhugh and Bradford (1983) point out the great similarity between Santa Inés and the Sahelian type of West African sheep.

The four Latin American goat breeds listed in table 3 are from North Eastern Brazil. Many observers consider that these represent different colour types, rather than true 'breed types' (Shelton and Figuereido 1981). Apart from sharing some common ancestry, with the exception of the Marota breed, the other three (Canindé, Moxotó and Repartida) are similar in form, function and apparently in performance (Shelton and Figuereido 1981).

In the Near East, Libyan Barbary sheep are considered the prototype for the Barbary sheep type of Northern Africa, to which the Barki (Egypt) also belongs (Devendra and McLeroy 1987). Barbary sheep are coarse-wooled and fat-tailed. They are a multiple purpose type of sheep, producing fibre, meat and some milk.

The Chios breed of Greece, renowned for its milk production and prolificacy gave origin to the Sakiz of Turkey (Mason 1988).

The Damascus, Nubian and Zaraibi goats all belong to the ‘Nubian Type’ (Mason 1988). These are dairy goats, with a Roman nose and long lop ears. Devendra and McLeroy (1987) state that
the Damascus goat found in Syria, Lebanon and Cyprus gave rise to the Zaraibi of Egypt and to the Nubian goat of Sudan.

Considering relationships among breeds is important when making decisions about which ones merit support for preservation, research and development programs. With limited resources it appears that it would be unwise to support two or more breeds that are closely related and have similar characteristics.
<table>
<thead>
<tr>
<th>Region</th>
<th>Sheep breed</th>
<th>Reference</th>
<th>Goat breed</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Adali</td>
<td>Setshwaele 1990</td>
<td>Boer</td>
<td>Casey and Van Niekerk 1988; Ngere 1987</td>
</tr>
<tr>
<td></td>
<td>Horro</td>
<td>Setshwaele 1990</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Masai</td>
<td>ILCA 1991 a, b; Turner (pers. comm.)</td>
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<tr>
<td></td>
<td>Sahelian</td>
<td>Bradford (pers. comm.)</td>
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<tr>
<td></td>
<td>Somali</td>
<td>Setshwaele 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tswana</td>
<td>Setshwaele 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>Bahama Native</td>
<td>FAO 1980c</td>
<td>Canindé</td>
<td>da Silva Mariante 1990</td>
</tr>
<tr>
<td></td>
<td>Criollo</td>
<td>Cardellino (pers. comm.); da Silva Mariante 1990</td>
<td>Repartida</td>
<td>da Silva Mariante 1990</td>
</tr>
<tr>
<td></td>
<td>Morada Nova</td>
<td>da Silva Mariante 1990; FAO 1980c; Fitzhugh &amp; Bradford 1983</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pelibuey</td>
<td>FAO 1980c; Fitzhugh &amp; Bradford 1983</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Santa Inés</td>
<td>da Silva Mariante 1990; Fitzhugh &amp; Bradford 1983</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uruguayan Rambouillet</td>
<td>Cardellino (pers. comm.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barki</td>
<td>Setshwaele 1990</td>
<td>Damascus</td>
<td>FAO 1980d; FAO 1987a; Mason 1981b</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td>Location</td>
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<td></td>
</tr>
<tr>
<td>Chios</td>
<td>FAO 1987a; Turner (pers. comm.)</td>
<td>Nubian</td>
<td>Ngere 1987</td>
<td></td>
</tr>
<tr>
<td>Imroz</td>
<td>Yalçin 1979</td>
<td>Zaraibi</td>
<td>Setshwaeło 1990</td>
<td></td>
</tr>
<tr>
<td>Libyan Barbary</td>
<td>Setshwaeło 1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ossimi</td>
<td>Setshwaeło 1990</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rahmani</td>
<td>Setshwaeło 1990</td>
<td></td>
<td></td>
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<tr>
<td>Sakiz</td>
<td>Yalçin 1979</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sudan Desert</td>
<td>Setshwaeło 1990</td>
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</table>

**Far East**

<table>
<thead>
<tr>
<th>Location</th>
<th>Reference(s)</th>
<th>Location</th>
<th>Reference(s)</th>
</tr>
</thead>
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<tr>
<td>Bhakarwal</td>
<td>Acharya 1990</td>
<td>Barbari</td>
<td>Acharya 1990; Bhat 1984; Bhat 1987; FAO 1987b</td>
</tr>
<tr>
<td>Chokla</td>
<td>Bhat 1984; Dolling (pers. comm.); Singh and Dolling 1970</td>
<td>Jamnapari</td>
<td>Acharya 1990; Bhat 1984; Bhat 1987; FAO 1987b</td>
</tr>
<tr>
<td>Gaddi</td>
<td>Bhat 1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gurez</td>
<td>Acharya 1990; Bhat 1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Han</td>
<td>FAO 1980c; Turner (pers. comm.); Yaochun 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henan Largetail</td>
<td>Yaochun 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hissardele</td>
<td>Acharya 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hu</td>
<td>FAO 1980c; Turner (pers. comm.); Yaochun 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Javanese Thintailed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karnah</td>
<td>Acharya 1990; Bhat 1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lanzhou Largetail</td>
<td>Yaochun 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magra</td>
<td>Bhat 1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malin</td>
<td>Bradford (pers. comm.);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandya</td>
<td>Acharya 1990; Bhat 1984</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nilgiri</td>
<td>Acharya 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Sumatran</td>
<td>Bradford (pers. comm.); Iniguez et al. 1991</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poonchi</td>
<td>Acharya 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pugal</td>
<td>Bhat 1984</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 Suggested breeds for immediate implementation of support programs

Given the relatively large number of sheep and goat breeds that have been identified as worthy of attention in preservation, research and development programs (table 3) it is clear that attending to all of them immediately will not be possible. Under such circumstances an overall strategy involving short term and long term activities appears to be required. In the short term, breeds about which sufficient information is available to make a positive judgement about their value should be the target of programs commencing as soon as possible. At the same time, but with a longer term view, activities directed at the establishment of a computerized data bank on all indigenous breeds should be undertaken so that other threatened and (or) potentially useful populations are identified. This latter activity would provide a sound basis for choosing breeds for future programs.

The terms of reference for the present review established that four or five breeds had to be recommended to receive immediate support for a preservation, research and development program. The suggested list of sheep and goat breeds is presented in table 4, together with a brief justification for the choice. In a few instances breed support programs have already been initiated.

The breeds were chosen more often because of some special and valuable characteristic they possess, than because of their current risk status. However, it may be worthwhile making a distinction between developed and developing countries in this respect. In the latter countries even livestock breeds that from a numeric point of view might appear quite 'safe', are often at much greater risk than their counterparts in developed countries. Threats to indigenous breeds in developing countries include natural disasters, expansion of other forms of land use, human population growth, and indiscriminate crossbreeding with 'improved' breeds. Crossbreeding is sometimes undertaken because of fashion, social pressure and prestige, rather than because of 'economic-genetic' reasons. Furthermore, in developing countries, even what may be considered the most important livestock breeds have very seldom been studied with the depth that important breeds in developed countries have. Therefore, the judgement of the risk status of breeds in developing countries requires more than simply increasing the minimum number of the various risk categories.

A number of criteria were used in the selection of the breeds listed in table 4. One of them was, of course, that the breed possessed one or more highly desirable attributes from the point of view of adaptation and (or) productivity. Another very important consideration made was in relation to the potential impact of the work in case it resulted in a favourable outcome. Preferred breeds were those in which preservation and improvement could have the potential for influencing relatively large populations, not only in the country in which the project was developed, but also in other countries with the same or with very similar breed types. Finally, an attempt was made to achieve some balance across world regions. The sheep and goat breeds listed in table 4 satisfy these criteria.

The literature cited in tables 2 and 3 contains ample information about all the breeds listed in table 4, which includes a brief justification for their choice. Therefore, only a few clarifying comments about some of the breeds will be made here.
Table 4
Sheep and goat breeds for immediate implementation of support programs

<table>
<thead>
<tr>
<th>Breed</th>
<th>Type of production</th>
<th>Region</th>
<th>Brief justification for choice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sheep</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Djallonké</td>
<td>Meat</td>
<td>Africa</td>
<td>Trypanotolerant, adapted to West African humid tropics.</td>
</tr>
<tr>
<td>2. Pelibuey</td>
<td>Meat</td>
<td>Latin America</td>
<td>Adapted to tropical areas of South and Central America and the Caribbean</td>
</tr>
<tr>
<td>3. Javanese Thin-tailed</td>
<td>Meat, coarse wool</td>
<td>Far East</td>
<td>Adapted to humid tropical conditions. Single gene for prolificacy segregating, which would enable development of strains 'with' and 'without' the gene for different production systems.</td>
</tr>
<tr>
<td>4. D'man</td>
<td>Meat, coarse wool</td>
<td>Africa</td>
<td>High reproductive rate, adapted to perform well in a very hot environment.</td>
</tr>
<tr>
<td>5. Awassi</td>
<td>Milk, meat, coarse wool</td>
<td>Near East</td>
<td>Good milk producer, adapted to the production system and semi-arid and arid sub-tropic areas of the region.</td>
</tr>
<tr>
<td><strong>Goats</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Fouta Djallon</td>
<td>Meat</td>
<td>Africa</td>
<td>Trypanotolerant, adapted to West African humid tropics.</td>
</tr>
<tr>
<td>2. Damascus</td>
<td>Milk</td>
<td>Near East</td>
<td>High milk production, good reproductive rate and heat tolerance.</td>
</tr>
<tr>
<td>4. Moxotó</td>
<td>Meat, skin</td>
<td>Latin America</td>
<td>Adapted to hot semi-arid tropical environment. Good reproductive rate and produces high quality skins. Threatened.</td>
</tr>
<tr>
<td>5. Boer</td>
<td>Meat</td>
<td>Africa</td>
<td>High growth rate, very good muscling and meat conformation. Would make an excellent terminal sire breed.</td>
</tr>
</tbody>
</table>
4.1 Sheep

Djallonké sheep (and Fouta Djallon goats) were suggested because of their ability to survive and reproduce in trypanosomiasis affected areas. Furthermore, it appears the area of West Africa to which these breeds are adapted would have a substantial amount of unused carrying capacity (FAO 1980a, Ch. 5). The name Djallonké sheep was preferred to West African Dwarf because as Fitzhugh and Bradford (1983) point out, these sheep are relatively small but they are not achondroplastic. Similarly, the name Fouta Djallon goats was preferred because these goats may (Mason 1984) or may not (Hall 1991) be achondroplastic. Note that the breed names Djallonké and Fouta Djallon are collective names that refer to a variety of ‘types’ distributed throughout the region. Studies on the genetic similarity among these ‘types’ would be of importance in establishing whether the whole population may be treated as a single breed or whether it should be subdivided.

Fitzhugh and Bradford (1983) have argued that with the exception of the Blackhead Persian (fat-rumped) all other American hair sheep could be considered as belonging to the same ‘genetic type’. In table 4 the Pelibuey was chosen as representative of that type. It was threatened by planned and by indiscriminate crossbreeding for some time, but it is now relatively safe (Baffi-personal communication). Because the island of Cuba is free from a number of diseases, livestock developed there should be acceptable from an animal health point of view to many other countries within and outside the region. The Cuban Pelibuey is not a uniform population. There is enough variation in coat colour, type and performance, which should enable the development of strains selected for different objectives (e.g. reproduction for a maternal line, growth rate for a terminal sire line).

Bradford (1989) points out that there is a potentially very large forage resource under tropical tree crop agricultural systems, which could be exploited with suitable genotypes. The Javanese Thin-tailed sheep are one such genotype. They are particularly interesting because the single gene for prolificacy segregating in the population should enable the development of strains differing in reproductive performance, and thus suited to production systems of different intensities.

The D'man breed from Morocco is a relatively minor breed in the country. Nevertheless, it has attracted attention because of its exceptionally large litter size, early puberty and short lambing interval (Bradford et al. 1989, Lahlou-Kassi et al. 1989). It appears that in the D'man the high litter size is transmitted in an additive manner (not via a single gene of large effect). Since the breed evolved in a very hot environment, apart from being valuable in itself, it could be useful for crossing with other breeds in similar environments.

The Awassi is the predominant breed in the Near East, where strains differing in milk production, size and wool quality can be found (FAO 1987a). The Awassi thrives under arid conditions and can tolerate extremely high ambient temperatures (Devendra and McLeroy 1987). Increasing our understanding of this breed so that its remarkable characteristics can be maintained and if possible improved further appears to be justified.

4.2 Goats

Comments on Fouta Djallon goats were made under the Sheep heading.
The Damascus or Shami goat originates in Syria, but it has spread to a number of countries of the Near East. It is believed to have given rise to the Zaraibi goat of Egypt and to be an ancestor of the Kilis breed of Turkey (Devendra and McLeroy 1987). The Damascus breed has high prolificacy and milk yields, combined with adaptation to hot environments. It has been identified as having great potential in the Near East (FAO 1987a).

The Jamnapari is the largest of the Indian goat breeds (Mason 1981b). It has contributed to the formation of the Anglo-Nubian breed (Bhat 1987). It is a dual purpose animal, useful for meat and milk, but it is mainly as a dairy animal that it is sought (Devendra and McLeroy 1987). Jamnapari goats have been taken to South East Asia, East Africa, the West Indies and South America to improve milk production (Mason 1981b, Devendra and McLeroy 1987). Bhat (1984) comments that there has been an alarming reduction of the number of animals of this breed. This decline, coupled with the valuable attributes of the Jamnapari have prompted suggestions that the breed is worthy of immediate attention.

The greatest concentration of goats in Brazil is in the North Eastern part of the country, in a drought prone hot semi-arid tropical environment (Figueredo et al. 1982). Of the 'local' breeds the Moxoto' is the most common one. It is a small, very good looking goat, highly adapted to the environment. It is kept as a meat animal and it produces a very valuable skin. As other goats in the region, it has often been indiscriminately crossed with imported breeds, such as the Anglo-Nubian and the Bhuj. Fears about declining numbers of the breed led to a small herd of Moxoto' goats being established in Brasilia, where a cryopreservation program started in 1989 (da Silva Mariante 1990).

The Boer goat of South Africa is derived principally from the goat of the Hottentots (Mason 1981b). The Improved Boer is a fast growing, well muscled and strong boned goat. It has good reproductive rate and milk production, but its greatest potential would seem as a terminal sire breed. In some production systems it could be used over small prolific dams to improve the growth rate and carcass attributes of their progeny. Boer goats have recently been introduced to Australia.

5 Final remarks

A note of caution in relation to the activities that support programs for sheep and goat breeds could entail may be appropriate. Very often preservation and breed development are mentioned as part of such programs, but research is seldom discussed. In simple terms breed development could be defined as the improvement of the breed's usefulness by genetic means, probably accompanied by its numerical expansion. With indigenous sheep and goat breeds, in most instances, the necessary information to implement a scientifically based program of genetic improvement is not currently available. Therefore, a period of intense research activities should often precede the implementation of genetic improvement programs. Intense selection for some simplified economic goal could result in the loss of valuable attributes in the population the program is trying to improve. For example, a common feature of many sheep and goat breeds adapted to tropical environments is their relatively small size, but very good reproductive rate. It is tempting to suggest that selection for greater growth rate should be recommended. However, intense selection in that direction would be risky, unless we knew the likely correlated responses in other important traits, such as reproductive rate or resistance to disease, and we had a clear understanding of the role played by body size in the adaptation of these breeds to harsh environments.
Support programs for indigenous sheep and goat breeds should have as one of the most important aims the establishment of resource flocks or herds (R F&H). These populations should have adequate size and design to enable the estimation genetic parameters, to provide experimental animals for physiological studies, and to undertake genetic studies at the gene and molecular levels. The range of characteristics recorded in the R F&H should be much greater than in normal genetic improvement programs so that correlated responses of interest can be predicted and genetic variation in potentially useful traits is uncovered (e.g. resistance to internal parasites, ability to hyperhydrate, etc.). The R F&H would ensure preservation of the breed, and could be a source of breeding stock. However, dissemination of the genes of the indigenous breed in question should be the aim, rather than intense selection in any direction. The latter should be delayed until such time as we have sufficient knowledge indicating that the pursuit of a particular goal will not result in the loss of the attributes that led us to preserve the breed in the first place.

At present, making suggestions about which sheep and goat breeds should be the target of support programs in the near future is a very difficult task. Injustices could be done simply because of ignorance about other breeds, or due to biased perceptions. It is hoped that in the future the situation will be such that making objective choices becomes easier, and that other valuable indigenous sheep and goat breeds can also be supported.

6 Acknowledgments

Dr G.E. Bradford, Mr R.C. Cardellino, Mr C.H.S. Dolling and Dr Helen N. Turner made many valuable suggestions during the preparation of this paper. They are, however, innocent of any omissions or errors of appreciation the paper could contain.

7 References


A GLOBAL REVIEW OF THE GENETIC RESOURCES OF PIGS

L. Ollivier and M. Molénat

1 Introduction

The pig is a major source of protein for human populations. According to FAO 1990 statistics it accounts for about 40% of the world production of meat. Regional variations however are important, as pig meat only represents 6% of the total meat production in Africa, whereas in China this percentage reaches 85%; Europe is a major area of production with about 51% percent (excluding the former USSR).

The pig is mainly fed on grain, which developed countries overproduce, while developing countries are badly in need of such food resources. Though it is impossible to forecast what will be the future balance in the allocation of resources between man and pigs, the evolution of pig will have in any case to be directed towards the most efficient use of whatever resources are available (Epstein and Bichard, 1984). Management of pig genetic resources should be envisaged in such a perspective. Various aspects of domestication, the present use of pig breeds and their conservation have already been dealt with in several reports, such as those by Epstein and Bichard (1984), Molénat and Legault (1986), Jonsson (1991), King (1991) and Steane (1991). This paper reviews the global situation of the pig genetic resources to-day, the objectives assigned to the management of such resources and the identification of priority breeds which deserve preservation/development action. Emphasis will be put on indigenous breeds in 3 world regions, where the need for international support can be considered the most urgent, namely Asia, Latin America and tropical Africa.

2 Management of genetic resources in pigs: general considerations

Potential resources include a wide spectrum of pig populations, which may be classified, according to a typology suggested by Lauvergne (1982), into four categories by increasing degree of evolution : (1) wild (or feral) populations, (2) traditional (or indigenous) populations, (3) standard breeds, and (4) selected lines (and so-called “new breeds”). Though a somewhat different classification has been retained by Mason (1988) in his dictionary, one can easily find in this compilation of over 500 pig breeds listed, representatives of all four categories of populations with a marked predominance of categories (2) and (3).

Management of genetic resources is usually understood in a longer term perspective than is the case for current breeding schemes oriented towards meeting rather near-term requirements. The goal is, in a long-term perspective, to maintain genetic variability, be it quantitative or qualitative (Ollivier and Lauvergne, 1988). In pigs, like in other livestock species, there is at present no indication that genetic variability is at risk for the traits usually considered by farmers and given present conditions of breeding (Fredeen, 1984). The highly polygenic nature of such traits, combined with systems of matings which largely favoring outbreeding, is a preventative against any significant decay of genetic variability. In addition, between-breed variation is generally thought to be the result of different frequencies of genes shared in common by several populations rather than of presence/absence of individual genes. In contrast, the risk of loss of variability may be greater for qualitative variation, especially when it has a monogenic basis.
The difficulty here is that our genetic knowledge of pig populations is presently too limited to allow tracing, with the required accuracy, the population-gene combinations really at risk.

Another, and perhaps more important, concept underlying genetic resources is genetic flexibility. Even assuming that genetic variability makes possible, in theory, changes in any population in any direction for any trait, flexibility in pig evolution is somewhat constrained by the multiplicity of objectives to be considered. Each one of these objectives needs an appropriate allocation of the limited opportunities for selection and is also constrained by the differing amounts of genetic variability depending on the trait considered. Between breed diversity plays an essential role by allowing changes to be made rather quickly to cope with new situations. A recent example is the repopulation of Haiti after the outbreak of African swine fever in 1983. The use of a combination of a Criollo pig from a neighboring island (Guadeloupe), a local European breed (Gascon from France) and the highly prolific Chinese breeds (Taihu) quickly provided genotypes well adapted to the variable and generally extremely harsh rural environment (Delatte et al., 1991). Because of their low heritability, traits related to fitness, such as fertility, longevity, general disease resistance, are particularly valuable criteria for deciding on priorities for conservation/development action.

Adaptation in pigs should probably be considered rather differently from that of ruminants as pigs, except in a few situations, are much less dependent upon the vegetation of a particular region than are cattle or sheep. In many cases, it will be preferable to introduce an improved pig breed rather than to establish an improvement programme in a native breed. In his discussion of dietary adaptation, King (1991) stresses the lack of significant interaction in many genotype-environment experiments, though he expresses caution on the need for more experiments with indigenous and improved breeds. In such experiments, as stressed by Molénat and Legault (1986), the improved breed × harsh environment combination is often missing, and this “empty cell” is usually difficult to fill. With regard to climatic adaptation, the success of feral populations shows the good adaptability of improved genotypes, and there is again surprisingly little scientific evidence on particular adaptation to hot or cold environment.

Our limited knowledge of several aspects of the pig's biology calls for further scientific investigations and some extreme genotypes may be of great utility for that purpose. Such is the case, for instance, with the European Wild Pig and the Chinese Meishan in the European pig gene mapping project (Haley and Archibald, 1991). A final point in this regard is the preservation of a world heritage, though in this respect the pig has a much less fashionable image in most of our societies than other farm animals.

A proper assessment of the available resources is of fundamental importance. Breeds have to be catalogued and evaluated. Information on pig breeds can be found in scientific literature and, more recently, following FAO, European and Asian (for example SABRAO) initiatives, regional and global data banks are being established. The catalogue by Mason (1988) provides an overview of the distribution of pig breeds across the world. As shown in table 1, over 300 breeds are currently exploited, the largest numbers of breeds being found in Asia and Europe. More detailed information can be found in several data banks, such as the EAAP/FAO Global Animal Genetic Data Bank (Simon, 1990), which now includes information on 68 European and 10 Chinese pig populations, and the Nordic Data Bank for Farmed Animal Genetic Resources. Various private or state organizations in U.S.A., Canada and India can also be consulted (D. Simon, personal communication). Information on regional data banks in developing countries is unfortunately limited. Breed comparison evaluations are being carried out in several countries, often using exotic and local breeds, but there is little connection between different countries. In
that respect, the world survey of Sutherland et al. (1985) merits being extended to more breeds and countries.

**Table 1.** An overview of pig breeds, types and varieties across the world (from Mason, 1988)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Africa</th>
<th>America</th>
<th>Asia</th>
<th>Europe</th>
<th>Oceania</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Important</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>44</td>
<td>-</td>
<td>71</td>
</tr>
<tr>
<td>Secondary</td>
<td>6</td>
<td>40</td>
<td>130</td>
<td>77</td>
<td>4</td>
<td>257</td>
</tr>
<tr>
<td>Rare</td>
<td>-</td>
<td>5</td>
<td>2</td>
<td>39</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>Extinct</td>
<td>-</td>
<td>16</td>
<td>8</td>
<td>114</td>
<td>1</td>
<td>139</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>72</td>
<td>155</td>
<td>274</td>
<td>6</td>
<td>514</td>
</tr>
</tbody>
</table>

In practice, genetic resources are managed using classical breeding plans, implying evaluation of either individual breeding values (for pure breeding) or of population mean values (for crossbreeding schemes), as reviewed by Glodek (1991). For conservation, live populations and cryoconservation can be used, as in other farm species, with the limitation that recovery of frozen embryos is not yet feasible in pigs (Steane, 1991). A.I. and the use of frozen semen have an important role to play (e.g. Walters and Hooper, 1990). Breeding can be managed at the farm level, provided minimal management conditions are met, whereas conservation techniques, to be reliable in the long term, should be envisaged within state or international institutions.

### 3 Regional survey

#### 3.1 Asia

About half of the world pig population is located in Southeast Asia, with an inventory of around 400 million heads. China represents the most of it with about 350 million, followed by Vietnam with 13 million. The enormous Chinese reservoir of genetic diversity for pigs, among other farm animals, was first drawn to the world’s attention by Epstein (1969) and later documented by Legault (1978) and Cheng (1984). In addition to results collected in China, research findings on a few local Chinese breeds imported by several western countries are also available.

China has a long history of domestication, going back more than a hundred centuries (Zhao, 1990). It is therefore likely that domestication in China started not later than and independently of the domestication center of Near-East Asia. A long tradition of pig husbandry under various climatic and geographic conditions is probably a major cause of the presently observed genetic diversity. From reports based on a comprehensive investigation launched in 1981 by the Chinese government (Zhang et al., 1987), the number of native breeds officially registered is about 50, to which 25 improved breeds (including imported foreign breeds) should be added. The local breeds belong to 6 different types: North China, Central China, Shanghai area, South China, Southwest China and Plateau.

Phenotypic variability among breeds is extremely large. In an attempt to characterize Chinese breeds by their phenotypic traits, Li and Enfield (1989) were able to classify 75 breeds into 6 clusters, mainly based on litter size and body weights. As shown in table 2, the range between extreme type averages is about 8 piglets for litter size (from 6.4 to 14.5) and 209 kg for adult body weight (from 33 to 242 kg).
Table 2 Characterization of Chinese breeds of pigs (from a cluster analysis by Li and Enfield, 1989)

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Type average</th>
<th>Breed example</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>medium</td>
<td>small</td>
<td>9.9</td>
</tr>
<tr>
<td>II</td>
<td>medium</td>
<td>medium</td>
<td>10.8</td>
</tr>
<tr>
<td>III</td>
<td>medium</td>
<td>large</td>
<td>10.4</td>
</tr>
<tr>
<td>IV</td>
<td>high</td>
<td>medium</td>
<td>14.5</td>
</tr>
<tr>
<td>V</td>
<td>high</td>
<td>small</td>
<td>13.4</td>
</tr>
<tr>
<td>VI</td>
<td>low</td>
<td>very small</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Among Chinese breeds, the Taihu group certainly deserves priority attention, because of the high prolificacy (going along with corresponding maternal abilities such as teat number) and the early sexual maturity of those breeds. Their merit under Chinese production conditions has been confirmed under intensive husbandry conditions in several other countries: see Legault and Caritez (1983) for one of the earliest evaluation of the Meishan and Jiaxing breeds outside China. These are really “improved” breeds as far as reproduction goes, compared to western breeds: the difference in litter size amounts to about one phenotypic standard deviation (sd), whereas for female sexual precocity the difference exceeds 4 sd, according to a recent French study (Després et al., 1992). Following the French importation of 1979, importations have followed in Hungary, Holland, Japan, U.K. and U.S.A.. Recent results can be found in the Toulouse symposium (Molénat and Legault, 1990).

However, owing to their extremely low potential for lean growth, the benefit from including those breeds into crossbreeding schemes, in order to exploit their complementarity with lean types, is highly dependent on the premium paid for leaner pork by the market. Present market conditions in China, as well as in many developing countries, still make crosses with Taihu breeds quite attractive, whereas in most developed countries, the loss in market value incurred by each individual pig is not compensated by the reduction in cost of piglet production.

According to a recent report by King (1992), the Taihu group includes seven genetically distinct breeds, some of them divided into strains (e.g. Meishan). The group has an estimated 600,000 breeding animals, distributed as shown in table 3, with a tendency to an increase in popularity of the Erhualian breed. None of those breeds is really in danger of extinction. Breeding is well organized and structured, and a clear hierarchy of herds exists. The danger for the future is an increased consumer demand for lean meat, which would put pressure on those breeds for crossing with exotic breeds. Taihu breeds will then be exposed to the risk of genetic dilution of their favorable reproductive characteristics, a risk which may be increased by a massive use of A.I. in the Taihu area.
### Table 3 Distribution of the Taihu breeding animals (from King, 1992)

<table>
<thead>
<tr>
<th>Breed</th>
<th>% of total</th>
<th>breeding herds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erhualian</td>
<td>36.7</td>
<td>10</td>
</tr>
<tr>
<td>Meishan</td>
<td>13.2</td>
<td>6</td>
</tr>
<tr>
<td>Fenjing</td>
<td>20.8</td>
<td>1</td>
</tr>
<tr>
<td>Jiaxing Black</td>
<td>10.9</td>
<td>1</td>
</tr>
<tr>
<td>Hengjing, Mi and Shawutou</td>
<td>18.4</td>
<td>3</td>
</tr>
</tbody>
</table>

Opportunities for meeting other requirements are also reported in Chinese breeds, such as resistance to extreme cold weather in the Min breed of North China, which appears to combine this favorable trait with high prolificacy. Special food-seeking abilities are mentioned for the Tibetan pig, which combines dwarfism with adaptation to cold, alertness and highly developed digestive organs able to utilize shrubs, stems, roots and seeds of wild plants.

Vietnam, the second largest pig producing country in Asia, relies on both intensive production systems and household production, the latter however representing 80% of the total output. Vietnam also shares with South-East Asia some unique features in the role played by the pig: fat as a source of essential fatty acids, manure as fertilizer for rice cultivation and frequent association with fish production. Vietnam has an abundance of local breeds, several extremely early reproducing, among which the Mong Cai is considered as a genetic type of interest for the future and currently under investigation in several state farms (Molénat and Tran The Thong, 1991).

### 3.2 Latin America and Caribbean zone

Indigenous (or so called native) pigs of this region actually derive from early importations. According to Epstein and Bichard (1984), pigs were introduced from China in the 15th century, and the colonists in the 16th century brought along both Celtic and Iberian types. A rather detailed survey of indigenous pigs in Latin American has been given by de Alba (1972). To-day indigenous breeds play a role depending on the production system. Beside intensive production based exclusively on improved breeds such as Large White, Landrace or Duroc, Latin America has an important sector of smallholder production, with moderate productivity and low inputs, which relies on local breeds either pure or used in crosses with improved breeds. Backyard pigs raised for self-consumption are also a constant feature of meat production in that region of the world and Criollo types usually serve that purpose: see Le Mentec (1970) and Canope and Raynaud (1981) for evaluations of the Criollo pig of Guadeloupe.

Half of the pigs of that region live in Brazil. This is also the only tropical country in this area which devotes significant efforts to study and to improve its local breeds. In 1986, a project for evaluating national breeds of pigs was started in South Brazil, under the auspices of the Agricultural Research Corporation (EMBRAPA) and of the National Center for Genetic Resources (CENARGEN). A survey covering seven breeds in danger of extinction is currently underway and preliminary results are shown in table 4. State support is provided for four breeds, Moura, Caruncho, Pirapitinga and Piau, and conservation nuclei for the latter breed have been established in the 3 southern provinces of Brazil. Crossbreeding experiments with improved breeds are carried on in the Santa Catarina and Paraná provinces. The objective is to obtain more precise information on the specific characteristics of those rather numerous local...
breeds, their nutritional requirements, their ability to survive in harsh environmental conditions and their possible resistances to diseases.

Table 4. Brazilian pig breeds in danger of extinction (from Mariante, 1990)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Population size</th>
<th>Degree of crossing</th>
<th>Status nuclei</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macao(or Tatu)</td>
<td>&gt; 500</td>
<td>high</td>
<td>decreasing</td>
<td>private</td>
</tr>
<tr>
<td>Moura</td>
<td>200–300</td>
<td>low</td>
<td>increasing</td>
<td>state/private</td>
</tr>
<tr>
<td>Caruncho</td>
<td>100–200</td>
<td>high</td>
<td>stable</td>
<td>state/private</td>
</tr>
<tr>
<td>Pirapitinga</td>
<td>10–20</td>
<td>low</td>
<td>stable</td>
<td>state</td>
</tr>
<tr>
<td>Piau</td>
<td>&gt; 1000</td>
<td>high</td>
<td>increasing</td>
<td>state/private</td>
</tr>
<tr>
<td>Nilo</td>
<td>&gt; 500</td>
<td>high</td>
<td>decreasing</td>
<td>private</td>
</tr>
<tr>
<td>Canastra</td>
<td>100–200</td>
<td>high</td>
<td>decreasing</td>
<td>private</td>
</tr>
</tbody>
</table>

Mexico also has several local breeds of interest, generally of small size and well adapted to various climates. The black hairless pig of Yucatan, in addition to being a natural miniature pig of about the same size as other artificially created strains (Panepinto et al., 1978), is reportedly well adapted to hot climates and to bulky diets. The Cuino miniature pig (10–12 kg adult weight), though nearly extinct according to Mason (1988), would deserve being conserved, as it is reported to be able to survive long periods of starvation under household conditions.

3.3 Tropical Africa

The pig population of tropical Africa is about 7.3 million, half of which is located in the coastal region of West Africa, from Senegal to Cameroon. The West African indigenous pig belongs to the Iberian type and includes such varieties as the Ashanti dwarf in Ghana, the Bakosi in Cameroon and the Nigerian native (Mason, 1988). This pig may have migrated from Northern Africa and Egypt (Pathiraja and Oyedipe, 1990), or, according to Epstein (1971) it would derive from early Portuguese imports in lower latitudes.

This type of pig is well adapted to the extensive conditions of the traditional village management, as it gets its food essentially from scavenging. It constitutes a valuable source of meat for the small-scale farmers of that region. In more intensively cultivated areas, indigenous pigs are kept under semi-intensive systems and fed agricultural by-products.

West African pigs grow slowly, produce small litters, partly because of an excessively early sexual precocity with a first farrowing at 8 month of age, but sows reproduce with regularity and may farrow 2.3 litters a year (Pathiraja and Oyedipe, 1990). There are indications that indigenous pigs may exhibit better heat and parasite tolerance than exotic breeds, and also better disease tolerance and trypanotolerance. However, these are field observations which would require the support of experimental evidence.

The best described genetic situation is that of the Nigerian native by Pathiraja and Oyedipe (1990). Between 1975 and 1985, the estimated pig population of Nigeria has increased from 867,000 to 1,050,000 heads, while a steady decline of the percentage of indigenous pigs has been observed, from 89 percent of the total in 1975 to 58 percent in 1985. As a consequence, in several major pig producing areas, indigenous pigs are virtually extinct. The same authors point
to a possible contribution of inbreeding to the low productivity observed under traditional management systems, owing to the small size of individual herds.

In addition to Nigeria, where scientific investigations on native and crosses with exotic breeds have been carried on, work done in Zimbabwe (Pig Industry Board) and in Bénin (D’Orgeval, personal communication) should also be mentioned. As pig is a species of relatively minor importance in Africa, the lack of accurate statistics and basic production data, recognized as a major constraint for an adequate management of farm animal genetic resources in this part of the world (Setshwaelo, 1990), applies even more to African indigenous breeds of pigs.

3.4 Other regions

Local breeds of pigs in other parts of the world will be briefly mentioned here for the sake of completeness. In Europe, where each country has its own set of local breeds, the conservation of rare breeds has received considerable attention in recent years as well as reasonable support from various state and private institutions. Similar efforts are made in Canada and U.S.A., through Rare Breed and Minor Breed Conservancy associations. In India, a National Bureau of Animal Genetic Resources has been established and is engaged in conservation and management of native populations, and studies on local breeds of pigs are reported from several research teams. Australia and New Zealand have no local breeds as they rely on imported British breeds, some of which have become feral since their introduction on this continent. Particular mention should be made of the village pig in the civilization of Papua-New-Guinea.

4 Conclusion on priorities

Breeds eligible for priority support of development-conservation action are to be found in the three regions considered above: Asia, Latin America and tropical Africa. China should probably come first as it is to-day the most important and the most diverse gene pool in the world. In Zhao's (1990) words, the pig breeds of China are “invaluable treasures which belong not only to the Chinese people but also to the people all over the world”, and they should play an increasing role in the future improvement of the species. With Chinese experts fully realizing the value of their national breeds, and adequate breeding structures for implementing development projects of sufficiently long term, a most favorable situation exists. The Taihu breeds may be regarded as a valuable genetic material for addressing an important research problem, which is to determine whether lean growth can be improved while maintaining a high level of prolificacy. Those populations also offer an opportunity to check the increase in annual genetic gain accruing from the higher selection intensity/generation interval ratio allowed by their fecundity and sexual precocity (Bidanel, 1988). In that respect, the 10-year project for improving the Erhualian breed proposed by King (1992) should receive due attention. Such trials would gain from being replicated in at least another breed of the Taihu group (Meishan or Jiaxing) and an additional candidate could be the Min breed, which combines the reproductive characteristics of Taihu with more specific qualities of adaptation to cold environments.

The situation in Latin America is very different, as risks of extinction of valuable genetic material exist on a rather short-term. Brazil was among the first countries in Latin America to establish a national programme for conservation and evaluation of native livestock populations (Primo, 1987). This effort deserves recognition by the international community, which should ensure that it can be pursued, in spite of present economic difficulties. The native pigs of Brazil represent a suitable material for studies of survival qualities and general adaptation, of which smallholders
can take advantage within production systems with very low inputs, typical of many tropical countries. The Brazilian Piau breed should be a valuable target of investigation, as it is generally considered as one of the best local breed for survival, growth and reproduction. More information is however needed on those breeds. A programme of evaluation of genetic distances can be recommended in order to more objectively justify priorities for conservation programmes.

Tropical Africa may be the region where the danger of extinction of local pig populations is highest, in the aggravating context of a limited number of such populations in the whole continent (see table 1). Measures of conservation of the West African pig are therefore urgently needed. Gene banks can here be recommended, as semen stores can be maintained at a much lower cost than live populations and with better prospects of continuity in most cases. Investigations on disease resistance, in particular to confirm the reported tolerance of local pigs to African swine fever, would be a further justification of the efforts needed to maintain this type of pig.

In practice, strong local support will obviously be needed for any long-term development project and national as well as regional initiatives should receive priority attention. The quality and the authority of the chosen local contacts will also be crucial to the success of any internationally coordinated project. The proposals presented in this report are to be considered as general guidelines, and they will certainly need further elaboration. As noted by de Alba (1972), an enormous gap exists in the annual output of slaughtered pigs relative to the inventory between tropical countries like Brazil, where a large part of the resources used by the pigs serves for herd maintenance, and developed countries like U.S.A. where proper housing and feeding allows a high proportion of the feed to be used to produce lean tissue. One cannot expect such a gap to disappear in a predictable future. A proper management of our genetic resources could however certainly contribute to narrowing it.

5 Acknowledgements

Information provided by C. Legault (Jouy-en-Josas), D. Simon (Hannover) and D. Steane (Rome) during the preparation of this report is gratefully acknowledged.

6 References


A GLOBAL REVIEW OF THE GENETIC RESOURCES OF CAMELIDAE

C. Novoa\(^1\) and T. Wilson\(^2\)

1 Introduction

Alpacas (\textit{L. pacos} Linnaeus, 1758) and llamas (\textit{L. glama} Linnaeus, 1758), which have been domesticated for centuries, together with guanacos (\textit{L. guanicoe} Muller, 1776) and vicuñas (\textit{L. vicugna}, Molina, 1782 or \textit{V. vicugna} [Molina] Miller, 1924) that still live in the wild in Latin America, constitute the four extant species of the genus \textit{llama}. These species together with the two species of the genus \textit{Camelus}, namely the dromedary or one-humped camel (\textit{C. dromedarius} Linnaeus, 1758) and the bactrian camel or two-humped camel (\textit{C. bactrianus} Linnaeus, 1758), form the Camelidae family (Blanc and Ennesser, 1989).

Because of the common ancestry and the fact that they have a similar karyotype and diploid chromosome number (2\textit{n}=74), it is not surprising that many physiological phenomena in Lamoids and Cameloids have been shown to be similar. Reproduction is a good example of this similarity. Lamoids and Cameloids are induced ovulators. The four species of Lamoids are inter fertile and their offspring, produced by all possible matches of both pure and hybrid parents, are also fertile. The two species of Cameloids also cross readily and the crosses are fertile in both sexes.

Both the Cameloids and Lamoids have evolved specialized anatomical and physiological adaptations to the arid and semi arid zones which they inhabit, but only the former can go for long periods without water. The Lamoids have also adjusted to the high elevations of the Andes through the development of haemoglobin and tissue characteristics which facilitate the concentration and utilization of oxygen under conditions of chronic hypoxia.

This paper contains a brief description of Camelidae population, distribution and status and on these grounds, priority breeds for conservation and improvement are identified.

2 Population and distribution

2.1 Lamoids

Pre-hispanic llama and alpaca herding spread well beyond the limits of the Puna ecosystem, where they were first domesticated. The maximum extension of their distribution from Southern Colombia to Central Chile, occurred under the Inca empire, but with the advent of Spanish rule and the introduction of European farm animals, camelid production and breeding control began a decline which has never been reversed. Estimates of the current population of Latin American camelids are shown in table 1.

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\(^2\) FAO/UNDP Regional Project RAF/88/100, Banjul, The Gambia.
Table 1. Estimated population of Latin American camelids (x 1,000)

<table>
<thead>
<tr>
<th>Country</th>
<th>Llama</th>
<th>Alpaca</th>
<th>Guanaco</th>
<th>Vicuña</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>200.0</td>
<td>.2</td>
<td>578.7</td>
<td>10.0</td>
</tr>
<tr>
<td>Bolivia</td>
<td>2500.0</td>
<td>300.0</td>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>Chile</td>
<td>85.0</td>
<td>.5</td>
<td>22.5</td>
<td>16.3</td>
</tr>
<tr>
<td>Colombia</td>
<td>.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perú</td>
<td>989.6</td>
<td>2600.0</td>
<td>1.6</td>
<td>62.0</td>
</tr>
<tr>
<td>Total</td>
<td>3776.8</td>
<td>2900.7</td>
<td>602.8</td>
<td>92.8</td>
</tr>
</tbody>
</table>


Llamas are found from Colombia to Chile and Argentina, with the zone of greatest concentration located between 11 degrees and 21 degrees south, whereas the distribution of alpacas extends from Cajamarca and Ancash in Northern Peru (a recent reintroduction) to lake Poopo in Bolivia with small numbers in Northern Chile and Northwestern Argentina. However, the foremost alpaca producing area is within a 50 to 100 km. radius of lake Titicaca.

Llamas and alpacas are usually kept at elevations from 2300 to 4000 and from 4000 to 4800 m., respectively. Although local llama and alpaca distribution is determined by altitudinal, topographical, and vegetational conditions and alpaca tend to occur at higher elevations, the two species can be found in the same area because of herding by man. Llama makes highly efficient use of the bunch grasses of the Puna which typically contain 5% protein, while the alpaca selects the shorter grasses (San Martin 1987). This dietary difference permits the two species to co-exist in the same ecosystem, and is reflected in incisor morphology. Llama incisors are spatulate in form and have an enamel covered crown which when worn has two cutting surfaces, while alpaca incisors have enamel only on the labial surface and, hence only one cutting surface when worn. Llamas prefer dryer forage and actually reduce food intake during the rainy season, whereas alpacas are found most frequently in wet boggy areas (San Martin 1987).

The guanaco is the widest ranging and occupies the most diverse habitat types. It is found both in shrublands and warm and cold grasslands at elevations from sea-level up to 4250 m. (Franklin 1982) or 4600 m. in the Andes. Its northernmost distribution is at present located at about 8 degrees south in the department of La Libertad, Perú. From there its range extends south along the Andean Cordillera to Navarino Island in Tierra del Fuego, east across Patagonia and as far north as the sierras of Curamalal and la Ventana in the province of Buenos Aires, Argentina. In contrast to the guanaco, the vicuña is found only at the highest elevations of the Andes between 4200–4800 m. above sea level (Franklin 1982). The northernmost distribution of the vicuña, both past and present, is 9 degrees 30 minutes south in the department of Ancash, Perú. The southern most limit is presently 29 degrees 0 minutes south in the province of Atacama, Chile.

2.2 Cameloids
In 1990 there were estimated 19 million Camels in the world, of which 93% were one-humped camels. Their distribution is shown in table 2. The one-humped camel is found in almost all the arid and semi arid regions of the old world. They are vital to the economy of northern Africa, the middle East and central Asia. In general, numbers of one-humped camel have increased over the last decade. Where numbers have declined it has been for two different reasons: in countries in which oil is the major commodity and where nomadism is no longer the major way of life and, the severe droughts of the 1970s and 1980s (Wilson 1991). The two-humped camel is cold resistant as shown by its presence in northern China, Mongolia and the southern part of the former Soviet Union (Turkmenistan, Siberia). It appears that numbers of two-humped camels have declined slowly in China and Mongolia over the last decade.

3 Description and present status of existing camelidae

3.1 Lamoids

Latin American Camelids have not been adequately evaluated and in some instances, are threatened with extinction even before they are properly described. Based on available information an attempt will be made to briefly describe both domestic and wild Camelids indicating their current status.

3.1.1 Domestic species

Llamas have been selectively bred for use as pack animals and meat producers. They are larger than their guanaco ancestor (Wheeler 1984 a and b; Wing 1977, 1986). Two different breeds are known, although it is likely that more exist. The majority (70–80%) of Andean llamas are of the Q'ara or non woolly breed, which is characterized by its nude face and limited fibre growth. Less common is the Chaku or woolly llama, which as its name implies, produces more fibre and typically has wool growing on its fore head and its ears. Colours vary from white to black and brown but is not generally uniform across the body. Intermediate phenotypes between Q'ara and Chaku, although rare, have also been recognized. Table 3, shows comparative data on llama fibre diameter.

The Andean llama has never been selected for fibre production and like the guanaco, its fleece contains up to 20% kemp (Carpio y Solari 1982) and is woven into saddle-bags and made into rope. Trade in llama wool has not developed due, in part to its coarseness and colouration irregularities.

Table 2 - Part 1. Numbers of one-humped camels by region and country (x 1000). Adapted from FAO Production Yearbooks.

<table>
<thead>
<tr>
<th></th>
<th>1979–81</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFRICA</strong></td>
<td><strong>12317</strong></td>
<td><strong>14509</strong></td>
</tr>
<tr>
<td>Algeria</td>
<td>150</td>
<td>135</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Chad</td>
<td>432</td>
<td>540</td>
</tr>
<tr>
<td>Djibouti</td>
<td>51</td>
<td>59</td>
</tr>
<tr>
<td>Egypt</td>
<td>84</td>
<td>190</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>980</td>
<td>1080</td>
</tr>
<tr>
<td>Country</td>
<td>1979–81</td>
<td>1990</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>China</td>
<td>597</td>
<td>476</td>
</tr>
<tr>
<td>Mongolia</td>
<td>601</td>
<td>560</td>
</tr>
<tr>
<td>USSR</td>
<td>235</td>
<td>300</td>
</tr>
<tr>
<td>Total two-humped</td>
<td>1433</td>
<td>1336</td>
</tr>
</tbody>
</table>
In contrast to llamas, alpacas have been specially bred as wool producers and two breeds are distinguished on the basis of their fibre characteristics. Approximately 90% of all alpacas exhibit the shorter, crimped fibres of the Huacaya breed, while 10% (though numbers are rapidly declining) have the long straight fibres of the Suri breed. In appearance the Huacaya is reminiscent of Corriedale, and Suri of Lincoln sheep. Animals with intermediate type wool exist, but are rare. The genetic factors which control these traits are not known; crosses Huacaya × Huacaya produce a certain percentage of Suri offspring and crosses of Suri × Suri produce some Huacaya offspring. Results in table 4 would indicate that Huacaya is recessive, however more data is needed to confirm these preliminary results.

Table 3. Fibre diameter (micron) in adult llamas by type and sex

<table>
<thead>
<tr>
<th>Type</th>
<th>Sex</th>
<th>Ave diameter</th>
<th>S.D.</th>
<th>CV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chaku</td>
<td>Males</td>
<td>27.6</td>
<td>9.3</td>
<td>33.6</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>25.5</td>
<td>9.2</td>
<td>29.2</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Males</td>
<td>28.9</td>
<td>11.6</td>
<td>44.4</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>26.7</td>
<td>12.3</td>
<td>25.8</td>
</tr>
<tr>
<td>Q'ara</td>
<td>Males</td>
<td>30.7</td>
<td>12.6</td>
<td>41.5</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>29.2</td>
<td>15.1</td>
<td>51.9</td>
</tr>
</tbody>
</table>

Sources: Vidal (1967).

Alpaca colour varies from white to black and brown, including all the intermediate shades and is fairly uniform across the body. Alpaca wool has a high commercial value because it contains little kemp, has a low felting quality, is very fine (see table 5) and can be woven into lightweight, soft and lustrous fabric.

Table 4. Huacaya and Suri Crosses

<table>
<thead>
<tr>
<th>Offspring trait</th>
<th>Huacaya × Huacaya</th>
<th>Suri × Suri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suri</td>
<td>0</td>
<td>422</td>
</tr>
<tr>
<td>Huacaya</td>
<td>129</td>
<td>89</td>
</tr>
</tbody>
</table>

Sources: Velasco (1980).

The demand for white wool greatly reduced colour variation in the Andean populations in recent years; however, local artisan production is creating more demand for other colours.
The exact mechanism of inheritance of colour pattern is unknown. Alpaca crosses between white individuals and white crossbreds, mottle or other colours produce a large proportion of offspring with white coat (Condorena 1983). On the other hand data from Velasco (1980) indicate that uniform colour (without white hairs) is dominant over mottle (with spots of white hairs); additionally brown appears to be dominant over black.

Table 5. Camelid fleece characteristics.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Llama</th>
<th>Alpaca</th>
<th>Guanaco</th>
<th>vicuña</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleece wt. (kg)</td>
<td>2.8±1.1</td>
<td>1.8</td>
<td>0.25</td>
<td>0.18–0.25</td>
</tr>
<tr>
<td>Staple length (cm)</td>
<td>10.2±2.2</td>
<td>8.9±1.5</td>
<td></td>
<td>3.4±0.83</td>
</tr>
<tr>
<td>Fibre diameter (micron)</td>
<td>31.5</td>
<td>20±6.6</td>
<td>16–18</td>
<td>11–14</td>
</tr>
</tbody>
</table>

Sources: Sumar, 1980; Bustinza and Belon 1982; Villarroel, 1963; Franklin, 1982.

Although llamas and alpacas are often herded together in Andean communities, care is taken to prevent cross-breeding. When this does occur, the resultant hybrid or Wari is considered to be an inferior product. Despite the fact that its wool it is not as fine as alpaca wool, and though it may be larger than an alpaca, it is not of sufficient size for use as a pack animal and it produces less meat than a llama. Wari’s are, however, fully fertile and hence tend to be rapidly eliminated from the herds.

The domestic camelids are well adapted to the rigors of life in the high Andes. In addition to physiological adaptations which offset the conditions of chronic hypoxia, their stomach is adapted for greater digestive efficiency than the advanced ruminant stomach (Vallenas et al 1971). Llamas and alpacas are principally raised on marginal lands located at, and above, the upper elevational limits of agricultural production. Their ability to convert the high cellulose pasture plants into a useful source of stored protein extends productivity into areas where crops cannot be grown and provides the most reliable human food resource in the high Andes (Thomas 1973; Novoa and Wheeler 1984).

In addition to meat for immediate consumption, or storage as sun-dried charqui, the herds provide other goods and services.

The llama is utilized primarily as a pack animal. It can transport loads weighing 25–30 kg. over distances of 15–20 km. daily (Flores Ochoa 1977), and is employed in both local and long-distance inter-Andean trade for obtaining goods and commodities which are not produced in the Puna.

The alpaca, on the other hand, is primarily a wool bearer whose fibre is utilized for the production of fine quality cloth. The skins, sinews and bones of both animals provide leather products, thongs and weaving tools. Dung is utilized as a primary source of fuel in the treeless tundra environment of the high Andes. It is also essential as a fertilizer for effective potato production in the poor soils of this zone.
At present, all llamas and 90% of all alpacas in the Andes are under the control of traditional pastoralists. These small herd holders maintain flocks of 30–500 animals on communal grazing lands. The remaining alpacas are kept in large herds which belong to rural cooperatives in Perú. Llamas and alpacas have survived within the framework of traditional, non-European socio-economic organization because they are an essential element of Andean culture. Breeding and herd management procedures are decided by traditional techniques which are not always efficient, but it is in this context that the majority of present day llama and alpaca occurs.

During the last decade llama population remained relatively stable with approximately 3.8 million in the Andean Countries. However transport by truck and rail is replacing the llama and therefore there is trend for llama numbers to decline. In relation to alpacas, 89% of the Andean population is located in Perú and 10% in Bolivia. During the last 25 years the alpaca population in Perú has been decreasing, from 3.3 million in 1967 to 2.8 (1971), 2.5 (1976) and 2.4 (1980). This reduction was partly due to the agrarian reform of the 1970's.

3.1.2 Wild species

The guanaco is the largest of the indigenous wild artiodactyla in Latin America and the ancestor of the domestic llama. Four geographic subspecies have been described. The first, *Lama guanicoe guanicoe* Muller, 1776 is found in Patagonia, Tierra del Fuego and Argentina south of 35 degrees latitude. The second subspecies *L.g.huanacus* Molina, 1782 is said to be restricted to Chile, while the third *L.g.cacsilensis* Lonnberg, 1913 inhabits the high Andes of Perú, Bolivia and north eastern Chile. The fourth, *L.g.voglii* Krumbiegel, 1944 is restricted to the eastern slope of the Andes between approximately 21 and 32 degrees south latitude in Argentina. Today there is a trend to only recognize *L.g. guanicoe* and *L.g. cacsilensis* (Dennler de la Tour, 1954; Torres 1985 a); however other subspecies might exist which are still unknown.

All subspecies exhibit similar dark brown to beige colouration, white under parts and grey to black faces. Comparative biological data on camelids including guanaco are shown in Tables 5 and 6.

### Table 6. Comparative biological data on Latin American camelids

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Llama</th>
<th>Alpaca</th>
<th>Guanaco</th>
<th>Vicuña</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestation Period (d)</td>
<td>348±9</td>
<td>342–345</td>
<td>345–360</td>
<td>346–356</td>
</tr>
<tr>
<td>Birth body wt (kg)</td>
<td>11.9±1.6</td>
<td>7–8</td>
<td>8–15</td>
<td>4–6</td>
</tr>
<tr>
<td>Weaning body wt (kg)</td>
<td>45.4±7.2</td>
<td>25–35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult body wt (kg)</td>
<td>115.7±22.0 (66–151)</td>
<td>58.3±9.0</td>
<td>120.2±12.2</td>
<td>35.3±1.6</td>
</tr>
<tr>
<td>Height to withers (cm)</td>
<td>109–119</td>
<td>110–120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carcass dressing, %</td>
<td>57.0</td>
<td>55.2±9.0</td>
<td>55.0</td>
<td></td>
</tr>
</tbody>
</table>

Sources: Sumar (1980); Bustinza and Belon (1982); Calderón y Fernandez Baca (1972); Franklin (1982).

Guanacos live in both migratory and sedentary groups, (Franklin 1982). They are easily hunted and in fact numbers have been drastically reduced in most of their range due to excessive hunting. Thus, guanacos in Perú were declared endangered by the Peruvian Government in
1971; later this status was changed to vulnerable by the World Conservation Union (IUCN) in 1974.

Today, there are 14 national reserves in Argentina, 4 in Chile and 3 in Perú; however they remain unprotected in Bolivia.

Regarding Vicuñas, two geographic subspecies have been described. The first *Vicugna vicugna vicugna* Molina, 1982, found south of 18 degrees, is larger and lighter in colour than the second, *V. mensalis* Thomas, 1917. This last one has been regarded as the alpaca ancestor (Wheeler 1984 a and b). Both subspecies are characterized by their short, extremely fine cinnamon to light tan coloured fibre growth, white underparts and gracile form, but only *V.v. mensalis* exhibits a tuft of long white hairs of the chest.

In contrast to the declining population of guanaco, numbers of vicuña are increasing. From being a species threatened with extinction in 1969 it passed to vulnerable in 1972. This change has been the result of preservation and population recovery projects carried out by the Andean countries during the last 20 years. Efforts for vicuña conservation started in Perú in 1968 establishing the Pampa Galeras National Reserve. Vicuñas are fully protected in Bolivia, Chile and Argentina.

**3.2 Cameloids**

In addition to the obvious difference, the two-humped variety differ from the one-humped in being woollier, shorter in the leg and darker in colour. It is also adapted to the low winter temperature of Central Asia while the one-humped type is the typical animal of the deserts of north Africa and the middle East.

**3.2.1 Types**

In most areas camels are multi-purpose animals, the females being used primarily as milk producers, the males being used for transport or draft and both sexes provide meat as a tertiary product. The hair is used only by a few groups of owners.

One-humped camels may be divided, according to habitat, into mountain and lowland types (Table 7). The former is small, compact and coarse-boned. The sole of foot is very hard; a long fur may develop in winter. It can be subdivided into pack or riding subtypes. The lowland camel is larger and the foot tends to be softer, it is subdivided into riverine and desert types.

**Table 7. Principal physical characters of lowland and mountain camels**

<table>
<thead>
<tr>
<th>CHARACTER</th>
<th>CAMEL TYPE</th>
<th>LOWLAND</th>
<th>MOUNTAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Size</td>
<td></td>
<td>large</td>
<td>small</td>
</tr>
<tr>
<td>Withers height(m)</td>
<td></td>
<td>1.93 – 2.13</td>
<td>1.82 – 1.95</td>
</tr>
<tr>
<td>Conformation</td>
<td></td>
<td>rangy</td>
<td>compact</td>
</tr>
<tr>
<td>Neck and legs</td>
<td></td>
<td>long</td>
<td>short</td>
</tr>
<tr>
<td>Hindquarters</td>
<td></td>
<td>light, sloping</td>
<td>well developed</td>
</tr>
</tbody>
</table>
Feet oval, soft round, hard
Coat short, fine long, coarse


Alternately the one-humped camel may be divided into baggage and riding types and the former into hill and plains sub-types.

There have been attempts to categorize camels as beef, dairy, dual purpose and racing. However there appears little justification for this classification at present. Racing camels do not constitute separate breeds but are selected from within existing populations after they have shown a particular aptitude for speed. They are not reared primarily as meat producers.

3.2.2 Breeds

There has been little attempt to assign quantitative production parameters to the breed description. Recently, an attempt to using a more quantitative approach has been made. It uses six morphological and biological characteristics of habitat, function and geographical distribution to describe the 48 main breeds of the one-humped camel. The classification assigns camels to nine regions and sub-regions in three main groups and eight (or nine) sub-groups. This classification may be found in Blanc and Ennesser (1989). Physical size based on a series of linear measurements was used in this analysis as the main means of identifying breeds. However, it is doubtful, if the majority of workers interested in breeds would limit their number to 48 main ones or even limit themselves to the classifying variables employed.

In Somalia, a recent typology of three breeds has included ease of milking and rapidity of weight gain as parameters in the breed description (table 8).

Table 8. Characteristics of three Somali camel breeds.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CAMEL BREED</th>
<th>Hoor</th>
<th>Siifdar</th>
<th>Eyddimo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td></td>
<td>small/compact</td>
<td>tall/light</td>
<td>tall/heavy</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>light</td>
<td>medium</td>
<td>heavy</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
<td>ashy/white</td>
<td>grey reddish brown</td>
<td>mostly white</td>
</tr>
</tbody>
</table>

PRODUCTS

MILK

daily yield(kg) 8 6 4
lactation length(months) 8–16 12 6–10
lactation yield(kg) 2050 1500 1000
let down difficult easy easy

WEIGHT CHANGES

gain after dry season  fast  medium  slow
loss in dry season  fast  medium  slow
MATURITY (years)
physiological  3–5  5–6  7–8
physical  5–6  6–7  7–8


Other recent attempts to classify breeds are shown in table 9. In the USSR all one-humped camels are of the Arvana breed (Turkmen=purebred). This is described as a dairy, transport and riding type whose qualities have been achieved through a long period of selection.

Table 9. Some camel breeds of arab Africa.

<table>
<thead>
<tr>
<th>Breed</th>
<th>Type</th>
<th>Area of distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al Jandaweel</td>
<td>Beef</td>
<td>Mauritania</td>
</tr>
<tr>
<td>Al Magribi</td>
<td>Beef</td>
<td>North Africa</td>
</tr>
<tr>
<td>Nabul</td>
<td>Beef</td>
<td>Tunisia</td>
</tr>
<tr>
<td>Al Kasabat</td>
<td>Beef</td>
<td>North-east Libya</td>
</tr>
<tr>
<td>Al Fallahi</td>
<td>Beef</td>
<td>Southern Egypt</td>
</tr>
<tr>
<td>Al Delta</td>
<td>Beef</td>
<td>Nile delta, Egypt</td>
</tr>
<tr>
<td>Al Mowallad</td>
<td>Beef</td>
<td>Egypt</td>
</tr>
<tr>
<td>Al Arabi</td>
<td>Beef</td>
<td>Sudan</td>
</tr>
<tr>
<td>Sifdaar</td>
<td>Beef</td>
<td>Somalia</td>
</tr>
<tr>
<td>Edimo</td>
<td>Beef</td>
<td>Somalia</td>
</tr>
<tr>
<td>Hoor</td>
<td>Dairy</td>
<td>Somalia</td>
</tr>
<tr>
<td>Sirtawi</td>
<td>Dairy</td>
<td>Libya</td>
</tr>
<tr>
<td>Oulad Sidi Al-Sheikh</td>
<td>Dairy</td>
<td>Algeria</td>
</tr>
<tr>
<td>Al Rashidi</td>
<td>Dual purpose</td>
<td>Sudan</td>
</tr>
<tr>
<td>Mehari</td>
<td>Racing</td>
<td>Mauritania-Sudan</td>
</tr>
<tr>
<td>Anafi</td>
<td>Racing</td>
<td>Sudan</td>
</tr>
<tr>
<td>Bishari</td>
<td>Racing</td>
<td>Sudan</td>
</tr>
<tr>
<td>Rukby [=?Reguib]</td>
<td>Racing</td>
<td>Mauritania/Morocco</td>
</tr>
<tr>
<td>Hogar</td>
<td>Racing</td>
<td>Algeria</td>
</tr>
<tr>
<td>Oulad Bou Sayf</td>
<td>Racing</td>
<td>Western Oasis, Libya</td>
</tr>
</tbody>
</table>


3.2.3 Hybrids

The most usual hybrid is the bactrian x dromedary. The F1 products show heterosis in respect of body size, hardiness, endurance and longevity. Some bactrian characters, such as the hairy beard and legs are retained, and the single hump is longer and not as well developed as in the
dromedary. This cross is a strong draft animal, whose wool yield tends towards that of the bactrian. The milk yield and the butterfat content of the hybrid are intermediate between the two parents.

4 Priority breeds for conservation and improvement

Given the situation outlined above, the following breeds of Lamoids have been identified for immediate development with criteria for their choice.

4.1 Huacaya

- Breed represents 90% of the world's Alpaca population.
- It is well adapted to the rigors of life of the high Andes.
- In addition to high quality fibre, they produce other valuable goods for industrial and artisan production.
- They are vital for the Andean economy especially for small farmers since 90% of all Huacayas are under their control.
- The breed is not efficiently utilized, its improvement can greatly benefit the people living in the High Andes. Recent experience, although limited, indicates that they can be reared in areas beyond the Andes and their capacity to utilize marginal pasture lands makes them an important potential resource on a world-wide scale.

4.2 Suri

- About 100% of the world's population of this breed is located in the southern Peruvian Altiplano, which unfortunately has declined drastically over the past 20 years.
- Suri alpaca once represented over 25% of the total alpaca population in Perú but represents only 5% today. In numbers of animals this is a decline from 700,00 down to just 130,000. Unless measures are taken to preserve and protect this germplasm now, suri alpaca could disappear by the year 2000.
- One primary cause relates to producers who unknowingly select against Suri through indiscriminate cross breeding with the Huacaya alpaca.

4.3 Qara

- This breed represents about 70–80% of the world's llama population.
- They have been selectively bred for use as pack animals and meat producers. However transport by truck and rail is replacing the llama and therefore there is a trend for llama numbers to decline.
- At present all llamas are under the control of small farmers. Their grazing habits, mostly on bunch grasses, and their resistance to hydrologic stress make them an important resource for arid zones and mixed grazing with sheep and/or alpacas.

While important progress has been made at research Centers in Perú, Bolivia and Argentina, much remains to be done before the full productive potential of alpacas and llamas can be realized. Of particular value are efforts to improve and standardize the production qualities of both Huacaya and Suri fibre and Qara meat and development of the necessary technology for implementing this knowledge.
To conserve and improve breeds, governmental physical facilities and flocks of llamas have been built in Argentina (Abrapampa) and Bolivia (Patacamaya and Turco) and of alpacas Huacaya in Perú (La Raya). However very little genetic progress have been made; inbreeding and lack of adequately defined breeding objectives are current problems affecting the vast majority of flocks especially those of the small farmers. Knowledge of the relevant genetic parameters is scarce. Conservation and development programmes of these breeds should aim at supporting the existing activities and place emphasis on the analysis of records and its use for selection.

As to the Suri alpaca, support should be given to assure its conservation, to develop and maintain a breeding flock, to conduct inter-disciplinary research and extend information to educate producers in the importance of maintaining the breed.

Regarding camels, it is not appropriate to make suggestions about which breeds should be given support for immediate development. Given the limited information that has been available, some injustices could be done. It is hoped that in the future, through the ongoing and new attempts to describe breeds objectively, breed selection for development programmes will be easier.

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A GLOBAL REVIEW OF THE GENETIC RESOURCES OF POULTRY

R.D. Crawford

1 Introduction

Status of the world's poultry genetic resources differs in several aspects from that of livestock. Indigenous poultry stocks contributing to food supplies in developing countries are only poorly described in the world literature. Chickens are best known as a food source. But there is only a sparse literature about other species such as turkeys, guinea fowl, domestic ducks, muscovy ducks and geese which also make a major contribution to food supplies. Accordingly, it is premature and perhaps impossible to recommend conservation and development of particular indigenous breeds since for the most part breeds have not been identified. Instead recommendations must be based on a broader view stressing particular poultry species and types.

2 Global Situation of Poultry Species and Types

2.1 Poultry species.

Nomenclature for domesticated birds can be confusing. The most serious confusion surrounds the term ‘poultry’. In some countries it is used as a general term to include all domesticated avian species. In other countries it refers only to chickens. And in some countries it refers to all except waterfowl species. In this report the term ‘poultry’ will be used in the general sense to include all domesticated avian species.

There are six poultry species that are a significant food resource in developing countries:

2.1.1 Chickens

Chickens are ubiquitous. They surpass all other domestic animal species as a source of protein in the human diet. There are three general types of food-producing chickens:

a. industrial stocks: bred by multinational corporations for mass production of eggs and meat. The production birds are terminal crosses. They monopolize urban cash economy markets in all developed countries, and increasingly in developing countries.

b. middle-level stocks: usually dual purpose (eggs and meat) stocks that have reasonably good production performance under reasonably good management conditions. They have disappeared from most developed countries.

c. indigenous stocks: the local unimproved poultry of developing countries. Production performance is usually poor, but they are widely held to have evolved adaptation to local environments. Their importance is in subsistence farming and village food production outside of a cash economy.

2.1.2 Turkeys
Turkeys as an indigenous form are ubiquitous in Latin America, but they are generally absent elsewhere. Industrial turkeys monopolize meat production in developed countries. Middle-level turkeys have been replaced by industrial stocks and only a few remain anywhere.

2.1.3 Guinea Fowl

Guinea fowl have major importance as a food source throughout developing countries of Africa; some of the birds are domestic, some are feral, and some are wild. They have only very minor importance elsewhere, although they are gaining favor in Europe as a specialty food product.

2.1.4 Domestic Ducks

Domestic ducks (Anas platyrhynchos) have immense importance as a food source in Asia, especially in the southeast. Eggs have more importance than meat. Some of the stocks are indigenous in type. Others are middle-level and are used locally by specialist producers. The species has only minor importance in Africa, Latin America, and the Near East. Industrial meat stocks are used in developed countries, but there are no major industrial egg production stocks.

2.1.5 Muscovy Ducks

Muscovy ducks (Cairina moschata) are the least known and understood of all poultry species. They can produce a sterile hybrid, the mulard, with domestic ducks. Muscovies were domesticated in Latin America where they remain ubiquitous. They are also prevalent in Africa and Asia. They are important in subsistence farming and village economies. Industrialization has begun in Europe.

2.1.6 Geese

Geese are a domestic bird of temperate climates. Except for China and southeast Asia, they are not characteristic of developing countries. Goose production there and in developed countries rests on indigenous and middle-level stocks. Industrial production has not yet begun.

3 World inventory of poultry genetic resources.

a. Knowledge about existing poultry genetic resources of the world is only fragmentary. It lags far behind that for livestock species, especially cattle and sheep. Breeders of industrial poultry will not reveal specific information about their foundation and grandparent lines, although broad generalities about their procedures are general knowledge. Middle-level poultry stocks of developed countries have been recorded to a variable extent, especially in Europe and North America, but those of developing countries have not. The biggest lack is that of information on indigenous poultry stocks of developing countries. There is essentially no information at all in the English literature about poultry genetic resources of Latin America, and very little concerning stocks of the Near East. Information from Africa and Asia has been increased through recent projects sponsored by FAO and others, particularly concerning indigenous chickens of India and domestic ducks of southeast Asia.

b. The European Association of Animal Production (EAAP)/FAO Global Animal Genetic Data Bank thus far has not included information on poultry resources. Descriptors suitable for encoding data on poultry have now been prepared for the major poultry species. Data recording should begin soon, if it has not already done so.
c. FAO should be reminded that in 1989 the World's Poultry Science Association (WPSA) presented a resolution to the FAO Expert Consultation on Animal Genetic Resources; the resolution was accepted by the consultation and was included in its proceedings (FAO, 1990). The resolution asked that FAO continue and increase its work in conservation and management of poultry genetic resources globally. WPSA offered to help FAO in any way possible in conducting this work. WPSA represents a powerful resource of professional people from nearly all countries. Total membership exceeds 5000. It is waiting for an initiative from FAO. For instance, it could provide priceless assistance in preparing a world inventory of poultry genetic resources, whereby FAO might provide leadership and coordination, and WPSA could provide field staff and information.

4 Distribution, utilization, vulnerability of poultry species.

4.1 Chickens

Chickens are ubiquitous. Globally they contribute more animal protein (eggs and meat) to the human diet than do any other domestic animal species. Indigenous chicken stocks are an important feature of village and subsistence farmers in virtually all developing countries. Their food production performance is usually poor, partly because of inadequate nutrition and management, disease exposure, and lack of selection for production traits. However it is widely presumed (without much solid evidence) that the indigenous stocks are genetically adapted for survival and reproduction in the local environment, and hence they are to be preferred. There is also increasing anecdotal information that eggs and meat from indigenous chickens are much preferred by consumers to those from industrial stocks.

Replacement and substitution of indigenous chicken stocks by both middle-level and industrial stocks from developed countries has been in progress for many years. At the village and subsistence farm level substitution has been mostly by middle-level dual-purpose stocks. The general result has been an increase in egg and meat production, but concurrently also a greatly increased mortality and morbidity due to disease and management shortcomings. It is a reasonable guess that in countries with a long history of improvement programmes, local indigenous stocks will have had considerable genetic influence from middle-level stocks. Where a commercial industry has developed near urban centres, the stocks in use are industrial from multinational corporations. It is unlikely that these are being used to replace indigenous stocks in rural areas, but they replace indigenous birds totally where there is a cash economy poultry industry near urban centres.

There is need for conservation action to ensure continuance and improvement of indigenous stocks in rural areas. Success in improving production performance through genetic selection has been demonstrated many times already, in Egypt, India, Iran, and Malaysia.

4.2 Turkeys

Turkeys have restricted distribution. They are ubiquitous in Latin America, where they were domesticated. But they are generally absent from other developing areas of the world. They play an important role in food production at village and subsistence farm level throughout Latin America. Curiously, their role is that of providing cash income rather than that of providing food for their owners. Production performance is generally poor because of inadequate nutrition and
management, and because they probably have had little selection for production performance. Mortality and morbidity are high.

It should be clearly recognized that the Latin American indigenous turkeys are very different in genetic origin from the turkeys utilized in developed countries (and in the commercial turkey industry within Latin America). Turkeys were domesticated in Mexico from *Meleagris gallopavo gallopavo*. They spread throughout Central and South America and have persisted as indigenous turkeys. Their plumage is mostly black. Meanwhile, those taken to Europe and subsequently to eastern North America hybridized with another wild subspecies, *Meleagris gallopavo silvestris*, to produce the bronze turkey, forerunner of all commercial turkeys in developed countries. Two types of commercial birds persist from the bronze hybrids. Industrial turkeys, all of them white, are bred by only a few multinational corporations; the birds have astounding meat production performance, but they have been bred beyond the limits of normal reproductive fitness; they can no longer mate naturally and must be bred by artificial insemination. A very few stocks of middle-level turkeys persist, some of them bronze and some of other colors. These have moderately good meat production performance while retaining natural mating ability.

There is no danger of industrial stocks replacing indigenous turkeys in rural areas, especially because the former reproduce only by A.I. But industrial production has probably already made major inroads into meat production near urban areas. Middle-level turkeys are being sold into Latin America, especially from Europe, and because of superior meat production they may be a threat to persistence of the indigenous birds.

4.3 Guinea Fowl

Guinea fowl are kept throughout the world, but only in developing countries of Africa do they have major importance as a food source. Both eggs and meat are utilized, and in some areas these products are preferred to those from chickens.

A problem peculiar to considerations of guinea fowl is that domestication status is only poorly understood. Some of the birds are domestic, but eggs and meat are also harvested from feral and wild populations. The relative proportions of each are not known. Literature on the species is scanty. Their production performance has been most studied in Nigeria.

Because guinea fowl are so little used throughout the world, there is no immediate threat of substituting indigenous stocks with improved stocks from elsewhere. However industrialization is underway in Europe, particularly in France, and it is beginning in other countries too. The needs presently are to define whether exploited stocks are domestic, feral, or wild; to identify and evaluate domestic stocks from various geographic areas, with a view to greater distribution and utilization of superior ones; and to attempt genetic improvement of stocks.

4.4 Domestic Duck

Domestic duck, *Anas platyrhynchos*, has immense importance as a food source in village economies of Asia, especially in southeast Asia. The species has only minor importance in Africa, Latin America, and the Near East. In some Asian countries only duck eggs are utilized; in other areas there is also strong demand for duck meat.
Domestic duck populations of Asia have been intensively studied in some countries but not in others. There appear to be two levels of production: small scale production by villagers and subsistence farmers using unimproved indigenous stocks; and large scale production of eggs and meat by specialists using the equivalent of western middle-level stocks that have undergone some genetic improvement through natural and artificial selection, and that receive careful and expert management.

Industrial production of ducks in developed countries is dominated by one major breeding company, and there are several smaller companies. Their main product is meat from the Pekin breed; they have lesser concern over egg producing stocks. The industrial stocks have entered developing countries and are claimed to be performing well. It remains to be seen whether they will persist and whether they will displace indigenous and local middle-level stocks. There is need for further inventory and assessment of indigenous and local middle-level stocks, and for selection improvement programmes.

4.5 Muscovy Duck

Muscovy duck, *Cairina moschata*, is the least known and understood of all poultry species. It was domesticated in Latin America where it remains ubiquitous. It is also found in all equatorial countries of Africa and Asia, and it is particularly prevalent in southeast Asia.

In Latin America and Africa, muscovy ducks are an important poultry species in subsistence farming and village economies. They are used for both egg and meat production, and fulfill a minor role in household insect control. They are successful in part because of their aggressive behavior and superior naturally reproducing abilities.

In Asia the species is also used in subsistence farming and village economies. But more importantly it is used for commercial production by specialists for quantity production of meat, either as a pure species, or as a hybrid with domestic ducks. Production of the sterile hybrid, or mulard, is particularly important in Taiwan and some other local areas.

Muscovy ducks have only recently been exploited in developed countries, particularly in France, where genetic selection has been successful in improving growth rate and meat production. Improved stocks will undoubtedly soon enter developing countries, especially in southeast Asia's specialized duck industry. Meanwhile there is need for inventory which exists nowhere, for assessment of local stocks, and for selection projects to increase food yield.

4.6 Geese

Geese are a domestic bird of temperate climates. Except for China and southeast Asia, they are not a characteristic species of developing countries. Domestic geese used in Asia resemble the Chinese and African breeds of western countries; they were domesticated from the swan goose, *Anser cygnoides* of eastern Asia. Western breeds were domesticated from the wild greylag, *Anser anser*; they do not perform well in hot climates.

The domestic geese of China and southeast Asia can be classed as indigenous. But some stocks have presumably undergone both natural and artificial selection for enhanced reproductive and growth performance; these stocks are held by local commercial producers, and could be regarded as middle-level. It should be noted that even in developed countries,
breeding and production of geese have not been industrialized, although genetic base is becoming monotypic using mostly the Emden breed.

Thus far there is no indication that geese of China and southeast Asia are being replaced by stocks from elsewhere, probably because industrial exploitation has not yet begun. However there is need for inventory and assessment, and for selection projects to enhance production performance.

5 Summary of Situation by Geographic Area

5.1 Africa.

The principal poultry species contributing to food supplies in developing countries of Africa are chickens and guinea fowl. Chickens have received considerable assessment and development attention. Guinea fowl have received almost none.

Guinea fowl are a major source of eggs and a lesser source of meat throughout developing Africa, and especially in west Africa. There is a distinct consumer preference for guinea fowl products over those from chickens. Relative consumption of products from the two species is not known. Unfortunately, knowledge concerning the birds is very scanty. It is known that some of the stocks are domestic, some are feral, and there is harvesting of products from wild populations, but proportions of each are unknown. There is no inventory of any sort. Except for some published research from Nigeria on production performance, nutrition, and management, there is almost no research information in the English literature. There is little danger of replacement by improved stocks from elsewhere since industrialization of guinea fowl has only just begun in Europe. However because of the importance of guinea fowl as a food source, efforts should be directed toward increasing knowledge about them - inventory and assessment, including storing of information in the EAAP/FAO Global Animal Genetic Data Bank, and toward improvement of existing stocks to enhance their use.

Chickens are ubiquitous and a major contributor to food supplies in subsistence farming and village economies. Indigenous stocks are poorly known, but there is scattered literature from some countries which includes FAO-sponsored studies. Improvement programmes in Egypt and Nigeria have demonstrated progress from genetic selection. There is anecdotal information to indicate that products from indigenous chickens are much preferred to those from improved commercial chickens. Industrial stocks have replaced indigenous near urban centres to monopolize the cash economy sector, but they are unlikely to have much influence in rural areas. In contrast, middle-level stocks have had a long history of introduction to developing countries; they probably have had some influence on indigenous populations.

5.2 Asia

The principal poultry species contributing to food supplies in Asia are chickens, domestic ducks, and muscovy ducks; geese have minor importance in China and in southeast Asia. Chickens and domestic ducks have received a lot of development attention but muscovy ducks have been generally overlooked.

Chickens have immense importance as a food source. Indigenous chicken populations have had prolonged study, especially in India and in Malaysia. They have been better characterized than stocks in other continents. Their situation is similar to that of indigenous chickens
elsewhere: industrial stocks have replaced all other types in commercial production units near urban centres, and products of industrial stocks prevail in cash economy markets; middle-level stocks continue to be used in upgrading schemes in rural areas, and they have undoubtedly altered some indigenous stocks permanently; other indigenous populations remain undisturbed. Continuing inventory, assessment, and improvement programmes for indigenous stocks should be encouraged.

Domestic ducks are the major poultry species in some areas of Asia, particularly in the southeast. Eggs are the principal food product, with meat having much less importance. Indigenous stocks have had intensive study as a result of projects and activities of FAO, SABRAO, national governments, and other agencies. Industrial stock from the world’s only major primary breeder of meat ducks has entered developing countries; there are no major industrial breeders of egg stocks. Asia has had its own middle-level stocks for centuries, kept by specialists for egg production primarily; anecdotal information implies that their production performance is excellent; it was these stocks that founded the egg production duck stocks of the western world. There is need for continuing inventory and assessment, including storage of information in the EAAP/FAO Global Animal Genetic Data Bank. There is value in considering more extensive use of the best Asian middle-level stocks, and in improving the local indigenous stocks in subsistence and village economies.

Muscovy ducks are widely used in Asia both at the subsistence farming/village level and in the local poultry industry. The birds are kept as a pure species in villages, and are produced as purebreds and as hybrids by industry specialists. The preferred hybrid is from a muscovy male mated to a domestic duck female by hand-mating or artificial insemination; fertility and hatchability are low but demand and price are such that hybrids are generated in large numbers. Census data seldom distinguish between muscovy and domestic species; neither do descriptive writings. Accordingly there is no information on muscovy duck numbers, populations, performance, etc. This void should be corrected.

5.3 Latin America

There are three major food-producing species in Latin America - chickens, turkeys, and muscovy ducks. There is a huge and rapidly growing commercial poultry industry in Latin America using industrial stocks and the infrastructure of developed countries; this industry provides for the food needs of urban centres. Although poorly documented, there have undoubtedly been repeated importations of middle-level stocks from elsewhere which have diluted (and sometimes replaced) the indigenous poultry of rural areas and which will have contributed to commercial production in urban areas. Unfortunately, almost nothing is recorded in the English literature about indigenous birds of these three species - no inventories or descriptive data, no assessments, and no reports of selection projects. Almost all of the available genetic resources literature from Latin America pertains to cattle and sheep.

Indigenous turkeys are an unusual case. They are ubiquitous in Latin America in subsistence farming and village economies, but they are not primarily a food source for the owners; instead they provide a source of cash income from urban users. They are genetically unique and different from all other domestic turkeys. The indigenous birds are presumed to derive exclusively from the original domestication of *Meleagris gallopavo gallopavo* that occurred in Mexico. All other domestic turkeys are presumed to derive from hybridization of *M.g. gallopavo* with *M.g.silvestris* that occurred in eastern North America in the 18th and 19th centuries. The Latin American indigenous turkeys have had virtually no study. Their attributes, status, and
performance relative to the *gallopavo-silvestris* hybrids are unknown. This void of information should be filled.

Muscovy ducks were domesticated in northern South America prior to the Spanish conquest. They have spread throughout Latin America as an indigenous poultry stock in subsistence farming and village economies. They provide a source of meat, and perhaps of eggs; they have had a historic role in household insect control. Hybrids with domestic ducks seem not to be important as a product. Muscovy ducks have not been commercialized in Latin America thus far, although that could happen soon using stocks and infrastructure developed in Europe. There has been almost no study of the species in its centre of origin. There is need for inventory, assessment, and improvement projects.

Chickens are ubiquitous in Latin America, as they are elsewhere. They have been there for centuries; there is ongoing academic debate on whether they were there before the Spanish conquest, and if so, where they came from. Indigenous stocks have been replaced by middle-level and industrial birds near urban areas. Middle-level stocks have undoubtedly diluted the indigenous stocks in rural areas. Meanwhile the indigenous stocks have had almost no study. This void should be corrected before there is further erosion.

5.4 Near East

As for Latin America, there seems to be very little published information on the poultry genetic resources of the Near East. It is presumed that the predominant poultry species is the chicken, with domestic ducks playing a much less important role. The status of chickens is probably the same as that in other developing areas - industrial stocks monopolizing urban food supplies, and middle-level stocks diluting indigenous stocks in rural areas. Indigenous stocks themselves are only poorly known. There are published studies from Iran, but recent political events may have altered the situation dramatically. Little information is available from other countries of the area. It is presumed that domestic ducks have secondary importance in appropriate areas of the Near East, but information is lacking. Because of the absence of information, little can be recommended except to stress the need for inventory and assessment surveys.

6 Priorities for FAO Work in Poultry Conservation and Management

6.1 Inventory and assessment of poultry genetic resources.

Because of the paucity of basic information on indigenous poultry genetic resources in all continents of the developing world, it is imperative that first priority be given to a world inventory and assessment, and assembling of that information in a data bank. Capability for data bank entry and storage is now available through the EAAP/FAO Global Animal Genetic Data Bank. The World’s Poultry Science Association has offered to collaborate with FAO in any way possible; a logical collaboration would be that of assembling the needed body of data.

6.2 Specific stocks targeted for conservation and improvement.

Again because of paucity of basic information, it is not appropriate or even possible to identify specific breeds for attention. Instead it is urged that species and broad types, which have thus far been ignored, be targeted for study and development by FAO. The following prioritized list is suggested:
6.2.1 Indigenous turkeys of Latin America

Inventory and assessment of local and regional resources throughout the area; conservation and selection of superior stocks for future use.

6.2.2 Guinea Fowl of Africa

Inventory and assessment of indigenous stocks to identify and distinguish them from feral and wild food sources; conservation and selection of the most likely stocks for future utilization.

6.2.3 Muscovy ducks of Latin America and Asia

Inventory and assessment of indigenous stocks, and of middle-level stocks used for purebred and hybrid (mulard) production in Asia; conservation and improvement of superior stocks for future utilization.

6.2.4 Domestic ducks of Asia

Continued assembling of information; conservation and improvement of superior stocks, both indigenous and middle-level, for future use.

6.2.5 Chickens

Inventory and assessment of indigenous stocks in Africa, Asia, and Latin America; conservation and improvement of superior stocks for future utilization.

7 References


1 Introduction

The horse contributes to human culture not only with meat and milk production, but also, and perhaps primarily, by its draught power in agriculture, transport and with other activities such as racing and leisure sports. The horse is closer to man than the other domestic animals because it has been a participant in the history of mankind throughout war and peace. It would not be right to limit this recognition only to the horse species and to forget the wild ancestors, the wild and feral relatives and the smaller “brothers and sisters”, the donkeys. In fact the latter with their hybrids, mules and hinnies, are in some places and circumstances even more important in everyday human life than the horse. (see table 4).

2 Horse and donkey population of the world

Table 1 gives a general survey of the zoological taxa of Equidae. These species of Equidae can all interbreed and produce viable foals which are rarely fertile. The exceptions are the wild ass and domestic donkey, horses and Przewalski horse give fertile progeny despite the different chromosome numbers (Table 2).

<table>
<thead>
<tr>
<th>Equidae</th>
<th>(after Walker, 1983 and Clutton-Brock 1987)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equus caballus</td>
<td>(horse)</td>
</tr>
<tr>
<td>Przewalski</td>
<td>(survived only in zoos)</td>
</tr>
<tr>
<td>Gmellini</td>
<td>(tarpan, extinct in Poland)</td>
</tr>
<tr>
<td>E. hemionus</td>
<td>khur (kulan, onager, from Syria to Manchuria in Pakistan and India)</td>
</tr>
<tr>
<td></td>
<td>hemihippus (extinct in Syria)</td>
</tr>
<tr>
<td>E. kiang</td>
<td>(in Tibet)</td>
</tr>
<tr>
<td>E. asinus</td>
<td>africanus (Nubian wild ass, extinct)</td>
</tr>
<tr>
<td></td>
<td>somaliensis (Somali wild ass)</td>
</tr>
<tr>
<td>E. grevyi</td>
<td>(zebra in Ethiopia. Somalia, Kenya)</td>
</tr>
<tr>
<td>E. zebra</td>
<td>(Angola, Namibia, S.Africa)</td>
</tr>
<tr>
<td>E. quagga</td>
<td>(extinct in S.W.Africa)</td>
</tr>
<tr>
<td>E. burchelli</td>
<td>(extinct in S.W.Africa).</td>
</tr>
</tbody>
</table>

All the wild species of Equidae are in danger of extinction or already extinct; therefore they are listed in the IUCN Red Data Books. Their survival is also in the interest of the breeders of domestic horse. The wild horse should be distinguished from the feral (de-domesticated) horses. These feral stocks are in competition with domestic herds and also with wild fauna and in this way they can sometimes cause problems. However, from a scientific and preservationist point of view they have great value. Feral populations in different parts of the world are shown in Table 3.

1 Department of Animal Breeding, University of Veterinary Science, Budapest, Hungary
Table 2. Chromosome number of Equidae species (Clutton-Brock 1987)

<table>
<thead>
<tr>
<th>Species</th>
<th>Chromosome Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. caballus</td>
<td>64</td>
</tr>
<tr>
<td>E. Przewalski</td>
<td>66</td>
</tr>
<tr>
<td>E. hemionus</td>
<td>56</td>
</tr>
<tr>
<td>E. asinus</td>
<td>62</td>
</tr>
<tr>
<td>E. a. africanus</td>
<td>62</td>
</tr>
<tr>
<td>E. zebrae</td>
<td>32–46</td>
</tr>
</tbody>
</table>

Table 3. Feral populations of Equidae (after Rudge, 1986)

<table>
<thead>
<tr>
<th>Region</th>
<th>Horse</th>
<th>Donkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceania</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>America</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Asia</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Europe</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>2</td>
</tr>
</tbody>
</table>

The stocks of domestic horses, donkeys and their hybrids are summarized in table 4.

Table 4. Horse stocks of the world (1000 heads) (FAO, 1991)

<table>
<thead>
<tr>
<th>Region</th>
<th>Horses</th>
<th>Mules</th>
<th>Asses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>1979</td>
<td>1990</td>
<td>1979</td>
</tr>
<tr>
<td>N.C. America</td>
<td>13979</td>
<td>14129</td>
<td>3592</td>
</tr>
<tr>
<td>S.America</td>
<td>12814</td>
<td>14329</td>
<td>2891</td>
</tr>
<tr>
<td>Asia</td>
<td>17521</td>
<td>16859</td>
<td>4780</td>
</tr>
<tr>
<td>Europe</td>
<td>5394</td>
<td>4198</td>
<td>585</td>
</tr>
<tr>
<td>Oceania</td>
<td>632</td>
<td>498</td>
<td>5</td>
</tr>
<tr>
<td>USSR</td>
<td>5623</td>
<td>5920</td>
<td>2</td>
</tr>
<tr>
<td>Developed</td>
<td>17243</td>
<td>16417</td>
<td>632</td>
</tr>
<tr>
<td>Developing</td>
<td>42448</td>
<td>44503</td>
<td>12716</td>
</tr>
<tr>
<td>Total</td>
<td>59691</td>
<td>60910</td>
<td>13348</td>
</tr>
</tbody>
</table>

The overall increases in stock show the important role of horses in the world economy. The greater part of these animals is in the developing countries despite the fact that scientific work and literature, with few exceptions, are focused upon the improvement of horses for performance and leisure (Fielding and Pearson 1991).
Table 5. Countries with more than one million horses (FAO, 1991)

<table>
<thead>
<tr>
<th>Country</th>
<th>Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>10294</td>
</tr>
<tr>
<td>Mexico</td>
<td>6170</td>
</tr>
<tr>
<td>Brazil</td>
<td>6100</td>
</tr>
<tr>
<td>USSR</td>
<td>5920</td>
</tr>
<tr>
<td>USA</td>
<td>5215</td>
</tr>
<tr>
<td>Argentine</td>
<td>3000</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>2650</td>
</tr>
<tr>
<td>Mongolia</td>
<td>2200</td>
</tr>
<tr>
<td>Colombia</td>
<td>1975</td>
</tr>
</tbody>
</table>

3 The homogenization for horse stocks

A constant danger for the maintenance of genetic diversity in horse species is the homogenization of horses. History shows that horse breeders have always been aware of the importance of genetic improvement to meet current requirements. Therefore horse breeds have changed under the impact of commercial fashion and demands of the era (Bodó 1990). Today this tendency should not be under estimated. In the evolution of warm blood (light) horses the impact of two basic breeds can be observed. These are the Mongolian horse (affecting horses from East Asia to India and to Europe) and the Arabian horse (affecting horse breeds all over the world, including the heavy draught horse and pony breeds). Nowadays the English Thoroughbred is the common factor found in most competition horses (Cook, 1991). This means that all horses for hunting, competition, show jumping and dressage are being improved by the English Thoroughbred breed. The genes of this breed are now used everywhere because demand for animal power has largely been replaced by machines and the demands for leisure horses is best served by the well selected Thoroughbred. This tendency has a detrimental effect on the local breeds like Cleveland Bay, Irish Draught horse and also the Dales and Fell ponies (Allen and Emmerson, 1990).

Crossbred, warm-blood breeds now dominate the sports events especially grand prix, jumping and competitive driving. The creation of these breeds has caused confusion over the concept of the breed (Bixby, 1991). There are some breeds which have been changed during recent decades from an agricultural draught horse to an excellent sport horse breed without changing the name of the breed, for example the Hannoverian and the Holstein. Without any doubt it can be considered an enormous genetic improvement, but not a contribution to conservation since the old types of these breeds are not preserved (Bodó, 1985 and Bodó, 1987). Therefore the older horse breeds should be considered valuable genetic resources with sufficient merit to justify preservation either because they are not too greatly infiltrated with genes of the widely used international breeds or because they have some special and exclusive traits. The most useful characters are found in commercial breeds and generally the comparative characterization of all the horse breeds of the world is not yet established.

In general horse populations, breeds and famous studs are not large compared to the other domestic animal species. The advantage of small populations is the detailed knowledge of individuals and the possibility of a complex matrix control on breeding which means that increases of inbreeding rate are sometimes lower than expected (Pirchner, 1984). Even in the
former USSR, animals with no foreign ancestors in the second and third generations are regarded as belonging to the breed, but only those without foreign genes up to the fifth generation are considered as purebreds (Dmitriev and Ernst, 1989). In China exotic breeds are used in addition to the Mongolian horses (such as the Kazah, Orlov and Arabian) (Cheng, 1984). The show rings in developed countries with their uniform fashion are also causes of the loss of genetic material and this is also a reason for maintaining breeds which are not currently popular, so as to cater for changing demand in the future.

Sometimes breeds without commercial attractions need financial support (Allen and Emmerson 1990). The survival of breeds which are well adapted to the harsh environment of their natural habitat is desirable. However hobby breeders sometimes take horses to another environment and then phenotypic changes due to different environments and genetic change caused by other selection pressures may occur. An example is the Caspian pony which has been investigated by Alderson (1990). On the other hand valuable genetic material can be preserved if strong breeders associations, for example in North America (Crawford, 1990, Bixby 1991) are aware of the concept of conservation. According to Crawford (1990), in North America only one horse breed from the seven rare horse breeds is of local origin; and of the six feral populations five are of local origin. The others are imported breeds.

The widespread use of Thoroughbred stallions causes an increase of inbreeding rate. The average degree of inbreeding of Thoroughbred horses based on 20 generations was 12.9 percent (Mahon and Cunningham 1982). The problem of hereditary disease like OCD (osteocondrosis dissecans) or RLN (recurrent laryngeal nervopathy) is increasing even in middle weight horses. Inbreeding increments of about 0.5% per generation appear tolerable when the minimum number of stallions is 2–3 dozen per generation and the import of related breeds can keep down the inbreeding rate. The problem can be solved also by several semi-isolated groups with somewhat different breeding goals (Pirchner 1983). The breeding method known as the nucleus system, which is now being applied to other domestic species, was invented by horse breeders long ago when they used small nuclei (national studs) for the permanent improvement of breeds like the Lipizzan and others in the Danubian countries Bodó (1985). Inbreeding depression was not observed with 0.61–0.75 percent increase in inbreeding rate per generation; in fact when the increased inbreeding was based upon superior animals the performance of the inbred animals was better (Petzold 1983). However Müller and Schleger (1983) found a significant relationship between heterozygosity and fitness (fertility, longevity and performance) using blood group markers in Lipizzan and Trotter horses.

The phenomenon of homogenization can also be observed in pony breeds. Suitability for children's riding and the performance of ponies is increased by using small sized Arabian and English Thoroughbred horses. There is no doubt that everybody is going to improve the applicability and marketability of the small sized horses. The use of modern, high performance sires is counterbalanced only by conservative breeders being in favour of pure breeding. Heavy draught horse breeds lost ground after the Second World War due to the mechanization of farm work and transport. In the case of several famous breeds there is a serious danger of extinction. The role of heavy draught horses changed in those countries, where the human population consumes horse meat (Belgium, France and Italy). In some cases, due to the energy crisis, the newly used draught horses can be seen in use for short distance transport.

4 Main types of horses and donkeys by regions

Within the domesticated horse species three main breed groups are usually distinguished:
• (warm-blood) horses
• (cold-blood) heavy draught horses
• pony breeds (small horses).

The distinction is not always exact as shown by the standard deviation within breeds and because of transition breeds which cannot be listed specifically in one group. For example, the Friesian horse in The Netherlands can be considered both a cold blood and a warm blood type. Therefore it seems more reasonable to summarize the different horse types of the world briefly by regions rather than by breed groups.

4.1 Asia

Moving across Asia from the north-east to the south-west, a transition from Mongolian horses to the Arabian can be observed. Some examples follow. In China, of the 66 registered horse breeds, 29 are local breeds the populations sizes of which are:

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Size</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>10,000</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>50,000</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>100,000</td>
<td>plus</td>
</tr>
</tbody>
</table>

(Changjiang 1991).

Despite the relatively large population sizes the danger of genetic loss exists because of crossing and the introduction of exotic breeds as was already reported in 1974 (Epstein, 1974).

In the Asian states of the former Soviet Union there are many different horse breeds. Some of them can be considered as pure and ancient, for example the Ahal Teke; others derive from these indigenous breeds or from the show Arabian horses or other introduced influences (Dmitriev and Ernst, 1989). In Asia there are many local variants within the Mongolian and Arabian type groups providing populations or sub populations of value. In China, near the Vietnamese border, a new breed called the Debao pony has been discovered (Allen and Emmerson, 1990). In addition to the local breeds, the international breeds like the English Thoroughbreds or Standardbred horses can be found, as in all other continents.

4.2 Africa

Adebambo (1991) listed 22 horse breeds and 27 pony breeds of Africa. The north coastal area is characterized by the Arabian horse type. The western variation of it is called the Barb and it is distinguished also by blood polymorphisms (Ouragh et al., 1991). Most African breeds derived from this Barb type and from Dongola varieties adapted to the north-east and central African environments. The Dongola practically disappeared in its homeland and residual populations can be found only in Sudan and in the western lowland of Eritrea. The Baronali horse (a Barb type) is extinct. The Basuto pony of Lesoto is threatened by crossing and upgrading with other breeds. These populations are good sources of meat and for carrying loads and drawing farm implements. However, despite this value, they are ignored in the search for solutions to transport problems in rural communities (Doutressoule, 1952, Mason and Maule 1960, Adebambo, 1991).
### 4.3 South America

This continent is characterized by the Criollo horse which has Spanish origin. There are many variations within this type. The Peruvian Paso is a famous breed and the polo-pony of Argentine is the result of crossing with the English Thoroughbred. There are also some small local populations which are well adapted to harsh environmental conditions such as the Pantaneiro (in flooded areas of the river Paraguay). The feral horses of Lavradeiro can also be mentioned (Roraima).

### 4.4 North America

In this continent nearly all the horse breeds can be found in the hands of hobby breeders and sometimes breeders' associations. Two great international performance breeds have their origin here: the Standard Bred Trotter and the Quarter Horse. Many show horse populations are born in North America for example, those described by coat color (Palomino, Cremello, Painted etc.), or by gait (Tennessee Walking Horse). The feral populations of mustangs should be also mentioned. These are a mixture of different breeds and crosses of which the most valuable is the pure progeny of the colonial Spanish horse which does not include the genes of international breeds (Sponenberg, 1991).

### 4.5 Europe

Tendencies which are seen throughout the world are observable in Europe. These include the homogenization of riding horses and ponies and the decline or disappearance of heavy draught horse breeds. These trends are indicated by some examples. In The Netherlands the population sizes of the breeds now threatened by extinction is the following:

<table>
<thead>
<tr>
<th>Breed</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dutch Draught Horse</td>
<td>40</td>
<td>1200</td>
</tr>
<tr>
<td>Friesian</td>
<td>20</td>
<td>700</td>
</tr>
<tr>
<td>Gelderland</td>
<td>7</td>
<td>250</td>
</tr>
<tr>
<td>Groningen</td>
<td>3</td>
<td>30</td>
</tr>
</tbody>
</table>

The Dutch Draught horse is already improved by the use of Belgians horses and Oldenburg stallions are used to avoid the extinction of the Groningen breed (Buis, 1984). In Hungary 6 blood horse populations and one draught horse population are considered as traditional and endangered (Bodó and Pataki, 1984). The Lipizzan nuclei are kept also in neighbouring countries and crossed only after 8 – 10 generations. The Jutland breed in Denmark has an average inbreeding coefficient of 14.7 and the rate of increase is 0.9 per generation. The Suffolk breed from Great Britain is used to avoid further increase in the rate of inbreeding (Johansen, 1984). The small Bosnian ponies are improved by Arabian horses in the Balkan peninsula (Habe and Telelbasic, 1988). In Germany there are many endangered horse breeds in a critical situation such as the Oldenburger, Ostfries, Rottaler, Schwarzwalder Fuchs and the Rhein-Westfalia Cold Blood; activities for their conservation started only in recent years (Bogner 1988, Kretschmar and Schwark 1988). In Scandinavia draught horses have become endangered because of the decreased demand for working horses such as the Norwegian Dole. The Icelandic horse is really a living gene museum because of its 1000 years of isolation and today it is more and more popular also in other countries. In Nordic countries the responsibility for each endangered horse breed is given to the countries concerned (Maijala et al., 1991).
4.6 Australia

In this continent the Waler halfbred was famous in the war. The common improved horse is called Australian stock horse. There is also a feral population which has the name Brumby.

4.7 Donkey breeds

Within the donkey breeds there are not such a good series of well improved breeds as in horses. Big sized and small sized donkeys can be distinguished. The small donkeys are widely spread all over the world and the donkey populations are scarcely distinguished as breeds, even in the so-called developed countries. In China 18 donkey breeds are registered of which one is really endangered while the population sizes of the others are larger than 10,000 heads (Changjiang, 1991). In the former USSR asses are small with height at wither of 90–110 cm. An exception is the Mary (Merv) breed having 142 cm. This breed is similar to the Iranian Hamadan. They carry in general 40–60 kg of pack weight and even up to 100 kgs, (Dmitriev and Ernst, 1989). In Europe among the many thousands of small animals there were three big ass populations in Sicily, in the Iberian peninsula and in France. The famous French large sized Poitou ass (145 cm) is in critical status and in 1977 only 44 animals existed. To save this valuable population some she asses were imported from Portugal (Audiot and Langlois, 1984).

5 Criteria for choice of breeds or populations of horses for improvement and preservation

The most important issues affecting the choice for conservation or preservation of horse populations are first, adaptability to a harsh environment and second the valuable and sometimes rare or even unique traits which distinguish a breed from others. Examples of the well adapted breeds are the Huzul or the other small mountain breeds which proved their value compared with other breeds during the World War, or the Pantaneiro breed which is well adapted to the flooded area of the river Paraguay. Work or draught power is doubtless the most important trait of horses and donkeys. In agriculture generally there is competition with other species primarily with cattle. Mules and donkeys are used all over the world as pack animals. In some places their replacement by machines is impossible. In modern life in developed countries, saddle horses serve leisure purposes rather than having a contribution to production. The genetic improvement of performance and use of population genetics in the field of race horses and sport horses (eventing, show jumping, dressage and competitive driving) is in an advanced stage. The production of horse meat is also important and competitive even with beef cattle (Bodó et al. 1991).

The milk production of horses is limited to the rearing of foals, but in some countries is used to produce alcoholic or non-alcoholic drinks for human consumption. The composition of horse milk is close to human milk and therefore some hospitals use it in therapy. The serum of the horse plays an important role in pharmacology but nobody wants to use genetic methods to increase this production. Morphological traits can be considered also as valuable parameters for improvement or preservation. Such a trait is, for instance, the body size of the horse which shows a wide range from the giant Shire breeds to the smallest Fallabella or mini-horse. Other traits like curly hair can also be mentioned (Thomas, 1990). The special gaits of horses also have great value because they touch the main use of these animals. Walk, trot, gallop, (jump and swimming) are quite common but there are some pacer breeds and even populations with five gaits. The high step is very elegant (Lipizzan or Spanish horses and Friesians) and therefore can be considered as a valuable trait. The sure step of pack animals in mountainous
areas is indispensable. In modern life professional horse men are rare. Therefore the good and quiet temperament of horses is important to avoid problems when animals are handled by outsiders or tourists (Haflinger). The value of individual populations depends on their distinctiveness from the other horse breeds. Therefore the most valuable ones are those which are more or less free of the genes of the large international breeds such as the Thoroughbreds, Arabians and Mongol horses. It is very difficult to find such pure breeds; even the Ahal Teke which is an indigenous breed of Turkish origin has a distant relationship with historical Arabian horses. The biochemical polymorphisms and other results of biological research (RFLP, VNTR, fingerprinting etc.) help in determining the differences between populations. For example, the priority of the American Minor Breeds Conservancy is to preserve breeds which are distinct from the Thoroughbred-Arabian family of breeds (Spanish Mustang) (Christman, 1991). Sometimes such a distinction is difficult due to the lack of pedigrees (Silvestrelli, 1991).

6 Priorities in conservation of horse and donkey breeds

Following what has been said above, it is obvious that it is not easy to give priorities among horse breeds for improvement or preservation. The first priority must be given to the characterization of the breeds and also to save those in a critical state. The identification of some populations and the evaluation of their value should be carried out urgently in certain cases, for example with donkeys and conservation programmes should be based upon the results. Some small populations, well adapted to their natural habitat, can sometimes be found with merits for preservation or improvement. Sometimes such operations do not need much support or money and even moral support can be important. The wild relatives and ancestors of horses, which are under the protection of IUCN are not mentioned here, although it is noted that a programme for the restoration of the Przewalski horse is well advanced (FAO/UNEP,1986).

The collaboration of horse breeders is of course desirable in this field. The old endangered and separate populations, like the Ahal Teke horse breed in Turkmenia, have priority. The Turkmanian horse was famous from the 8th century in both Western and Eastern countries because of its conformation. It has a light and clean cut head, long and muscular neck sometimes with a protruding throat-latch, long and high withers, long and often slightly dipped back, long loin, straight croup and a not very deep, narrow chest. It has sloping shoulders, clean long legs, hard but moderately developed joints, long and often steeply sloping pasterns, large and hard low-heeled hoofs, tight thin skin, thin hair coat, main and tail. The height at withers of stallions is about 158 cm, oblique body length 159.8 cm, chest girth 176.3 cm, cannon bone girth 19.1 cm and body weight 30–500 kg. It is a late maturing horse with excellent speed though lacking range and strength. Its movement is well appreciated in modern sport events. The jump is very soft and elastic. The breed combines average fertility with longevity. The gene pool of pure Ahal Teke is limited. In the 1981 stud book there were only 87 stallions and 300 mares comprising 7 male lines and 5 mare families. Cross breeding with Trakehner, Hannover and Latvian riding horses is going on, (Dmitriev and Ernst, 1989). Ahal Teke can be a priority breed because its traits are well known.

On the other hand priorities must also be given to some endangered working horse breeds in Africa like the Dongola breed. The value of the traits is not completely clear but they are well adapted populations or strains and preservation can start in parallel with the identification and description of these breeds. The same can be said of some less well known breeds in Asia or South America like the Pantaneiro breed. When the programme of improvement and preservation of horse breeds is planned some European breeds should not be neglected such as the heavy draught horses (Clydesdale, Murinsulaner) and warm blooded working horses like
old Mecklenburger or the Kladrub breed. The maintenance of pony breeds in their original habitat is also important with the original use included, for example the Caspian pony and the Dartmoor Pony. Concerning asses, the identification and description of the most valuable populations is of great importance. The big sized asses all over the world should be saved from extinction (Iran, Spain, Italy, France etc.).

7 Conclusions

Horses and donkeys are as important in the economic life of the world as other farm animals. It would be a great mistake to consider them only as hobby animals. They work all over the world as draught, saddle and pack horses or donkeys and even their meat and milk production is not yet exploited enough. It is difficult to give priorities in preservation and improvement of the horse stock of the world for several reasons. First there are many populations which can not be considered as breeds and their evaluation would be necessary. Some breeds with well known characteristics are in danger of extinction first of all in developed countries where economic factors are not in favour of draught horses. In some cases the moral support of FAO could help in addition to money. Priority should be given to in situ conservation and to the development of cryogenic methods. Those populations which serve the everyday life of farmers must be given priority.

In spite of these facts there are some breeds which could be made the focus of preservation activity of the world like the Ahal Teke horse in Turkmenia or the Dongola in Africa or some small horse or ass populations all over the world with valuable traits. In summary, a survey on the horse breeds and small populations is needed in order to create a world programme for Equidae.

8 References


1 Introduction

The loss of biodiversity within wild faunas and floras that has been steadily increasing since the first spread of agriculture, has now become evident in domesticated species, too. This lack of diversity in domesticated livestock is particularly dangerous for those species whose wild progenitor is already extinct, for once the genetic material of the wild form is lost, it is gone forever. And recourse to captive-bred stocks for genetic material may not be satisfactory since some wild species have been held in captivity for many generations and are based on a very small gene pool which may already be exhibiting signs of inbreeding depression.

Domestication itself -- and one may call captive breeding whether in zoological collections or in more extensive conditions, a form of creeping domestication -- is an irreversible genetic process that removes the animals from the selective pressures of their natural environment.

In the event, genetic material from wild animals, whether for storage in cryopreservation or for the production of hybrids, should wherever possible be taken from a healthy, wild population occupying the environment to which it has become adapted.

1 This paper gives the summary and conclusions from a more extensive paper made available at the Expert Consultation.

2 Washington, D.C., U.S.A.

2 Objectives

There is then the question as to whether we should be attempting to domesticate new species of wild animals at all. It seems likely that we may have already exploited to the full the indigenous genes of our domestic stock that adapted most of them to their original temperate environment. It has even been suggested (Short, 1976) that apart from the romantic appeal it may have for conservationists there may be little point in preserving rare domestic breeds for their genetic potential. Their very scarcity may be an indication that they have lost their usefulness and become museum pieces. Maybe what we should be doing now is collecting and evaluating the genes of more tropical and polar species for infusion into existing domestic stock of temperate origin.

Tropical species are not usually seasonal breeders and even when transported to temperate zones their reproduction may continue to be non-seasonal. Examples are the chital or axis deer, Axis axis, of India, the Barbary sheep, Ammotragus lervia, of North Africa and the eland, Taurotragus oryx, of southern Africa, all of which breed throughout the year in their natural habitats and continue to do so even when translocated to northerly latitudes such as Britain (Zuckerman, 1952). The introduction of these tropical genes into a domestic species might therefore be expected to extend its mating season. In contrast to this, animals living in polar regions or at high altitudes in the temperate zone would be expected to have a very restricted breeding season. This would be an undesirable characteristic in a domestic animal. Nevertheless, they would theoretically have a number of highly desirable attributes, such as large body size, evolved to minimize heat loss, and a rapid growth rate and high food conversion ratio, associated with the need to reach maturity in the short summer growing
season. Thus the introduction of “polar genes” or “high altitude genes” into a suitable domestic species might be expected to increase body size, accelerate growth rates and improve efficiency of food conversion. The ideal new domestic animal could thus be a man-made blend of desirable genes selected for under environmental extremes and infused into stock of proven domestic temperament (Short, op. cit.)

3 Which wild species?

The question of what wild species should be given priority for both in situ and ex situ conservation must be addressed.

3.1 Cattle

From the documentation it would seem that those wild cattle which are classified as “vulnerable” or “endangered” should receive priority. The wild cattle of Asia comprise several potentially valuable species: the kouprey, Novibos sauveli, of Thailand, Laos, Vietnam and Cambodia; the gaur, Bos gaurus, of India and the forests of southeast Asia; two species of anoa, Bubalis spp., from Indonesia and the tamaraw, Bubalis mindorensis, on Mindoro in the Philippines. The productive and economic potential of these tropical, forest-dwelling bovids is almost unknown. A little more is known of the banteng, Bos javanicus, of which a domesticated form, known as “Bali cattle” is kept for draught and meat production in Indonesia and for the production of hybrids when crossed with zebu cattle on the island of Madura. Yaks, Bos grunniens, too, are domesticated in the high country of the Himalayas and hybrids with both humped and humpless cattle (yakows) are also produced in Central Asia. The mithan, Bos frontalis, is believed to be a domesticated form of the gaur, however, some authorities think that it is a progeny of a gaur/cattle cross while others favour a gaur/banteng cross. Whichever is correct, the mithan has valuable attributes of great docility and high milk production. Most of the wild Asian cattle species are threatened with extinction and attention to their conservation is urgent. All inhabit tropical forests and savannas, regions which are subject to environmental extremes to which conventional livestock is poorly adapted and in which more than half the world’s human population subsists. While the wild cattle of Asia may be resistant to some of the disease and parasites which occur in their native environment, there is however no doubt that diseases of domestic cattle are a serious threat to their continued existence in some areas.

3.1.1 Other wild relatives of cattle

Some wild species which are truly relatives of domesticated forms (yak, banteng, gaur) are important genetic reservoirs and yet others may have potential for the production of new domesticates (anoa, tamaraw, kouprey).

The African Cape buffalo, Syncerus caffer, is not threatened with extinction and the European and American bison, Bison bison, (now thought to be conspecific) are safely conserved by governments and individuals.

3.2 Sheep

The mouflon-urial are considered to be the ancestors of the domestic sheep. The taxonomic status of the members of genus Ovis is open to dispute (Schaller, 1977). For mouflon and urial some authorities distinguish a single species, Ovis orientalis, while others call the mouflon O. gmelini and the urial O. vignei.
Almost all European, Asiatic and north American wild sheep species will produce fertile hybrids when crossed with domestic sheep and there may be some advantages especially in the production of extended breeding seasons by back-crossing to the ancestral stock (Zuckerman, 1952).

### 3.3 Goats

The wild goat species, believed to be the ancestor of the domestic goat is *Capra aegagrus*. This species is well distributed throughout the Middle East but the populations, often small and isolated, occur mainly outside protected areas. In Turkey alone is the wild goat population not threatened. A hybrid between the Sinai Desert goat, and the wild Nubian ibex, *C. ibex nubiana*, has been developed in Israel with the object of improving the palatability of the desert goat's meat.

### 3.4 Horses

Przewalski’s horse, *Equus przewalskii*, is now extinct in the wild but is safe in captivity. Plans are being made to return this species to its native environment in Mongolia. The wild asses of the world are in a critical state, especially the one surviving African species, the Somali wild ass, *Equus africanus somalicus*, thought to be the progenitor of the domestic donkey. No representative of the eight sub-species of the Asian wild ass has been domesticated and all are now considered either endangered or vulnerable. The Somali wild ass will interbreed with its Asian cousins but the hybrids are infertile.

### 3.5 Pigs

The wild ancestor of the majority of the domestic breeds of pig is the Eurasian wild pig, *Sus scrofa*. The Sulawesi warty pig, *Sus celebensis*, has also long been domesticated on the island of Sulawesi and elsewhere in Indonesia. The species only occurs in its wild, native form on Sulawesi and some adjacent islands. Pigs are likely to be of increasing importance to mankind as a source of protein and the regional genetic variants of the Eurasian wild pig and those of the Sulawesi warty pig and other Asian wild pigs species are of great interest.

### 3.6 Camelids

Of the three wild camelids, two occur in Latin America and one in central Asia. The Latin American wild camelids are the vicuna, *Vicugna vicugna*, and the guanaco, *Lama guanicoe*. The latter is the ancestor of the domesticated llama and alpaca. The largest population of vicuna is in Peru where political unrest threatens the species. The world population of the vicuna is stable by could rapidly fall if conservation efforts were to be relaxed.

The guanaco is present in considerable numbers in Argentina but everywhere in Latin America it is over-hunted and persecuted by farmers who believe that it competes for grazing with their sheep and presents a disease risk.

The wild two-humped, so-called Bactrian camel, *Camelus ferus*, is now reduced to about 500 head and confined to two small areas Mongolia and China.

### 3.7 Deer
Some deer species are officially considered to be domesticated and others will follow them. Their wild relatives, although often under pressure, are generally not immediately threatened but in a world in which the human population is increasing by one million every four days this can hardly be a matter for complacency. Musk deer, *Moschus spp.*, are over-exploited throughout their range which stretches from Afghanistan through northern India to China, for the musk used by the perfume industry. Pere David's deer, *Elaphus davidianus*, has been extinct in the wild for 800 years and has recently been returned to its original habitat in China from captive sources in Britain.

Hybridization of deer of temperate zone origin with other species of tropical origin is becoming a common practice, especially in New Zealand deer farms, in an attempt to maximize production by manipulating changes in the time of the mating season and gestation length which are displayed by the hybrids. Wapiti, *Cervus canadensis*, sika, *C. nippon*, and Pere David's deer all hybridise with red deer, *C. elaphus*, and produce fertile offspring. Tuberculosis is proving to be a considerable problem in domesticated deer herds especially in New Zealand, United Kingdom and U.S.A. New Zealand now has over 5,000 deer farms carrying more than a million deer.

### 3.8 Antelope

There are a number of African and Asian antelopes which may have potential for domestication or semi-domestication. These come from diverse habitats ranging from moist rain forest to arid savanna and semi-desert. They are thus adapted to some environmental conditions which are marginal for the production of conventional livestock because of drought, heat, disease, altitude, humidity and other constraints. Even if not subjected to the long process of domestication their genes may be of value for improving the performance of domestic stock in marginal areas.

### 3.9 Musk Ox

Among the wild species which have potential for future domestication are the musk ox, *Ovibos moschatus*.

### 3.10 Rodents

The rodents particularly are likely to become extremely important as a source of future domesticates. Some Latin American and African rodents have potential for domestication. They are the world's most adaptable and prolific animals. They reproduce well in captivity, grow fast and adapt to a wide variety of local conditions. Many convert coarse vegetation into meat efficiently even though they have only a simple stomach. Much rodent meat is consumed throughout the world, especially in Latin America and west Africa. Peru alone has 20 million domestic guinea-pigs and several other species are undergoing experimental domestication. Some of these are more productive than domestic livestock in marginal or degraded areas and others are adapted to thrive where for one reason or another conventional livestock do not.

Many valuable rodent species are classified by IUCN as “endangered” or “vulnerable” and some have already been hunted to extinction. If the considerable productive potential of these and other members of the Order Rodentia was more widely known in development and agricultural economic circles, it is possible that an important incentive would be provided for the urgent conservation actions needed to ensure that these most valuable food animals do not become extinct. Under semi-domestication few have been selectively bred for docility or productivity, nor have the characteristics of the various races of those species which occupy a variety of different


habitats been tested. However, there are several important factors to be considered before recommending the introduction of a newly domesticated rodent (or indeed any other species) into a new country or culture. Largely because of their fecundity many rodents are agricultural pests in their natural range and since some species have a remarkable propensity for escape there is a danger that an alien species could establish itself in an exotic new environment and become a serious problem for local farmers. For this reason, rodents may be appropriate for raising only where they are already indigenous. Such potentially invasive animals should not be introduced into another environment where they could escape and become an agricultural liability. The subject of disease carriage has also been mentioned. Some rodent species are carriers of dangerous human disease, e.g. Chaga's disease, leishmaniasis, trichinellosis, tuberculosis, bubonic plague and tularemia and this must be borne in mind when the introduction of a new domesticated animal into a new area is considered.

3.11 Poultry

In the case of poultry, the genes of the high arctic breeding species such as the greater snow goose, *Anser caerulescens*, and the red-breasted goose, *Branta ruficollis*, will surely be needed for the improvement of the domestic goose, as will those of the bar-headed goose, *Branta indicus*, and the ne-ne, *Branta sandvicensis*, (Kear, 1975). The first two of these wild geese are high arctic nesters and have incubation periods of only 23–24 days (the domestic goose incubates for 33–35 days) and have a very rapid growth rate and an excellent efficiency of food conversion. The red-breasted goose, for example, attains 17.7 times its hatching weight by three weeks of age, which is about twice the growth rate of the domestic gosling. The bar-headed goose nests at high altitudes and has an advantage over the high latitude species in that it has a long breeding season. The endangered ne-ne from Hawaii actually lays its eggs on a decreasing day-length in winter.

3.12 Lizards

Large lizards have been important food animals since prehistoric times. Some, such as the monitor lizards, *Varanus spp.*, frequently seen trussed-up in the markets of Indo-China, are carnivorous species and may be difficult to raise economically for meat. However, they may be very valuable to raise for “medicine” for the Chinese pharmacopeia as is done on a small scale in Thailand. Iguana meat is popular in Latin America and everywhere the lizards are hunted relentlessly. As a result they are now becoming scare and their decline is accelerated by habitat destruction as the tropical forests are felled. But iguanas are forest-edge species and will thrive on farms and ranches as long as some patches of woodland are left standing.

Iguanas, *Iguana spp.*, are best semi-domesticated since they normally inhabit the treetops, feeding on leaves, shoots and fruit in the canopy. Few other herbivores are able to convert such forest foliage into food for human consumption. Research indicates that 200–300 kg of iguana meat can be produced each year from an hectare of forest. The meat tastes like chicken and the eggs are also consumed throughout Latin America. Iguana skin has barely been exploited as yet. It sells on the international reptile leather market as “chameleon lizard” and is used for making ladies' accessories. The main constraint on iguana farming is that the lizards take three years to reach marketable size.
### 3.13 Cats

Two civet cats, one African and one Asian are currently exploited for the very valuable musk secreted by their anal glands. The African civet, *Civetrixis spp.*, is kept in some numbers in semi-domestication by small farmers in Ethiopia, solely for its musk production which is exported for the perfume industry.

The Small Indian civet, *Viverricula indica*, is similarly raised in Thailand. The musk produced by this species is exported to China for the Chinese pharmaceutical industry. The Thai civet farms are run in association with chicken hatcheries and the civets are fed on boiled dead-in-shell chicks. Both these civet cats are common and are widely distributed throughout Africa and Asia respectively.

### 4 Conclusion

Genetic material from all the wild relatives of domestic livestock and indeed from those species which are unrelated but exhibit attributes that could be of potential use for improving the productive performance of existing domesticated animals, must be collected and stored whenever the opportunity presents itself, and material from truly wild populations must have priority over captive-bred or zoo specimens.

### 5 References


1 Introduction

There is a multitude of breeds, local types, strains or geographically separated populations of domestic animals in the tropical and developing countries, and they are presumed to be generally well-adapted to the existing climate-husbandry-economic conditions. However, they have not, in general, been well characterized or evaluated for their productive performance.

The future improvement and development of livestock to meet human needs is dependent on genetic variation - both the variation within breeds and the variation between breeds, strains and populations. Genetic variation is the primary resource, and loss of variation will restrict the options available to meet unpredictable future requirements. While loss of genetic variation within breeds or populations is continually countered by the introduction of new variation through mutation, the genetic variation represented as differences among breeds, strains or populations cannot be readily regenerated. Each breed or strain is the product of separate evolution and adaptation over many centuries, with differing selection pressures imposed by climate, endemic parasites and diseases, available nutrition and criteria imposed by man. Each is thus likely to represent a unique combination of genes.

However, high production of breeds in developed countries relative to that of native strains in less developed countries has lead in the past to unrealistic expectations of the potential for rapid improvement of productivity in the less developed countries through importation. Whether this importation and crossbreeding with native strains be indiscriminate or planned, the net result will be loss of the native genetic resources before their true value is known.

Already a substantial number of local populations or strains in the less developed countries have been seriously diluted by transfer of genetic material from exotic breeds or have disappeared completely. This increasing loss of diversity has been recognized for some years, as has the consequent need for conservation of animal genetic resources.

Since the FAO/UNEP Technical Consultation in 1980 (FAO, 1981), methodologies for a global programme for animal genetic resources have been researched. These have included procedures for description and characterization of breeds and the development of data banks (FAO, 1986a, b, c), and for the establishment of genebanks as repositories for frozen animal genetic material (Hodges 1989, 1990a), and the overall programme has been reviewed by Hodges (1990b).

As a result, three key issues for an immediate programme for the conservation of animal genetic resources have been identified, namely:

a. characterization and enumeration of all breeds of livestock used in animal agriculture,
b. an action program to identify breeds at risk of extinction, coupled with appropriate preservation measures,
c. a development programme to enhance the productivity of those indigenous breeds at risk of being replaced in breed substitution or up-grading (continuous crossbreeding) programmes.

Here we deal with the third of these issues - conservation and improvement of priority breeds.

2 Specification of breeds for development

Ideally, the choice of breeds to be given priority in development programmes would be based on objective evaluation of the current status of all breeds and strains of each species - number and distribution, trends in numbers (increasing or decreasing), population structure, productive performance, adaptive characters and existence of specific or unique traits such as resistance to particular diseases/parasites and tolerance of environmental stresses.

Unfortunately, but in reality, we are not in this ideal situation, and this required information will only become available as specific and conscious efforts are made to document and collect it, and record it in the global data bank. That, however, is not an excuse for doing nothing; the need for action is critical, and our best available subjective judgement must be exercised. The breeds that are chosen and recommended for development programmes may turn out later not to include some that should have been given priority. That will be a price of not having sufficient information, but it will be a small price relative to the potential improvement to be made in the chosen breeds, and the knowledge gained and expertise developed in the process of organizing, initiating and maintaining breeding programmes for the first set of priority breeds.

The programme for the specification of priority breeds, therefore, should have two components:

a. identification of those breeds with highest priority for development - based on whatever information is available, and a considered, but certainly partially subjective judgement,

b. identification of breeds for future development - specification of procedures for continuous monitoring of data bank information, and initiation of programmes for comparative evaluation of breeds and strains.

3 Identification of priority breeds for immediate development

This identification is one of the briefs for this Expert Consultation. In order to provide a basis for discussion, the authors of each of the six Working Papers for this Session were asked to provide a brief review of the global situation and to indicate those breeds judged to be of highest priority for development. Their recommendations are summarized in Table 1.

Table 1. Breeds suggested as those having highest priority for immediate development

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>ASIA</th>
<th>AFRICA</th>
<th>SOUTH AMERICA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Sahiwal</td>
<td>N'Dama</td>
<td>Criollo</td>
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<tr>
<td></td>
<td></td>
<td>Kenana</td>
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<td></td>
<td></td>
<td>Boran</td>
<td></td>
</tr>
<tr>
<td>Buffalo</td>
<td>Murrah</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal</td>
<td>Breed</td>
<td>Breed</td>
<td>Breed</td>
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<tr>
<td>------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Sheep</td>
<td>Nili-Ravi</td>
<td>Swamp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Awassi</td>
<td>Djallonke</td>
<td>Pelibuey</td>
</tr>
<tr>
<td></td>
<td>Javanese</td>
<td>D'man</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thin-tail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goats</td>
<td>Damascus</td>
<td>Fouta Djallon</td>
<td>Moxoto</td>
</tr>
<tr>
<td></td>
<td>Jamnapari</td>
<td>Boer</td>
<td></td>
</tr>
<tr>
<td>Pig</td>
<td>Taihu</td>
<td>West African</td>
<td>Plau</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camelidae</td>
<td></td>
<td></td>
<td>Alpaca</td>
</tr>
<tr>
<td>Poultry</td>
<td>Domestic ducks</td>
<td>Guinea fowl</td>
<td>Indig. Turkeys</td>
</tr>
<tr>
<td></td>
<td>Muscovy ducks</td>
<td>Chickens</td>
<td>Muscovy ducks</td>
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<tr>
<td></td>
<td>Chickens</td>
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<td>Chickens</td>
</tr>
</tbody>
</table>

Clearly the authors of papers on individual species for this Expert Consultation had a very difficult task, given the lack of a comprehensive data base containing breed characterizations in terms of population numbers, productivity, unique characteristics, and so on.

In general, the principles used in the selection of the breeds that they have suggested include:

- the breed possesses one or more highly desirable attributes in terms of productivity and/or adaptation,
- the breed is threatened, or is not efficiently utilized,
- the breed should be one whose improvement could have the potential to influence large populations, either of the same breed in one or more countries, or other very similar breed types.

Further, the breeds were selected to include a range of different types within each species, and where appropriate, to include representatives from each of the three main regions of the developing world. In four cases, for poultry in general, swamp buffalo, alpaca and West African pigs, either no specific breeds are recognized and/or the species exists over a wide geographical area including more than one country, so these present a special problem. While in his paper entitled “A Global Review of the Genetic resources of Poultry” in this volume, Dr. R.D.Crawford emphasizes the lack of documented information on indigenous poultry, all four species are similar in that breeds as such are not defined. Many different local types and strains or geographic populations exist, but the extent of genetic differences among them or particular attributes of any of them are unknown.

If a genetic improvement programme is to be initiated for any of these species, there is then the problem of identifying which particular population should be used. In the absence of any other criteria, a decision could be based on:
a. the country (or region of a country) where the species is, relative to other countries, more important to the small farmer and to the national economy,
b. availability of infrastructure, facilities and expertise.

4 Identification of breeds for future development programmes

Breed characterization information will be accumulated in the global data bank, but obviously this information will need to be monitored so that:

a. threatened breeds are identified as soon as possible,
b. gaps in the data base are recognized, and specific efforts made to collect the information, or if no information is available, programmes developed to generate it,
c. comparative evaluation studies are planned, so as to provide a sound basis for optimum utilization of between breed or strain genetic variation.

Comparative evaluation provides the major problem. Comparisons of performance and other data in the data bank, for say two breeds, will not necessarily reflect their true relative genetic merits, as their performance, etc. will likely have been measured in two different environments. Even with extensive and excellent data, subjective judgements will have to be made, and great care will be needed in making them.

Ideally again, and something to be planned for the longer term, evaluation is the prerequisite to optimum utilization - to provide the data on the comparative productivity and adaptability of existing native breeds and strains, and of crosses, backcrosses, etc., both among them and with exotic breeds. Utilization then involves the development of breeding programmes (selection and/or crossbreeding) to increase productivity and efficiency of production.

5 Genetic improvement programmes

For each of the breeds identified for immediate improvement, appropriate breeding programmes are to be developed and implemented. Here “appropriate” is the key word - it is not just a matter of transferring designs and technology from the developed countries.

While specific details of the improvement programme for each of the priority breeds will vary from breed to breed, it is suggested that all should be based on the Genetic Screening/Open Nucleus Breeding System (GS/ONBS).

The concept of an Open Nucleus Breeding System (James 1977) developed from cooperative (or group) breeding schemes in Australia and New Zealand. By concentrating selection in part of the total population (the Nucleus), ONBS offers the potential for higher rates of genetic progress than would be obtained by traditional within-herd selection.

For breeds in the developing countries, herd or flock sizes often are small and the basic infrastructure for recording of performance and pedigree does not exist, so that within-herd selection is not an option. The particular advantage of the open nucleus system in this case is again the concentration of selection in the nucleus - so that smaller numbers of animals need to be performance recorded and more detailed information can be obtained on each animal, yet the genetic gains achieved in the nucleus are transmitted to the whole population. The principles of the system are shown in Figure 1. The nucleus is established by selecting the best animals (males and females) from the base herds. Depending on the efficiency of this initial
selection, a substantial immediate gain in merit of the nucleus relative to the base can be obtained. Once the nucleus is established, all males selected to be used as sires in the nucleus are bred in the nucleus, as are most of the females selected as dams for the nucleus. However, some proportion of the females needed for breeding in the nucleus are selected from the base herds. Selected males and females in the nucleus that are surplus to requirements for breeding in the nucleus are transferred to the base herds. Thus the genetic improvement made in the nucleus is continuously transmitted to the base population.

Fig. 1: OPEN NUCLEUS BREEDING SCHEME (ONBS)

6 Open nucleus breeding systems - operational considerations

While the theory of the system as outlined is quite straightforward, there are many issues which must be addressed in designing a system for any particular breed. These include:

a. breeding objectives and selection criteria, including measurement techniques and recording procedures,

b. size of nucleus - number of males and females to be used for breeding, and selection intensity,

c. initial sampling of population (base herds) to set-up the nucleus,

d. environment and management practices of the nucleus,

e. ownership of the scheme and the nucleus animals, and access to the genetic material, i.e. availability of animals, semen or embryos to other populations, organizations, etc.,

f. storage of germplasm as insurance against disease losses, changes in future direction of breeding programme, etc.,
The overall design that follows from consideration of these issues will likely differ from species to species, breed to breed, or country to country, depending on the biology of the species (reproductive rates, etc.) and constraints specific to each case. Therefore, no single general system can be defined, but the factors to be considered in developing a particular system can be outlined.

6.1 Breeding objectives and selection criteria

Clearly the first step in any breeding programme is to define the objectives - what characteristics of the animals are to be improved, and the criteria for which animals will be evaluated and selected, in order to produce genetic improvement in the objectives. While apparently obvious, the importance of this step is often overlooked. The breeding objective and the selection criterion may sometimes be the same, but not necessarily so. For example, an objective might be increased resistance to a particular disease, with the selection criterion an immunological response test.

However, specification of the breeding objectives and the overall economic goal implies knowledge of the relevant genetic parameters - heritabilities of and genetic correlations among the traits of interest in the breeding objective. The need for this information is emphasized by Dr. R.W. Ponzoni in his paper in this volume entitled “A Global Review of the Genetic Resources of Sheep and Goats”, who suggests therefore a period of intense research activity before implementation of a genetic improvement programme.

Obviously, all available information on genetic parameters for the species in question should be reviewed from the literature, and used in defining breeding objectives and the economic goal. Nevertheless, this available information may be inadequate. In this case, but given the critical need to implement improvement programmes, it would seem better to start the programme as soon as possible, but using a limited breeding objective - perhaps even a single trait. Where possible, research to estimate genetic parameters for all traits of importance could be done using the animals and facilities of the nucleus, as well as any other institution herds or flocks that may be available.

Clearly it may take some years to obtain these estimates, but the breeding objectives can be refined as information becomes available. Any concern that the breeding programme may in some way be directed towards objectives that later prove not to be optimal should be lessened by recognizing that genetic progress in the early years will be slow, and that adequate stored semen samples will provide a backup.

The breeding objectives must be those that are relevant and of most significance to the potential users of nucleus stock. Preconceived notions of which traits should be improved may lead to failure because the “improved” animals are not acceptable to the users. Thus the potential users (i.e. primarily the owners of animals in the base herds) must be involved in development of the system. It is essential that they understand the programme and that all known (or likely) consequences of selection for the defined objectives are discussed with them. This will ensure not only that the objectives are right, but that they feel part of the programme, that it is their programme and that they will benefit.

6.2 Size of nucleus
The optimum size of the nucleus, i.e. the size that will maximize the rate of genetic improvement, varies with the selection intensity to be imposed in both males and females in the nucleus, but generally will be about 10–20% of the total female population (James 1977). While the optimum size can be defined, practical constraints may limit the size that can be used. On the one hand, the numbers in the nucleus should not be so small that selection is inefficient and inbreeding accumulates rapidly. On the other, it should not be so large that standard management and conditions for all animals cannot be maintained.

One advantage of the open nucleus system, as compared with a closed population of the same size, is the increase in effective size and thus reduction in the rate of inbreeding. The magnitude of this difference depends on the proportion of breeding females in the nucleus that are introduced from the base herds. This proportion of breeding females introduced from base herds itself depends on the accuracies of selection in the nucleus and the base. As the accuracy of selection of females in the base decreases relative to that in the nucleus, then the optimum proportion of females from the base also decreases. In the extreme, if the relative accuracy of the base test is very poor, then no females should be introduced to the nucleus from the base. This means that if the nucleus size is constrained for whatever reason, additional effort should be devoted to increasing the accuracy of base testing, so that a higher proportion of females can be introduced from the base, and inbreeding minimized in the nucleus.

Even so, the continued screening of the base herds in most programmes will be at relatively low levels of accuracy. For this reason, nucleus size must be sufficient to maintain the rate of inbreeding to an acceptable level and to allow adequate selection intensity. These two words “acceptable” and “adequate” will have to be quantified for each programme, taking into account all factors and constraints affecting that programme.

6.3 Sampling of population to set-up nucleus

Open nucleus systems are usually initiated with a screening of all animals in the base herds to select the best males and females for the nucleus. Optimally, “best” in this sense means those animals that have highest performance for the defined selection criteria. However, objective records for these criteria generally will not be available in the base herds. Even in this case, some selection gain can usually be achieved. The number of animals required for the nucleus is only a small proportion of the total population, so that only extreme animals are required. Thus the subjective evaluation by owners of the base herd animals can be valuable. Discussions with the owners in this context can be a very useful part of the process of gaining their confidence in and support for the whole breeding programme, and confirming their support for the defined breeding objectives. In addition, where no records exist, some indication of merit can be gained, for example, by measuring body weights, or milk yield over one or two days. Such sample measurements can also provide the basis for development of measurement procedures for later selection of females from the base herds.

6.4 Environment and management practices of the nucleus

As the aim of the breeding programme is to improve performance in farmers' herds, selection in the nucleus should be done in the same environment as that of the base herds. This means in the same region, exposed to the same climate, and under the same management levels as the base herds. Thus for example, treatment for a disease or parasite should not be given unless the same treatment is freely and practically available in the base herds.
Although care is necessary in exercising it, there is one possible modification to this specification of same environment. When an open nucleus system is fully operational and rates of genetic gain stabilize, the base herds will lag two generations behind the nucleus in average genetic merit. Thus the environment for evaluation and selection in the nucleus could be one which it is anticipated will be that of the base herds in 2–3 generations.

**6.5 Ownership and access to material**

The development of an open nucleus scheme for any breed in the developing countries will likely involve government organizations in one (or more) countries, the farmers who are owners of the base herd animals and one (or more) international agencies. All will be contributing - either expertise, funds or animals. The animals in the nucleus may be purchased from the base herds, or they may continue to be owned by the farmers and loaned for use in the nucleus.

Further, while the primary aim of the programme is to make genetic improvement in the base herds, the superior animals in the nucleus are a resource that could be used for improvement of other populations of the same breed (perhaps in another country) or for crossbreeding (in the same or another country).

These possibilities must be recognized when the programme is being set-up, and clear and specific agreements made as to ownership of the animals present in the nucleus at any time, ownership of genetic material (e.g. frozen semen), and possible use of both outside the herds that constitute the breeding population.

**6.6 Storage of germplasm**

The continuous introduction of females to the nucleus clearly involves health risks. Policies, therefore, must be defined to protect the nucleus as much as possible, and all procedures for movement of animals strictly adhered to. Further, breeding objectives may change over time. For both of these reasons, consideration should be given to the desirability of germplasm preservation. This storage will normally be frozen semen, but for some species may include now or in the future, frozen embryos. The questions to be considered include:

- Numbers of males to be sampled and how much semen from each,
- Whether the males sampled should be a random sample or the best available at the time,
- Frequency of collection and storage of new material - at initiation of the programme, and then every X years,
- Location of stored material - national or regional gene banks,

**7 Application of open nucleus breeding systems - successes and failures**

Open nucleus breeding systems are in operation in a number of countries such as the Australia, Denmark, New Zealand, Poland, and the U.K. In some cases, these schemes include the additional technology of multiple ovulation and egg transfer (MOET), but they also depend on existing recording programmes and other infrastructure. They are, therefore, less relevant as examples for breed improvement in developing countries.

However, FAO has been interested in the possibilities of ONBS for some years, and already has sponsored two meetings on this topic (Polish Academy of Sciences 1990, Steane and Alexiev
Further, starting in 1987, FAO initiated an open nucleus breeding system for Awassi sheep in Turkey, Syria, Iraq and Jordan, aimed at the genetic improvement of milk yield in this breed. This project can be considered a pilot scheme for the development of ONBS in developing countries, and preliminary results are very encouraging (Table 2).

Schemes have also been initiated in Djalonke sheep and, very recently, in D’Nama cattle. In addition, in India a scheme is being developed based on the use of the urban dairy animal (usually milked for only one lactation) in which the best of these will be purchased for use in a MOET scheme.

While these ONBS schemes are already being developed, it is useful to consider past breeding schemes used in developing countries to see what can be learned from them. Most schemes involved the use of an exotic breed imported to provide immediate and hopefully spectacular gains. Frequently the F1 performed successfully and the programmes continued to use the exotic.

Table 2. Nucleus-control comparisons (year 1)

<table>
<thead>
<tr>
<th></th>
<th>Turkey</th>
<th>Jordan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nucleus</td>
<td>control</td>
</tr>
<tr>
<td>No. animals</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>Lactation yield (kg)</td>
<td>231</td>
<td>170</td>
</tr>
<tr>
<td>Nucleus superiority (%)</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

from Jasiorowski (1990).

There are a number of reviews documenting the results, most of which indicate that the F1 outperformed all other crosses when overall performance rather than one specific trait was considered. Valuable reports and reviews include Vaccaro (1979), McDowell (1983), FAO (1987) and Bondoc, Smith and Gibson (1989). However, even where the F1 are superior, careful consideration must be given to what is feasible. In particular, is the infrastructure adequate to maintain continuous production of F1 animals? How are the F1 to be used as far as further breeding is concerned? This latter is very important, but is often forgotten, and either backcrossing or *inter se* mating among the F1 may be quite undesirable.

Essentially, past failures can be attributed to inadequate information and poor definition of objectives, for example:

- schemes based on high output figures without consideration of required inputs
- failure to consider environmental constraints such as potential feed resources, disease impacts, etc
- inadequate definition of breeding objectives, and failure to consider all outputs in these objectives (e.g. in several countries, the value of dung is similar to that of milk)
- insufficient population size
- failure to consider possible genotype x environment interactions, with the selection programme operating in an environment not representative of farmers’ conditions (e.g. institutional herds)
• failure to be guided by farmer opinion concerning objectives, so that animals from the programme are not acceptable to local farmers.

8 Biodiversity, conservation and genetic improvement

The major emphasis here has been on identification of priority breeds and considerations necessary for the specification of appropriate breeding programmes for these breeds. However, it would be remiss not to give consideration to longer term aspects of the breeds. However, it would be remiss not to give consideration to longer term aspects of the utilization of animal genetic resources.

The question of the identification of breeds for future development programmes was introduced earlier. The suggestion then was made that a start should be made now in the planning of comparative evaluation studies. But given the wealth of breeds, strains and geographical populations that exist within each species, it obviously will not be possible to evaluate all of them with the limited resources available. In essence, the existing biodiversity is too great; the scope of the problem must be reduced.

One solution to this dilemma (Barker 1980, 1985) is to determine the genetic relationships among the breeds, strains or populations of each species of livestock, so that they may be grouped into sets that are genetically similar, and then to include in evaluation studies one representative from each set.

The genetic relationships may be determined using biochemical genetic and/or molecular markers, and these studies can usefully be coordinated with genome mapping, further extending their value. Such studies should be seen as an essential component of work that is necessary to both understand and utilize existing biodiversity; the question that needs to be resolved relates to the proportion of available resources (financial, human expertise) that should be devoted to immediate development of priority breeds on the one hand, and identification of diversity for future use on the other.

Such studies of the genetic relationships among strains and geographical populations of a particular species can also be valuable in determining the population to be chosen as the base for a genetic improvement programme. For swamp buffalo, alpaca, West African pigs and species of poultry, the problem was noted earlier that breeds are not recognized, so that some particular local population (or populations) has to be chosen if a development programme is to be initiated. If all populations were closely related (i.e. high genetic similarity or small genetic distances among them), it would not matter which population was chosen, as all would provide a similar genetic base. However, what should be done if there are significant genetic differences among the populations, as has been found for swamp buffalo populations in southeast Asia (Mukherjee et al. 1991). Although the populations have been shown to be genetically different for biochemical markers, they are presumed also to differ genetically for production traits. In the absence of comparative evaluation data, the choice of population will have to be pragmatic as noted earlier. But in this case, the breeding programme should be designed to include introduction of genetic material (males or semen) from other populations, both to broaden the genetic base for selection and genetic improvement, and with appropriate planning and design, to gain information on the comparative genetic merit of different populations.

9 References


1 Introduction

Over the past decade there has been widespread concern about the loss of valuable animal genetic resources through indiscriminate crossbreeding, breed replacement and neglect. The concern has intensified over time despite the potential of new techniques to artificially generate new genetic variation. So why all the concern? In short, the elegance, sophistication and subtlety of nature is still poorly understood. Much remains to be learnt about the creation, maintenance and evolutionary role of natural genetic variation before man can sensibly devise ways for its more effective utilization in a sustainable manner. For this reason alone, protection of the world's genetic resource base is a high priority.

The purpose of this paper is to discuss how DNA based technologies can contribute to the conservation and utilization of animal genetic resources. Three main areas have been addressed. These are the storage of DNA from threatened breeds/strains, the analysis of population structure to prioritize breeds for conservation and the mapping of genes unique to adapted breeds. Ways of measuring genetic variability at the DNA level will also be considered since they are central to more effective use of genetic resources. Key technologies for the preservation of gametes or embryos including cryogenic storage and related techniques have recently been reviewed (47) and will therefore not be discussed in this paper.

2 Collection and storage of DNA

The genetic information essential for the development, growth and efficient functioning of animals is housed within the DNA molecule. In higher mammals, around 3000 million individual bits of information are stored in each of the billions of cells that make up the entire organism. When conservation of this genetic information is considered, it is essential to preserve a sample that is representative of the organism, to purify and preserve it in a way that maintains the basic structure of the DNA molecule, and to store the DNA in alternative forms that allow easy access to the genetic information. Biochemical methods are available to meet these requirements.

2.1 Structure and Properties of DNA

Fortunately DNA is a very resilient molecule. The four basic nucleotides are linked by a sugar-phosphate backbone forming a long molecule (eg. a chromosome) that may be up to 100 million nucleotides in length. Two complementary strands are combined in a double helix formation held together by hydrogen bonds. In cattle, the entire genetic information content is found within sixty chromosomes in the nucleus of each cell. To attain the high degree of condensation that is required to allow such large DNA molecules to be physically housed in the cell nucleus, the DNA is wound around protein molecules and stacked in highly space efficient tertiary structures.
It is the extraordinary length of the DNA molecules together with their highly ordered packing that imparts mechanical and chemical stability. DNA can be treated with organic solvents, exposed to natural enzymes, heated to 75°C, desiccated and stored for thousands of years and its basic structure can still remain intact. It is however not totally impervious to damage. To be conserved efficiently it must be collected and stored with care.

2.2 Harvesting DNA

DNA is present in virtually every mammalian cell type. Any tissue, therefore, is a source of DNA. The ease of extracting the DNA is usually dependent on the tissue type. In dense tissues such as skin and tendon, DNA is difficult to obtain as the cells cannot be dissociated easily. Blood, however, provides an excellent source of loose cells and accessible DNA. A variety of DNA extraction procedures exist (1, 2) each of which incorporate the same basic principles. The cells must be ruptured, endogenous DNA degrading enzymes denatured and removed, the DNA packing protein removed, all lingering traces of any organic solvents removed, and the DNA resolubilized in a stable buffer. These procedures apply to specialized organelle DNA such as mitochondrial DNA, as well as nuclear genomic DNA. Care must be taken to minimize the physical breakage of DNA, as large molecular size is essential for some analytical procedures.

2.3 Storage of DNA

DNA can be stably stored in a variety of ways. The method of choice often relates to the quantities of DNA required and to its intended use.

2.3.1 Tissue

The most basic storage form is frozen whole tissue. In this form, large amounts of DNA and RNA can be maintained with little preparation. The feasibility of this procedure is evident in the ability to recover DNA from whole mammals that have been entombed in glaciers for several thousand years. The key to the success of this method is rapid freezing of the tissue, and constant low temperature during the storage. RNA is not as well suited as DNA to long term storage in this form. An obvious drawback is the potential bulk of the tissue samples, with the exception of frozen semen. Semen samples have a high concentration of DNA and represent a convenient tissue for collection as well as long term storage. In addition, use can be made of existing artificial breeding infrastructures.

2.3.2 Cells/nuclei

Tissue bulk can be minimized by reducing the tissue to a whole cell or cell nuclei preparation before freezing. By removing the cellular cytoplasm in the nuclei preparation, the potential for autolysis by endogenous nucleases is also reduced. An alternative to dead cell storage is the generation of cell cultures from tissues such as skin or lymphocytes. This provides a pure, dissociated cell type that can be multiplied before harvesting the cells for storage as intact cells or as cell nuclei. The cell lines can also be stored live by freezing in liquid nitrogen, stored, and then revived and re-multiplied as necessary. However there is a risk of somatic mutations occurring as the cell line multiplies, thus creating material that is not identical to the original animal source.

2.3.3 Pure DNA
Purified DNA is certainly the preferred choice for the long term stable storage of DNA. Once dissociated from all protein, and free from bacterial or fungal contaminants, DNA can be stored indefinitely at -20°C. A 10ml/10mg quantity of DNA extracted from any tissue and distributed in a number of “banks” could provide the basic resource from the conservation of the entire genetic information from a representative individual.

2.3.4 Libraries

Within the context of genetic conservation, there not only needs to be a means of storing a genetic resource; there also needs to be a method by which the information stored can be retrieved, studied and if necessary reused. The cloning of DNA into “libraries” can achieve this. A gene library is a representative portion of the genomic DNA that has been inserted into a “vector”. Amplification of a library allows any single DNA fragment to be multiplied many times in number thereby facilitating analysis. Libraries can also be derived from an RNA rather than DNA source. Such libraries contain the genes that were transcriptionally active in the original tissue. Both RNA and DNA libraries can be used as a storage source of genetic information. However the biological limitations of cloning mean that libraries are not always fully representative. These libraries do, however, offer the only means to identify and isolate entire genes, and as such offer an opportunity to investigate important production characteristics found in exotic and threatened domestic animals.

2.4 DNA and RNA Storage in Conservation Programmes

At the present time, live animals cannot be regenerated from isolated DNA. Therefore DNA storage is complementary rather than an alternative to cryopreservation of semen and embryos and the *in situ* preservation of animals. DNA does contain the essential genetic information that allows each animal to express its particular phenotype. It is therefore a crucial resource in investigating the function of each gene. As the function of newly discovered genes are elucidated, their role in animal growth development and survival can be determined. DNA cloning together with gene transfer technologies allow single genes, modified genes, or gene systems to be expressed in novel genetic backgrounds. These technologies make very effective use of stored DNA. A situation can be envisaged where a desirable production gene is identified using DNA marker analysis on stored DNA samples of a particular breed, the gene is isolated from a DNA or RNA library made from a representative of the breed, and the gene reintroduced and expressed in the genome of the donor breed. Hence the unique gene is conserved and propagated.

The storage of RNA as cDNA libraries derived from RNA must be an integral part of a conservation programme. RNA allows individual genes to be rapidly isolated, and the gene product expressed. The collection of a representative sample of RNA from an organism is very difficult due to tissue and time specific expression of genes. Hence a broad based collection of RNA could not be considered in the same manner as DNA. Conservation of RNA stocks in the form of cDNA libraries would have to be undertaken on a more selective basis.

The type and amount of stored genetic material should be related to the risk of losing a particular breed and the cost of storing different forms. In general DNA storage is cheap relative to live animal or embryo storage. For breeds at low risk, storage of purified DNA is adequate insurance. However for high risk breeds, DNA, tissue and RNA (in library form) should be preserved for future use. DNA banks should be viewed as genetic information resources for future use.
3 DNA sequence variation

In the process of domestication, limited population size and an increasing reliance on “superior” animals, genetic variation is reduced (3). Techniques for the analysis of variability are therefore an essential ingredient for conservation programmes. These techniques can be used to analyze the phylogeny of breed divergence, to follow gene segregation within populations, and ultimately, to associate nucleotide variation with changes in gene function and expression of animal phenotype. The most appropriate techniques for assessing DNA variation in a variety of applications include sequencing, Restriction Fragment Length Polymorphisms and conformational polymorphisms.

3.1 Sequencing

DNA sequencing provides the highest level of resolution that can be obtained in genome analysis (4). Sequence analysis reveals the fundamental structure of genes and allows an understanding of how nucleotide variation can influence gene expression. The concept of total genome sequencing is rapidly gaining acceptance with new automated sequencing technologies beginning to demonstrate the feasibility of the task. The sequencing of full mammalian genomes is understandably a massive undertaking, but not an unrealistic one. It is already practical to use DNA sequencing to analyze nucleotide variation in large animal populations. Using Polymerase Chain Reaction (PCR) and cycle sequencing technologies, highly variable sections of the genome can be rapidly analyzed in a moderate number of individuals.

3.2 Restriction Fragment Length Polymorphisms

3.2.1 Simple Length Polymorphism

Nucleotide variation can be highlighted by bacterial restriction enzymes which cut genomic DNA at specific sequences. Variation at the enzyme target site or insertions or deletions of DNA sequences between two enzyme sites produce fragments of variable length. The cut genomic DNA is size sorted by electrophoresis in agarose gels and then transferred to nylon support membranes. The specific DNA fragments of interest can be highlighted on the membranes by hybridization with labelled DNA probes. Unfortunately, simple RFLPs only exploit a fraction of the total variation in DNA sequence because only mutations which change the relative position of restrictive enzyme sites are detected. This is an important consideration in domestic animals since variability is lower than other outbred mammals (3).

RFLP systems can be made more informative by altering the analysis technique to produce multiple alleles. This can be achieved in two ways. Firstly by using a long DNA probe (e.g. 50 kbp), a haplotype of many restriction fragments may be revealed with the same enzyme (5). Secondly, the polymerase chain reaction (PCR) (6) can be used to generate a fragment in the region of interest, which is then cut with numerous high cutting frequency restriction enzymes. The resulting multi-fragment pattern can be visualized on a high resolution acrylamide gel. Both procedures do however have practical drawbacks. In haplotyping, the large DNA probe often contains highly repetitive DNA which mask the RFLP signal, and the multicut PCR method requires the nucleotide sequence of the marker region to be known. In many cases, the difficulties of RFLP systems can be overcome by simply using DNA markers that are more polymorphic.
3.2.2 Minisatellites

Another class of RFLPs arises not due to point mutations or chromosomal rearrangements but to variability in the number of repetitive DNA elements. The polymorphism is revealed by restriction enzymes which cut the DNA outside the repetitive sequence.

Minisatellites are fragments of DNA characterized by the tandem repetition of a sequence usually around 25 bp in length (7). The DNA is visualized by gel electrophoresis, blotting and DNA probing. Variation in the number of repeats can be high, with some loci in humans being heterozygous in 99% of individuals (8). In cattle the mean heterozygosity of 50 minisatellite loci was found to be 51% (5). Minisatellite loci exist in high numbers in any genome, and there is a strong sequence similarity between many of these loci. Thus when the genomic DNA is visualized by a minisatellite probe at low DNA hybridization stringencies, many loci become visible simultaneously. This results in a DNA fingerprint, which permits the absolute identification of animals, and under certain circumstances, provides a means of rapidly screening genomes to find DNA markers that are linked to production genes. When used at high stringency, minisatellite probes reveal only two alleles, but with a high probability that the locus is heterozygous and with different length alleles in each parent in a pedigree. This greatly expands the amount of genotype information available for analysis of genetic linkage between a DNA marker and a production trait. One possible limitation to minisatellite systems is a non-random distribution of genomic loci, with a bias towards chromosome telomeres (9, 10). There may be some regions of a genome which do not have minisatellite sequences.

3.2.3 Microsatellites

DNA microsatellites are highly variable polyallelic systems composed of DNA repeated in tandem at each locus (11, 12). The tandem repeats in microsatellites are usually simple dinucleotides (such as (CA)_n) with each dinucleotide repeated on average twenty times. The length of each allele is determined by PCR analysis using unique oligonucleotide primers flanking the repeat sequence. The DNA products are visualized on sequencing gels. There are thought to be around 100,000 microsatellite loci in any animal genome (12), which means that any position on the genome lies within 25–50 kbp of a microsatellite. With such a widespread genome coverage and the ability to run up to five microsatellite loci in a single ‘multiplexed’ PCR, microsatellite systems have an analytical power approaching the level of minisatellite systems and are more convenient to use.

3.3 Conformational polymorphism

3.3.1 Single strand conformational polymorphism (SSCP)

SSCP techniques are a rapid and relatively simple means of detecting most DNA sequence changes. They rely on the concept that the conformation of a DNA strand is altered by a nucleotide change, and this new conformation can be detected as a mobility shift in gel electrophoresis (13,14). The method does require either sequence information for PCR primer sites at the site to be analyzed, or a DNA probe that will bind at the site.

3.4 DNA variability, conservation and animal improvement

Quantifying genetic variability at the DNA level is an important requirement for rational conservation and improvement programmes. The following sections will discuss in detail how...
DNA variation can be used to define population structures and how it can be associated with phenotypic variability.

4 Population structure analysis

The selection of breeds or strains of livestock for conservation or improvement programmes can be hampered by an inadequate description of population structure both within and between populations. Geographic isolation over time has built up a plethora of genetic types but the magnitude of genetic differentiation has rarely been quantified. The situation is further clouded when recent crossbreeding has occurred. A key element of the conservation strategy must be the characterization of breeds and strains to provide an overall picture of genetic diversity. The choice of appropriate populations for conservation or improvement should be based on a combination of phenotypic and genetic data.

4.1 General approach

A preliminary classification of livestock diversity, based largely on phenotypic observations has been made (15). However further refinements are necessary. DNA based measures of variation are potentially very useful in this work. The procedure basically involves four steps:

A. Obtain representative samples from described populations - sample numbers will be determined from breeding structure and planned analysis methods.
B. Measure between and within population genetic variation. A number of alternative systems have been discussed in section 3 and their applicability to population structure analysis will be considered below.
C. Calculate indices of genetic similarity/dissimilarity between populations. A large number of indices have been proposed, through the most widely used index, probably because of its conceptual appeal, is that of genetic distance (16). Other measures (17) may be more useful for short term evolution such as the divergence between livestock breeds.
D. Construct phylogenetic trees to describe both the current population structure and the evolutionary history of sub populations.

Clearly the success of each study is very dependent on the effectiveness of the sampling procedure and the extent to which variation in the total genome can be reassessed. A major limitation in the past has been the limited capacity to measure genetic variability at the DNA level. However, this limitation is now removed.

4.2 Measurement of genetic variability

Genetic variability can be measured in nuclear DNA or in the maternally inherited mitochondrial DNA. The latter type has the advantage of being unaffected by meiotic recombination. On the other hand, mitochondrial DNA is more subject to genetic bottlenecks. Thus it is advisable to use both sources of genetic information. Where the genetic distance between populations is likely to be relatively small, sensitive measures of variability are required. For this reason, protein polymorphisms or RFLPs are generally not sufficiently variable for efficient use. On the other hand, repetitive sequences such as mini-and micro-satellites, although characterized by hypervariability, will underestimate the rate of genetic divergence because repeat units are both added and subtracted during evolution.
Conventional RFLPs, which reveal less than 20% of total sequence variation, are now being supplemented with conformational polymorphisms such as SSCP, which are of course equally applicable to nuclear and mitochondrial DNA analysis.

However, with the advent of direct sequencing methods, which avoid the need for subcloning steps, the sequence analysis of discrete regions of DNA is now being used for genetic divergence studies. (eg 18) Mitochondrial DNA has been widely used for evolutionary studies because of its rapid evolution. In particular the displacement (D) loop contains several hypervariable (non coding) regions which can be readily sequenced. (18) Such studies have recently been initiated in cattle in an attempt to quantify differences between African, Indian and European cattle breeds. (D. Bradley, personal communication) With automation of sequencing now achieved, it is likely that future studies in other livestock species will also use sequence analysis as the primary method. However phenotype information and, where appropriate protein polymorphism data, should also be considered.

5 Gene mapping

The future use of animal genetic resources will be based on identification of genes associated with specific phenotypic characteristics. Techniques for rapidly mapping and isolating genes and characterizing them in terms of DNA structure and function are being refined. It is likely that in the near future, breeds and strains of livestock with unique or rare characteristics will be able to be characterized at the molecular level. The advantage of this approach is that utilization of unique or rare alleles will be greatly facilitated through programmes to introduce variants of genes into other populations, or to increase the frequency of such alleles within existing populations.

In the following sections, the current status of gene maps for livestock will be briefly reviewed and strategies for mapping individual genes will be discussed.

5.1 Gene maps

Gene maps have three main functions. First, they serve as repositories for gene mapping data ie. the location, order and spacing of genes or genetic markers. Second, maps can be used to facilitate mapping of new genes by providing reference points for searches. Third, by cross-referencing gene mapping information from one mammalian species to another, homologous chromosomal regions can be identified thereby permitting the extrapolation of information on gene location. Thus gene maps are an extremely valuable resource for mapping studies.

5.1.1 Physical maps

Physical gene maps indicate the location of genes on specific chromosomes, chromosomal regions or syntenic groups. The latter comprise groups of genes known to reside on a chromosome of unknown identity. The coordinates and therefore units of a localization will depend on the mapping method used. For example, at present, somatic cell hybrid analysis in cattle can map genes to either the chromosomal or syntenic group level (21). However, in situ hybridization results in assignment to chromosomal region with reference to a banded karyotype (22). Recent developments in the use of nonradioactive methods of hybridization to interphase chromosomes have greatly increased mapping resolution (24). Pulsed field gel electrophoresis is used for fine scale mapping where distances are measured in base pairs of DNA (23).
A recent summary on the status of mammalian gene maps (Table 1), demonstrates that relatively few of the estimated 50 – 100,000 genes have been localized on mammalian genomes. However, research effort in this area is increasing worldwide, particularly with recent initiatives in human genome mapping.

As far as livestock are concerned, the cow is the best documented species. However, it must be realized that only around 25% of the mapped genes have been regionally assigned as distinct from localization to only a chromosome or syntenic group. Thus the task ahead for livestock gene mapping is considerable.

On the other hand, there will be considerable spinoffs to livestock from genome research in other species. Much of the basic work on genome organization and function will be carried out in man, mouse and other experimental organisms such as yeast, *Drosophila*, *C. elegans*, and *E. coli*. As will be discussed later, opportunities for making use of this information are considerable.

### Table 1. Current status of physical gene maps in various mammalian species

<table>
<thead>
<tr>
<th>Species</th>
<th>Haploid Chromosome No.</th>
<th>No. Syntenic Groups</th>
<th>Number of Genes Mapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>23</td>
<td>23</td>
<td>2500</td>
</tr>
<tr>
<td>Mouse</td>
<td>20</td>
<td>20</td>
<td>2200</td>
</tr>
<tr>
<td>Cattle</td>
<td>30</td>
<td>29</td>
<td>250</td>
</tr>
<tr>
<td>Sheep</td>
<td>27</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>Pig</td>
<td>19</td>
<td>17</td>
<td>80</td>
</tr>
</tbody>
</table>

Source: Ref (29)

### 5.1.2 Genetic maps

Genetic or linkage maps document the order and spacing of genes or genetic markers where distances are measured in recombination units.

The frequency of recombination between homologous chromosomes, a normal event in meiosis, is generally proportional to the distance between two linked loci and can therefore be used as a unit of chromosomal length. The unit, is known as the Morgan (M), and one centimorgan (cM) corresponds to the distance separating two loci exhibiting a 1% recombination rate. For short distances, eg. less than 30cM, the relationship between physical distances and recombination rate is essentially linear. However over longer distances, interference and the occurrence of double crossovers can reduce the concordance.

Measuring recombination rates or linkage relies on being able to distinguish parental and recombinant genotypes. It therefore requires polymorphism to be defined at each locus, and the analysis of segregation from doubly heterozygous individuals (25). Recently, it has become possible to genotype individual gametes ie. sperm and ova (26). However, genetic contribution is generally inferred for the genotypes of offspring and linkage studies are carried out within families.
As discussed earlier, there are a wide range of polymorphic markers available. However the most numerous and in many ways the most practical are based on DNA sequence variation. Accordingly, such markers are now being widely studied. Each marker permits the segregation of a discrete chromosomal region to be followed. Pairs of flanking markers provide even greater precision.

It is difficult to assess the current status of genetic maps of livestock for two reasons. First, there is currently a large amount of activity around the world directed at linkage maps in all of the economically important livestock species. Thus even a recently published list is quickly out of date. Second, some research is being carried out in the private sector and for reasons of competitive advantage, is not being published. To take the linkage map of the cow as an example, the most recent published report cites a total of 8 linkage groups comprising 64 markers (27). However, our own group alone has mapped a further 80 markers in the past two years and we are aware of another group which has mapped more than 100 other markers.

The challenge in the future will be to collate all the linkage information generated within a species into a common framework. In other words, there is a need to avoid the construction of a large number of genetic maps for a single species with little cross-referencing between them. This will arise if different markers are mapped in different sets of families. Although there will probably be some differences in recombination rate between strains and breeds of the same species, their magnitude will be relatively small in most cases. Given the crude state of livestock genetic maps, it is more important at this stage to collate information across breeds within a species.

To this end, the use of common sets of reference families have been proposed (28). By sharing a limited number of families for use worldwide, the collation of linkage data is greatly simplified. Reference families for cattle are being distributed (28) and such families are being prepared in other livestock species.

A complete linkage map is a powerful tool for gene mapping since it permits systematic and thorough searches of the genome for genes and genetic regions associated with specific traits. An initial goal is a 20cM index marker map i.e. where the maximum spacing between polymorphic markers on the chromosome is 20cM. Given that it is not presently possible to choose from where on the genome the markers are isolated, the initial strategy must be to randomly map markers. At some later stage, chromosomal regions which are underpresented with markers can be targeted.

Assuming a total map length of 30M as for humans, and a marker spacing of 20cM, an index maker map of the genome will require around 150 polymorphic markers. In order to achieve this target when markers are isolated at random, in excess of 500 markers will be required for each livestock species. However, 80% genome coverage could be achieved with around half that number (30). Index maker maps, based on a subset of available markers will be then used in the systematic analysis of the genomes.

5.1.3 Comparative maps

Comparative gene mapping involves the mapping of homologous gene loci in multiple species. The principal aim is to identify the boundaries of genomic conservation between evolutionary divergent species. Although the ultimate goal of comparative mapping is to understand the pathways by which chromosomal evolution has accompanied speciation, it has proved to be a
very powerful means of extrapolating mapping data from one species to another based on the establishment of conserved chromosomal segments.

Extensive gene and chromosomal homologies have now been identified between man and mouse (31) and between man, mouse and the cow (32). Although the boundaries of conserved segments need further definition, it is now possible to both interpolate and extrapolate the position of genes between these three species. Thus as genes are mapped as one species, their likely position in the other species can be predicted. This will be an important source of mapping information in the future since genome research in human and mouse has accelerated rapidly.

Chromosomal homologies between closely related livestock species have been observed at the cytogenetic level. For instance, the banded karyotypes of sheep and cattle have been matched up almost perfectly and homology has been confirmed by in situ localization of a number of genes (33). Although some minor rearrangements affecting the spacing, and in some cases the order of genes can be expected, it will be possible to exchange information between the cow and sheep gene maps.

5.2 Strategies for mapping genes

There are basically two approaches to mapping genes for which the gene product is unknown. The first of these, referred to as the candidate gene approach, relies on some background biochemical knowledge and is therefore limited in its application. The second approach which defines a linked genetic marker as an intermediate step towards cloning the gene is more generally applicable because it requires no knowledge of gene function. The two approaches are not mutually exclusive. Once the search for a gene is narrowed down to a discrete region, other genes may suggest themselves as candidates where previously they were not obviously connected. So in practice, a combination of both approaches is appropriate, especially as mammalian gene maps become denser, providing a larger number of potential candidates.

5.2.1 Candidate genes

The candidate gene approach is an attractive option because it may give a quick answer and involves an element of hypothesis testing. However, the selection of candidates should be based on solid biochemical data or physiological observations. It should be appreciated that an altered level of a particular enzyme or other gene product does not imply an alteration in the structural gene for that product. Gene expression is frequently very complex, involving a number of regulatory genes, in some cases located on distant parts of the genome to the structural gene. Nevertheless, the hypothesis of whether variability at or around the site of a gene exists, can be tested if appropriate reagents and/or sequence information and pedigrees are available. The requirements include multigeneration pedigrees with appropriate genotype and/or phenotype data. The optimum pedigree structures will differ depending on whether simple or polygenic inheritance is expected. Secondly, there is a requirement to measure genetic variability at the candidate gene locus. DNA markers are most frequently used for this purpose. By analyzing for co-segregation at the candidate gene locus and locus of interest, the hypothesis can be tested. Since the candidate gene marker effectively tags a segment of DNA, the involvement of other genes on that segment is tested simultaneously.

There are reports in the literature where candidate gene approaches have been successful. Presumably there are many other unpublished studies which have produced negative results.
cattle, a number of single gene disorders have been mapped and diagnostic marker tests developed via candidate genes. These include Pompe's Disease (34), and Bovine Leucocyte Antigen Deficiency (M. Georges, personal communication). The gene for malignant hypothermia in man and pigs was mapped in a similar way (36). In all cases, detailed biochemical data suggested a strong candidate.

5.2.2 Linked markers

Another approach to mapping genes involves an initial localization to a chromosomal segment via anonymous genetic markers. Detailed analysis of the segment can refine the localization. This approach procedure, part of the so called 'Reverse Genetics' approach to gene analysis, is inherently more laborious, but, if used methodically has a higher probability of success. The approach is equally applicable to simply inherited and polygenic effects although the optimum pedigree structures will vary and there is a limit to the size of gene effects detectable in the polygenic situation.

The basic procedure involves genotyping multigeneration families, which have been phenotyped for the trait of interest (Fig 1). The probability of detecting a linked marker or markers is directly related to the distribution of markers and the number of informative matings for linkage analysis. Ideally, the markers will be chosen from an index marker map to ensure complete screening of the genome with a minimum number of markers. However, such maps are not yet available for livestock. Assuming there are sufficient informative meioses to be analyzed, linkage between one or more of the markers and the gene or associated phenotypic effect should be found. By localizing the markers, if they have not already been mapped, the chromosomal segment carrying the gene of interest can be defined. This is a very significant step for two reasons. First, it considerably narrows down the area to be analyzed for closer markers. Second, an approximate localization of a gene allows a re-evaluation of possible candidate genes which have previously been mapped to this region. Homologous regions in other genomes can also be surveyed, thereby expanding the number of potential candidates. Recent reports where the approach of firstly localizing a gene marker followed by successfully selecting from candidate genes in the region include studies on Waardenburg's syndrome (37) and hypertension (38).

Isolation of a gene by using positional cloning techniques is still not a trivial task, although recent successes include Type 1 - Neurofibromatosis (39) and the testis determining factor (40). Nevertheless, once a gene has been mapped by flanking markers, it can be efficiently tagged within families, and used in marker based selection programmes.

5.3 Analysis of quantitative traits

By and large, the traits related to growth, reproduction, fitness, milk production, parasite and disease resistance and tolerance to climatic variables are characterized by continuous variation. Differences between individuals are of a quantitative rather than qualitative nature. This has led to the assumption that such traits are controlled by a large number of genes, each of small effect (see 41). The true genetic basis of quantitative traits has until recently, remained largely unknown, because studies were general based on statistical methods of low power. More recently and with the use of molecular genetic techniques, a more intensive analysis of quantitative traits has begun.

Evidence is accumulating that variability in such traits may be associated with a small a combination of a small number of genes of intermediate to large effect eg. 0.2 – 1.5 phenotypic
standard deviations, and an unknown number of genes of smaller effect. Recent studies on yield traits in maize (42), water use efficiency in tomatoes (43), fruit mass, and fruit pH in tomatoes (44) and predisposition to hypertension in rats (38) have strongly suggested a range of gene effects. The contribution of intermediate - large effect genes to the total genetic variation, will be small if the ir frequency is either low or high. As molecular techniques for genome analysis in livestock are refined, it is becoming feasible to analyze the genetic basis of quantitative traits. It is clear that the utilization of such genes, which may be unique to specific populations, will be facilitated by genetic markers. However the resources required to map such genes are substantial and it will therefore be important to optimize experimental designs in order to maximize the probability of success.

5.3.1 Experimental designs for quantitative trait analysis

Quantitative trait analysis measures the association between specific chromosomal segments tagged by markers and phenotypic effects. The phenotypic effects are assumed to be due to the presence of one gene or several genes on the chromosomal segment. Matings are only informative if one or both of the parents are heterozygous for both the marker and gene. The design of QTL mapping experiments fall into two categories viz analysis of crosses between breeds/lines and analyses of families within populations.

Design considerations have recently been reviewed (46). In an extension of the crossed line design, M. MacKinnon (unpublished) has evaluated within family analysis of F1 sires resulting from crosses of divergent breeds.

General conclusions from these studies are;

1. The analysis of either backcross or F2 families is highly efficient where alternative alleles have been fixed or allele frequencies are very different (eg. 0.8 vs 0.2) in the two breeds/lines. However if allele frequency differences are less than 0.5, there is considerable loss of power over some within family designs.

2. F1 cross sire families are frequently as efficient for quantitative trait analysis as F2 families, since the availability of polyallelic markers considerably reduce the need to genotype dams. However progeny group sizes must be larger than normal, eg. 100 – 150, for reasonable efficiency. F1 cross sire families are inefficient at detecting rare alleles in one of the parental breeds and are less sensitive to dominance effects than the F2 design.

3. The analysis of families within straightbred populations generally has low power because the frequency of sires heterozygous at both marker and quantitative trait locus is normally low. Progeny testing can however significantly improve power. (45)

Overall, the power of mapping experiments can be further improved by selective genotyping (35), interval mapping (35) and the use of DNA pools (19). Nevertheless, the required animal and laboratory resources remain substantial. Yet such experiments are likely to be the best approach to analyzing the genetic basis of quantitative traits, and are directly applicable to exotic and rare livestock breeds.

Crosses between resistant and susceptible cattle breeds are being generated in an attempt to understand the inheritance of trypanosomiasis in Africa (20). Other breeds with unique characteristics or adaptations could be utilized in a similar way.
6 Concluding remarks

It has been suggested that DNA technologies can assist livestock conservation and improvement in three major ways. Firstly, various forms of DNA can be stored to preserve genetic variability for future use. Secondly DNA sequence polymorphism and associated sequencing techniques provide the means to decide which livestock populations should be targeted in conservation programmes. And thirdly, gene mapping technologies are capable of identifying the discrete regions of DNA which account for unusual performance characteristic adaptations. Such information will have direct use in future breed improvement programmes. It is therefore essential that not only is livestock genetic diversity preserved, but also that investigations continue on its biological basis. These investigations will provide the foundations for future long term use of livestock with special characteristics.

Figure 1 Steps Involved in the Reverse Genetics Approach to Gene Localization and Characterization

- Segregating families ➔ Genotype with markers
  - (± candidate gene markers)
  - Linked marker ➔ Map linked marker
    - (if previously unmapped)
  - Evaluate other markers in the region
    - Closely linked marker ➔ Positional cloning
      - Isolate gene ➔ Study structure/function

7 References


E. LEGAL AND REGULATORY ISSUES FOR THE MANAGEMENT OF
GLOBAL ANIMAL GENETIC RESOURCES AND THE APPLICATION OF
RELEVANT BIOTECHNOLOGIES

A preliminary review

1 Background

From its early days FAO has been active in the field of animal genetic resources. Animal genetic resources have been subject to various conservation and management programmes since 1973. Appropriate methods for characterizing breeds and for storing germplasm have been developed and, in 1983, a joint FAO/UNEP Panel of Experts on Animal Genetic Resources Conservation and Management was established in order to coordinate and further the efforts in this field. Due to lack of funding, the Panel of Experts met only once in 1983 and again once in 1986.

In 1987, FAO embarked on the establishment of Regional Animal Gene Banks which are to become regional focal points for the cryogenic storage of semen and embryos in Africa, Asia and the Pacific, Latin America and the Caribbean. The action plan for the programme provides that two centres are to be established in each region for the storage of semen and/or embryos of threatened breeds. Once training has been provided, participating countries in each region will contribute to the gene banks free of charge.

FAO has also worked together with the European Association of Animal Production (EAAP) to establish in 1988 the EAAP/FAO Global Animal Genetic Data Bank in Hannover, Germany, for the purpose of storing genetic characterizations and population census data. The data bank will be used to produce a World Watch List of Threatened Breeds and to provide an Early Warning System to governments.

2 Recent decisions of FAO governing bodies on the animal genetic resources programme

In April 1989, the Tenth Session of the FAO Committee on Agriculture (COAG) reviewed the FAO programme of animal genetic resources. The COAG recommended its expansion into a globally effective system in order to offer support to all member countries wishing to take part.

The FAO Council, at its 95th meeting in June 1989, recognized that animal genetic resources were part of the larger topic of biological diversity and called for the programme to be expanded and further developed. Consequently, an Expert Consultation on animal genetic resources was held in September 1989. The Working Group of the Commission on Plant Genetic Resources, at its October 1989 meeting, considered the same subject.
The FAO Council, at its Ninety-eighth Session in November 1990, recommended that FAO prepare a detailed programme for the sustainable development of animal genetic resources on a global level. The FAO Council, at its Ninety-Ninth Session in June 1991, endorsed the plans for the preservation and improvement of animal genetic resources, and supported the COAG’s recommendation to hold an Expert Consultation to consider an action programme and necessary legal instruments to protect animal biodiversity.

3 Integration of institutional infrastructures for animal and plant genetic resources within one system

During its 95th Session, in June 1989, the FAO Council requested the Director General to examine the possibilities of integrating the institutional infrastructures for animal and plant genetic resources within one system, while at the same time taking account of the relationships and needs of fisheries and wildlife. The Expert Consultation on FAO programmes for the preservation of animal genetic resources, held in Rome in September 1989, recommended that animal genetic resources should not be incorporated into the FAO Undertaking on Plant Genetic Resources due to issues (for example ownership, access and rights) specific to animals and clearly different from those affecting plants.

At its Ninety-eighth session, November 1990, the FAO Council discussed the widening of the mandate of the Commission on Plant Genetic Resources to become a commission on biological diversity for food and agriculture, which would include plant and animal genetic resources. The Council agreed that the subject needed to be further discussed by both the Commission on Plant Genetic Resources and the Committee on Agriculture (COAG), taking into consideration technical, legal, institutional and financial implications.

At its Ninety-ninth Session in June 1991, the FAO Council noted that COAG had examined the question of widening the mandate of the Commission on Plant Genetic Resources to include *inter alia* animal genetic resources, but did not agree to broaden the mandate at this time. The Council recommended calling an Expert Consultation to assist in making a more informed judgement about the desirability of establishing a separate forum for animal genetic resources. Such an Expert Consultation would also assess the proposed programme on animal genetic resources.

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4 The precedent of the plant genetic resources system

In terms of institutional structure, the FAO Global System on Plant Genetic Resources developed since 1983 is relatively advanced. The objectives of the Global System are to ensure the safe conservation, and promote the unrestricted availability and sustainable utilization of plant genetic resources for present and future generations, by providing a flexible framework for sharing the benefits and burdens. The System covers the conservation (ex situ and in situ) and utilization of plant genetic resources at molecular, population, species and ecosystem level.

The basic institutional components of the system are:

1. A flexible framework, the International Undertaking on Plant Genetic Resources.
2. An intergovernmental forum, the Commission.
3. A financial mechanism, the International Fund for Plant Genetic Resources.

To date, some 130 countries are formally part of the Global System, through becoming members of the Commission, or adhering to the International Undertaking, or taking both steps.

5 The relevance of the plant genetic resources system

It is widely recognized that there are important differences in the biology, technology and methodology, and social and economic orientation between animal and plant genetic resources. Animal genetic resources are, in practical terms, more subject to private ownership than plant genetic resources. In fact, most species or breeds of animals of economic importance seem to be already in private ownership. This means that access to and rights on animal genetic resources present specific problems.

Nevertheless, a number of important lessons which could be of some relevance to the institutional and regulatory aspects for the management of global animal genetic resources can be drawn.

1. Financial resources required to support an effective programme are not likely to be forthcoming on a sustainable basis. Inactive collections of un-utilized materials do not attract conscientious capable curators and the quality of information about the materials, if not the material itself, declines.
2. Information on environmental, as well as genetic background of preserved materials, is critical to efficient utilization for scientific and economic purposes.
3. The development of an international institutional support for animal genetic resources has to cope with political and economic concerns as well as with possible activities of other institutions. In this respect the mandates and objectives of the FAO programme should be precisely defined.
4. An important lesson from experiences with Plant Genetic Resources gene banks is that good documentation and good organization are essential elements in order for these banks not to remain under-utilized. In addition, design and management of data banks should be done in concert with gene banks to ensure that essential data are available, possibly under the umbrella of the same institutional structure.

6 The definition of genetic material in the context of animal genetic resources
Discussions are currently underway within the Intergovernmental Negotiating Committee for a Convention on Biological Diversity on a definition of genetic material or genetic resources. On a provisional basis, “genetic material means hereditary material found in living organisms or parts thereof. The characteristics of an organism are derived from this material”.

In addition, a provisional definition of “animal genetic resources” is under discussion at the FAO Secretariat level in connection with the preparation of an International Undertaking on Animal Genetic Resources which is being prepared:

"Animal genetic resources means: the animals themselves as well as all somatic or germinal cellular lines belonging to:

i. species, subspecies and breeds currently exploited or newly created;
ii. outmoded species or breeds;
iii. feral or related wild species;
iv. special genetic lines."

From a legal point of view, the effectiveness of any global management of animal genetic resources will be dependent upon a clear technical definition of its objectives. It will also be necessary to define the kind of animals to be included into the International Undertaking on Animal Genetic Resources.

7 Institutional structures

The global system for Animal Genetic Resources could be built on the model of the instruments which already form the FAO global system on Plant Genetic Resources. They would be as follows:

1. The International Undertaking on Animal Genetic Resources:

   This could be an international legally non-binding agreement that would provide for identifying potentially valuable animal genetic resources that are in danger of becoming extinct as well as other animal genetic resources in the country which may be useful for development and for taking appropriate legal and other measures for their conservation and sustainable use. It should be based on the principle that animal genetic resources are subject to the sovereign rights of states.

   FAO's technical divisions and the legal office are currently working on a draft International Undertaking on Animal Genetic Resources which could provide a solid and equitable system, taking into account the rights and obligations of donors and recipients of germplasm.

2. The Commission on Animal Genetic Resources:

   A Commission on Animal Genetic Resources could be the intergovernmental global forum to monitor the operation of the Undertaking and to recommend measures that are necessary or desirable in order to ensure the comprehensiveness of the Global System and the efficiency of its operation in line with the Undertaking.
The Commission should review, in particular, all matters relating to the policy, programmes and activities of FAO in the field of animal genetic resources, and to give advice to the Committee of Agriculture.

3. The International Fund for Animal Genetic Resources:

An International Fund for Animal Genetic Resources could provide a channel for countries, inter-governmental and non-governmental organizations, private industry, and individuals to support the conservation, and promote the use of animal genetic resources on a sustainable basis, at world level. In the long term, the International Fund should become a critical element in ensuring the equitability of the Global System.

A number of other international agreements or arrangements may prove necessary to facilitate the conservation and the use of animal genetic resources.

8 Regulatory aspects of animal biotechnology

There seems to be a great potential for biotechnology in the conservation and use of animal genetic resources.

A draft Code of Conduct on Biotechnology is being prepared on an issue-by-issue basis, in close collaboration with the appropriate organizations, taking into account the equitable sharing of the benefits of biotechnology between the developers of that technology and the donors of the germplasm it uses.

Emphasis should be put on training scientists and technicians of the developing countries in the use of appropriate technologies, especially biotechnologies, so as to ensure the effective transfer and utilization of such knowledge.

9 Legal aspects of animal patenting

The subject of animals is perhaps the most complex class of products to which patent protection is to be extended. The complexity stems from the legal issues associated with anything as individual as a multicellular animal: from the complexity of the science involved with such sophisticated life forms, and from the mammoth size of the potentially affected industries.

Regarding the patenting of animals, various approaches have been followed in national legislation.

1. Concerning United States, the US Patent and Trademark Office (PTO) has issued in April 1987 a formal pronouncement of the patentability, in principle, of “non-human” multicellular organisms, be it plant or animal, that were not “naturally occurring”.


As regards the patentability of products of animal biotechnology, the draft directive ensures the patentability of living matter in general and clarifies the point that any exclusion of animal varieties shall not extend to the patenting of parts of animal varieties.
Finally, the draft directive clarifies that surgical or diagnostic methods practised on an animal body are excluded from patent protection only if practised for a therapeutic purpose.

Thus such methods as embryo recovery and transfer employed for animal production should be patentable in European Community member states in the future. The eventual adoption of the European Community draft directive would make the legal status of European law comparable to that of the USA.

12 See Animal Patents, the Legal, Economic and Social Issues, Stockton Press 1989, p.xi.


10 Impact on national and regional levels

It is expected that country level activities should greatly facilitate the establishment of national animal genetic resource programmes. The basic activities at national level would consist of the preparation of an inventory of available animal genetic resources. The establishment of appropriate national infrastructures providing support for national programmes and reviewing the situation of animal genetic resources should be recommended.

Assistance could be also provided to developing countries in order to carry out a wide range of activities including census studies, genetic characterization, preservation in situ and ex situ, documentation, genetic improvement, comparative evaluation and exchange of germplasm.

Regional level activities will be focused on the existing Regional Animal Gene Banks. An important contribution of the regional centres will be also to provide technical and, where necessary, material assistance to national governments cooperating in the Regional Animal Gene Bank. With regard to the legal status of the germplasm collections of the regional centres, a review of establishments and headquarters agreements of centres holding and maintaining germplasm collections should be carried out.
1 Introduction

Widespread concerns about the loss of genetic diversity from domestic livestock populations are of relatively recent origin. However, within the past few decades many reports have called attention to such losses and the probable future consequences (Maijala et al, 1984; FAO, 1984a,b; Hall 1990). Public awareness and concerns have been stimulated by the well-publicized losses of species, especially in tropical rain forests. This has led to calls for action programmes by existing organizations and the establishment of new organizations to conserve genetic diversity.

Loss of species diversity is not a concern for domestic livestock. However, there is potential for loss of genetic diversity within the 30 plus domesticated mammalian and avian species. The nature of these losses and their consequences have relevance to the organizational structures required for conservation.

To date, most attention about loss of genetic diversity has been directed towards rare breeds in developed countries - particularly in so far as attention has been translated into action programmes. However, most who have studied the problem agree that both the greatest diversity and the highest loss potential are in the developing regions (FAO, 1984a,b). This, too, has important ramifications for programme and organizational requirements.

Significant advances in biotechnology in the past decade have increased the value of genetic diversity as well as the potential for genetic erosion. Additionally, social and economic issues arise with the growing ability to modify domestic livestock through genetic engineering. These require an organized forum for debate and resolution.

As a consequence of concerns for genetic diversity, the Board on Agriculture of the US National Research Council, National Academy of Science undertook the study: “Managing Global Genetic Resources: Agricultural Imperatives”. A subcommittee on animal genetic resources was assembled to develop a report on livestock genetic resources.

1 International Livestock Centre for Africa (ILCA), P.O. Box 5689, Addis Ababa, Ethiopia.

2 American Association for the Advancement of Science, 1333 H Street NW, Washington, DC. USA.

3 The subcommittee included H.A. Fitzhugh (chairman), E.L. Henson, J.Hodges, D.R.Notter, D. Plasse, L.L. Setshwaelo, T.E. Wagner and J.E. Womack; committee staff were B.Ballachey, J.A. Pino, and M.S. Strauss.

The deliberations of this subcommittee have substantially influenced the views expressed in this paper; however, other sources and the authors' own experience are also brought to bear on the topic of organizational and institutional structures for management of animal genetic resources.

2 Approach to conservation
Two general approaches can be discerned in livestock conservation: utilization and preservation (Notter and Strauss, 1992). In the first approach, priority is given to utilization of genetic resources to improve livestock production. Emphasis is given to the fact that most genetic diversity is maintained in working herds and flocks kept by farmers and pastoralists around the world. Utilizationists endorse the preservation of that genetic diversity which has current or potential utility, including scientific as well as commercial uses.

The preservationists emphasize importance of preserving all genetic diversity, because of the difficulty of predicting future needs accurately. Cultural and historical values associated with breeds also are considered. Emphasis is placed on maintaining breed identity.

Proponents of both approaches can, however, agree that conservation of genetic diversity is an essential component of sustainable livestock improvement, given the vagaries of future production and market requirements. Recognizing the limited resources available to support conservation, priorities must be set both in terms of genetic diversity to be conserved and the conservation programmes and organizational structures developed and supported. Minimally, conservation should focus on that genetic diversity which either has potential economic value or is both threatened and biologically unique.

2.1 Maintenance of breeding populations

Most genetic diversity will be maintained in herds and flocks for agricultural production. Most of these are privately owned. As long as the effective population size \((N_e)\) remains sufficient, directed conservation efforts are not needed. For effective populations that are declining sharply in number or those which are already small, purposeful conservation in live herds or flocks allow continued adaptation to changing environmental conditions.

Conservation may involve maintaining breed integrity through pure breeding or through crossbreeding to establish gene pools. The organizational requirements and net costs of conservation through maintenance of breeding populations largely depend on the type and amount of income earned from sale of livestock products (including fees earned from exhibiting rare and unusual breeds). Generally, however, some external subsidy is required because most breeds have become rare because they are not economically competitive under prevailing production and market conditions.

2.2 Cryopreservation of gametes and embryos

The major costs for conservation are in sampling populations. However, when the costs of collection are combined with those for maintaining frozen specimens they are low, relative to the maintenance of breeding populations (Smith, 1984a,b). There are differences among and within domestic species in the success rate for cryopreservation. However, the presumption is that research can improve success rate where there are difficulties. The greater problems (which have increasing political overtones) are deciding where frozen stores will be maintained and the criteria determining who has access to them and for what purpose.

3 Conservation activities

Organizational support will be required for a range of activities in order for conservation programmes to be effective.
3.1 **Inventory and characterization of existing populations**

Priorities for conservation should be populations sharply declining or already small in number, especially if these populations are genetically unique. Much progress has been made in the inventory and characterization of livestock populations in developed regions (e.g. Maijala et al., 1984) but little is known about population number or biological characteristics of livestock in developing regions. Biotechnological advances provide additional means to measure genetic distance between populations as part of the process to identify candidates for conservation.

3.2 **Genetic evaluation**

Characterization, at least in the early stages, will likely concentrate on phenotype because of limited time and financial resources and limited knowledge of relationships among individuals sampled. However, decisions on sampling for conservation and for future utilization of genetic resources will require evaluation at genotypic level. This has major organizational implications, particularly in the need for programme continuity at least equivalent to the life cycle of populations being evaluated. Use of genetic markers and other biochemical tools may shorten this time requirement in future.

3.3 **Maintenance**

Whether as breeding populations or frozen stores, organizational requirements are for stability and continuity over an indefinite time period. Unless these organizational requirements can be met with high degree of certainty, initiating programmes may actually do harm. At minimum, failure will discourage future initiatives. And if a population is seriously at risk, the sampling process may further erode genetic diversity to no avail.

3.4 **Research**

Although technologies are available to support effective conservation of most livestock species, research is needed to provide more efficient, less expensive technologies. These are needed to improve the success rate of cryopreservation for sheep, goats, pigs, horses, poultry and most minor domestic species. Readily applicable molecular techniques are needed to help characterize genetic diversity and measure genetic distance between populations.

3.5 **Training**

Training is an effective means of mobilizing and motivating technical personnel required to staff conservation programmes. Generally these personnel, whether from private or public sector, will service conservation on part-time basis. They may include farmers, extension agents, veterinarians, AI specialists, as well as scientists. Training is needed in the areas of inventory and characterization, data base management, sampling and performance evaluation, maintenance of living herds and frozen stores, etc.

3.6 **Public awareness**

Public concerns that genetic diversity is at risk is an important element in directing attention and securing resources to conservation programmes. Short-term private interests may be set aside if the long term public interests served by conservation efforts are generally known. In any
event, organizations involved in conservation require considerable resources, some of which may come from private sector, but most will come from the public sector.

4 The plant conservation experience

It is useful when considering programmes for conserving livestock genetic resources to examine the experiences and lessons from plant genetic resources conservation. Efforts to conserve plant germplasm have been ongoing for most of this century, but it was not until the 1960s that their importance gained major international prominence. An FAO technical conference, held in the late 1960s, alerted the scientific, agricultural, and policy communities to the need to conserve plant germplasm for future use. Since then, national and international conservation programmes and a loose global network have been established (Anishetty and Esquinas-Alcazar, 1991; Plucknett et al., 1987; Keystone Centre 1990, 1991).

In total, world collections of plant genetic resources comprise approximately 3.5 million accessions. Half of these are conserved in subfreezing storage. Some fifty nations have facilities for long term storage with more than half of these (29) located in developing countries. Global expenditures for plant germplasm conservation are an estimated US$75 million (Keystone, 1991).

Plant germplasm conservation efforts have not, however, developed without encountering some significant challenges. Today, there are national and international efforts in the public and private sectors. These programmes do not always co-operate and important questions of ownership and control of germplasm remain to be resolved.

Plant germplasm programmes include those sponsored or administered by governments, international organizations, and those co-ordinated through private nongovernmental organizations, including botanic gardens and arboreta. While the goals for all such programmes are largely the conservation of plant genetic resources, the methods and objectives may differ.

Most frequently, governmental programmes seek to preserve agricultural genetic diversity for use in breeding and development. These programmes have historically focused on landraces, breeding lines, and a few related wild species. By contrast, private nongovernmental organizations (NGOs) frequently preserve particular obsolete or antique cultivars for cultural, historical, or social reasons as well as to conserve crop genetic diversity. These efforts may also be linked to preserving traditional agricultural systems and community or on-farm conservation. Worldwide, NGOs foster on-farm conservation of approximately US$7 million annually (Keystone Centre, 1991).

4.1 National programmes

National programmes have been identified as the essential core for plant conservation activities (Keystone Centre 1990). There is, however, no uniform model for public sector national programmes. Activities are most frequently administered through a ministry of agriculture, but range from those operating a central seed bank, such as programmes in Greece, Italy, or a consortium of Nordic countries; to the more decentralized system of sites and activities of the U.S. NPGS.

A national programme to conserve genetic resources may have many elements (Keystone Centre, 1991). In addition to collections of seeds or plants, these include facilities and staff for
collecting, managing, multiplying, characterizing, and documenting holdings; linkages to crop breeding and improvement programmes; and for large programmes, a formal co-ordinating mechanism to include the concerns of NGOs, private industry, and relevant conservation groups.

Significant government-sponsored plant conservation efforts exist in developed and developing nations. The National Plant Germplasm System (NPGS) of the United States is the largest and most diverse. Important and growing programmes exist in virtually all regions. Many, such as those in India, Ethiopia, and China have received significant bilateral aid from industrialized countries for their development. FAO and IBPGR also have supplied assistance in the form of equipment, expert advice, and information to establish national programmes.

NGOs, such as the Seed Savers Exchange (SSE) in the U.S., frequently depend on a network of non-technical volunteer farmers or gardeners to preserve seed. SSE serves as a model for independent seed conservation networks around the world. Another private group, Native Seed/SEARCH, includes aspects of in situ monitoring and conservation, particularly within the American Southwest. Similar programmes to preserve heirloom and antique crop varieties, such as Arche Noah, which coordinates more than 200 individuals in European German-speaking countries, exist.

Although many of the goals of NGO and government-sponsored conservation efforts may differ, they should not be considered mutually exclusive. Neither, however, should they be seen as competitive. Because the holdings of each are to some extent unique, the potential exists for the exchange of both germplasm and technical assistance. Thus, it is important for national programmes to allow for co-operation between the private and nongovernmental sectors. Because they frequently operate at the community level, NGOs foster increased public awareness and support of conservation and, thereby, may benefit more formal national programmes (Keystone, 1991).

Despite significant growth in national programmes for conserving plants since 1970, much remains to be accomplished. Collection size for many major crops has grown to a degree that the cost of their maintenance threatens to exceed the available resources. Proposals for establishing core subsets of large collections are intended to address this by improving access, guiding priorities for such activities as characterization and evaluation, and providing a mechanism for more rational genetic screening of collections (Brown, 1989a,b; Marshall, 1989; NRC, 1991, Strauss et al., 1988). Collecting of wild species that could provide important genetic improvements and traditional landraces in many areas is needed.

With political and economic changes, such as those in the former Soviet Union, have come fiscal constraints and changing priorities that can render the future of historically important collections unsure. In such situations the links with other national and international programmes can provide security against loss.

Ultimately, conservation efforts must be an essential part of national agriculture, development, or environment programmes. Despite bilateral or international funds to support facilities construction, some national programmes have not functioned effectively because of a lack of basic operating funds or adequately trained personnel (Keystone Centre, 1991). In the absence of such support, germplasm programmes become little more than what one report has termed “seed morgues” (Goodman and Castillo-Gonzales, 1991).
4.2 International programmes

International programmes are the mechanisms for linking diverse national programmes. They provide important resources of information, germplasm conservation, co-ordination, and a limited level of funding. Involvement ranges from the major collections of the International Agricultural Research Centres (IARCs) to the policy and community-level advocacy of NGOs such as the Rural Advancement Foundation, International (RAFI).

The collections of IARCs are important elements of the global plant genetic resources effort. At least twelve of the centres of the Consultative Group for International Agricultural Research (CGIAR) are involved in aspects of the conservation and use of plant genetic resources. These centres have provided collections to national programmes, trained national germplasm scientists and technicians, supported exploration and collection, fostered in situ conservation of unique materials, and been leaders in the use of germplasm in crop improvement, particularly in developing countries.

The establishment of the International Board for Plant Genetic Resources (IBPGR) as part of the CGIAR in 1974 was a significant step forward in the fostering of national and international conservation (Keystone Centre, 1991). IBPGR has coordinated a wide and diverse array of programmes and encouraged establishment of many national efforts. For the future it is looking to the establishment of crop networks and the support and encouragement of research to improve conservation, management and use of germplasm.

The FAO has long provided a forum for discussions and the advocacy of germplasm conservation, management, and use. Through the Commission on Plant Genetic Resources and the Undertaking on Plant Genetic Resources, the FAO provides for discussion and airing of national and international concerns. In the past, the relationships between FAO Commission, the IBPGR, and national programmes have been strained, but recent developments within the Commission and the imminent move of IBPGR from FAO (to become the International Plant Genetic Resources Institute, IPGRI), have led to improved, co-operative arrangements (Keystone Centre, 1991).

Private, nongovernmental groups, such as RAFI and the Genetic Resources Action International (GRAIN) work to influence national and international policies related to germplasm access, management, and use. They operate through liaison with other international organization, such as the FAO or the European Community (Keystone Centre, 1991). At the national and regional level they may provide support to community-based activities.

Some regional networks of national programmes co-operatively support facilities. These provide links for programmes having common concerns but limited resources. Examples include the collaboration of the Southern African Development Co-ordination Conference (SADCC) countries to foster the development of national programmes among its member states (Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe) and to operate a regional bank for crops and forest seeds (Kyomo, 1991). The Centro Agronómico Tropical de Investigaciones y Enseñanza (CATIE) is an active centre for regional research and co-operation in Central America. Other examples of regional co-operation include the Nordic Gene Bank, the Andean Crop Network, the Southeast Asian Regional Committee on Plant Genetic Resources; the European Cooperative Programme on Genetic Resources, and the Mediterranean Gene Bank.
4.3 Private industry

Industry has continued to play a role in the conservation and use of genetic resources. This has historically been a source of controversy for some who have viewed the involvement as detrimental to the welfare of developing countries (see for example, Fowler and Mooney, 1991). The involvement of industry has been in a relatively few major, largely grain, crops; and primarily as a user of germplasm resources.

Emerging technologies have provided powerful new tools for isolation and use of specific genes. Private industry has frequently been in the forefront of developing and applying these tools to the improvement and development of major crops. This, however, has led to discussion of patenting and other forms of proprietary protection, which in turn has led to debate in fora such as the FAO Commission about ownership, exchange, and use of genetic resources.

5 Organizational and institutional structure for livestock programmes

The organizational requirements for effective conservation of livestock genetic diversity obviously start at the local level where the populations to be conserved are found. Most conservation efforts at the local level will depend on the interests and priorities of individual farmers. However, there may be an opportunity to establish conservation activities within producer associations. Breed societies and groups of producers who share interest in conservation can provide necessary organizational infrastructure for maintaining data bases and gene banks (e.g. the British Rare Breeds Survival Trust which has 8500 members, 1000 of whom keep small herds of rare breeds).

Although specific circumstances vary from site to site, the general requirements of conservation programmes will be consistent across locales and even across national boundaries. In contrast, public interests, policies and priorities (and institutional capacities to service conservation programmes) vary greatly among nations. Therefore, the success of a global programme for management of animal genetic resources rests on establishment of effective programmes at the national level which address these specific national priorities.

In support of national programmes, international activities should focus on:

- providing a forum for debate and development of options on technical issues such as priorities for conservation, such as defining when is a breed at risk; and on legal issues, such as patents;
- developing minimum standards for inventory, characterization, sampling, evaluation of germplasm, and its safe international movement;
- providing training in conservation methodologies (usually for trainers who return to national programmes);
- mobilizing international political and financial support for national programmes;
- facilitating organization and operation of regional initiatives;
- and when appropriate, establishing and operating facilities shared by national programmes, such as central data bases or cryogenic stores.

5.1 National programmes

National programmes should address the dual goals of aggressively pursuing genetic improvement while protecting the genetic resource base required for future improvement. They
should coordinate public and private efforts within the country and with relevant regional and global programmes. Therefore, a single entity should be given a clear mandate to coordinate the national programme. This may be an institution, an agency, a standing committee or even an individual as long as there is a clear mandate and necessary resources are provided.

Important elements of national programmes include:

5.1.1 *Inventory, characterization and documentation*

Assessment should be made of population number, status, (increasing, decreasing, stable) and vulnerability including risk of dilution or replacement by different populations. All populations should be characterized phenotypically and genetically with first priority given to indigenous populations and those thought to be at risk of loss of genetic diversity. Populations at risk should be monitored periodically to assess current status. Nations may pool resources to develop and maintain computerized data bases with the caveat that there must be clear agreement about who has access to data and under which circumstances.

5.1.2 *Conservation of unique and threatened populations*

Although most genetic diversity is maintained in working herds, threatened breeds may not be commercially viable. National programmes may provide subsidies for private efforts to conserve these stocks (Henson, 1990). Cryogenic stores of gametes and embryos will most likely be managed by public institutions, (e.g. research organizations); however, commercial firms might also contract to provide these services.

5.1.3 *Collaboration with other conservation programmes*

Collaboration should take many forms including participation in international fora which develop standard procedures, provide training, support cooperative data bases and gene banks, propose policy options on access, movement and utilization of germplasm and other legal and technical issues. Collaboration with regional data bases and gene banks will often be more cost-effective and may encourage financial support from these developed countries concerned with conservation of genetic diversity in developing countries.

5.1.4 *Research*

Priority research needs include: characterization and evaluation of indigenous populations; cryopreservation technology for avian semen, swine and poultry embryos, and semen and embryos from minor species and wild relatives; development of effective field techniques for collecting semen and embryos; molecular techniques to measure genetic differences within and between breeds; development and utilization of DNA libraries; and methods for fertility and reproductive enhancement.

Results from basic, strategic and most applied research can be readily transferred among agro-ecological zones and nations. However, national capacity is required for adaptation of technologies to the specific local requirements for conservation of genetic diversity. National scientists in developing countries have major comparative advantages in terms of access to local populations. These advantages include first-hand knowledge of local production conditions, long term continuing presence required for life cycle characterization, and the political approval more likely to be granted to nationals.
5.1.5 Policy

An agreed national policy for conservation of animal genetic resources is essential. Elements of this policy include decisions on legal issues involving ownership and access to data bases and germplasm, especially those maintained with public support. These issues have become increasingly complex with the availability of research-based biotechnologies to manipulate genetic diversity (Belcher and Hawtin, 1991). The development of an effective policy will depend on building consensus among representatives from private and public sector including both non-profit and for-profit organizations. This will not be a simple task because the vested interests of these groups often do not coincide.

5.2 International programmes

International programmes include both regional or global levels. Established regional organizations such as the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Central America, the Inter-African Bureau for Animal Resources of the Organization for African Unity (OAU-IBAR) in Africa and the Southern African Centre for Cooperation in Agricultural Research (SACCAR) in the Southern African Development Coordination Conference (SADCC) region have in place intergovernmental agreements which could allow them to service regional programmes for conservation of genetic diversity. However, these regional organizations were not established for this purpose. Therefore, an expansion of their mandate will be required, and perhaps, the establishment of necessary infrastructure (e.g. computerized data bases, cryogenic stores).

Even if effective national and regional institutional structures are established, a global mechanism is required as well. Three options can be envisioned.

5.2.1 Institutes within CGIAR

As described earlier, IBPGR has been an effective means to promote and coordinate the inventory, collection, exchange, evaluation and preservation of crop germplasm. Within CGIAR, two centres have a livestock mandate: International Livestock Centre for Africa (ILCA) and International Laboratory for Research on Animal Diseases (ILRAD). Both are based in sub-Saharan Africa; however, ILRAD has a global mandate for animal disease and much of ILCA’s research is relevant to livestock production systems outside Africa. With respect to research on genetic diversity, ILRAD collaborates with other research institutes mapping the bovine genome. ILCA supports substantial efforts by national and ILCA scientists to analyze performance records and describe African livestock populations (cattle, sheep, goats). Additionally, the evaluation of performance of cattle and sheep under trypanosomiasis challenge has received particular attention by ILCA in the past decade. A new initiative to inventory and characterize indigenous populations of cattle, sheep and goats in sub-Saharan Africa has started in 1992 (Rege, 1992). This initiative will contract with national scientists to inventory and describe local population following standard protocols to obtain minimum essential data for characterization.

These efforts by ILCA and ILRAD can provide a base for extension outside Africa. However, there would be value in an institution such as IBPGR to coordinate research based conservation of animal genetic resources on a global basis. Establishing a new institute within the CGIAR would require additional new funding or major reductions in ongoing programme activities of existing CGIAR centres; neither seems appropriate. A less costly option would be to expand the mandate of IBPGR to include animal genetic resources. Another possibility would be to expand
the mandate of ILCA outside sub-Saharan Africa and to change ILCA programme strategy to include all livestock (currently ILCA only deals with cattle, sheep and goats). Conservation activities within CGIAR would necessarily focus on research.

5.2.2 Conservation organizations

Organizations such as the World Conservation Union (IUCN) and the Worldwide Fund for Nature (WWF) have been in the forefront of developing public support for conservation. The IUCN membership includes governmental as well as nongovernmental organization. It has been highly effective in fostering international cooperation for conservation, developing and maintaining data bases, monitoring populations at risk and generally supporting conservation efforts. However, IUCN does not address livestock at present. Philosophical conflicts between the environmental priorities of IUCN and similar organizations and economic development through livestock might also arise.

5.2.3 Food and Agriculture Organization

FAO has been concerned with animal genetic resources for more than two decades. In 1973, FAO and UNEP initiated a livestock conservation programme and, subsequently, in 1980 established the Joint Expert Panel on Animal Genetic Resources Conservation and Management. This panel has developed technical recommendations on data bases, cryogenic storage, genetic engineering and other aspects of conservation and utilization of animal genetic resources, especially for developing regions.

The FAO and UNEP have encouraged and supported both national and regional efforts to manage animal genetic resources. Regional activities have included establishment of the Expert Committee on Animal Genetic Resources by the OAU-IBAR; a commission on evaluating and conserving animal genetic resources in Latin America within the Asociacion Latino-americana de Produccion Animal (ALPA); and an expert committee on animal genetic resources within the Society for the Advancement of Breeding Researches in Asia and Oceania (SABRAO). The European Association for Animal Production (EAAP) established a working party which assists and coordinates various European activities involving animal genetic resources. In 1985, EAAP supported development of a central data base for European countries by the University of Hannover, which has been expanded in cooperation with FAO to create the Global Animal Genetic Resources Data Bank (Simon, 1990).

FAO and UNEP have also supported training courses for scientists, development of manuals on operation of data bases and gene banks, and publications describing indigenous livestock populations in developing countries and regions, including China and the former Soviet Union.

In recent years, funding has not been adequate for FAO to implement many of the recommendations made by the Expert Panel and other advisory committees. However, a five-year, five point programme has been recently announced (Food and Agriculture Organization, 1992). The goals of this programme are:

- A world inventory of native livestock breeds and strains
- Establishment of conservation banks of frozen semen and embryos of animals judged to be threatened and valuable
- Conservation programmes in developing countries to save threatened livestock breeds in their native habitats
• Use of DNA technology to determine genetic characteristics of livestock in the developing world and to help in the improvement of breeds
• Development of the first international legal framework on the global trade in animals and their germplasm, and on the intellectual property rights related to animal genetic resources.

The announcement indicated that the programme would be “…funded jointly by FAO, international donors and the participating countries in the developing world. Those nations would provide the physical infrastructure and operating costs, largely in kind. FAO will fund the major professional staff costs, plus professional support costs, and technical consultancies. Donor funding of $15 million is sought to meet the direct action costs of the programme.” (Food and Agriculture Organization, 1992)

6 Conclusions

The most effective global strategy to promote and secure conservation of animal genetic resources will combine the best elements of the three options presented. By doing so, organizational strength in building research, public awareness, development and coordinating programmes will be combined. However, there will be need for a single institution to assume leadership for this effort. The FAO, because of its record of activities in this area is a most appropriate institution for facilitating and coordinating a global effort. However, because of the significant levels of extra budgetary funding that will be required, FAO will need to secure and maintain confidence of potential donors in its ability to accomplish this task. Essential to this will be actions that will prevent the animal genetic resources activities from becoming embroiled in the political controversies that have, in the past, hindered plant genetic resources efforts.

Perhaps the most important lesson to be gained from the experience with plant germplasm conservation is the need for continuing international dialogue. While it may not be necessary to establish a parallel commission for livestock, it is essential that a continuing flow of information about national and international activities be maintained. This information provides a basis for establishing cooperative efforts and enables limited international resources to address the most urgent needs.

The significant of the issue of proprietary ownership of germplasm must not be underestimated. For plants, it is somewhat simplified by the uniqueness of the seed as a fully contained, reproducible unit. The issues of access and control of resources become more complex where regional facilities must depend on original donors for renewal of accessions, as might be the case for animal semen or embryo storage.

Ultimately, the basis for success must rest on the establishment of functional national programmes. This does not necessarily imply creation of institutes, laboratories, or storage facilities in all nations. However, it minimally necessitates the commitment to conservation of genetic resources in the form of an agreed national policy and programme. Operational responsibilities can fall to national institutes or cooperative regional programmes. Such efforts must be closely linked to the use of conserved resources for the support and economic development of national agriculture.

The need is sufficiently great that all institutions - whether private or public - should pool their capabilities and seek complementarities in order that a global conservation programme will be successful.
7 References


AGENDA

Tuesday, 7 April 1992

SESSION 1. OPENING

0830 – 0900 Registration

0900 – 0930 Opening statement: Dr. H.de Haen, Assistant Director-General, Agriculture Department
Election of Chairman and Vice-Chairman

SESSION 2. GENERAL INTRODUCTION

0930 – 1000 Review of past and present activities and potential for the future:
Dr. J. Hodges

1000 – 1045 FAO outline policy:
Dr. E.P. Cunningham, Director, Animal Production and Health Division, FAO

1100 – 1245 Issues and financial requirements of a global programme for animal genetic resources: Dr. J. Hodges

Session 3.
MONITORING ANIMAL GENETIC RESOURCES AND CRITERIA FOR PRIORITY ORDER OF ENDANGERED BREEDS

1400 – 1730 Monitoring animal genetic resources and criteria for prioritization of endangered breeds: Prof. K. Maijala, Prof. I. Bodo

Wednesday, 8 April

SESSION 4.
PRACTICAL ISSUES FOR THE CONSERVATION AND IMPROVEMENT OF PRIORITY BREEDS

0900 – 1230 Practical issues for the conservation and improvement of priority breeds - individual species and breeds: Prof. C. Chantalakhana, Prof. J. Philipsson, Dr. R. Ponzoni, Dr. L. Ollivier, Prof. C. Novoa, Dr. R. Crawford, Prof. I. Bodo, Dr. M. Woodford.

1400 – 1800 General approach: Prof. J.S.F. Barker.
Thursday 9 April

SESSION 5
FUTURE ROLE OF BIOTECHNOLOGIES IN THE CONSERVATION AND IMPROVED USE OF ANIMAL GENETIC RESOURCES

0900 – 1030 Future role of biotechnologies in the conservation and improved use of animal genetic resources: Dr. J. Hetzel

SESSION 6
LEGAL AND REGULATORY ISSUES FOR THE MANAGEMENT OF GLOBAL ANIMAL GENETIC RESOURCES AND THE APPLICATION OF RELEVANT BIOTECHNOLOGIES

1030 – 1230 Legal and regulatory issues for the management of global animal genetic resources and for the application of relevant biotechnologies:
Dr. L. Bombin.

SESSION 7
ORGANIZATIONAL AND INSTITUTIONAL STRUCTURE

1400 – 1600 Organizational and institutional structure: Dr. H.A.Fitzhugh and Dr. M.Strauss.

SESSION 8
AGENDA FOR ACTION AT NATIONAL AND INTERNATIONAL LEVELS

1600 – 1800 Agenda for action at national, regional and international levels

Friday 10 April

SESSION 9.
APPROVAL OF RECOMMENDATIONS

0930 – 1230 Agenda for action: conclusions and recommendations
1400 – 1530 Approval of recommendations
1600 Closing of the Expert Consultation
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Dr. R. Kwaschik, Associate Professional Officer, Research Development Centre, Research and Technology Development Division
2. Eradication of hog cholera and African swine fever, 1976 (E F S)
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<td>Genetic improvement of hair sheep in the tropics, 1992</td>
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