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Front cover illustration. This image, used on the poster for the International Day for Biological Diversity 2008, has been designed from a traditional Gabba embroidered tapestry from Pakistan that was donated to the CBD Museum of Nature and Culture in 2006 by Pakistan's Minister for Environment. Measuring some two meters across and two meters high, the intricately stitched and brightly coloured Gabba depicts scenes of everyday life and the rich heritage of biodiversity and agriculture in a farming landscape of Pakistan.

SPECIAL ISSUE

The Value of Biodiversity to Food and Agriculture

To those who farm the living earth and nurture our livestock– may they reap a rich and full harvest as they continue to respect the diversity of life.

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Back Cover: Rice, *Oryza sativa* L., see caption page 35.
Inside Front Cover Art: The Diversity of Life by *Roelof Idema*

Sustaining livestock biodiversity – from assessment to action

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Abstract. Livestock are important elements of many agro-ecosystems. Their contributions to the livelihoods of their keepers (many of whom are among the world's poor) are often manifold – food, fibre, transport, agricultural inputs, socio-cultural roles, etc. If well managed, livestock can also contribute to wider ecological and landscape services. Diverse roles and production environments have, over millennia, led to the development of great genetic diversity among the world's livestock.

Livestock biodiversity has always been dynamic, new breeds have emerged and others have disappeared as environments and societies have changed. At present, however, production systems are changing at an unprecedented rate, driven *inter alia* by surging demand, pressure on natural resources, and technological developments. This rapid change threatens livestock diversity – 20 % of breeds are classified as at risk. It also underscores the importance of retaining a broad portfolio of genetic resources to facilitate adaptation to new challenges – climate change and emerging diseases are among the most prominent.

Agricultural biodiversity is increasingly prominent on international agendas; its "special nature" is recognized by the Convention on Biological Diversity which has a programme of work in this field. A key development in 2007 was the adoption of the *Global Plan of Action for Animal Genetic Resources* at a conference organized by FAO. *The Global Plan of Action* – the outcome of an extended international process of reporting, analysis and negotiation – covers four priority areas: characterization, inventory and monitoring; sustainable use and development; conservation; and policies, institutions and capacity-building. The task facing the international community is now to implement the *Global Plan of Action* through concrete action.

INTRODUCTION

It is increasingly recognized that the use, development and conservation of livestock biodiversity are of great importance to food security, rural development and the environment. The realization that action is required to improve the management of animal genetic resources for food and agriculture (AnGR) is given added impetus by the urgent need to step up efforts to meet the Millennium Development Goals and by growing concerns about the effects of climate change on agriculture and food production. This awareness took more concrete form in 2007 with the adoption of the *Global Plan of Action for Animal Genetic Resources* (GPA), the first internationally agreed framework for AnGR management, and the *Interlaken Declaration on Animal Genetic Resources*, through which countries affirmed their common and individual responsibilities with respect to these resources (FAO 2007a).

This paper describes the roles of livestock within the world's agro-ecosystems, with a focus on the significance of genetic diversity. It outlines threats to AnGR and challenges facing the livestock sector. It draws attention to gaps in capacity to manage AnGR. Finally, it describes the development of the GPA as a response to these challenges, and briefly outlines some of the key future actions required to promote effective global management of AnGR. A more detailed discussion of the tasks facing the international community as it seeks to implement the GPA is presented by Hoffmann *et al*. (2008).

ANIMAL GENETIC RESOURCES AND BREEDS

The term "animal genetic resources for food and agriculture" or "AnGR" is used by the Food and Agriculture Organization of the United Nations (FAO) to describe avian and mammalian species that are used, or are potentially of use, for agriculture and food production. These species are also described as "livestock". A total of 37 species are currently included in FAO's Global Databank for Animal Genetic Resources (http://fao.org/dad-is). AnGR encompass the individuals and populations within these species, as well as genetic material (semen, oocytes, embryos, etc.) which may exist outside the living animals. Aquatic species (wild and farmed), and in places wild terrestrial animals, are also important sources of food for human populations. However, management and policy challenges for these species are very different from those affecting livestock; they are therefore excluded from the definition of AnGR.

AnGR diversity is generally discussed in terms of breeds. However, it has proven difficult to establish a definition of the term "breed" that is applicable throughout the world. FAO uses the following definition, which acknowledges the ambiguities inherent in the term:

"Either a subspecific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups with the same species, or a group for which geographical and/or cultural separation from phenotypically similar groups has led to acceptance of its separate identity." (FAO 1999).

This difficulty has to be borne in mind. Nonetheless, it can be argued that given current levels of knowledge, the concept of the breed is often the best available basis for decision-making (FAO 2007b). The diversity of breeds or distinct populations that have developed in distinct environments, and have been able to survive, produce and reproduce within these environments, provides a useful proxy for diversity in the traits and functions of importance. Breed diversity does not, however, represent the whole picture of genetic diversity within a livestock species. It is important that within-breed diversity is also considered.

THE ORIGINS OF AnGR DIVERSITY

The origins of our most important livestock species lie in the "agricultural revolution" of the early Neolithic. Goats, for example, are thought to have been first domesticated in the Zagros Mountains of the Fertile Crescent around 10,000 years before present (Zeder and Hesse 2000). Cattle, sheep, pigs, chickens, donkeys, horses, llamas, alpacas and dromedaries were all domesticated at least 6,000 years ago. Molecular genetic and archaeological evidence is gradually providing a fuller picture of the domestication process (Zeder *et al*. 2006).

As livestock populations spread from their centres of domestication, as a result of human migration, trade and conquest, they encountered new ecological conditions. As societies developed and diversified, new demands were placed on livestock, and knowledge and skills in husbandry and breeding were accumulated. The natural and human-controlled selection that accompanied these processes led to the development of great genetic diversity among the world's livestock. The situation was never static, breeds emerged, mixed and disappeared over time, but diversity prevailed.

THE USES AND VALUES OF AnGR

Livestock production (meat, milk, eggs, fibres, hides, etc) accounts for 40 % of the value of world agricultural output (FAO 2006a). In some developing countries, its contribution is particularly important. In Mongolia, for example, livestock production is reported to account for almost 90 % of agricultural gross domestic product (GDP) and almost 30 % of total GDP (CR Mongolia 2004) However, raw economic figures do not capture the full significance of livestock production to economies and livelihoods around the world. One important consideration is the prevalence of livestock keeping among the world's poor. Precise data are difficult to obtain, but it is clear that there are many hundreds of millions of poor livestock keepers (Thornton *et al.* 2002; IFAD 2004). Also important are the many livestock products and services that are not commoditized and are difficult to quantify. At the household level, functions may include (in addition to supplying the above-mentioned products) providing inputs to crop production (draft and manure), fuel, transport, a basis for social networking and cultural activities, a means of accumulation (savings and insurance), and recycling waste products. In many cases, it is this potential for fulfilling multiple roles, which makes livestock particularly valuable assets for poor people. Multiple roles and combinations of roles, and diverse production conditions, require diverse animals. It is important that this requirement is not overlooked in the planning of livestock development interventions for smallholder systems.

Livestock also provide a number of wider ecological services. It has always been the case that animals, including in recent millennia domesticated animals, have contributed to the functioning of the ecosystems of which they form a part – nutrient cycling, seed dispersal, etc. Today, there is growing awareness among those involved in conservation management, of the potential for managing grazing livestock specifically to sustain wildlife habitats and promote biodiversity. Some plant species thrive under grazing pressure, others are unable to survive in grazed habitats, while others are able to thrive if grazing is avoided during growing periods. As such, it is possible to use managed grazing to control the distribution of plants in accordance with conservation objectives (Harris 2002; Small 2004). The grazing behaviours required are sometimes very specific, and the animals involved often have to be able to thrive in relatively harsh environments. The existence of a wide range of breeds with a range of adaptations increases the options available for conservation grazing.

To highlight the potential contribution of diverse AnGR to meet conservation objectives is not to ignore some serious environmental problems associated with livestock production. Prominent among these concerns are greenhouse gas emissions from ruminant livestock, deforestation to make way for grazing or feed production, and the pollution of aquatic environments with livestock wastes (FAO 2006a). Developing production systems that are more environmentally sustainable is one of the most pressing challenges facing the livestock sector worldwide.

The value of AnGR diversity goes beyond benefits derived from current uses. So-called "option values" also need to be considered (Roosen *et al*. 2005). Breeds that are of little practical use today may prove very valuable under future conditions. One example of a breed that was once in danger of extinction but is now widely used in commercial production is the Lleyn sheep of the United Kingdom. Another example is the Piétrain pig of Belgium, now used in many cross-breeding programmes, which almost became extinct during the Second World War (Vergotte de Lansheere *et al*. 1974). Animal health is a field in which the importance of AnGR diversity for future production is increasingly recognized, as new diseases emerge and the current disease management strategies are threatened by the spread of resistance to drugs and pesticides among pathogens and disease vectors. Numerous studies have shown that particular breeds show unusually high levels of resistance or tolerance to economically important health problems, including trypanosomiasis, gastro-intestinal nematodes, tick burden and various tick-borne diseases (see for example: Claxton & Leperre, 1991; Mattioli *et al*. 1995; Baker, 1998; Glass *et al*. 2005). A well-known example is the Red Maasai sheep of East Africa, which is noted for its resistance to the stomach worm *Haemonchus contortus* (Baker, 1998). Unfortunately, pure-bred populations of this breed are now difficult to find. In addition to the examples recorded in the scientific literature, many other breeds are reported to show resistance to specific diseases but have not been subject to controlled investigations (FAO 2007b).

Providing options for the future is one of the main motivations for conserving breeds that are under threat. The importance of retaining a wide portfolio of AnGR (and of better understanding their characteristics) as a basis for adapting the production systems of the future is underlined by the prospect of global climate change over the coming decades.

THE STATUS OF AnGR

The most comprehensive source of information on the size and structure of livestock breed populations is FAO's Global Databank for Animal Genetic Resources. More than

7,600 breeds are currently recorded. More than 1,000 are "transboundary" breeds (reported from more than one country) – a reflection of the interdependence of countries in the use of AnGR.

Among recorded breeds, 9 % are already extinct, and 20 % are classified as at risk. For a further 36 %, risk status is unknown because of a lack of data. Recent trends in risk status present a mixed picture. Between December 1999 and January 2006, 60 breeds moved from the "at risk" to the "not at risk" category. However, almost as many (a total of 59) moved into the "at risk" category. More worrying is the ongoing loss of breeds; 62 extinctions were recorded during this period – amounting to almost one per month.

It is important to recognize that an assessment based on breed population size does not fully describe the state of genetic diversity. Genetic dilution as a result of uncontrolled cross-breeding – a major threat to AnGR diversity – is not captured. Risk status figures also do not reveal the high levels of inbreeding that may arise, even within breeds that have large populations, as a result of the heavy use of a few popular sires.

THREATS TO AnGR

The rapid changes currently affecting livestock production systems present a threat to many breeds. The rapid rise in demand for food of animal origin which is occurring in many parts of the developing world is a major driver of change; other drivers include the changing structure of the food processing and retail industries, food safety considerations in longer food chains, technological developments, environmental factors (ecosystem degradation, climate change) and changing policy pressures. Traditional production systems, home to much of the world's AnGR diversity, are often being marginalized or transformed, and the associated knowledge lost. Small-scale producers may be driven into money economies under unfavourable terms, or crowded out of existing markets. The need to increase production means that local animals are often replaced by, or crossed with, exotic breeds. Mechanization is tending to displace draught animals (although animal power is increasingly important in parts of Africa). The natural resources (particularly grazing land and water) on which small-scale producers depend are often under threat. Such problems involve political and institutional factors – lack of access or a lack of equitable arrangements for the use of resources – as well as physical loss.

The outcome of these processes is that the world's supply of animal products is increasingly based on a narrow range of breeds – those that are profitably utilized in today's high external input production systems. Clearly, it is not possible, nor is it desirable, that livestock production systems should be preserved unchanged. There is, however, a need to be aware that valuable genetic resources will be lost if no remedial action is taken. Unfortunately, inappropriate policies (e.g. subsidies favouring large-scale production) (Drucker *et al.* 2006) and management strategies (e.g. uncontrolled cross-breeding) remain among the factors contributing to genetic erosion (FAO 2007b).

Acute events, such as natural or human-induced disasters and disease epidemics, are also a threat, particularly to breeds confined to limited geographical areas. In the case of disease outbreaks, control measures (mass culling) may constitute a bigger threat than the disease itself. Recent outbreaks of avian influenza in Asia have resulted in the slaughter of tens of millions of birds (Rushton *et al*. 2005); the effect on AnGR is unquantified (Hoffmann 2007). Better recorded was the impact of the 2001 outbreak of foot-and-mouth disease in the United Kingdom. A number of sheep and cattle breeds were quite seriously affected in terms of population size. The endangered Whitebred Shorthorn cattle and Whitefaced Woodland sheep saw a decline of 21 % and 23 %, respectively, in the number breeding females during 2001 (Roper 2005). In the case of disasters and emergencies (droughts, armed conflicts, etc.), measures implemented in the aftermath of the event, particularly the restocking of livestock populations, can have serious implications for AnGR diversity, and for livestock based livelihoods, if they are not well planned (FAO 2006b).

THE STATE OF CAPACITY

The reporting process which underpinned the preparation of *The State of the World's Animal Genetic Resources for Food and Agriculture* (SOW-AnGR) (FAO 2007b) provided an overview of global capacity to manage AnGR (see below for a further description of the process). In many countries, particularly developing countries and countries with economies in transition, capacity to manage AnGR remains weak. There is a shortage of trained personnel, and technical and institutional resources are often inadequate.

Conservation programmes for threatened breeds are limited. Many countries (48 %) reported no *in vivo* conservation schemes (measures that involve the maintenance of live animals and which may include farm parks, protected areas, or support for livestock keepers to maintain breeds in their usual production environments). Similarly, 63 % reported no *in vitro* programmes (conservation of genetic material in liquid nitrogen). Moreover, the effectiveness of existing programmes is often difficult to assess (ibid.). Conservation measures are much more widespread in Europe and in North America than in other regions. Note that the SoW-AnGR reporting process extended over several years, and may in itself have stimulated conservation efforts. It is therefore possible that these figures have improved to some extent.

Structured breeding programmes are a key means to increase output and product quality, improve productivity and cost efficiency, and support the conservation and sustainable use of specific breeds. However, throughout much of the developing world the impact of such programmes is very limited.

Another finding of the SoW-AnGR is that the policy and legal frameworks necessary to promote and enable the sustainable management of AnGR are often lacking. Moreover, even where good laws and policies exist on paper, they may not be implemented.

At present, much of the world's AnGR diversity is maintained by the farmers and herders of developing countries. This ongoing use allows for continued development and co-evolution of breeds with their production environments. It also helps to ensure that resources remain available for future use by the wider livestock sector. The role of these, often poor and politically marginalized, livestock keepers in maintaining genetic diversity should not be overlooked.

THE POLICY RESPONSE – GLOBAL EFFORTS TO PROMOTE THE WISE MANAGEMENT OF AnGR

Throughout this paper, attention has been drawn to the many challenges facing the livestock sector – surging demand, poverty, climate change, threats to livestock-based livelihoods, emerging animal health problems, environmental degradation – in addition to the loss of livestock biodiversity. All are influenced by policy developments in many sectors, and at national, regional and global levels. It is beyond the scope of a short paper to offer a comprehensive account of policy matters that influence the management of AnGR. Indeed, much work remains to be done to provide a clearer understanding of these issues, and to ensure that as policy across all relevant sectors evolves, the needs of AnGR are not neglected. The objective of the following paragraphs is, therefore, merely to describe how growing policy-level interest in AnGR has been translated into an internationally agreed framework to promote the sustainable use development and conservation of AnGR.

Since the 1960s, FAO has worked on genetic resources for food and agriculture. Initially, it concentrated on plant genetic resources, but since 1990, it increasingly developed work in the area of AnGR. The Commission on Genetic Resources for Food and Agriculture (CGRFA) is a permanent intergovernmental forum, and currently has 168 countries, plus the European Community, as members. It has developed several international agreements, voluntary undertakings and codes of conduct, to promote and facilitate wise management, and access and benefit-sharing of genetic resources. The CGRFA has two subsidiary bodies: the Intergovernmental Technical Working Group on Plant Genetic Resources and the Intergovernmental Technical Working Group on Animal Genetic Resources. The CGRFA coordinates its efforts with the Convention on Biological Diversity (CBD).

International concerns about agricultural biodiversity were also reflected in the decision of the Conference of the Parties (COP) to the CBD, at its Third Meeting in 1996, to instigate a programme of work in this field. The objectives of this programme were set out in COP Decision III/11 as follows:

"First, to promote the positive effects and mitigate the negative impacts of agricultural practices on biological diversity in agro-ecosystems and their interface with other ecosystems; second, to promote the conservation and sustainable use of genetic resources of actual or potential value for food and agriculture; and third, to promote the fair and equitable sharing of benefits arising out of the utilization of genetic resources."

The SoW-AnGR process and the Global Plan of Action

The *Global Plan of Action for Animal Genetic Resources* (GPA) (FAO 2007a) is the outcome of a long process of reporting, analysis and negotiation. In 1999, the CGRFA requested FAO to coordinate the preparation of a country-driven report on the state of the world's AnGR. In addition to its technical content, the SoW-AnGR process was to encompass the identification of strategic priorities for action (SPAs) in the field of AnGR. In 2001, FAO invited all member countries to submit reports describing the state of AnGR and capacity to manage them at national level. By December 2005, 169 country reports had been received. These reports, along with nine submissions from international organizations, 12 commissioned thematic studies, FAO's Domestic Animal Diversity Information System, and the wider scientific literature, were the key resources used to prepare the technical report.

In line with the country-driven character of the SoW-AnGR process, a set of SPAs was distilled from the country reports by the FAO Secretariat, and assembled into a coherent draft document which also took into account the conclusions of various consultations, studies and expert meetings. The draft was reviewed by the Intergovernmental Technical Working Group on Animal Genetic Resources in December 2006 (FAO 2007c). Following further revision of the draft, the CGRFA at its Eleventh Meeting in June 2007 decided to proceed with the negotiation of a global plan of action based on the SPAs, with the intention that it should be adopted at the first International Technical Conference on Animal Genetic Resources for Food and Agriculture, to be held in Interlaken, Switzerland, in September 2007 (FAO 2007d). In parallel, the technical SoW-AnGR was drafted, reviewed and finalized, ready for launch at the conference.

The Interlaken Conference and the adoption of the GPA, the first international framework for AnGR adopted by an intergovernmental forum, although not legally binding, represented a milestone for the livestock sector. The GPA is a building block for international efforts to enhance the management of agricultural biodiversity as a whole, and will contribute to the implementation of the CBD's Programme of Work in this field. It offers a means to increase the overall effectiveness of national, regional and global efforts to promote the sustainable use, development and conservation of AnGR. The GPA includes 23 Strategic Priorities, which cover: characterization, inventory and monitoring of trends and associated risks; sustainable use and development; conservation; and policies, institutions and capacity-building.

The conference also adopted the *Interlaken Declaration on Animal Genetic Resources*. The *Declaration* recognizes that the wise management of AnGR will make a significant contribution to achieving the Millennium Development Goals. It notes the ongoing loss of livestock breeds and calls for prompt action to conserve breeds at risk. It acknowledges that maintaining AnGR diversity is essential to enable the livestock sector to meet current and future production challenges resulting from changes in the environment, including climate change; to enhance resistance to diseases and parasites; and to respond to changes in consumer demand for animal products. It recognizes the enormous contribution that farmers, pastoralists, animal breeders and indigenous communities have made, and continue to make, to the sustainable use, conservation and development of AnGR. By adopting the *Declaration* governments have committed themselves to implementing the *Global Plan of Action*, and to facilitating access to AnGR and ensuring the fair and equitable sharing of the benefits arising from their use.

The *Interlaken Declaration* recognizes that the main responsibility for implementing the GPA rests with national governments. Countries committed to the implementation of the GPA will have to develop or strengthen national measures for the characterization, monitoring, conservation and development of AnGR. This is likely to require designating clear institutional responsibilities for the management of AnGR, setting strategic priorities for conservation and breeding goals, developing national action plans or strategies, and mainstreaming the aims of the GPA into existing livestock, environmental and agricultural policies and programmes. At the international level, FAO, through the CGRFA, will develop measures to assist developing countries in the implementation of the GPA, including through the development of technical guidelines and the mobilization of financial resources. The CGRFA, within the context of its Multi-year Programme of Work, will review international policies of relevance to AnGR, including measures to facilitate access to AnGR and the fair and equitable sharing of benefits arising from their use. Additionally, the provisions of the GPA regarding the identification of breeds at risk and the development of regional or global *ex situ* back-up systems require further development.

CONCLUSIONS

There are many reasons to value livestock biodiversity. It provides diverse products and services to humankind, and supports the livelihoods of many of our planet's poorest and most marginalized citizens. It offers options for the future in a rapidly changing world. It is the product of thousands of years of human endeavour and millions of years of natural selection. It is, however, under threat. The GPA and the *Interlaken Declaration* represent an acknowledgement on the part of the world's governments that a "hands-off" attitude to the management of AnGR is unacceptable. The task now facing the international community is to implement the GPA through concrete action.

The views expressed in this publication are those of the authors and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

REFERENCES

Baker, R.L. 1998. Genetic resistance to endoparasites in sheep and goats. A review of genetic resistance to gastrointestinal nematode parasites in sheep and goats in the tropics and evidence for resistance in some sheep and goat breeds in sub-humid coastal Kenya. *Animal Genetic Resources Information*, 24: 13-30.

Claxton, J. and P. Leperre. 1991. Parasite burdens and host susceptibility of Zebu and N'Dama cattle in village herds in the Gambia. *Veterinary Parasitology,* 40(3-4): 293-304.

CR Mongolia. 2004. *The country report on animal genetic resources.* Ulan Bator. Ministry of Food and Agriculture. (available at ftp://ftp.fao.org/docrep/fao/010/a1250e/annexes/CountryReports/Mongolia.pdf).

Drucker, A., E. Bergeron, U. Lemke, L.T. Thuy, and A. Valle Zárate. 2006. Identification and quantification of subsidies relevant to the production of local and imported pig breeds in Vietnam. *Tropical Animal Health and Production*, 38(4): 305-322.

FAO. 1999. *The global strategy for the management of farm animal genetic resources.* Executive Brief. Rome. (available at http://lprdad.fao.org/cgi-bin/getblob.cgi?sid=-1,50006152).

FAO. **2006a.** *Livestock's long shadow – environmental issues and options,* by H. Steinfeld, P. Gerber, T. Wassenaar, V. Castel, M. Rosales & C. de Haan. Rome. (available at http://www.virtualcentre.org/en/library/key_pub/longshad/a0701e/A0701E00.pdf).

FAO. 2006b. *The impact of disasters and emergencies on animal genetic resources: a scoping document*, by C. Heffernan & M. Goe. Rome. (available at ftp://ftp.fao.org/ag/cgrfa/BSP/bsp32e.pdf).

FAO. 2007a. *Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration*. Rome. (available at http://www.fao.org/ag/againfo/programmes/en/genetics/documents/Interlaken/GPA_en.pdf).

FAO. 2007b. *The State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B. Rischkowsky & D. Pilling. Rome. (available at http://www.fao.org/docrep/010/a1250e/a1250e00.htm).

FAO. 2007c. *Report of the Fourth Session of the Intergovernmental Technical Working Group on Animal Genetic Resources*. Rome, 13–15 December 2006, CGRFA-11/07/3. Rome. (available at ftp://ftp.fao.org/ag/cgrfa/cgrfa11/r11w3e.pdf).

FAO. 2007d. *Report of the Eleventh Regular Session of the Commission on Genetic Resources for Food and Agriculture*. Rome, Italy, 11–15 June 2007. CGRFA-11/07/Report. Rome. (available at ftp://ftp.fao.org/ag/cgrfa/cgrfa11/r11repe.pdf).

Glass, E.J., P.M. Preston, A. Springbett, S. Craigmile, E. Kirvar, G. Wilkie, and C.G.D. Brown. 2005. *Bos taurus* and *Bos indicus* (Sahiwal) calves respond differently to infection with *Theileria annulata* and produce markedly different levels of acute phase proteins. *International Journal for Parasitology*, 35(3): 337-347.

Harris, R.A. 2002. Suitability of grazing and mowing as management tools in Western Europe. Experiences in Scotland and the United Kingdom. *In* J. Bokdam, A. van Braeckel, C.Werpachowski and M. Znaniecka, eds. *Grazing as a conservation management tool in peatland.* Report of a Workshop held 22–26 April 2002 in Goniadz Poland. Wageningen, the Netherlands. University of Wageningen/Biebrza National Park/WWF.

Hoffmann, I. 2007. Vaccination – a means for preserving poultry genetic resources? *Developments in Biologicals,* 130: 111-118.

Hoffmann, I, B. Scherf, and D. Boerma. 2008. The global plan of action for animal genetic resources**.** *Livestock Science***,** (forthcoming).

IFAD. 2004. *Livestock services and the poor. A global initiative. collecting, coordinating and sharing experiences.* Rome. (available at http://www.ifad.org/lrkm/book/english.pdf).

Mattioli R.C., M. Bah, S. Kora, M. Cassama, and D.J. Clifford. 1995. Susceptibility to different tick genera in Gambian N'Dama and Gobra zebu cattle exposed to naturally occurring tick infection. *Tropical Animal Health and Production* 27(2): 995-1005.

Roosen, J., A. Fadlaoui, and M. Bertaglia. 2005. Economic evaluation for conservation of farm animal genetic resources. J*ournal of Animal Breeding and Genetics*, 122(4): 217-228.

Roper, M. 2005. *Effects of disease on diversity*. Paper presented at the International Conference on Options and strategies for the conservation of farm animal genetic resources, Agropolis, Montpellier, 7–10 November 2005.

Rushton, J., R. Viscarra, E. Guern-Bleiche, and A. McLeod. 2005. Impact of avian influenza outbreaks in the poultry sectors of five South East Asian countries (Cambodia, Indonesia, Lao PDR, Thailand, Viet Nam) outbreak costs, responses and potential long term control. *World's Poultry Science Journal*, 61(3): 491-514.

Small, R. 2004. The role of rare and traditional breeds in conservation: the Grazing Animals Project. *In* G. Simm, B. Villanueva, K.D. Sinclair and S. Townsend, (Eds.) *Farm animal genetic resources*, pp. 263-280. Nottingham, UK. British Society of Animal Science.

Thornton, P.K., R.L. Kruska, N. Henninger, P.M. Kristjanson, R.S. Reid, F. Atieno, A.N. Odero, and T. Ndegwa. 2002. *Mapping poverty and livestock in the developing world.* Nairobi. International Livestock Research Institute. (available at http://www.ilri.org/InfoServ/Webpub/fulldocs/mappingPLDW/index.htm).

Vergotte de Lantsheere, W., A. Lejeune, and G. Van Snick. 1974. L'élevage du porc en Belgique: amelioration et sélection. *Revue de l'Agriculture*, 5: 980-1007.

Zeder, M.A., E. Emshwiller, B.D. Smith, and D.G. Bradley. 2006. Documenting domestication: the intersection of genetics and archaeology. *Trends in Genetics,* 22(3): 139-155.

Zeder, M.A. and B. Hesse. 2000. The initial domestication of goats *(Capra hircus)* in the Zagros mountains 10,000 years ago. *Science,* 287(5461): 2254-2257.