The use of reproductive and molecular biotechnology in Animal Genetic Resources management – a global overview[1]

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Summary

As part of the country-driven strategy for the management of animal genetic resources, FAO invited 188 countries to participate in the preparation of the First Report on the State of the World's Animal Genetic Resources. Utilizing the information provided in the 148 country reports ready for analysis in July 2005, this paper presents a global overview of the state of capacity and utilization of reproductive and molecular biotechnologies in the management of animal genetic resources. Regional descriptions outline the distribution of different biotechnologies, along with a discussion of the species and breed focus of their use, and stakeholder involvement in service delivery. Unsurprisingly, there is a big gap in biotechnology use between developed and developing countries, with artificial insemination being the technology most widely applied in developing countries. More complex technologies such as embryo transfer and molecular tools, are even less common in developing countries. Use of biotechnologies is in general biased towards cattle, and examples of the application of biotechnologies in the management of locally adapted breeds are limited. Most developing countries express the wish to increase the utilization of biotechnologies. However, in many cases clear plans for incorporating technologies into animal genetic resource management are lacking.

Resumen

Como parte de la estrategia de liderazgo de los países en la gestión de los recursos zoogenéticos, la FAO invitó 188 países a participar en la preparación del Primer Informe sobre la situación mundial de los recursos zoogenéticos. Utilizando la información proporcionada por los 148 informes nacionales listos para analizar en julio del 2005, este artículo presenta una visión global de la capacidad y utilización des las biotecnologías reproductivas y moleculares en la gestión de los recursos zoogenéticos. Las descripciones regionales evidencian la distribución de las distintas biotecnologías junto con una discusión sobre especies y razas focalizada sobre su uso, así como la implicación de los ganaderos en la entrega de servicios. Se comprueba sin sorpresa que existe una gran diferencia en la utilización de la biotecnología entre países desarrollados y en desarrollo. Tecnologías más complejas, tales como la transferencia de embriones y herramientas moleculares son incluso menos comunes en los países en desarrollo. La utilización de biotecnologías está orientada hacia los bovinos y los ejemplos de aplicación de biotecnologías en la gestión de razas locales adaptadas es muy limitado. Muchos de los países en desarrollo solicitan un aumento en la utilización de las biotecnologías. Sin embargo, en muchos casos existe una escasez de planes efectivos para la incorporación de nuevas tecnologías en la gestión de los recursos zoogenéticos.

Keywords: *Biotechnology, Animal genetic resources, Artificial insemination, Embryo transfer, Molecular genetics.*

Introduction

The development of biotechnologies in the fields of breeding, reproduction and molecular genetics has advanced markedly in recent years. Reproductive biotechnologies for livestock have the potential to increase reproductive efficiency and rates of animal genetic improvement. Advances in artificial insemination (AI) and multiple ovulation followed by embryo transfer (MOET) have already had a major impact on livestock improvement programmes in developed countries. AI and MOET

[1]This paper updates and completes the preliminary analysis published in an earlier paper by Cardellino *et al.*, 2005.

speed up genetic progress, reduce the risk of disease transmission and expand the number of animals that can be bred from a superior parent. Technologies such as genomics and molecular markers are valuable in understanding, characterizing and managing animal genetic resources (FAO, 2004).

Recent years have also seen an increased recognition that farm animal genetic diversity is an important resource, which enables the livestock sector to meet diverse requirements and to adapt to emerging needs and challenges. Similarly, it is recognized that this diversity is eroding at a worrying speed. The urgent need to address the issue is heightened by rapid changes to the livestock sector associated with the increasing demand for livestock products, which is occurring in many developing countries (Delgado *et al.*, 1999). At the same time, the Millennium Development Goals have focussed attention on poverty alleviation, and the immediate concerns in the developing world are for food security and economic development. While reproductive biotechnologies, have the potential to enhance livestock productivity, there is also a concern that inappropriate or unplanned use, in particular of AI, can lead to increased rates of genetic erosion and breed extinction.

The Food and Agriculture Organization of the United Nations (FAO) has been asked by its member countries to develop and implement a country-driven Global Strategy for the Management of Farm Animal Genetic Resources. One part of the process is to understand and analyse the national and global state of animal genetic resources. FAO invited 188 countries to submit country reports (CRs), which are currently being analysed to obtain a global picture and to produce the First Report on the State of the World's Animal Genetic Resources.

The objective of this paper is to distil and analyse the information provided in the CRs regarding the use of biotechnologies in livestock breeding and reproduction, as well as for research into livestock genetics. Examples, illustrating the application of biotechnologies, in particular in the management of locally adapted breeds of livestock, are drawn from the CRs. It should be noted that applications of biotechnology, not related to reproduction and breeding, are not considered. Moreover, a detailed assessment of the use of biotechnologies for the purposes of cryoconservation is not included. The paper also outlines the views expressed in the CRs regarding constraints, opportunities and priorities related to the development and utilization of biotechnologies for the management of farm animal genetic resources.

Methods

The findings presented in this paper are based on the 148 CRs that were available by July 2005 (the completion date for each CR is shown in Appendix 1). The countries had been offered guidelines for the preparation of the reports, one section of which was to be devoted to reviewing the state of national capacities, and assessing future capacity building requirements (FAO, 2001). The CRs, thus, offered a useful resource on which to base an assessment of the current global state of capacity and utilization of biotechnologies across a wide range of production systems, and in the context of ongoing changes to the livestock sector.

Reports were classified on the basis of the regional classification established by FAO for the purposes of preparing the First Report on the State of the World's Animal Genetic Resources (a total of seven regions). The study considered 42 reports from Africa, 25 from Asia, 39 from Europe, 22 from Latin America and the Caribbean, 7 from the Near and Middle East, 2 from North America and 11 from the Southwest Pacific. The distribution of the countries covered in this paper, by region is shown in Appendix 1.

The numbers of countries within each region reporting a particular activity is presented. Data relating to the species and type of breeds to which the biotechnologies are applied, and the types of institutions involved in the provision and utilization of the biotechnologies, are analysed where available. As the data was not obtained on the basis of formal sampling or a standard questionnaire, no statistical analysis was carried out, and the results are presented descriptively. As it was not always clear from the CRs whether a particular technology was being used or not, the number of reports providing the relevant information is presented for each set of results. The names of individual countries are not mentioned in the presentation of the quantitative information. However, where illustrative examples are offered, the relevant CR(s) are cited. Also, where a small number of countries depart markedly from the general pattern of the region, this is indicated.

Table 1. Reported use of biotechnologies by region.

Region	No. of CRs	Artificial insemination		Embryo transfer		Molecular genetic technologies	
		No. providing info.	Reporting use of the technology	No. providing info.	Reporting use of the technology	No. providing info.	Reporting use of the technology
Africa	42	42	74%	30	17%	29	14%
Asia	25	22	86%	17	47%	16	50%
Europe	39	39	97%	25	64%	29	83%
Latin America and the Caribbean	22	22	95%	14	86%	15	73%
Near and Middle East	7	6	100%	3	33%	5	40%
North America	2	2	100%	2	100%	2	100%
Southwest Pacific	11	11	55%	10	10%	9	11%

Table 2. Reported use of biotechnologies by species.

Region	Artificial insemination			Embryo transfer			Molecular genetic technologies		
	No. with info on species	Reporting use of the technology:		No. with info on species	Reporting use of the technology:		No. with info on species	Reporting use of the technology:	
		In cattle	In other species		In cattle	In other species		In cattle	In other species
Africa	31	100%	10%	4	100%	0%	3	100%	33%
Asia	18	94%	56%	6	100%	50%	7	86%	100%
Europe	38	100%	66%	11	100%	36%	18	89%	100%
Latin America and the Caribbean	21	100%	71%	12	100%	33%	9	78%	89%
Near and Middle East	6	100%	33%	1	0%	100%	2	0%	100%
North America	2	100%	50%	0	-	-	1	100%	100%
Southwest Pacific	5	100%	80%	2	100%	0%	0	-	-

Results

Table 1 presents a region-by-region overview of the proportion of countries reporting the use of different classes of biotechnology. It can be seen that AI is by far the most widely used biotechnology, but particularly in the Africa and Southwest Pacific regions, there are many countries where it is unavailable. In the case of ET and molecular techniques the gap between the developed and developing regions is even greater. Table 2 gives an indication of the bias in favour of cattle in the application of biotechnologies. The table shows a greater bias with respect to ET, but it can also be seen that in most regions the use of AI is also dominated by the cattle sector. In the Africa region in particular, few countries have extended the use of AI to other species. The evidence for such a species bias is rather less in the case of molecular genetic technologies. The number of countries reporting the use of such technologies is quite low. However, among these a relatively high number report studies of molecular characteristics in at least one species other than cattle. Nonetheless, cattle remain the single dominant species in most regions; particularly so where commercial applications of the technologies are concerned. Further details of the distribution of biotechnology use and of the species to which they are applied are included in the following regional descriptions.

Africa

The CRs indicate that AI is the biotechnology most commonly used in the management of animal genetic resources in Africa. The CRs generally express an aspiration for greater use of the technology in the management of genetic resources, notably in facilitating breeding programmes and the introduction of exotic germplasm. This aspiration corresponds to the overall objective expressed in most African CRs, of promoting food security through increased livestock productivity. In many cases, the desire for more widespread use of AI is tempered by concern regarding the implications of its inappropriate or uncontrolled use for genetic diversity and the availability of livestock well adapted to the local production conditions. A number of CRs also mention the potential use of AI facilities for purposes of cryoconservation.

Thirty-one out of 42 countries report the use of AI. A few other countries report that AI has been carried out experimentally in the past, but never applied routinely, or that former AI programmes have been abandoned through lack of financial resources or other constraints. AI use in Africa is predominantly concerned with cattle. All 31 CRs reporting the use of AI mentioned that the technology is used in cattle. Two countries report the use of AI in sheep, 1 in goats, 1 in horses and 1 in pigs. The semen used for AI tends to be from exotic breeds rather than local breeds. Nineteen countries indicate that AI was performed using semen from exotic cattle breeds, 2 report using semen from local breeds and 6 report use of both local and exotic semen. Where details of programmes are provided, the objective is often the upgrading of indigenous livestock using semen from exotic breeds, most frequently of dairy cattle. Exotic beef cattle semen is also utilized in a number of countries.

Some CRs from West Africa mention the use of exotic semen for cross-breeding with trypanotolerant cattle breeds (Guinea CR; Côte d'Ivoire CR). A limited number of AI programmes utilizing semen from indigenous animals are reported, including in one country the use of semen from trypanotolerant cattle (Côte d'Ivoire CR). The Madagascar CR notes the use of AI in *in situ* conservation programmes for the endangered Renitilo cattle breed. However, even in countries where indigenous breeds are included in AI programmes, the balance appears to favour exotics. One report indicates that 94.1 percent of AI services were carried out using the semen of exotic breeds (Botswana CR). One report notes considerable use of AI to introduce exotic germplasm into the breeding of race horses (Senegal CR). The use of AI by smallholders is largely restricted to dairy producers and is concentrated in peri-urban areas. A small number of CRs mention efforts to promote a wider diffusion of the technology, including less easily accessible areas.

There is considerable variation from country to country in terms of the development of facilities and human resources for the implementation of AI programmes, in terms of the availability of services to the farmer, and in terms of the providers involved in service delivery. The public sector is the most frequently reported provider of AI services. Among the 27 reports providing information on service providers, 26 mention the public sector and 12 mention private companies. NGOs are mentioned as providers of AI services by 8 CRs, while breeders' organizations are mentioned in 2 reports (Burkina Faso and Madagascar). The CR from Niger mentions collaboration between two Italian universities, a local university and a local research station in establishing an AI programme for cattle. The CR from Zambia indicates that individual private farmers have imported exotic semen for the purposes of improving their cattle herds.

Several countries report that problems with the financing of government services are a constraint to the provision of AI. Increased involvement by the private sector is noted as an objective in several CRs. A few countries are able to report significant progress in this direction (for example, Kenya CR, Zambia CR). The CR from Zambia notes that the private sector has taken the lead in providing imported semen, while the government trains and supervises A.I. technicians. However, as the above figures indicate the role of the private sector appears to be limited or absent in most countries. Few CRs discuss constraints to the involvement of the private sector in any detail. However, the CR from Côte d'Ivoire reports that the single private operator in the country had ceased activities as a result of financial difficulties.

Five countries (Côte d'Ivoire, Kenya, Madagascar, Zambia, and Zimbabwe) report the use of embryo transfer (ET) technologies. Use of the technology appears to be limited. In one country, the technology is reported only to have been used on Holstein-Friesian cattle on a single private farm (Madagascar CR). The CR from Côte d'Ivoire notes that some individual cattle owners have introduced Brazilian Zebu genetic material through the import of frozen embryos. In Zimbabwe, the technology is available through two private breeding companies (Zimbabwe CR). Several CRs state that the introduction of ET is an objective. However, the specific role that the technology could be expected to play in the management of genetic resources in the local production systems is rarely elucidated. There is a lack of discussion of how it could be integrated within organized breeding programmes. The potential use of the technology for purposes of cryoconservation is, however, noted in several CRs. Very few countries report the use of other biotechnologies. Molecular genetic evaluation and distancing studies in cattle are each mentioned in two CRs.

Asia

Among the Asian CRs 19 out of 22 countries providing information indicate the use of AI. From 18 countries providing details of the species inseminated, 17 mention cattle, 8 pigs, 5 buffaloes, 4 sheep, 3 chickens, 2 goats, 2 horses, and 1 camels and 1 ducks. Details of the breeds used as the source of semen are limited. However, in the case of cattle 8 CRs indicate the use of semen from both local and exotic breeds, 4 mention only exotic breeds, and 2 mention only local breeds. Provision of AI services appears to be dominated by the public sector. Of 17 reports giving details of service providers, all 17 mention the public sector, with 6 mentioning the private sector, 5 breeders' organizations 4 NGOs and 1 universities. There is much variation from country to country in the extent to which AI is used. In an industrialized country such as Japan, almost all cattle breeding (99.4 percent in dairy herds and 97.8 percent in beef herds) is carried out using AI (Japan CR). In most other Asian countries, services are much more limited and tend to be focused on the dairy sector and peri-urban production systems. Several reports indicate that service coverage is limited by financial and technical constraints. Indeed, a few reports indicate a decline in the use of the technology.

The desire to establish or to increase the availability of AI services is expressed as an objective in many reports. In a number of countries AI has served as a means of introducing exotic germplasm for the purposes of cross-breeding with local breeds. The technology has been used in the development of synthetic breeds incorporating both exotic and indigenous genes, an example being the Jermasia goat (Malaysia CR). In some cases, AI has also been used to upgrade cross-breeds back to indigenous breeds through back-crossing to promote hardiness. This approach has been applied, for example, using Kedah-Kelantan semen in cattle herds introduced to tree plantations (Malaysia CR). In some cases, AI services supply semen from indigenous breeds, for example Sahiwal cattle (Pakistan CR). However, the same CR indicates that the collection of semen from some other indigenous cattle breeds was discontinued because of a lack of demand.

Eight out of 17 Asian countries providing information on the matter indicate some use of ET technology. Among the 6 countries providing details of the species in which the technology is implemented, 6 mention cattle, 2 buffaloes, 1 horses and 1 goats. The breeds involved are rarely detailed, but one report mentions the transfer of embryos from indigenous cattle breeds and one mentions exotic breeds. In most countries ET is used on a very limited scale and is often largely confined to research. One CR indicates that although capacity to use the technology was previously developed it has now been abandoned. ET technology was used in the development of the Mafriwal cattle breed (Malaysia CR). The potential role of the technology in cryoconservation programmes is noted in several CRs.

Eight out of 16 Asian countries providing information on the matter report the use of molecular genetic technologies. Among these countries, 6 specify genetic distancing studies, and 2 mention marker assisted selection. Among the 7 countries providing details of the species involved in molecular evaluation studies, 6 mention cattle, 5 chickens, 4 sheep, 4 goats, 4 pigs, 3 buffaloes, 2 ducks, 2 horses, 1 camels, 1 deer, 1 quail and 1 guinea fowl. In the case of distancing studies, among the 5 countries providing details of the species involved, 4 mention chickens, 3 cattle, 3 sheep, 3 goats, 2 pigs, 2 buffaloes, 2 horses, 1 ducks, and 1 deer. With regard to the breeds involved in molecular genetic studies, systemized studies on Asian breeds are being conducted by the Society for Research on Native Livestock in Japan, including analysis based of genetic relationships based on mitochondrial DNA polymorphisms and other DNA markers (Japan CR). Native Japanese breeds covered by the studies include Mishima cattle and Kuchinoshima feral cattle (ibid.).

Other biotechnologies are very largely restricted to the most industrialized countries in the region. The use of *in vitro* fertilization is mentioned in two CRs. The Japan CR indicates that a number of other reproductive biotechnologies with potential for use in the propagation of rare breeds, as well as commercial applications, have been utilized at an experimental level. The technologies include sperm microinjection to fertilize eggs – applied in pigs; primordial germ cell (PGC) and chimera germline techniques – applied in chickens; and cloning technologies used in cattle, pigs and goats (ibid.).

Europe

Thirty eight of 39 European countries report the use of AI. All 38 mention the use of the technology in cattle, 23 in pigs, 16 in sheep, 9 in horses, 8 in goats, 2 in rabbits, and in 1 chickens. Most countries which give details report using semen from both local and imported breeds of cattle, pigs and sheep. While most countries are able to report the existence of some AI provision, there is great variation between countries in the extent to which the technology is utilized. In many countries, particularly in western Europe, AI is widely available and used throughout the livestock sector, most notably in dairy cattle. However, a number of CRs from eastern Europe and the Caucasus, where the livestock sector has often faced considerable problems and declining populations, indicate that capacity to provide AI services is severely limited as a result of the disintegration of formerly existing infrastructure.

A range of providers are involved in the delivery of AI services. Of the 32 countries giving details of providers, 24 mention the private sector, 20 the public sector, 19 breeders' organizations and 3 universities. In eastern Europe and the Caucasus, services where they are available, are more likely to be provided by the public sector. Conversely, elsewhere in the region, the private sector and farmers' organizations are the most frequently mentioned service providers, although in many countries there is still considerable involvement or support from the public sector. Transfer of services to the private sector has not always been without problems; the CR from Romania reports that reogranization and greater independence of AI institutes, along with the introduction of service charges, led to a decline in uptake.

In some countries, AI using imported semen has been widely used to increase the productivity of local breeds. However, some concerns are raised in the CRs. Attempts to upgrade local livestock using exotic semen have sometimes failed because the resulting cross-bred animals have proved to be poorly adapted to the local conditions. There is also a potential threat to genetic resource diversity. According to the CR from Greece, inappropriate and unplanned use of AI contributed markedly to the loss of some indigenous breeds.

Sixteen of the 25 countries providing information on the matter report the use of ET. Of the 11 countries providing details of the species involved, all 11 mention cattle, 3 sheep, 2 goats, 1 pigs, 1 horses and 1 rabbits. Where specified, ET is carried out using embryos from both imported and local breeds of cattle. Again, it is the dairy industry which is the main user of the ET. The technology has contributed significantly to increasing the rate at which increased productivity has been achieved through selective breeding. However, as a result of the costs involved in the utilization of the technology it is less widely used than AI, and in some countries ET programmes have ceased as a result of the high costs. In the case of ET, out of 8 countries providing details of service providers, 4 mention the private sector, 4 the public sector, 4 breeders' organizations and 3 universities. Other reproductive technologies such as embryo sexing, cloning and transgenetics are mentioned in a very few CRs as subjects for research.

Twenty-four out of 29 CRs providing information on the matter indicate the use of molecular genetic technologies. Marker assisted selection, for example, is used in commercial animal production in a number of European countries. The technology can be applied to eliminate a number of undesirable traits related to health or fertility from livestock populations and to assist selective breeding for greater productivity. The importance of ensuring that information on such new technologies, including their economic benefits, are made available to farmers and breeders' organizations is noted in one report (Hungary CR). Another report highlights the prospect that molecular biological methods will facilitate the discovery of genes for economically important traits in locally adapted breeds, thereby enhancing their value in breeding programmes (Germany CR). However, the same report raises the concern that the use of molecular technologies in the context of market-driven attempts to increase productivity could exacerbate a trend towards inbreeding and loss of genetic diversity within livestock populations. Similar apprehensions are expressed in a small number of other reports. Genetic distancing studies are considered important from the point of view of planning and prioritizing conservation efforts. One CR, however, notes that progress to this end has been limited as interest in the subject is largely restricted to universities, and funding is limited (Belgium CR). Another report puts forward a potential commercial role for such techniques in relation to the development of niche products and the marketing of livestock breeds on the grounds of their close association with a particular geographical location (France CR).

Among the CRs providing details of the use of molecular technologies, 11 specify the implementation of molecular genetic distancing studies and 7 mention the use of marker assisted selection. Out of 17 countries providing information on the species involved in molecular characterization studies, 14 mention cattle, 13 sheep, 11 pigs, 8 horses, 5 goats, 3 chickens, 1 donkeys, 1 turkeys and 1 geese. Out of 12 countries providing information on the species involved in distancing studies, 11 mention sheep, 9 cattle, 5 horses, 4 pigs, 3 chickens, 3 goats, 2 geese, 1duck, 1 donkeys, 1 rabbits, and 1 deer. Out of 4 countries providing information on the species on which marker assisted selection is practised, 4 mention cattle, 4 pigs, 1 chickens and 1 horses. Details of the specific breeds to which technologies have been applied are quite limited in the CRs. Among the local breeds for which molecular characterization or distancing studies are mentioned in the CRs are the Turopljе and Black Slavonian pigs, Ruda sheep, sheep of the islands of Rab, Pag and KrK (Croatia CR); Wallachian and Sumava sheep, Brown goats and White goats (Czech Republic CR) and the Karakachanska sheep (Former Yugoslav Republic of Macedonia CR).

Latin America and the Caribbean

AI is widely practised in the countries of this region. Twenty-one out of 22 countries indicate the use of the technology. All 21 countries report the use of AI in cattle, 13 mention pigs, 8 sheep, 8 goats, 5 horses, 1 rabbits, 1 buffaloes, 1 donkeys 1 llamas, 1 alpacas and 1 turkeys. With regard to the cattle breeds providing the semen used for AI, 13 reports mention only exotic breeds, while 4 mention both local and exotic. In the cases of sheep, 5 reports mention exotic breeds and 1 mentions both exotic and local; and in the case of pigs, 9 CRs mention only exotic breeds while one mentions both local and exotic. It is clear that the predominant objective is to increase the genetic merit of livestock populations using semen from exotic breeds. In many countries, semen is imported from overseas. Use of the technology is most common in the dairy sector. In some countries it is also quite widely used by commercial producers of beef cattle, pigs and small ruminants. However, there is marked variation between countries and between production systems in terms of the extent to which AI is used. In many small-scale or low external input systems, use of the technology is very limited. A number of countries indicate that improving the provision of AI services is an important objective. A small number of reports, however, mention concerns regarding the decrease of genetic diversity arising as a result of the inappropriate use of AI. With regard to the providers involved in the delivery of AI services, the private sector plays an important role in this region. Of 17 reports giving details of service providers, 11 mention the public sector, 9 mention the private sector, and 5 breeders' organizations.

ET technology is increasingly being used by commercial livestock producers in several countries of the region. Twelve reports, out of 14 providing information, report the use of ET. All 12 mention the use of the technology in cattle, 3 in horses, 2 in goats, 2 in sheep, 1 in llamas, 1 in alpacas and 1 in donkeys. Transplanted embryos largely come from exotic breeds – the six countries that provided details of the cattle breeds involved indicate the use of embryos only from exotic breeds. As in the case of AI, though on a more limited scale, use of ET technology is dominated by the dairy industry, with restricted use in other types of commercial livestock production. Some CRs indicate the importation of embryos from overseas. Information on the providers of ET services is limited. However, two CRs (Brazil and Chile) mention private sector organizations involved in the provision of the technology. Additionally, two CRs indicate some commercial use of *in vitro* fertilization, while one mentions the development of embryo sexing and cloning technologies.

Eleven countries, out of 15 providing information, indicate some use of molecular genetic technologies. With regard to molecular characterization studies, out of 9 countries providing information on the species involved, 7 mention cattle, 3 sheep, 3 pigs, 2 chickens, 2 horses, 1 goats, 1 buffaloes, 1 llamas, 1 alpacas, 1 vicuñas, 1 guanacos and 2 unspecified camelids. Several countries indicate that locally adapted breeds have been included in such studies. The CR from Peru mentions molecular investigations of the genetic distances between South American camelid species. Few reports, however, indicate that molecular technologies have been incorporated in breeding programmes. The Colombia CR notes the potential significance of marker assisted selection programmes utilizing the genes of the Blanco Orejinegro cattle breed, which is reported to show resistance to brucellosis, and which has been the object of molecular characterization studies.

Near and Middle East

In this region all six countries providing information on the matter report the use of AI. With regard to the species involved, all 6 mention cattle, 1 camels and 1 rabbits. One CR mentions the use of ET in camels (Oman CR). The semen used in AI programmes is largely obtained from exotic breeds, either from local populations or imported. A number of CRs note that the use of AI has had an adverse effect on genetic diversity and contributed to the decline of local livestock breeds. One CR indicates some use of semen from a local cattle breed (Syrian Arab Republic CR). Some CRs indicate that the development of AI programmes for local breeds of sheep, goats and/or buffaloes is a priority. The CR from the Syrian Arab Republic, for example, notes that the local Awassi sheep and Shami goats are much sought after in neighbouring countries for breeding, and that plans are in hand to develop AI and ET programmes to meet the demand. Among 6 countries giving information on service providers, 5 mention the public sector, 4 the private sector and 2 breeders' organizations. Some reports, however, indicate constraints to the provision of AI, such as a lack of trained personnel. Several reports note the potential use of AI and ET technologies in cryoconservation. The use of other biotechnologies is limited. One report (Jordan CR) indicates molecular characterization and genetic distancing studies in indigenous goats, while another (Egypt CR) notes that molecular genetic studies of buffalo, sheep and goats have recently been initiated with the aid of regional and international organizations.

North America

In the United States of America and Canada reproductive biotechnologies are readily available. AI is widespread in the dairy and pig industries, and is used to a lesser extent in other sectors such as beef cattle and small ruminants. Concern is expressed at the role of AI in contributing to a reduction in the effective population size of some dairy cattle breeds. Details of the utilization of other biotechnologies are limited in the CRs from this region. In the United States, molecular characterization studies have been carried out, by the industry and public sector institutions, for the most widely kept breeds of dairy cattle and pigs, and also in a number of beef cattle breeds (United States CR). Molecular markers are particularly used for the identification of recessive defects in bulls used for AI. Molecular studies, providing measures of within and between breed genetic diversity, are also used by the National Animal Germplasm Program (NAGP) in the planning of conservation programmes for livestock genetic resources (ibid.).

Southwest Pacific

Biotechnologies are not widely used in this region. Six of the 11 CRs indicate the use of AI. Out of 5 countries indicating the species involved in AI programmes, 5 mention cattle, 4 pigs, 1 sheep and 1 goats. With regard to AI service providers, 2 reports mention the public sector, 2 the private sector and 1 mentions an individual volunteer from a developed country. Several reports from small island countries note the potential of AI as a means of introducing exotic germplasm, but the use of the technology appears to be limited. In some countries a small number of private livestock producers are involved in the import of semen for the purposes of AI in their herds. Two countries (Australia and Vanuatu) indicate the use of ET technology, both reports referring to cattle. Additionally, the CR from Samoa notes the use of the technology for the introduction of the Piedmontese breed during the 1980s. Capacity for the use of biotechnologies is well developed in Australia, which is the only country from the region reporting the use of molecular genetic techniques to underpin characterization and selection efforts (Australia CR).

Discussion

The information provided by the CRs unsurprisingly indicates that there is a large gap between developed and developing countries in terms of their capacity to make use of biotechnologies in the management and development of livestock genetic resources. Some livestock production systems in a number of South American countries are, however, relatively well able to access biotechnologies as compared to other developing-country systems.

In the developing countries, AI is the most common technology used. A probable reason is that AI has the most favourable cost-benefit ratio of the reproductive biotechnologies (Thibier *et al*., 2004) and also requires comparatively less technical skill and equipment. However, in Africa and in the Southwest Pacific even AI is not practised in all countries. Constraints to the development and utilization of biotechnologies in general include a lack of financial, human and technical resources. Moreover, the provision of services such as AI often has to overcome difficulties relating to access, affordability, farmer awareness and knowledge, and the need to tailor services to the needs of livestock keepers within diverse local production systems. In the case of more complex technologies such as ET the constraints are magnified to an even greater extent. The use of reproductive biotechnologies is most widespread in cattle. The low natural reproductive rate of cattle increases motivation to develop and utilize technologies which allow the rate of genetic improvement to be increased (FAO, 1996). Moreover, the high value of the animals makes expenditure on AI or ET more economically attractive. The technical ease of deep-freezing semen and embryos is also highest in cattle (Hiemstra *et al*., 2005). However, the finding may also reflect the general pro-cattle bias which has been observed in livestock development efforts (FAO, 1993). With regard to the breeds involved, there are only a limited number of examples in the CRs of programmes which make use of biotechnologies to facilitate the development, utilization or conservation of locally adapted breeds.

While the expansion of the use of biotechnologies is clearly considered to be an important objective, many CRs express concern regarding the inappropriate use of AI. Concerns largely relate to the unplanned use of the technology to introduce exotic germplasm, which may threaten the existence of indigenous genetic resources. With regard to productive breeds kept under high external input conditions, some concerns are also expressed with regard to a narrowing of the genetic resource base. As such, there is a need for careful attention to be given to identifying appropriate policies, programmes and regulatory frameworks for the use of biotechnologies in the management of livestock breeding and reproduction. Such deliberations require good knowledge of the characteristics of the relevant genetic resources, an understanding of the production systems in question, and consideration of the above-mentioned constraints to service delivery.

Molecular genetic studies offer a potentially important tool for the characterization of livestock genetic resources. However, the use of molecular techniques to evaluate genetic resources, to plan of conservation efforts, or to facilitate the achievement of desired breeding objectives is limited or absent in most developing countries. A desire to develop greater capacity to conduct molecular genetic studies is expressed as a priority in many CRs. However, the successful application of technologies such as marker assisted selection necessitates a high level of expenditure in terms of establishment and maintenance costs, and requires skilled human resources, equipment, laboratories and supportive infrastructure (FAO, 2005). As such, the cost-effectiveness of strategies based on the use of the technologies has to be carefully evaluated.

The desire to make greater use of biotechnologies to raise livestock productivity and increase the supply of livestock products is widely expressed in the CRs from developing countries. In a number of regions, there is increasing diversity in terms of the stakeholders providing services, with greater involvement of the private sector and breeders' organizations. However, the extent to which such developments will overcome the constraints to the utilization of biotechnologies in developing countries is not clear. It is evident from the CRs that in this respect, progress is often very limited. A widespread use of biotechnology is hindered by the gaps in infrastructure, markets, breeding capacity, input delivery systems and extension services, which hinder all efforts to promote livestock development in poor, remote areas (FAO, 2004). As such, many of those most dependent on livestock to support their livelihoods are denied the option of utilizing biotechnologies as a means of developing animal genetic resources to meet their needs. However, there is also concern that the potential of biotechnology to make a substantial contribution to poverty reduction is overrated in relation to livestock production (Bayer, 2005).

In contrast to the research that drove the Green Revolution, the majority of agricultural biotechnology research and commercialization is being carried out by private firms based in industrialized countries (FAO, 2004). This is evident in the production of genetically modified crops but also in the concentration of the market in the hands of a small number of breeding companies in the poultry sector, a development which seems to be followed in the pig industry. The dominance of the private sector in the "gene revolution" raises concerns that farmers in developing countries, particularly poor farmers may not benefit, or indeed may lose out, either because innovations are not accessible, are too expensive, or are inappropriate to their needs.

Conclusions

It is evident that there are numerous constraints and pitfalls to be overcome if reproductive biotechnologies are to make a significant positive contribution to the management of animal genetic resources in developing countries. Investment in infrastructure, and human and technical capacity building is required; and this desire is clearly expressed in many CRs. However, it is also essential that increased utilization of the technologies is well planned, has clear objectives and takes account of local conditions. To this end, improved characterization of breeds and production environments is required. Better understanding is vital to ensure that the more rapid genetic change made possible by biotechnologies is actually beneficial to livestock keepers and society, and that threats to genetic diversity are minimized. Biotechnologies will contribute little to genetic improvement unless calls for their introduction are accompanied by a vision of how they can be incorporated within targeted breed development programmes. Few programmes capable of incorporating the more advanced biotechnologies into livestock genetic improvement activities exist in developing countries at present. The situation is unlikely to change without significant public as well as private sector investment.

Constraints to the delivery, uptake and successful application of biotechnologies in developing-country conditions need to be addressed. Consideration should be given to any accompanying improvements to animal health, nutrition and management which may be necessary to achieve the desired outcomes. As well as considering impacts on genetic diversity, the short and long-term socio-economic implications of promoting the increased use of biotechnologies by small-scale producers also need to be assessed. Potentialities, constraints and problems related to the roles of alternative service providers require investigation. Livestock keepers, their associations, and relevant NGOs should be involved in the process of setting priorities for biotechnology use, the organization of breed development programmes, and in resolving problems associated with the provision of biotechnology services.

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Appendix 1. Distribution of countries by region (and dates when country reports were completed)

Africa: Algeria (October 2003), Angola (May 2004), Benin (July 2003), Botswana (November 2003), Burkina Faso (May 2003), Burundi (December 2003), Cameroon (February 2003), Cape Verde (January 2003), Central African Republic (June 2003), Chad (April 2003), Comoros (March 2005), Congo (April 2003), Democratic Republic of the Congo (January 2005), Côte d'Ivoire (March 2003), Equatorial Guinea (May 2003), Eritrea (July 2003), Ethiopia (July 2004), Gabon (March 2003), Gambia (January 2003), Ghana (October 2003), Guinea (April 2003), Guinea-Bissau (July 2002), Kenya (June 2004), Lesotho (April 2005), Madagascar (March 2003), Malawi (April 2004), Mali (September 2002), Mauritania (February 2004), Mauritius (August 2004), Mozambique (March 2004), Niger (May 2003), Nigeria (March 2004), Rwanda (May 2004), Sao Tome and Principe (May 2003), Senegal (April 2003), Swaziland (December 2004), Togo (March 2003), Tunisia (December 2003), Uganda (February 2004), United Republic of Tanzania (October 2004), Zambia (November 2003), Zimbabwe (May 2004).

Asia: Bangladesh (June 2004), Bhutan (September 2002), Cambodia (August 2003), China (June 2003), India (December 2004), Indonesia (August 2003), Iran (Islamic Republic of) (July 2004), Japan (April 2003), Kazakhstan (December 2003), Kyrgyzstan (November 2003), Laos (May 2005), Malaysia (August 2003), Maldives (September 2004), Mongolia (September 2002), Myanmar (March 2004), Nepal (January 2004), Pakistan (March 2003), Papua New Guinea (November 2004), Philippines (August 2004), Republic of Korea (March 2004), Sri Lanka (August 2002), Tajikistan (December 2003), Turkmenistan (August 2004), Uzbekistan (August 2003), Viet Nam (April 2003).

Europe: Albania (December 2002), Armenia (June 2003), Azerbaijan (December 2003), Belarus (2003), Belgium (January 2005), Bosnia and Herzegovina (2003), Bulgaria (March 2004), Croatia (July 2003), Cyprus (October 2003), Czech Republic (July 2003), Denmark (April 2004), Estonia (March 2004), Finland (January 2004), France (June 2004), Georgia (February 2004), Germany (June 2003), Greece (February 2004), Hungary (June 2003), Iceland (December 2003), Ireland (July 2003), Latvia (December 2003), Lithuania (November 2003), Netherlands (November 2002), Norway (December 2002), Poland (October 2002), Portugal (June 2004), Moldova (December 2004), Romania (December 2003), Russian Federation (December 2003), Serbia and Montenegro (March 2003), Slovakia (June 2003), Slovenia (June 2003), Spain (June 2004), Sweden (September 2002), Switzerland (December 2002), The Former Yugoslav Republic of Macedonia (November 2003), Turkey (August 2004), Ukraine (February 2004), United Kingdom (November 2002).

Latin America and the Caribbean: Argentina (September 2003), Barbados (January 2005), Bolivia (January 2004), Brazil (February 2004), Chile (December 2003), Colombia (October 2003), Costa Rica (June 2004), Cuba (March 2003), Dominican Republic (March 2004), Ecuador (December 2003), El Salvador (December 2003), Guatemala (April 2004), Haiti (October 2004), Honduras, Jamaica, Mexico (July 2002), Nicaragua (August 2004), Paraguay (June 2004), Peru (May 2004), Trinidad and Tobago (May 2005), Uruguay (December 2003), Venezuela (Bolivarian Republic of) (December 2003).

Near and Middle East: Egypt (June 2003), Iraq (January 2003), Jordan (March 2003), Oman (March 2004), Sudan (January 2004), Syrian Arab Republic (May 2003), Yemen (November 2003).

North America: Canada (February 2004), United States of America (December 2003).

Southwest Pacific: Australia (November 2004), Cook Islands (October 2003), Fiji (March 2004), Kiribati (March 2004), Northern Mariana Islands (February 2004), Palau (2003), Samoa (March 2004), Solomon Islands (February 2004), Tonga (January 2005), Tuvalu (January 2005), Vanuatu (December 2003).

The status of cattle genetic resources in North Ethiopia: On-farm characterization of six major cattle breeds

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Summary

On-farm surveys and characterisation of six indigenous north Ethiopian cattle breeds (Afar, Arado, Begait, Fogera, Medenes and Raya) was carried out with the objective of determining the current status of these breeds. Information from a structured questionnaire distributed to 450 farmers, 37 group discussions, field measurements of heart girth and height on 25 males and 25 females from each breed and secondary information were used to carry out the study. Population size of the Arado breed increased by more than three fold between 1992 and 1999, while the Raya, Fogera and Begait population decreased by 57, 27 and 67%; between 1981 and 1999 respectively. Three distinctive types were identified within the Afar and Begait breeds with different adaptation and threat levels in relation to changes to the bio-physical and social environment. Overall production and reproduction performance of the breeds in the pastoral production system (Afar and Begait) was higher than the Raya and Medenes, and Arado and Fogera breeds of the agro-pastoral and mixed crop/livestock production systems respectively. Extinction probability for most of the breeds was high, the highest (0.67) being for the Begait breed. On the other hand, except for the initiative taken to evaluate, improve and conserve the Fogera breed at the Metekel and Andasa cattle breeding ranches, there are no institutionalized attempts towards improving and/or conserving the other breeds.

Resumen

Se llevó a cabo una serie de encuestas sobre el terreno sobre caracterización de seis razas bovinas indígenas del norte de Etiopía (Afar, Arado, Begait, Fogera, Medenes y Raya) con el objetivo de determinar la situación actual de estas razas. Se utilizó la información proveniente de un cuestionario estructurado distribuido a 450 ganaderos, 37 grupos de discusión, medidas tomadas sobre el terreno de circunferencia torácica y altura de 25 machos y 25 hembras de cada raza así como información secundaria utilizada para el estudio. El tamaño de la población de la raza Arado se incrementó por más de tres veces entre 1992 y 1999, mientras que las razas Raya, Fogera y Begait disminuyeron de 57, 27 y 67%, respectivamente, entre 1981 y 1999. Se identificaron tres tipos diversos entre las razas Afar y Begait con diferente adaptación y niveles en relación a los cambios biofísicos y de entorno social. La producción global y rendimiento de reproducción de las razas Afar y Begait en el sistema pastoral fue superior al de las razas Raya y Medenes, y de las razas Arado y Fogera en sistema agropastoral y mixto en sistemas de agricultura/ganadería. La probabilidad de extinción para muchas de las razas fue elevada, la mayor (0,67) correspondía a la raza Begait. Por otra parte, salvo por las iniciativas tomadas para la evaluación, mejora y conservación de la raza Fogera en la zona de Metekel y Andasa, no existen intentos institucionalizados con el objetivo de mejorar y/o conservar las demás razas.

Keywords: *Cattle, Genetic resource, On-farm, characterization, Ethiopia, Extinction, Afar, Arado, Begait, Fogera, Medenes, Raya.*

Introduction

Cattle production has been a crucial part of the production and livelihood systems of the north Ethiopian population as providers of food, draught power and as important hedge during crop failure and drought periods, accumulation of assets and other socio-cultural functions. The north Ethiopian region has been a centre of some of the longest civil wars in Africa and this has led among other things, to the accelerated destruction of eco-systems and natural resource degradation resulting in recurrent drought and famine.

There have been little or no efforts exerted to study the animal genetic resources in general and cattle breeds in particular that have been utilised in the different production systems of the region, which are believed to have close to 50% of the genetic diversity in the country. Due to the fact that there have been major socio-political (civil wars and urbanization) and environmental (drought and destruction of ecosystems) changes in the last 25 years, useful information such as population sizes on most of the cattle breeds is not available and unfortunately most studies seem to have used breed population data that are too old to describe the current status of animal genetic resources in the region.

A recent estimate of extinction probability for 49 African breeds (Reist-Marti *et al.*, 2003) showed that half of the cattle diversity in Africa will be lost in the next 20-50 years if no conservation efforts are made.

The objective of this paper was therefore to provide information on the current status, threat of extinction and on-farm characterisation of the Afar, Raya, Arado, Begait, Medenes and Fogera breeds found in north Ethiopia based on an on-farm characterisation and field measurement.

Materials and Methods

Study area and data collection

The present survey was carried out in six major breeding areas of the six breeds studied: the northern part of the Afar region for the Afar breed; central, southern and western zones of Tigray region for the Arado, Raya, Medenes and Begait breeds respectively; Bahirdar Zuria zone, Andasa and Metekele cattle breeding centres of the Amhara region for the Fogera breed (Figure 1).

The survey was conducted in four villages of the Alamata district of south Tigray (Kelkala, Selienwuha, Fatcha and Gerjele), four villages of the Ahferom district in central Tigray (Igella, Gerhusernay, Semhal and Irdijeganu), three villages of Tahtayadiabo district in west Tigray (Aditsetser, Adiaser, Maykuhli and Gemhalo), four villages of the Abala district, North Afar region (Kala, Weqrigubi, Irebti and Irkudi) and three villages in the Bahirdar Zuria district Amhara region (Kidisthana, Wagtera and Shada) and two cattle breeding centres (Andasa and Metekel).

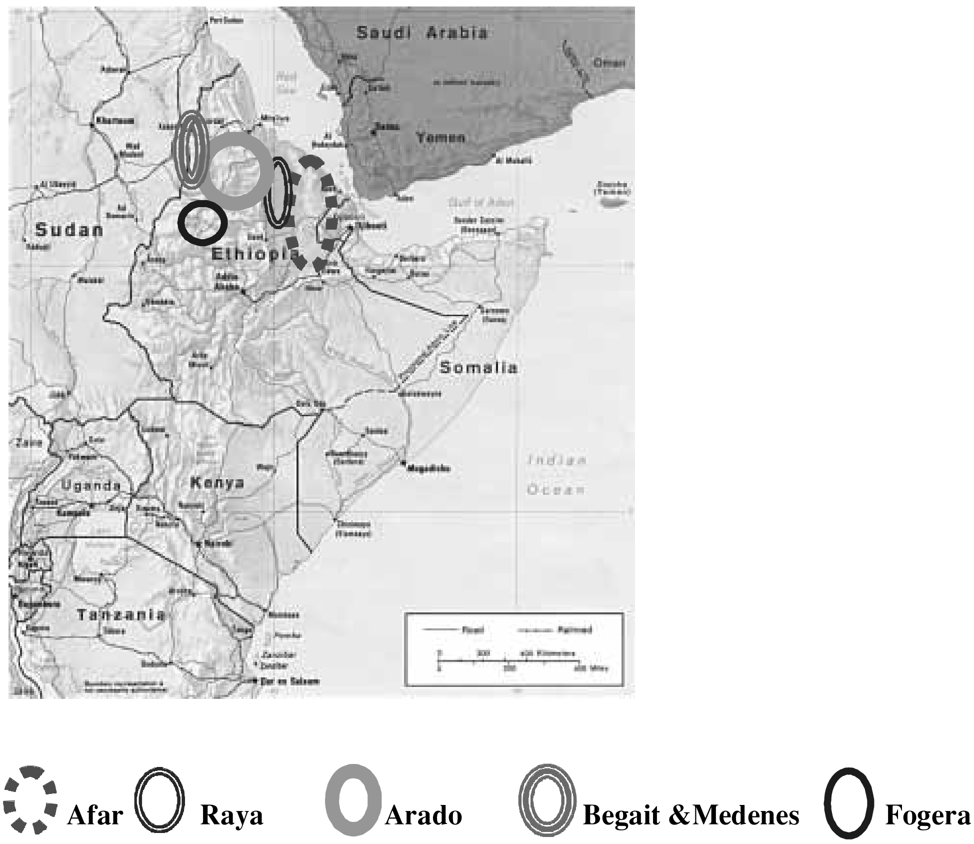

Figure 1. Geographical location of the study and major breeding areas

Villages for this study were selected based on information from the respective regional offices of the Ministry of Agriculture, while cattle owners in those villages were selected randomly. Two cattle breeding centres (Andasa and Metekel) were also included.

An average of 75 cattle owners from each breed were interviewed based on a structured questionnaire designed to collect data for each of the six breeds studied and formal group discussions were conducted. The questionnaire was designed to collect data on the origin of the breeds, physical descriptors, their main purpose, productive and reproductive performance, management and breeding practices, population trends, uniqueness (special traits), farmers' preference and opinions on comparisons of these breeds with other breeds known to the cattle owners. The Arado breed was compared with Begait and Medenes, the Afar breed with Raya and the Fogera breed was compared with highland zebu cattle for 15 traits of economic and adaptive importance. The formal group discussions focussed on general issues such as:

1. status of the breed;
2. breeding management and goals;
3. awareness of diversity;
4. population trends and major threats to the breed.

Three group discussions with 7-10 farmers in each group, were conducted in each village. Information on the bio-physical conditions and production environment (Table 1) and size of breed population (Table 2) was compiled from reports of earlier surveys (BoNAR, 1999; FAO DAD-IS, Haile and Kebede, 1996; Tekleab, 2000; Rege, 1999; Rege and Tawa, 1999; Woldu, 1999). A questionnaire developed for an on-farm characterization of other breeds (Zerabruk and Vangen, 2005) was used in the present study.

Height at withers and heart girth measurements of 25 males and 25 females of each breed were recorded and pictures were taken from representative animals. Adult body weight was estimated from heart girth measurements (Daltons supplies Ltd).

Cattle breeds

Six major breeds found in north Ethiopia - the Afar, Arado, Raya, Begait, Medenese and Fogera - have been included in the present study. The Afar and Begait, Raya and Medenes, and Arado and Fogera are reared in the pastoral, agro-pastoral and mixed crop/livestock production systems respectively (Table 3).

The Afar breed is mainly found in the north-eastern lowlands of the Afar and adjacent regions of Ethiopia. It is adapted to the arid and semiarid range land conditions and to the pastoral and/or agro-pastoral way of life of the Afar people. The breed is mainly reared for its milk production (Albero and Hailemariam, 1982; Rege, 1999).

The Raya breed is found in the south-eastern lowlands and adjacent part of Tigray region, Ethiopia. It is believed to be a variety of the Afar breed adapted to the crop/livestock production system of the area. The breed is popular and reared for its draught power and meat. The Afar and Raya breeds belong to the East African sanga breeds cluster and are further grouped with the Abyssinian sanga breeds (Rege, 1999).

The Arado breed is found widely distributed in the northern highlands of Ethiopia and adjacent areas in Eritrea. It is mainly reared for draught power. The breed subsists mainly on crop residues and is well adapted to seasonal feed shortages associated with the mixed crop/livestock production system in the area (Rege, 1999; Tekleab, 2000).

The Fogrea breed is found in the surrounding area of the Lake Tana region and mainly distributed along the vast area of the Fogera plain, in the north-west highlands of Ethiopia. The breed is popular for its adaptation to seasonal flooding and the swampy conditions of the area. It is reared for its draught and dairy production abilities. The Arado and Fogera breeds belong to the Zenga group (Zebu-sanga cross-bred) (Albero and Hailemariam, 1982; Rege, 1999).

The Medenes breed is a relatively new breed and a result of cross breeding between the Arado and Begait breeds. It is found in the western highlands of Tigray and is bred for both milk and draught purposes (Tekleab, 2000).

The Begait (also known as Barka) breed is found in the western lowlands of Eritrea and north-west of Ethiopia. Animals of this breed are popularly bred for milk production and play an important role in the livelihood of the pastoral and agro-pastoral people in the area. The Begait breed belongs to the cluster of the north Sudan Zebu breeds (Albero and Hailemariam, 1982; Rege, 1999; Tekleab, 2000).

Extinction probability

Extinction probability for the six cattle breeds within the next 20-50 years was calculated using a method described by Reist-Marti *et al.* (2003) as:

Table 1. Characteristics of the major production environment of six indigenous cattle breeds of north Ethiopia[1].

Breed	Agro ecological zones	Altitude m.a.s.l	Major vegetation types	Dominant soil types	Production system
Afar	Hot to warm arid lowland plains	<1400	Bushland, riverine acacia	Solonchacks/ Fluvisols	Pastoralism
Arado	Tepid to cool semi-arid mid highlands	1500-2500	Bushland and cultivation	Cambisols/ Leptisols	Crop/Livestock
Begait	Hot to warm semi-arid lowlands	500-1500	Bushland & grassland.Ballanites, Zeziphus,Boswellia, riverine	Vertisols	Pastoralism
Fogera	Tepid to cool moist mid-highlands	1500-2500	Bushland and cultivation	Vertisols/Luvisols/ Fluvisols Seasonally flooded	Crop/Livestock
Raya	Hot to warm sub-moist lowlands	500-1500	Bushland & cultivation. Acacia, Ballanites, Zeziphus and cactus	Vertisols/Fluvisols/ Leptisols	Agro-pastoralism, Crop/Livestock
Medenes	Hot to warm semi-arid lowlands	500-2000	Bushland and cultivation	Vertisols, Cambisols	Agro-pastoralism, Crop/Livestock

[1]Sources: Haile, and Kebede (1996), Woldu (1999).

Table 2. Distribution and population size of six indigenous cattle breeds of north Ethiopia.

Breed	Village	Population size[1]	Population size[2]
Raya	• Rayaazebo	111 019	
	• Alamata	67 684	
	• Wajerat	23 266	
	• Others	23 709	
	Total	225 678	521 000 (1992)
Arado			
	Total	1 426 644	440 000 (1992)
Begait	• Tahtayadiabo	32 132	
	• Kaftahumera	13 755	
	• Welqait	10 698	
	• Asgedetsimbla	7 328	
	• Others	12 793	
	Total	76 706	
Medenes	• Tahtayadiabo	29 042	
	• Asgedetsimbla	23 946	
	• Tselemti	3 838	
	• Welqite	3 835	
	• Tsegede	3 232	
	Total	63 893	
Begait(Begait and Medenes)		N/A	850 000 (1981)
Afar		N/A	680 590 (1992)
Fogera		N/A	868 000 (1992)
			636 000 (1998)

[1](BoNAR, 1999).
[2](FAO DAD-IS).

$$z_i = \frac{0.8}{1.2} * \sum_{a=1}^{10} z_{ia} + 0.1$$

Where is the extinction probability of breed $_i$ computed as the sum of the value of ten variables rescaled to a value between 0.1 and 0.9.
This method compared to other risk assessment methods (Rege, 1999; Scherf, 2000), uses a scheme with ten breed specific variables considered important to evaluate the threat of extinction of a given breed (Table 5). However, one out of the ten variables used to derive extinction probability (political situation of the country) was modified to reflect the direct impact of war and conflicts on animal genetic resources rather than the one ("security information for travellers") used by Reist-Marti *et al*. (2003). Two of the ten variables (population size and population size change) were derived from population size information of a livestock census (BoNAR, 1999) and from the FAO DAD-IS data base. The remaining variables were derived from information collected in the present study.

Result and discussion

Population size and description

Population size and distribution of the breeds studied are given in table 2. Population data for the Raya, Arado, Begait, and Medenese were obtained from the Tigray regional livestock census report (BoNAR, 1999). Data from the global data base (DAD-IS) was used for the Afar and Fogera breeds for lack of recent information for comparative purposes.

Except for the Arado, Medenes and Afar breeds, all interviewed farmers indicated a dramatic decrease in population size over the past 20-30 years. The Raya and Fogera breed population sizes have decreased by 57% and 27% respectively between 1992-1999, (Table 2).

The situation with the Begait breed is even more alarming. Even if we combine the Begait and Medenes populations in Ethiopia and assume there is about the same size in Eritrea, the population size has decreased by 67% between 1981 and 1999 due to two major famines in the area in 1984/1985 and

Table 3. Mean and standard deviation for production, reproduction, body weight[1] and height measurement traits in six indigenous cattle breeds of north Ethiopia.

Trait	Afar n (100) $\bar{X}$ ± S.D	Raya n (100) $\bar{X}$ ± S.D	Arado n (100) $\bar{X}$ ± S.D	Medenes n (75) $\bar{X}$ ± S.D	Begait n (75) $\bar{X}$ ± S.D	Fogera n (100) $\bar{X}$ ± S.D
Milk yield/day (kg)	4±1	3±1	1.8±0.4	2.5±1	5±0.5	2±0.7
Lactation length (days)	271±22	210±17	242±20	162±29	205±32	159±24
Age at 1st calving (mo)	37±11	41±10	50±7	42±8	38±5	44±6
Calving interval (mo)	14±2	15±3	22±3	19±5	16±2	20±4
Adult body weight (kg)						
• Male	298±43	281±41	254±46	260±23	333±51	301±28
• Female	224±17	219±26	201±39	248±21	278±41	265±20
Adult height (cm)						
• Male	124±4	122±4	114±3	117±3	131±4	137±9
• Female	115±4	113±4	108±4	115±2	125±4	118±4

[1]Body weight is estimated from heart girth measurements.

1995/1997. According to Sanford and Yohannes (2000) a 72, 60 and 78% decline in cattle population was reported for the Afar region during the 1972/1974 famine, the 1984/85 famine in the Borena area of south Ethiopia and the 1995/1997 famine in Somali and Borena regions respectively. A more than 70% reduction in population size was recorded between May 1999 and May 2000 in the southern Somali and Borena regions (Devereux, 2000). Currently, the populations of most of the breeds studied and other small ruminant breeds are under extreme pressure as a result of increased demand for meat from the presence of a huge number of army personnel in the northern part of the country since the 1998 border war between Ethiopia and Eritrea.

Afar

Most of the interviewed pastoralists (89%) indicated that the Afar breed is native to the region while the remaining 11% believed the breed migrated from present day Yemen across the Red Sea. According to results from group discussions, three distinct types of the Afar breed namely Bedaeru, Igahiboda and an intermediate between the two have been identified.

The Bedaeru type is described as a relatively small sized animal with short horns, higher milk production, a tolerance for drought and feed shortages and adaptation to the hot, flat dry land areas of the Bada and Afdera plains of the region. They have mostly a grey or white smooth and shiny coat colour. The population size of this type is small and is decreasing, according to interviewed pastoralists.

The Igahiboda is a large sized animal with large lyre shaped horns, suited for both the dry lowlands and adjacent highlands. This type is found in Abala, Megale, Irebti and Berahle of the Afar region and Raya and Wajerat of the Tigray region. This type is phenotypically similar to the Raya breed (Figure 2 and 3).

The intermediate type is medium sized, mostly with a red coat colour and is found mainly in the Dalol and Kuneba areas of north Afar.
Nearly all information from interviewed pastoralists and results from the group discussions indicated that the overall population size of the breed is increasing due to the availability of vaccinations against major cattle diseases such as reinderpest, CBPP and anthrax, regardless of the chronic droughts in the area. Moreover, change in the rangeland condition has favoured cattle rearing compared to camel and goat production which used to dominate the pastoral production system (Diress, *et al.*2003). This change has led cattle breeders towards the development and utilization of conventional breeding practices (identification, selection, controlled breeding).

Raya

The Raya breed is believed to have originated mainly in the adjacent parts of the Afar region. 93, 5 and 2% of respondents believed the origin to be from the Afar, the result of introduction following

Table 4. Comparisons by farmers among six indigenous cattle breeds of north Ethiopia for some traits of importance.

Trait	Comparison	Arado vs Begait	Arado vs Medenes	Begait vs Medenes	Raya vs Arado	Afar vs Raya	Fogera vs Highland
Body size	Smaller	100	87	-	-	-	-
	Comparable	-	13	7	-	8	-
	Larger	-	-	93	100	92	100
Age at first calving	Younger	3	16	21	68	84	75
	Comparable	19	31	32	19	16	25
	Older	78	43	47	13	-	-
Calving interval	Shorter	-	6	3	86	96	42
	Comparable	27	11	86	12	4	38
	Longer	73	83	11	2	-	20
Milk yield	Higher	-	2	93	100	100	97
	Comparable	-	7	7	-	-	3
	Lower	100	91	-	-	-	-
Lactation length	Longer	39	13	96	100	100	100
	Comparable	42	69	4	-	-	-
	Shorter	19	18	-	-	-	-
Milk fat percentage	Higher	68	26	28	29	89	91
	Comparable	24	71	64	45	11	6
	Lower	18	3	8	26	-	3
Draught power	Better	-	56	13	100	-	97
(speed & length of	Comparable	11	29	72	-	17	3
working hours)	Worse	89	15	15	-	83	-
Disease resistance	Better	72	69	-	12	69	-
	Comparable	28	25	17	77	26	16
	Worse	-	6	83	11	5	84
Tick resistance	Better	63	88	9	-	9	12
	Comparable	29	11	24	95	26	88
	Worse	8	1	67	5	65	-
Feed shortage	Better	100	100	-	-	37	17
	Comparable	-	-	2	39	32	67
	Worse	-	-	98	61	31	16
Watering frequency	Better	-	35	95	88	98	21
	Comparable	9	49	5	8	2	79
	Worse	91	16	-	4	-	-
Grazing	Better	7	2	99	93	100	78
	Comparable	37	21	1	7	-	22
	Worse	56	77	-	-	-	-
Meat quality	Better	83	63	-	-	-	6
	Comparable	14	19	11	6	56	23
	Worse	3	18	89	94	44	71
Hide quality	Better	96	81	-	-	-	2
	Comparable	4	16	3	11	19	9
	Worse	-	3	97	89	81	89
Market value of live	Better	-	-	57	97	16	47
animals	Comparable	2	37	43	3	71	38
	Worse	98	63	-	-	13	15