THE BRAZILIAN MODEL FOR THE CONSERVATION OF GENETIC RESOURCES

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INTRODUCTION

Most livestock are not indigenous to Brazil. Several animal species were considered domesticated in the pre-colonial period, since the indigenous people manage them as would be typical of European livestock production. For over 500 years there have been periodic introductions resulting in the wide range of genetic diversity that for centuries supported domestic animal production in the country (Mariante *et al*., 2003a). These naturalized breeds have been subjected to natural selection, leading to adaptation characteristics to biotic and abiotic pressures typical to Brazil. From the beginning of the 20th century, some exotic breeds, selected in temperate regions, have been imported. Although more productive, most of these breeds do not have adaptive traits, such as resistance to disease and parasites found in the naturalized breeds. Even so, they gradually replaced the native breeds to such an extent, that the latter are in danger of extinction (Mariante & Cavalcante, 2000, Mariante & Egito, 2002). To avoid further loss of this important genetic material, in 1983 the National Research Center for Genetic Resources and Biotechnology of the Brazilian Agricultural Research Corporation (Embrapa) decided to include conservation of animal genetic resources among its priorities (Mariante *et al*., 2000, 2003b). In this paper we describe the development and evolution of the Brazilian Genetic Resources Network and efforts to facilitate the conservation of genetic resources of domestic animals in the country.

NATIONAL GENETIC RESOURCES NETWORK - RENARGEN

Since the beginning of the 1970s, there has been a global concern about the need to preserve genetic resources essential for food and agriculture. In 1974 the Brazilian Government created within the Brazilian Agricultural Research Corporation - EMBRAPA a research unit whose basic mission was to coordinate the appropriate means of management of the genetic resources in the country. This unit was called the National Centre of Genetic Resources (CENARGEN). In 1984, this unit also incorporated research activities using biotechnology aimed at the conservation and use of genetic resources, becoming the Genetic Resources and Biotechnology Center of the EMBRAPA Network (Mariante *et al*., 2000, 2003).

The Genetic Resources and Biotechnology Center is a thematic center of Embrapa with a total staff of 289 employees and 130 researchers. The Centre aims to conserve and characterize genetic resources (plants, animals and micro-organisms), as well as to develop information and technologies in Advanced Biotechnology, Biological Control and Biological Security. With the creation of the Genetic Resources and Biotechnology Center and the consolidation of the National System of Agricultural Research in Brazil, an environment was established for the development of a National Network of Genetic Resources – RENARGEN. This helped to organize and increase the efficiency of activities of collection, exchange and quarantine, characterization, evaluation, documentation, and most importantly, conservation of germplasm critical to support research in food and agriculture in the country.

The National Network of Genetic Resources has provided key support for the tremendous technological advances obtained by Brazilian agriculture over the last three decades, enabling

the R&D system to incorporate and utilize genetic resources for development of plant cultivars, breeds of animals and strains of micro-organisms of importance to the agro-industry and agro-food sectors in the country. Also, the Network has made significant efforts to raise the awareness of the Brazilian society with regard to the strategic importance of genetic resources and biodiversity for the country's future. Considerable effort has been made to conserve and to promote the sustainable use of native plants and naturalized animals of economic interest, as well as to consolidate *in situ* and *on-farm* conservation strategies, creating the basis for increasing income, food sufficiency and the aggregation of environmental and social values to traditional communities dependent on biodiversity (Mariante & Cavalcante, 2000, Mariante *et al.,* 2000, 2003a; Mariante & Egito, 2002).

NATIONAL NETWORK OF GENETIC RESOURCES - RENARGEN

The major activities of the National Network of Genetic Resources are the following: (a) *Enrichment*: Germplasm collection, introduction, exchange and quarantine; (b) *Conservation*: *In-situ* (either in nature or *on-farm*) and *Ex-situ* (seeds in cold storage; explants *in vitro*, microorganisms culture; cryopreservation of semen, embryos and oocytes); (c) *Characterization*: phenotypic and genetic; and (d) *Information*: The Network maintains a Curatorship System and a documentation platform known as SIBRARGEN - Brazilian Information System for Genetic Resources, and is composed by the eleven Projects, shown in Table 1.

Table 1. Components of the National Network of Genetic Resources – RENARGEN

No.	PROJECT
1	Enrichment and documentation of genetic variability
2	Collection, characterization and *ex-situ* conservation of cereal genetic resources
3	Collection, characterization and *ex-situ* conservation of legume, oil and fiber plants
4	Collection, characterization and *ex-situ* conservation of fruit tree germplasm
5	Collection, characterization and *ex-situ* conservation of plant forage germplasm
6	Collection, characterization and *ex-situ* conservation of vegetable, root, tuber and spice germplasm
7	Collection, characterization and *ex-situ* conservation of forest and palm genetic resources
8	Collection, characterization and *ex-situ* conservation of industrial, medicinal, aromatic and ornamental plant germplasm
9	Collection, characterization and *ex-situ* conservation of genetic resources of microorganisms
10	Collection, characterization and ex-situ conservation of domestic animal germplasm
11	Curatorship system and long term *ex-situ* conservation of seeds, tissues, embryos and semen

CONSERVATION OF ANIMAL GENETIC RESOURCES IN THE RENARGEN NETWORK

Embrapa's Genetic Resources and Biotechnology Center has an animal genetic resources research team with 12 researchers specialized in conservation *per se*, genetic characterization and animal reproduction. This team runs an Animal Germplasm Bank, located at the Sucupira Experimental Farm, a 1,800 hectare property, located approximately 30 km from the base unit. The Animal Genetics Laboratory, three Animal Reproduction Laboratories and a modern Genome Laboratory, complete the infrastructure (Mariante *et al*., 2000, 2003).

This team coordinates the strategy of conservation of animal genetic resources within RENARGEN. The objectives of this component of RENARGEN include the following: (a)

identification of populations in advanced state of genetic dilution; (b) phenotypic and genetic characterization of germplasm; and (c) evaluation of production potential. Conservation is carried out in nucleus herds (Conservation Nuclei), maintained in the habitats where the animals have been naturally selected (*in-situ*), and embryo and semen storage (*ex-situ*), is carried out by the Animal Germplasm Bank (BGA), on the Sucupira Experimental Farm. The conservation nuclei are organized in ten Action Plans within RENARGEN. These Action Plans are presented on Table 2.

The articulation between the conservation nuclei and the Genetic Resources and Biotechnology Center is carried out by the Germplasm Curator (located in Brasilia) and the Curators of Germplasm Banks (Leaders of research projects located in diverse research centers). In the present structure, there are two curators for animals in the Genetic Resources and Biotechnology Center: one for large livestock species (cattle, buffaloes, horses and donkeys) and one for small livestock species (sheep, goats, pigs and poultry) (Mariante *et al.*, 2000, 2003a).

Table 2. Action Plans of the Project Collection, Characterization and Ex-situ Conservation of Domestic Animal Germplasm

No.	ACTION PLAN
1	Identification of Animal Populations and their Long Term Conservation
2	Genetic Characterization of Animal Germplasm
3	Conservation Nuclei for Goats
4	Conservation Nuclei for Hair Sheep
5	Conservation Nuclei for Animal Genetic Resources of the Amazon Region
6	Conservation Nuclei for Animal Genetic Resources in the Pantanal
7	Conservation Nuclei for Animal Genetic Resources in Mid Northern Brazil
8	Conservation of Animal Genetic Resources in the Brazilian Southern Fields
9	Conservation Nuclei for Animal Genetic Resources of the Lavrado
10	Conservation Nuclei for Swine and Poultry Genetic Resources

To be able to collect semen, embryos and oocytes of domestic animals and/or breeds threatened with extinction, the Conservation Nuclei where this material can be collected have to exist, thereby making the *in-situ* conservation a fundamental part of the conservation. These Nuclei are located in the habitats where the animals have been subjected to natural selection. When there are human and physical resources in the Nucleus for collection and freezing of genetic material, this is carried out *on-farm* and when this is not possible, some animals are temporarily transferred to Sucupira Experimental Farm in Brasilia for collection of the genetic material. This involves storage of semen and embryos from cattle, horses, buffaloes, donkeys, goats, sheep, and pigs. The Brazilian Animal Germplasm Bank is kept at the Genetic Resources and Biotechnology Center, which is responsible for the storage of semen and embryos of various breeds of domestic animals threatened by extinction, where almost 54,000 doses of semen and more than 250 embryos exist at present.

The creation of the Animal Genetics Laboratory at the Genetic Resources and Biotechnology Center led to the beginning of genetic characterization studies in the species included in the RENARGEN Program. From the results of this research it will be possible to compare the native breeds and estimate genetic distances between them, quantifying the uniqueness of each population, helping the monitoring and maintenance of maximum genetic variability in the Conservation Nuclei (Mariante & Egito, 2002).

CAPACITY BUILGING EFFORTS - LINK BETWEEN RESEARCH AND EDUCATION

Over the years, various international courses have been offered Embrapa in the framework of the animal genetic resources component of RENARGEN. Many of these courses are offered in partnership with FAO. Also, there is a growing demand for technical courses on embryo transfer and *in-vitro* fertilization, which are offered each year, reflecting the interest of the research community and producers in using the technologies generated by the network (Mariante *et al*., 2003b).

Due to a close partnership with the University of Brasilia (UnB), a capacity building effort has been developed, with two main lines of research at master's level offered together with the Genetic Resources and Biotechnology Center, one with emphasis on characterization and conservation of Animal Genetic Resources and the other on animal reproduction strategies. This collaboration has been fundamental for recent advances in the conservation and characterization of animal genetic resources in Brazil. To date, 37 Master's Dissertations have been completed due to this partnership. These dissertations deal in general with topics associated with quantitative genetics (17 dissertations mainly on sheep, cattle, buffaloes and horses), molecular genetics (5 dissertations on the same species) and reproduction (14 dissertations). This has meant that there is now information on production parameters for the Pantaneiro (Miserani *et al*., 2003) and Campeiro (McManus *et al*., 2005a) horses, Buffaloes (Cassiano *et al*., 2004), Pantaneiro (McManus *et al*., 2002; Abreu *et al*., 2002) and Mocho Nacional (McManus *et al*., 2005b) cattle, Morada Nova (Quesada *et al*., 2002), Santa Inês and Brazilian Bergamácia sheep (McManus *et al*., 2003), heat tolerance measures for 5 Brazilian breeds of cattle and 3 breeds of sheep (Prescott, 2004; Oliveira, 2005), as well as genetic distances between the main breeds of cattle (Spritze *et al*., 2003; Serrano *et al*., 2004; Egito *et al*., 2005), buffaloes (Albuquerque *et al*., 2005), sheep (Paiva *et al*., 2004), goats (Oliveira *et al*., 2005), horses (Fuck, 2002; Silva *et al*., 2005) and pigs (Mariante *et al*., 2003b).

These studies were also carried out with the help of students on study scholarships to the Genetic Resources and Biotechnology Center or Universities and researchers from the Center doing their doctor's theses in other Brazilian universities. Many samples and data were collected by researchers in different Research centers of EMBRAPA, as well as in state research institutions. These relationships have also led to an increased participation of all involved in publication in national and international congresses, books and scientific papers. International cooperation has also increased with funding from CNPq (Brazilian National Research Council) for projects with other countries in South America (Prosul - Uruguay and Colombia) as well projects with universities and research centers on the Iberian Peninsula.

Despite the increase in information over the last five years, much has yet to be done. Funding is limited as usually it is disputed with all other areas and the number of researchers involved is low but increasing. The student workforce has been vital for the success of the process in recent years. It would be very irresponsible to suppose that after graduation these students would continue actively working in animal conservation. The job opportunities are extremely limited in this area and efforts are made to show that the use of this knowledge is not limited to a conservation framework. In this way the students have a wider knowledge of animal genetics themes, have contributed to the conservation knowledge and have acquired techniques for use in their professional work after graduation. The fact that these students also have been exposed to this type of work would hopefully also mean that if in the future they were confronted with a situation involving conservation issues they would be better equipped on how to resolve the problem in a more informed way.

TRENDS AND CHALLENGES TO THE CONSERVATION AND USE OF ANIMAL GENETIC RESOURCES IN BRAZIL

VALUING AND PROMOTING STRATEGIC RESOURCES FOR THE FUTURE

It is important to emphasize that the Brazilian Program for the Conservation of Animal Genetic Resources is meeting its objectives, conserving *in-situ* and *ex-situ* valuable genetic material, characterizing it genetically and revealing its importance to the various segments of society (Mariante, 1993). The preservation of the Brazilian naturalized breeds has its historical side, which is the "genetic memory" of animals that helped to colonize the country. In a more or less intensive form, there are still remains of all of these breeds, through their crossbreds. If these breeds were able to overcome, after dozens of generations of natural selection, the environmental challenges to which they were subjected, it is because they unite genotypes compatible with the most diverse conditions. Also, man's intervention in their reproductive and selection processes were, at most, modest and did not cause any appreciable modification in their potential, other than those received from nature. Another aspect, which deserves consideration, is in relation to the proper dynamics of natural selection, which turns these native germplasm into authentic genetic reserves, especially when selection provokes the exhaustion of additive genetic variation and there is no more response in the animal breeding programs (Pereira, 1996).

NETWORKING AND STRENGTHENING NATIONAL R&D CAPACITY

Conservation and promotion of the sustainable use of animal genetic resources has to be understood as part of a complex process. Complementarities, mix of technologies and capabilities, together with effective approaches to networking must be viewed as key ingredients in developing this process. One of the key problems limiting the effective implementation of a complex process is the difficulty to build effective teams and networks (Lopes, 2000). Approaches to networking and partnerships have become important means of enabling organizations attain otherwise unattainable goals, add value to their products and processes and reduce costs. Also, the demand for efficiency and relevance presses R&D programs move in the direction of cooperation efforts. For example, modern biotechnology cannot be considered an end in itself or a tool detached from the complexities of genetic resources conservation and use or from breeding strategies. It has to be understood and analyzed in the context of an interacting mix of tools and strategies that have to be targeted towards crop and livestock improvement in a coordinated manner. The need for an expanded networking approach to breeding and biotechnological research will always be an objective to be pursued. This need arises because networking and partnerships have become an important means of enabling organizations attain otherwise unattainable goals, add value to their products and processes and reduce costs.

EMPHASIS IN CAPACITY BUILDING AND EFFECTIVE R&D MANAGEMENT

The future of genetic resources research points to increasing interdependence of traditional and upstream disciplines, making it necessary to build and manage multidisciplinary teams, a goal difficult to achieve. Also, in addition to the challenge of working within team alignments and cooperation, there is a pressing need for the development of ways to develop and share capacities, infrastructure, materials and information amongst research teams located across a country, a region, or even continents (Lopes, 2000). Effective training and capacity building to prepare scientists for future challenges is essential, as it is the development of effective organization and management strategies to build and manage programs compatible with the country needs and challenges.

REGULATION OF ACCESS AND USE OF GENETIC RESOURCES IN BRAZIL

As signatory of the Convention on Biological Diversity - CBD and as one of the countries with the highest mega-diversity in the world, Brazil has tried to adapt its public policies to the

requirements for use and conservation of biological resources, highlighting the proposal of National Policy on Biodiversity, which is in discussion in Brazilian society. The country adopted a formal commitment with its three main objectives - the conservation of the biological diversity, the sustainable use of its components and the fair and equal sharing of the benefits attained with this use. Also, the country established legal instruments to regulate the access and the use of the genetic resources under Brazilian Law, ensuring protection of the traditional knowledge associated with them. The Brazilian Government edited a Provisional Act in 2001 to regulate access and use of Brazilian biological diversity and to incorporate the principles and purposes of the Convention. The Provisional Act establishes that the access to genetic resources of Brazil and to any associated traditional knowledge for purposes of scientific research, technological development or biodiversity prospecting is subject to the prior authorization of the 'Brazilian Genetic Heritage Management Council' (CGEN). Such access is authorized solely to the Brazilian public or private institutions which perform research and development activities in the biological field and alike. Additionally, if there is any perspective of commercial use of the genetic resource and/or the associated traditional knowledge, it is also necessary to register an agreement for the use of the genetic heritage and benefit-sharing is an integrate part. The agreement must establish, among other things, a fair and equitable share of benefits arising from the economic exploitation of the product or process resulting from the access among the participating parties (Lopes, 2004).

Although the principle of sovereignty of the States over their genetic resources and the need to develop strategies to ensure benefit sharing among providers and users are generally well accepted, the instruments that have been adopted by Brazil have been frequently questioned. There is much concern over excessive protection of resources which have not even been assessed. Also, there is a sense that the legislation is overly restrictive, inhibiting research and development initiatives. Since the country will eventually have a definite law to substitute the Provisional Act of 2001, the scientific community expects that the evolving legislation will bring a much needed balance to ensure both the protection for biological resources while acknowledging the need to enhance their utilization (Lopes, 2004).

FINE TUNNING: THE NEED FOR PRIORITY SETTING AND SISTEMATIC CONNECTION TO FUTURE INNOVATION STRATEGIES

For many reasons, developing countries do not put conservation of domestic animal resources as a priority, principally when the main goals are increased production and competitiveness in the global market in the short term. Brazil is one of the countries in this situation.

Future configuration of domestic animal genetic resources and breeding programs is dependent on knowledge to guide strategic decisions about structures, methods, and capacities in order to take advantage of new opportunities and technological niches that can benefit from strong programs in genetic resources conservation and use. Unfortunately, there are very few prospective efforts directed to thinking about the future of genetic resources and breeding programs, especially in developing countries. Research organizations need information that is not currently available, about the changes and influences and their impact in the future of key activities (Lima et al., 2005). To obtain and organize this information, prospective studies on the present and future performance of genetic resources and breeding programs and their related activities will have to be systematically developed in the country. These prospective studies and priority setting mechanisms, together with cost benefit analysis will be valuable to guide informed decisions on how to organize and manage future crop and livestock genetic resources and breeding programs in Brazil.

REFERENCES

Abreu, U.G.P. et al. (2002) *Arch. Zootec*. **51**:83-89.

Albuquerque, M.S.M et al. (2005). VI Simp. Iberoamer. Conserv. Utiliz. Rec. Genét. CD-ROM.

Cassiano, L. et al. (2004) *Pesq. Agropec. Bras*. **39**: 451-457.

Egito, A.A. et al. (2005) VI Simp.Iberoamer. Conserv. Utiliz. Rec. Genét. CD- ROM.

Fuck, B.H. (2002) MSc. Thesis, University of Brasília, Brasília, Brazil.

Lima, S.M.V. et al. (2005) O Futuro da Pesquisa Agropecuária Brasileira, Brasília, Brazil.

Lopes, M.A. (2000) Proc. Int. Workshop Embrapa/IDB/World Bank: 219-230.

Lopes, M.A. (2004) National policies towards access to genetic resources - The situation in Brazil. (unpublished).

Mariante, A.S. (1993) Proc. 30th Reunião Anual SBZ: 16-23.

Mariante, A.S.; Castro, S.R.; Wetzel, M.M.V. (2000) Proc. 5th Global Conf. Conserv. Dom. An. Genét. Res. CD-ROM.

Mariante A.S.; Cavalcante N. (2000) <Animals of the Discovery: Domestic breeds in the History of Brazil.> Embrapa, Brasília, Brazil.

Mariante, A.S.; Egito, A.A. (2002) *Theriog*. **57**: 223-235.

Mariante, A.S. et al. (2003b) *Arch. Zootec*. **52**: 245-248.

Mariante A.S.; McManus, C.M.; Mendonça, J.F. (2003a) <Country report on the state of animal genetic resources: Brazil.> Embrapa Genetic Resources and Biotechnology, Brasília, Brazil.

McManus, C. et al. (2002) Arch. Zootec. **51**: 91-97.

McManus, C. et al. (2003). *Rev. Bras. Zootec.* **32:** 1202-1207.

McManus, C.M. et al. (2005a) Rev. Bras. Zootec. **34**: 1553-1562.

McManus, C.M. et al. (2005b) *Arch. Zootec*. **54**: 459-464,

Miserani, M. et al. (2003) *Rev.Bras. Zootec.* **31**: 335-341.

Oliveira, E.B. (2005) MSc. Thesis, University of Brasília, Brasília, Brazil.

Oliveira, R.R. et al.(2005) *Pesq. Agropec. Bras*. **40**: 233-239.

Paiva, S.R. et al. (2004). V Simp. Iberoam. Conserv. Utiliz. Rec. Genét. 81-83.

Pereira, J.C.C. (1996) Melhoramento genético aplicado à produção animal. Belo Horizonte. 416p.

Prescott, E. (2004) MSc. Thesis. University of Brasília, Brasília, Brazil.

Quesada, M.; McManus, C.M.; Couto, F.A.D. (2002). Rev. Bras. Zootec. 31:342-349.

Serrano, G.M.S. et al. (2004). Pesq. Agropec. Bras. 29: 543-549.

Silva, A.C. et al. (2005). Proc. VI Simp. Iberoam. Conserv. Utiliz. Rec. Genét. CD-ROM.

Spritze, A.L. et al. (2003). Pesq. Agropec.Bras. **38**: 1157-1164.