Tropentag 2006
Bonn, October 11-13, 2006

Conference on International Agricultural Research for Development

Insights from FAO's State of the World's Animal Genetic Resources reporting process

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Abstract

FAO's programme for Animal Genetic Resources (AnGR) Management is guided by the Commission on Genetic Resources for Food and Agriculture. Important elements are reporting on the status of animal genetic diversity and supporting the development of methodological tools to support decision-making and implementation of national AnGR management programmes. As a first step in the reporting process, FAO invited 188 countries to submit national reports on AnGR management. The process also included the establishment of a network of National Coordinators and Consultative Committees. Subregional training and follow-up workshops were organized. The Country Reports were seen as the base for developing the first report on the State of the World's Animal Genetic Resources (SoW-AnGR). A total of 169 Country Reports were received. The 148 reports available by June 2005 were used to assess institutional and human capacity, breeding and conservation programmes, use of biotechnology, and legal frameworks affecting AnGR management. The analysis of FAO's Global Databank for Farm Animal Genetic Resources revealed a total of 7616 breeds reported world-wide, 20 percent of which are classified as at risk and 9 percent of which (mostly in Europe) are already extinct. Large differences in countries' AnGR management capacities were apparent between, but also within regions. As expected, human and institutional capacities in Europe, North America, Australia, and parts of Asia and Latin America are more developed than elsewhere. The SoW-AnGR report also analyses scientific methods and tools related to AnGR management. Although research interest has increased in recent years, there remains a great need for improved methods for characterization, and for defining goals and organizational structures for breeding and conservation programmes, in particular in lower input production systems. Concerted efforts are also needed to improve criteria for prioritizing breeds for genetic improvement and conservation programmes at national, regional and international levels. Plant genetic resources have long been acknowledged as part of human heritage, and awareness has grown that the same is true for animal genetic resources. To maintain at least the most precious part of this heritage clearly requires more coordinated efforts and a rapid increase in human and financial capacities.

Keywords: animal genetic diversity, erosion of animal genetic resources, management capacities, State of the World report, global assessment

Reporting process

In 1990, FAO member countries requested the organisation to prepare a comprehensive programme for the sustainable management of animal genetic resources for food and agriculture

(AnGR). In response, the Global Strategy for the Management of Farm AnGR[1] was developed, and is being guided by FAO's Commission on Genetic Resources for Food and Agriculture (CGRFA) (167 member countries and the European Community). Assessment of the status of AnGR management at country level and of methodological tools to support decision-making was considered to be an important first step in the programme. In 1999, the CGRFA agreed that FAO should coordinate the preparation of a country-driven first *Report on the State of the World's Animal Genetic Resources* (SoW-AnGR). To initiate the reporting process, FAO in March 2001, invited 188 countries to submit reports on AnGR management.

The reporting process included the establishment of a network of National Coordinators and Consultative Committees. Guidelines for Country Report preparation were agreed by the countries. Fifteen regional training workshops were organized between June 2001 and August 2002. Subsequently, fifteen follow-up workshops were held to report on progress and exchange experiences. The process of developing the first SoW-AnGR report was considered as important as the outcome.

The overall objectives of the Country Reports were to analyse and report on the state of AnGR, on the status and trends of these resources, and on their current and potential contribution to food, agriculture and rural development; to assess the state of the country's capacity to manage AnGR, in order to determine priorities for future capacity building; and to identify national priorities for action in the field of sustainable conservation and utilization of AnGR, along with related requirements for international cooperation. The first Country Reports were received in the second half of 2002, the majority were submitted during 2003 and 2004, and the last in October 2005, which brought the total to 169. In addition to the Country Reports, nine reports from international organizations were received. Moreover, to address specific topics, such as the impact of emergencies on AnGR, access and benefit sharing, and the use of biotechnologies, a number of thematic studies were commissioned by FAO. The draft SoW-AnGR report will be reviewed by the Inter-governmental Technical Working Group on Animal Genetic Resources (ITWG a subsidiary body of the Commission) in December 2006 and by the Commission in June 2007, and presented at the First International Technical Conference on Animal Genetic Resources to be held in Interlaken, Switzerland (1–7 September 2007).

Content and preparation of the report

The report commences with a description of the state of livestock diversity. It includes information on the origin and domestication of AnGR; the status of livestock diversity; a section on utilization, sharing and exchange of AnGR; a discussion of threats to AnGR such as disease epidemics, disasters and emergencies; as well as information on genetic resistance to diseases. The description of the status of livestock diversity is based on an analysis of FAO's Domestic Animal Diversity Information System (DAD-IS), which had been updated with breed-related data extracted from the 169 Country Reports. The other sections in the first chapter, and the chapters on livestock sector trends drew largely on the wider scientific literature, expert knowledge and on FAO's statistical database (FAOSTAT), rather than on the information gathered specifically for the SoW-AnGR process.

A chapter describing the state of human capacity, breeding and conservation programmes, legislation and biotechnologies is the result of detailed analyses of the 148 Country Reports available by June 2005. A chapter on the state of the art in AnGR management consists of several

[1]The term "farm animal genetic resources", used by FAO earlier on, had been criticized on the grounds that it appeared to exclude animals not kept on farms, but in mobile systems. Fish are excluded as management requirements and breeding techniques are very different.

sections written by experts in the respective fields. These four thematic chapters are complemented by a summary of the main gaps in current AnGR management, which is then related to available capacities and the state of knowledge regarding relevant methodologies.

Findings

Status of livestock diversity

Systematic documentation of AnGR on a supranational level commenced in Europe in the 1980s. In the early 1990s, FAO started building up the Global Databank for Farm Animal Genetic Resources (Global Databank). This data bank forms the backbone of DAD-IS (http://www.fao.org/dad-is/), which was launched in 1995. National-level information is being actively entered into the system by, currently, 140 officially appointed National Coordinators for the Management of Animal Genetic Resources. FAO analysed the information reported by countries in 1993, 1995 and 2000 in three consecutive editions of the World Watch List for Domestic Animal Diversity. FAO's role in assessing the state of AnGR diversity is recognized by the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD). Decision V/5, taken at the fifth meeting of the COP in 2000 states that "Country-driven assessments of genetic resources of importance for food and agriculture...shall be implemented, including through programmes of FAO".

By January 2006, the number of recorded within-country breed populations had risen to 14 017 – more than double the number recorded in 1999. This large increase has occurred because countries have now been encouraged to report not only on their local breeds, but also on imported genetic resources. It can be assumed that as a result of the massive effort undertaken by 169 countries in preparing Country Reports, and FAO's effort to extract breed-related information from these reports and integrate it into the Global Databank, the documentation of existing national livestock populations is now much more complete than in the past. However, large gaps remain in the data related to population size and structure. Similarly, data on breed characteristics, such as basic descriptions of physical characteristics, unique traits and genes, and the breeds' typical production environments, remain incomplete. Overall, the status of reporting is less complete for avian species than for mammalian species.

In January 2006, the Global Databank included information from 182 countries and 34 species of birds and mammals. More than half (6 792) of the 13 328 within-country breed populations occur in more than one country. A first attempt has, therefore, been made by FAO to link breed populations that may belong to a common gene pool and therefore be considered the same breed. These breeds have been termed "transboundary breeds", as opposed to "local breeds" which occur only in one country. The linking of breeds was based on expert knowledge, and National Coordinators were asked to review the proposed linkages. Transboundary breeds were further differentiated into "transboundary regional" and "transboundary international" breeds. Transboundary regional breeds were defined as those that are found in only one of the seven regions used for the purposes of the SoW-AnGR report (Africa, Asia, Europe and the Caucasus, Latin America and the Caribbean, the Near and Middle East, North America, and the Southwest Pacific); transboundary international breeds were defined as those present in more than one region. This rather schematic categorization needs further refinement, as some neighbouring regions, e.g. Africa and the Near and Middle East, share AnGR, which are now considered to be transboundary international breeds, but actually rather have a regionally limited distribution.

Taking account of the above-described linking process, the overall number of breeds reported is 7 616, of which 6 536 are local and 1 080 transboundary breeds. The latter can be divided into 523 regional transboundary breeds and 557 international transboundary breeds. Excluding extinct breeds, 4 956 mammalian and 1 970 avian breeds have been reported (Figure 1). While in mammalian species the number of regional and international transboundary breeds does not differ much, the number of transboundary international breeds in avian species is double the number of transboundary regional breeds.

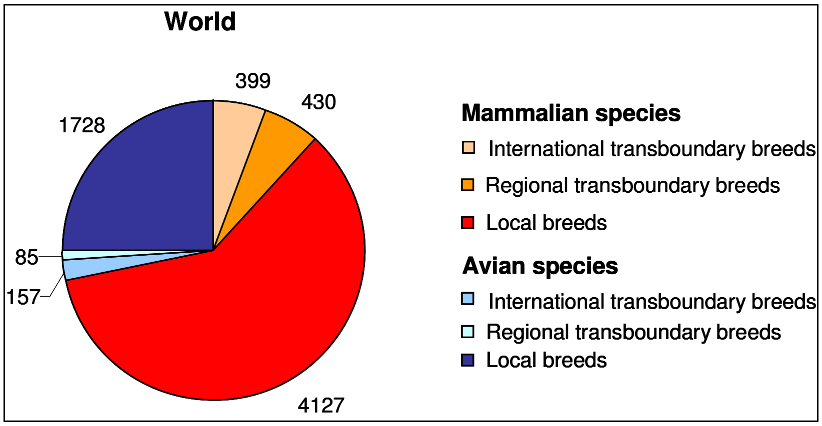

Figure 1. Proportion of the world's avian and mammalian breeds falling within each of the three breed categories (excluding extinct breeds)

Examples of transboundary international breeds that occur in more than 50 countries include Holstein cattle, which have been reported by 128 countries in seven regions, Large White pigs – 117 countries in six regions, Saanen goats – 81 countries in seven regions, Arab horses – 52 countries in seven regions and commercial Leghorn chicken – 51 countries in seven regions. There are no coherent data on the distribution of commercial layer and broiler strains, as these would only be available from private companies and not from country sources. It is interesting to note that no sheep breed was reported by more than 50 countries and that transboundary sheep breeds showed more regionally limited distribution patterns.

Studying the distribution patterns of transboundary breeds allows insights into patterns of exchange of AnGR. During the past two centuries, global livestock numbers and the exchange of breeds and genetic material have greatly increased. Movement and exchange have been especially intensive in the dairy cattle, pig and chicken sectors. North to North[2] exchanges have prevailed; North to South and South to South exchanges have been more limited, and South to North flows have been the least common. Among South to North geneflows, ruminant breeds of Southern origin have mainly been introduced to the United States of America and Australia. In some cases, "fancy" breeds of Southern origin or attractive species, e.g. llamas and alpacas, have been introduced into Northern Countries by hobby breeders. Cattle breeds of South Asian ancestry have also been quite successful in terms of their worldwide distribution. These include Brahman (ranked ninth in the worldwide distribution of cattle, and found in 45 countries), Sahiwal (29 countries), and also Gir, Red Sindhi, Indo-Brazilian, Guzerat, and Nelore, all of which are of the humped *Bos indicus* type. The N'dama, a trypanotolerant beef breed thought to have been developed in Fouta-Djallon highlands of Guinea, is reported in 20 countries; all of which are, however, in West and Central Africa

A total of 1 491 breeds, or 20 percent, are classified as being "at risk"[3]. The proportion of breeds classified as at risk is, in general, lower (16 percent) for mammalian species than for avian

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[2] The terms "North" and "South" are used here to refer to developed and developing countries respectively.

[3] A breed is categorized as "at risk" if the total number of breeding females is less than or equal to 1 000 and the total number of breeding males is less than or equal to 20; or the overall population size is less than 100 and increasing and the percentage of females being bred to males of the same breed is above 80 percent; or the overall population

species (30 percent) (Figure 2). However, in absolute terms the number of breeds at risk is higher for mammalian species (881 breeds) than for avian species (610 breeds). More than one-third of the reported mammalian and avian breeds could not be classified because of a lack of information on population size and structure.

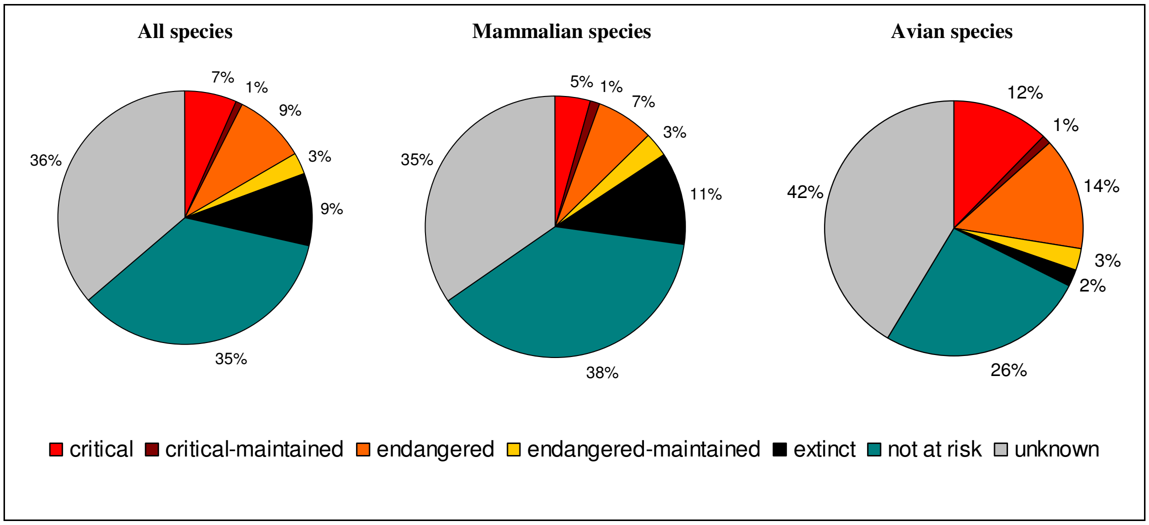

Figure 2. Proportion of the World's breeds recorded in each risk status category

Dilution of breeds' genetic make-up by the introgression of genes from other breeds or cross-breeding is not yet documented and is difficult to capture in the Global Databank. Indiscriminate cross-breeding and gradual breed replacement are thought to be the major reasons for the erosion of genetic resources. To date, 643 mammalian and 47 avian breeds have been reported extinct, 75 percent of which are in Europe and the Caucasus (75 percent of the extinct mammalian and 83 percent of the extinct avian breeds). Cattle are the species with the highest number of breeds (209) reported as extinct, followed by large numbers of extinct pig, sheep and horse breeds.

Management capacities at national level

The above analysis shows that big gaps remain in AnGR characterization, resulting from a lack of capacity in surveying and monitoring at the country level. Adequate characterization of AnGR is required for informed decision-making and planning of national livestock development programmes. Although a rich diversity of AnGR exists in many countries in Africa, Eastern Europe and the Caucasus, the Near and Middle East, and Central and South Asia, its value is often unrecognized by national authorities. Thus, very few national programmes for AnGR management exist, and consequently, very few formal breeding and conservation programmes for local breeds have been implemented. In most countries, awareness at the governmental level has to be increased if financial resources for such programmes are to be made available.

Although livestock owners practice breeding interventions in most production systems, the review of the Country Reports reveals a considerable variation in the extent of control over the process and the degree to which genetic change takes place in a planned direction. There are large differences between regions and species with respect to planned breeding activities and their support with public funding. The reproductive capacity of pigs and poultry allows the implementation of planned breeding programmes by a small number of breeders or breeding

size is less than or equal to 1 200 and decreasing and the percentage of females being bred to males of the same breed is below 80 percent (for definitions of the other categories shown in Figure 2 see FAO/UNEP, 2000).

companies within a short period of time. However, this is more difficult for cattle and small ruminants. The potential to implement formal breeding programmes through private organizations which exists in Europe and the Americas is the consequence of structures that had a long process of development. Conversely, many developing countries face problems in implementing formal breeding programmes. This is particularly true for low and medium external input production systems, which tend to be associated with locally adapted breeds. It is unlikely that the private sector will contribute significantly to the cost of new national ruminant breeding programmes in developing countries given the limited potential for increased production. Such costs would, therefore, have to be borne by national institutions. The cost of breeding activities, market competition and the international availability of suitable breeding material are important considerations when taking decisions regarding public funding for national breeding programmes. To date, many governments have decided to rely on international genetic material for genetic improvement, especially in poultry and pigs. Collaboration in breeding activities between countries with similar production conditions, such as already occurs in Europe, is an opportunity to share costs and make breeding programmes more sustainable.

The central problem for establishing *in situ in vivo* conservation[4] measures is the heterogeneity of the users of AnGR and the diverse conditions under which local breeds are kept. When changing economic, ecological and political conditions, threaten the viability of production systems (e.g. pastoral systems) and the associated breeds, it is difficult to create sustainable opportunities for *in situ in vivo* conservation. In some European countries, specific local breeds are kept only by older farmers. When the working lives of these farmers end, the keeping of these local breeds will also end unless steps are taken to promote continued use. For local and specially developed breeds and lines that will not be widely used in the future, all opportunities for *in vivo* conservation, including *ex situ in vivo*[5] conservation should be explored: nature management, organic farming, participatory breeding, production for niche markets, and hobby farming.

Ex situ in vitro (cryo)conservation[6] can be an important supplement to *in vivo* conservation or in some cases may be the only option for conserving a breed. Up to the present, cryoconservation has been used mainly by breeding organizations and the breeding industry to maintain genetic diversity within breeds and as a back up for their breeding material. In most countries, cryoconservation facilities are lacking and cannot be established without international support. However, to safeguard genetic diversity against unpredictable threats, it is necessary that countries have their own or shared gene banks containing material from their locally developed breeds and lines. Coordination between countries is required to organize conservation of the many transboundary breeds.

In the past, the institutional and structural situation at national, regional and international level was unfavourable for AnGR management in most developing countries. In Europe and the Caucasus, North America, South America, the Caribbean, and East Asia more activities have been undertaken, and capacities for AnGR management have been developed during the last 15 years. In these regions activities could be based on existing livestock management programmes.

The relevance of AnGR to food security and poverty alleviation has not been recognized, and this is reflected in the low level of awareness of the subject in many countries and by its limited presence on international agendas and in the work of international organizations. As a result,

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[4] *In situ in vivo* conservation: means conservation of livestock through continued use by livestock keepers in the production system in which the livestock evolved or are now normally found and bred.
[5] *Ex situ in vivo* conservation: means conservation through maintenance of live animal populations not kept under normal management conditions (e.g. zoological parks and in some cases governmental farms) and/or outside of the area in which they evolved or are now normally found.
[6] *Ex situ in vitro* conservation: means conservation external to the living animal in an artificial environment, under cryogenic conditions

legal structures, policies and development programmes with a focus on AnGR are often lacking, as are institutions for characterization, inventory, and monitoring, and structures for national and international cooperation. Even where networks for cooperation exist, there is frequently a need for further efforts to vitalize these networks or to establish new structures. In many countries there also seems to be a lack of national Non-Governmental Organisations interested and active in AnGR management. The National Agricultural Research Systems, key players in research and knowledge at the country level, have often not prioritized AnGR management in their activities. The same has been true for the international donor community. However, the Consultative Group on International Agricultural Research (CGIAR) has now identified conservation of indigenous livestock as a one of 20 priorities for CGIAR research from 2005 to 2015.

The Country Reports did, however, indicate that the preparation process of the SoW-AnGR report has induced changes in the field of AnGR management. Awareness, the key to policy and institutional change, is growing in most countries, and new networks are being developed. There is a need for continued support for the national and regional structures established as a part of the reporting process. Further efforts are needed, both at the country level and by the international community, to strengthen the involvement of all stakeholders in AnGR management.

Scientific methods and tools related to AnGR management.

The SoW-AnGR report also reviews relevant scientific methods and tools; the selection was guided by FAO's definition of AnGR management:

> AnGR management encompasses all technical, policy, and logistical operations involved in understanding (characterization), using and developing (utilization), maintaining (conservation), accessing, and sharing the benefits of animal genetic resources (FAO, 2001).

As such, methodologies for characterization, molecular methods, and conservation methods are described. With regard to utilization of AnGR – using and developing AnGR for agriculture and food production – no clear scientific concept has yet emerged. However, methods for economic valuation of AnGR and genetic improvement are seen as important elements.

The review shows that improved methods for characterization are needed to inform prioritization in AnGR development and conservation. In particular, a scientific concept needs to be developed to identify when breed populations that occur in different countries should be linked. Given that in some cases immediate decisions are required, there is a need for methods that make effective use of (incomplete) information combined from different sources such as molecular characterization, phenotypic descriptions, specific breed characteristics and breed origin. Member countries have long asked for the development of early warning and response mechanisms. Such systems would need to be based on breed prioritization and on the georeferencing of breed distribution, for which information is still very limited.

With regard to genetic improvement, scientific principles and methods are well developed, but have not been adapted to the needs of lower external input environments, e.g. defining breeding goals for multiple purpose breeds or implementing programmes under unfavourable infrastructural and institutional conditions. Indeed, viable organizational structures for breeding and also for *in situ in vivo* conservation programmes under such conditions remain to be defined. *Ex-ante* economic method for assessing the livelihood implications of genetic improvement programmes relative to the effects of other options livestock development interventions would also be useful tools.

Successful examples of *in situ in vivo* conservation strategies have mainly been identified in developed countries. Even these have not been examined from a theoretical or conceptual standpoint. Even less is known about which models could work in developing countries. The available methods for cryoconservation do not cover all domesticated species, as they have focussed on species that have been included in planned breeding programmes. With regard to gene banks, biosecurity issues can present problems for the inclusion of genetic material from local breeds. Minimum requirements and safe options for the parallel storage of material meeting different biosecurity standards need to be identified. To allow informed decision-making, cost estimates for different conservation strategies have to be established.

Few studies have analysed the impact of livestock sector policies on smallholders. However, this research area requires further attention. There is a need, for example, to clarify the effects of government policies, direct or indirect subsidies, and food-safety regulations on market access for smallholders. In turn, the implications of these policies for the use of locally adapted AnGR need to be elaborated.

Relatively little is known about the regulatory frameworks needed to ensure maintenance of genetic diversity and exchange of AnGR while respecting livestock keeper rights. The analysis of existing national regulations in the SoW-AnGR report is limited to an inventory of legal instruments that are in place in the reporting countries. In many cases, it is unclear how effective these regulations are and what their implications are for AnGR management. Zoosanitary regulations, however, are known to have a strong effect on the movement and trade of live animals and genetic material. It is also clear that specific legal regulations are required for gene banks, to address questions of ownership, access, information and documentation. Analysis of potential instruments to regulate access and benefit sharing for AnGR needs to address differences between the exchange of AnGR and the exchange of plant genetic resources for food and agriculture (PGR) (regulated by the legally binding International Treaty on PGR), and the exchange of biological diversity in general (for which regimes are currently being negotiated as part of the work programme of the CBD). A variety of legal instruments (codes of conduct, Material Transfer Agreements, livestock keeper rights) are currently being discussed. However, any developments need to be supported by a sound analysis of the potential implications. The role of patent laws when applied to the livestock sector needs attention. Recent applications have highlighted potential effects on AnGR management and have given rise much discussion.

Conclusions

Research interest in AnGR management has increased in recent years, but scientific concepts remain sketchy or poorly adapted to lower external input production systems, where organizational structures and livestock services are often lacking. To maintain at least the most precious elements of the human heritage of animal genetic resources clearly requires more coordinated efforts in research and development, and an increase in human and financial capacities. In many developing countries, bilateral or multilateral aid programmes for genetic improvement or conservation are necessary, and intercountry, subregional and regional programmes should be encouraged and supported through external technical and financial assistance. However, solutions for maintaining unique genetic resources at country or regional level will not always be feasible. Consequently, a global programme for cryoconservation as a last resort needs to be discussed, and will surely provide a major scientific and political challenge.

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