Section B

Methods for characterization

1 Introduction

Characterization of AnGR encompasses all activities associated with the identification, quantitative and qualitative description, and documentation of breed populations and the natural habitats and production systems to which they are or are not adapted. The aim is to obtain better knowledge of AnGR, of their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (FAO, 1984; Rege, 1992). National-level characterization comprises the identification of the country's AnGR and the surveying of these resources. The process also includes the systematic documentation of the information gathered so as to allow easy access. Characterization activities should contribute to objective and reliable prediction of animal performance in defined environments, so as to allow a comparison of potential performance within the various major production systems found in a country or region. It is, therefore, more than the mere accumulation of existing reports.

The information provided through the characterization process enables a range of interest groups, including farmers, national governments and regional as well as global bodies to make informed decisions on priorities for the management of AnGR (FAO, 1992; FAO/UNEP, 1998). Such policy decisions aim to promote further development of AnGR while ensuring that these resources are conserved for the needs of present and future generations.

2 Characterization – as the basis for decision-making

A key consideration for the management of AnGR at the national level is whether, at a given point in time, a particular breed population is self-sustainable or whether it is at risk. This primary assessment (baseline survey[2]) of breed/population status is based on information on:

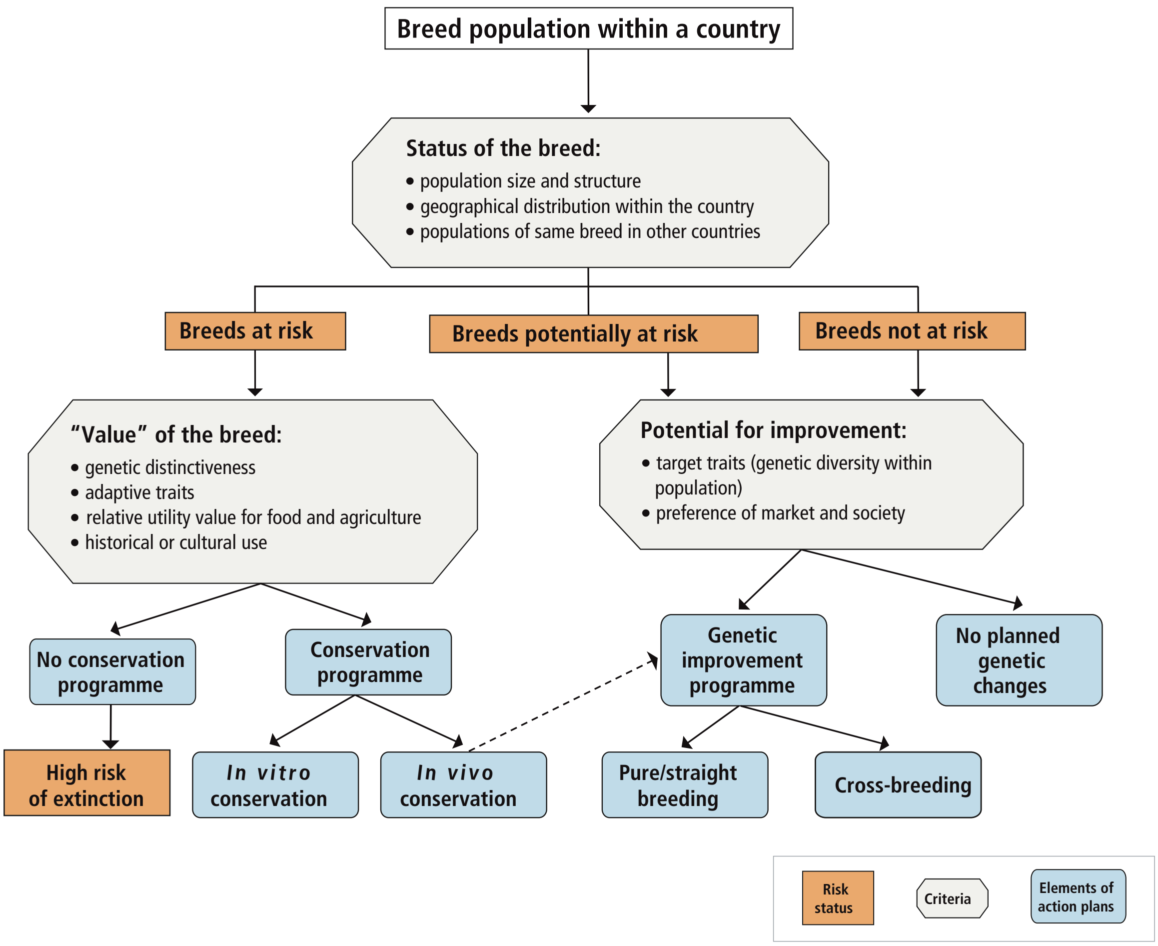
- population size and structure;
- geographical distribution;
- within-breed genetic diversity; and
- the genetic connectedness of breeds when populations are found in more than one country (e.g. the Djallonke sheep of West Africa).

If a breed/population is not as risk, no immediate steps to implement conservation measures are necessary. Nevertheless, as part of national livestock development plans, decisions have to be taken as to whether a genetic improvement programme is needed – in response, for example, to changing market conditions. Decisions regarding such improvement programmes are mainly guided by information on long-term benefits to livestock keepers and society.

[2] Baseline information is related to a particular target animal population at a given time and within a given production environment. Depending on the degree of change, these descriptions may need to be updated about once a generation. The baseline study should characterize phenotypic and molecular attributes of the breeding females and males in the population. About 100 adult females and about 30 adult males are needed for phenotypic characterization, but about a third of this size may be sufficient for molecular diversity estimation.

When a breed/population is found to be at risk, active conservation strategies have to be implemented or the potential loss of the breed must be accepted. To allocate the limited resources that are available for conservation programmes, breeds need to be prioritized. These decisions may be based on the genetic distinctiveness, adaptive traits, relative value for food and agriculture, or historical and cultural values of the breeds in question. This information is also needed to decide, whether *in vivo* or *in vitro* strategies or a combination of both appears to be the most promising approach. If the breeds to be conserved are found in more than one country, decisions should be taken at the regional level. Thus, regional coordinating institutions/organizations, and supporting national policies, are required to facilitate such decisions and to implement actions. To date, only a few examples of multi-country actions in AnGR management have been reported.

FIGURE 47
Information required to design management strategies



For decisions on conservation strategies and on development programmes for self-sustainable breeds, comprehensive information is needed, and should include:

- description of the typical phenotypic characteristics of the breed population, including physical features and appearance, economic traits (e.g. growth, reproduction and product yield/quality) and some measures (e.g. range) of variation in these traits – the focus is generally on the productive and adaptive attributes of the breed;
- description of the production environments (Box 68), both the original habitat and the current production system in which the population is kept – some breeds are kept in more than one production environment, in a number of countries, and sometimes outside their original geographical area;
- documentation of any special characteristics (unique features) of the population in terms of adaptation and production – including responses to environmental stressors (disease and parasite challenge, extremes of climate, poor feed quality, etc.);
- images of typical adult males and females in their typical production environment;
- relevant indigenous knowledge (including but not limited to gender-specific knowledge) of traditional management strategies used by communities to utilize the genetic diversity of their livestock;
- description of ongoing management (utilization and conservation) actions and the stakeholders involved; and
- description of any known genetic relationships between breeds within or outside the country.

In addition to the information listed for both pathways (conservation and development), the following supplementary information is useful to guide the choice of priority breeds and geographic areas for conservation programmes:

- genetic distinctiveness of the breeds and their significance with respect to the total genetic diversity among the breeds under consideration (in order to maximize the diversity conserved for the benefit of future human generations);
- origin and development of the breeds; and
- unique genetic (or phenotypic if genetic attributes are not known) characteristics and their significance in current or anticipated production settings.

National decision-makers need to identify the breeds in which genetic improvement programmes would be most beneficial. Such programmes could include breeds classified as at risk, and form part of a conservation programme. Investments in breed improvement should be justified by adequate returns to investment. These are determined by performance levels, special adaptive characteristics and/or specific uses and values of the breeds in a given production environment or in relation to anticipated changes in the production environment (including market conditions). Thus, performance data, description of particularly useful attributes and values, and a detailed description of the general production environment are essential to guide decisions on breed development programmes.

The set of information needed for the development of appropriate breeding programmes also allows the choice of breed to be reconsidered as the production environment evolves, whether through changes to husbandry practices, market conditions, cultural preferences, or biophysical (e.g. climatic stress or disease challenge) factors. Similarly, this information is needed in the design of AnGR restocking schemes undertaken following natural disasters (drought, floods, etc.), disease outbreaks or civil unrest. Restocking may be based on AnGR available within the country, from other countries in the region, or from another region of the world. In all cases, restocking schemes should seek to obtain the animals that are best adapted to the production environment into which they will be introduced.

Management decisions may differ in type and scope at subnational, national, regional and

Box 68
Production environment descriptors for animal genetic resources

A comprehensive description of the production environment is essential to make use of performance data and to understand the special adaptations of breeds/populations. Adaptive fitness of breeds is complex and difficult to measure directly, but can be characterized indirectly by describing the primary variables (criteria) which have affected an animal gene pool (breed) over time, and have probably maximized its adaptive fitness for that environment. Thus, an (improved) description of production environments would be extremely valuable, in order to better understand the comparative adaptive fitness of specific AnGR.

In January 1998, an expert group met in Armidale, Australia, and devised a very detailed and well-structured approach, using five main criteria to characterize most, if not all, production environments, for all animal species used for food and agriculture. The five criteria were: climate; terrain; disease, disease complexes and parasites; resource availability; and management interventions (FAO, 1998). At a second level of hierarchy, three to seven indicators for each criterion were formulated to characterize (i.e. describe and measure variables in) the production environments. For each indicator two or more verifiers were identified to specify or measure each indicator. The workshop noted that many developing countries had very little capacity to collect and analyse production environment variables, and that, a less complex descriptive system would, therefore, be preferable as it would be more likely to be used. Despite these concerns, the system proposed required very detailed information. A less detailed and more pragmatic approach to describing production systems would probably facilitate efforts to begin to fill the current large gaps in breed documentation. However, a detailed approach should be encouraged whenever this is possible.

The system devised at the meeting in Armidale appears to be the first attempt to develop a structured set of production environment descriptors (PEDs) for use in the characterization of livestock breeds. The Domestic Animal Genetic Resources Information System (DAGRIS) database, developed by the International Livestock Research Institute (ILRI) includes a field devoted to the "habitat" of each breed, but there is no set structure to the entries, and the information provided to date is quite limited. Oklahoma State University's "Breeds of Livestock" database provides some information on production environments, but this is again not based on a systematic set of descriptors.

international levels. It is, therefore, important that relevant information on breed characteristics is made accessible to decision-makers at all levels. For example, it may happen that a country decides not to invest in the conservation of a specific local breed, but a regional or international organization decides that the breed is a unique genetic resource, and that it is in the global interest to conserve it.

3 Tools for characterization

3.1 Surveying

Surveys are undertaken to systematically collect data needed to identify breed populations and describe their observable characteristics, geographical distribution, uses and general husbandry, as well as their production environments. Full baseline surveys need to be undertaken once; some elements of the survey may be repeated when significant changes are observed in the livestock sector.

As part of the effort to develop global databanks for the management of AnGR, FAO developed a comprehensive list of animal and environment descriptors to serve as a guide for standardized characterization activities at various levels (FAO, 1986a,b,c). However, these descriptors were far too complex for universal application. In recognition of this fact, FAO developed simplified formats for data collection for mammalian and avian species (see summary of data items in Tables 97 and 98). This was based on the experience of the EAAP, which started collecting data in the 1980s and later built the first computer-based information system known as EAAP–AGDB. ILRI, in collaboration with FAO (Rowlands *et al.*, 2003) has developed and tested an approach for collecting and analysing on-farm breed-level information in Zimbabwe. The same approach has been applied in Ethiopia. A key lesson from this work was that logistic and time requirements for extensive livestock surveys, data management and analysis, can be grossly underestimated. It was also found that the outcomes of multivariate survey techniques

TABLE 97
Information recorded for mammalian species in the Global Databank for Animal Genetic Resources

- **GENERAL INFORMATION**

  Species
  Breed name (most common name and other local names)
  Distribution

- **POPULATION DATA**

  Basic Population Information:
  Year of data collection
  Total population size (range or exact figure)
  Reliability of population data
  Population trend (increasing, stable, decreasing)
  Population figures based on (census/survey at species/breed level or estimate)

  Advanced Population Information:
  Number of breeding females and males
  Percentage of females bred to males of the same breed and percentage of males used for breeding
  Number of females registered in herd book/register
  Artificial Insemination usage and storage of semen and embryos
  Number of herds and average herd size

- **MAIN USES**

  Listed in order of importance

- **ORIGIN AND DEVELOPMENT**

  Current domestication status (domestic/wild/feral)
  Taxonomic classification (breed/variety/strain/line)
  Origin (description and year)
  Import
  Year of herd book establishment
  Organization monitoring breed (address)

- **MORPHOLOGY**

  Adult height and weight
  Number and shape/size of horns
  Colour
  Specific visible traits
  Hair and/or wool type

- **SPECIAL QUALITIES**

  Specific quality of products
  Specific health characteristics
  Adaptability to specific environment
  Special reproductive characteristics
  Other special qualities

- **MANAGEMENT CONDITIONS**

  Management system
  Mobility
  Feeding of adults
  Housing period
  Specific management conditions

- ***IN SITU* CONSERVATION**

  Description of *in situ* conservation programmes

- ***EX SITU* CONSERVATION**

  Semen stored and number of sires represented
  Embryos stored and number of dams and sires represented in embryos
  Description of *ex situ* conservation programmes

- **PERFORMANCE**

  Birth weight
  Age at sexual maturity
  Average age of breeding males
  Age at first parturition and parturition interval
  Length of productive life
  Milk yield and lactation length (mammals)
  Milk fat
  Lean meat
  Daily gain
  Carcass Weight
  Dressing percentage
  Management conditions under which performance was measured

Source: FAO/UNEP (2000).

TABLE 98
Information recorded for avian species in the Global Databank for Animal Genetic Resources

- **GENERAL INFORMATION**

  Species
  Breed name (most common name and other local names)
  Distribution

- **POPULATION DATA**

  Basic Population Information:
  Year of data collection
  Total population size (range or exact figure)
  Reliability of population data
  Population trend (increasing, stable, decreasing)
  Population figures based on (census/survey at species/breed level or estimate)

  Advanced Population Information:
  Number of breeding females and males
  Percentage of females bred to males of the same breed and percentage of males used for breeding.
  Number of females registered in herd book/register
  Artificial Insemination usage and storage of semen and embryos
  Number of herds and average herd size

- **MAIN USES**

  Listed in order of importance

- **ORIGIN AND DEVELOPMENT**

  Current domestication status (domestic/wild/feral)
  Taxonomic classification (breed/variety/strain/line)
  Origin (description and year)
  Import
  Year of herd book establishment
  Organization monitoring breed (address)

- **MORPHOLOGY**

  Adult live weight
  Patterns within feathers
  Plumage pattern
  Skin colour
  Shank and foot colour
  Comb type
  Egg shell colour
  Specific visible traits

- **SPECIAL QUALITIES**

  Specific quality of products
  Specific health characteristics
  Adaptability to specific environment
  Special reproductive characteristics
  Other special qualities

- **MANAGEMENT CONDITIONS**

  Management system
  Mobility
  Feeding of adults
  Housing period
  Specific management conditions

- ***IN SITU* CONSERVATION**

  Description of *in situ* conservation programmes

- ***EX SITU* CONSERVATION**

  Semen stored and number of sires represented
  Description of *ex situ* conservation programmes

- **PERFORMANCE**

  Age at sexual maturity
  Age at first egg and clutch interval
  Length of productive life
  Number of eggs per year
  Daily gain
  Carcass Weight
  Dressing percentage
  Management conditions under which performance was measured

Source: FAO/UNEP (2000).

need to be verified by complementary molecular genetic studies (Ayalew *et al*., 2004).

Based on the Global Strategy for the Management of AnGR, ten categories of variables are covered in AnGR surveys, including basic and advanced breed population information, main uses of the breed, origin and development/evolution of the breed, typical morphological features, average performance levels, special characteristics, and ongoing conservation activities.

3.2 Monitoring

Changes in population size and structure need to be documented regularly for all breeds. This should be carried out on a yearly or biennial basis, as the application of modern reproductive technologies, global trade, market demands, and policies favouring particular breeds, can lead to rapid changes in the size and structure of breed populations.

Monitoring should be conducted at least once per generation of the species, particularly for breeds classified as at risk or potentially at risk. This requires surveys at intervals of about eight years for horses and donkeys, five years for cattle, buffalo, sheep and goats, three years for pigs and two years for poultry species.

At present, most national livestock censuses do not contain breed-level data, and so regular reporting of breed population numbers does not take place. Species and breeds that have been classified as at risk should be monitored on a regular basis. This monitoring should serve as the basis for national early warning.

Information collected during monitoring activities enables adjustments to be made to management plans for AnGR. Monitoring programmes need to be carefully designed so that they provide feedback to farmers, managers and other stakeholders. Monitoring approaches need to be flexible, and activities by different players need to be well coordinated, as different groups will monitor different parameters. For example, farmers may wish to monitor production parameters; resource managers may wish to monitor completion of breed inventories; and administrators may wish to monitor the cost-effectiveness of various programmes. Monitoring is also necessary to evaluate progress in the implementation of action plans, and to identify new priorities, issues and opportunities.

Monitoring can be an extremely expensive aspect of AnGR management. However, if countries are strategic in their approaches to monitoring, and take advantage of existing resources, it can be cost effective. For managing genetic resources at high risk, data on current population size and geographic location are required. For such populations, regular and simple quantification and reporting of actual population sizes by those directly involved may be adequate and achievable. Large and widely dispersed populations may require the establishment of stratified samples, where a portion of the population in each major geographical region of the country is monitored. Lack of easy-to-apply tools for collecting such data, general lack of trained persons to undertake assessments, and lack of awareness on the part of policy-makers and implementers regarding the importance of such information, represent important challenges.

In every country there may be opportunities to monitor AnGR by taking advantage of existing activities, and thereby avoiding significant additional costs. National livestock censuses offer good opportunities. It may also be possible to set up effective monitoring stations in locations where livestock are sold or traded, such as auctions and local markets. This approach can greatly reduce costs by bringing the livestock to the monitors. However, a focus on traded animals may not accurately reflect the structure of the target populations on the farms. In countries where farmer groups, breed societies, or herd or stud books exist, tracking registrations can be a very effective means to monitor particular breeds. There may also be opportunities to combine monitoring activities with the tasks of existing government offices. For example, wildlife biologists could assist in monitoring livestock populations as part of wildlife surveys. Health officials could record livestock population numbers by breed when conducting food-processing inspections or delivering veterinary services. All these options, however, have to be treated with caution and potential biases need to be considered. The value of the information obtainable on the basis of existing activities has to be weighed against the additional information, but also greater costs, associated with surveys specifically designed and conducted to monitor AnGR.

As a step towards the inclusion of breed-level data in national livestock censuses, the next World

Programme for Census of Agriculture (produced by FAO every ten years to guide countries in conducting of their agricultural census) (FAO, 2006) encourages countries to collect and report livestock data at breed level.

3.3 Molecular genetic characterization

Molecular genetic characterization explores polymorphism in selected protein molecules and DNA markers in order to measure genetic variation at the population level. Because of the low level of polymorphism observed in proteins, and hence limited applicability in diversity studies, DNA-level polymorphisms are the markers of choice for molecular genetic characterization (see Section C).

The process of molecular genetic characterization comprises field sampling of biological material (often blood or hair root samples), laboratory extraction of DNA from the samples, DNA storage, laboratory assaying (e.g. genotyping or sequencing), data analysis, report writing, and maintenance of a molecular genetic information database. Sampling for molecular analysis may be combined with surveying and/or monitoring, as molecular information on its own cannot be used for utilization and conservation decisions.

Characterization at the molecular genetic level is undertaken mainly to explore genetic diversity within and between animal populations, and to determine genetic relationships among such populations. More specifically, the results from the laboratory work are used to:

- determine within and between-breed diversity parameters;
- identify the geographical locations of particular populations, and/or of admixture among populations of different genetic origins;
- provide information on evolutionary relationships (phylogenetic trees) and clarify centres of origin and migration routes;
- implement gene mapping activities, including identification of carriers of known genes;
- identify parentage and genetic relationships (e.g. DNA fingerprinting) within populations;
- support marker assisted genetic improvement of animal populations; and
- develop DNA repositories for research and development (FAO, 2005).
- In populations with limited or no information on pedigrees and population structure, molecular markers can also be used to estimate the effective population size (N_e).

In the absence of comprehensive breed characterization data and documentation of the origin of breeding populations, molecular marker information may provide the most easily obtainable estimates of genetic diversity within and between a given set of populations.

3.4 Information systems

Information systems or databases can serve a variety of different purposes, but collectively they contain important information for decision-making, research, training, planning and evaluation of programmes, progress reporting and public awareness. An information system normally includes hardware, software (applications), organized data (information) and facilities for communication. It can be operated either manually, electronically using computers, or through a combination of both. The information may be on a single desktop machine, or a network of computers. Alternatively, it may be on the Internet, allowing external access to view or, in case of interactive dynamic systems, update the information.

The overall purpose of information systems is to enable and support decision-making regarding the present value and potential future uses of AnGR, by a range of stakeholders, including policy-makers, development practitioners, farmers and researchers. Thus, they need to incorporate essential decision-support tools to meet the needs of stakeholders at subnational, national, subregional, regional and global levels. However, users operating at these different hierarchies or levels will each have different objectives, and be interested in different aspects of the data contained within the information system. For instance, users operating at regional or global levels will be more interested in the cross-border distribution of breeds, cross-border livestock markets, transboundary disease risks, and germplasm exchange across borders. Conversely, more relevant issues for users at national and subnational (local) levels are breed population size, herd/flock structures, production levels, and stressors associated with local environments. Linkages and information exchange between the hierarchies, as well as with external information sources can add value to information systems. Complementary databases may exchange information through a system of data transfer, or can serve as "gateways" to each other through electronic links via the Internet. For instance, national and subnational AnGR databases could be linked to geophysical databases (climate, soils, water or landscape). Functional linkages between these sets of data could lead to the generation of animal disease risk maps, and information on specific adaptations of particular breeds to stressful environments.

National databases of domestic animal diversity are essential planning tools. They present the current state of knowledge on the size, distribution, status, and utility value of AnGR. They allow access to information on planned and ongoing management activities. Moreover, they facilitate the identification of gaps in existing information.

At present, a number of public-domain electronic information systems for animal genetic diversity are globally accessible and contain data from more than one country. Two of these – the Domestic Animal Diversity Information System (DAD-IS) and the European Farm Animal Biodiversity Information System (EFABIS) (previously EAAP–AGDB) – are related to the FAO global information system for AnGR. The Domestic Animal Genetic Resources Information System (DAGRIS), managed by ILRI is a database of synthesized research information from published and grey literature. Oklahoma State University's Breeds of Livestock information system provides brief summaries of breed origins, characteristics and uses. The content of these information systems is described in Box 69.

Currently, the information resources have facilities for simple searches by country or breed only. Ideally, they should have as much research information as is available, and enable users to make informed judgements about the value of each item of information. If researchers and decision-makers are to have the information they require, the functionality of the existing information systems will need to be greatly increased, to allow extraction and customized analysis of various categories of information within and between data sources. The scope of data acquisition also needs to be expanded so that breed information can be linked to geographical information system (GIS)-based environment and production system mapping. This will allow poorly documented adaptation traits such as disease resistance to be predicted from past and current breed distribution and use (Gibson *et al.*, 2007).

Information systems for AnGR have been developed and administered as global public goods, and have limited ability to attract investment from the private sector or major funding agencies. This explains the very limited information that the systems contain compared to that which is potentially possible and which would be necessary for them to effectively achieve their stated purposes. One possibility to circumvent such limitations is to establish functionalities for interconnectivity and interoperability between information systems. This has been achieved with FABISnet (a distributed information system for AnGR) which enables countries to set up national Web-based information systems that can exchange core data with the higher levels of the network – regional systems (such as EFABIS) and the global system (DAD-IS).

Box 69
Information systems at global level

DAD-IS [http://www.fao.org/dad-is]
The Domestic Animal Diversity Information System (DAD-IS) developed by FAO is the first globally accessible dynamic multilingual database of AnGR. It was initiated as a key communication and information tool for implementing the Global Strategy for the Management of AnGR, to assist countries and country networks in their respective programmes (FAO, 1999). Apart from country-level breed information and images, DAD-IS provides a virtual library containing a large number of selected technical and policy documents, including tools and guidelines for research related to AnGR. It offers Web-links to relevant electronic information resources. It also has a facility for the exchange of views and for addressing specific information requests, by linking a range of stakeholders: farmers, scientists, researchers, development practitioners and policy-makers.
DAD-IS provides a summary of national breed-level information on the origin, population, risk status, special characteristics, morphology and performance of breeds, as provided by FAO member countries. Currently, the database contains more than 14 000 national breed populations from 35 species and 181 countries. A key feature of DAD-IS is that it provides a country-secure information storage and communication tool. Each country decides when and what breed data are released through their officially designated contact person (the National Coordinator (NC) for the Management of AnGR). See Tables 97 and 98 for a summary of information recorded, stored and disseminated in the global breeds database contained in DAD-IS.

DAD-IS:3 has been rebuilt based on the same software and functionality as EFABIS (European Farm Animal Biodiversity Information System – http://efabis-eaap.tzv.fal.de), and with a similar interface. The software was developed within a European Union project in order to overcome the problem of incompatibility between EAAP–AGDB (an earlier European system) and DAD-IS. The new system allows for the creation of a network of distributed information systems with automatic data synchronization. Countries and regions are provided with tools to set up their own Web-based information systems. Information content and interface can be translated to any local language. The appearance of the interface can be adapted to reflect local flavours. Outside the core data structure, countries and regions may further define data structures that specifically reflect their needs. These specificities would not be synchronized with the higher-level information systems. Poland set up the first national information system under this new framework (http://efabis.izoo.krakow.pl), and defined additional structures to accommodate data on farmed fish and bees. NCs can enter breed information, images, publications, links to external Web sites, contact addresses and news into the system.

DAGRIS [http://dagris.ilri.cgiar.org/]
The Domestic Animal Genetic Resources Information System (DAGRIS) is developed and managed by the International Livestock Research Institute (ILRI). It was initiated in 1999 as a tool to collate research information available on global AnGR. In addition to containing information, obtained from a synthesis of the literature on the origin, distribution, diversity, characteristics, present uses and status of indigenous breeds. DAGRIS is unique in that it includes complete references and abstracts of published or unpublished scientific literature pertaining to the breeds in the system. DAGRIS is designed to support research, training, public awareness, genetic improvement and conservation. Version I of the database was released on the Web in April 2003, and is also available on CD-ROM. Currently, the database contains over 19 200 trait records on 154 cattle, 98 sheep, and 62 goat breeds of Africa, plus 129 chicken ecotypes/breeds and 165 pig breeds of Africa and some Asian countries. The breed information pages in DAGRIS provide a Web link to the page for the corresponding breed in the FAO's DAD-IS system and vice versa.

• *continues*

Box 69 *cont.*
Information systems at global level

The scope of DAGRIS is being expanded so that it will, in the near future, cover more species (turkeys, geese and ducks) and countries in Asia (Ayalew *et al.*, 2003). The priority next-steps for DAGRIS are:

1. development of a new module to allow all users to upload relevant research information into the database so that database administrators can capture and collate otherwise unavailable breed-level information;
2. development of GIS linkages in the database to allow georeferencing of as much of the breed-level information as possible; and
3. development of a template for a country module of DAGRIS to assist interested countries to further develop and customize the database.

Breeds of Livestock – Oklahoma State University [http://www.ansi.okstate.edu/breeds]
The Department of Animal Science of Oklahoma State University, in the United States of America, manages this information resource which was established in 1995. It provides a brief description of breeds in terms of origin, distribution, typical features, uses, and population status, along with photographs/images and key references for breed information. It presents a list of breeds from all over the world, with options to sort by region. As of January 2006, the database displayed a total of 1 063 breeds including 280 sheep, 262 cattle, 217 horse, 100 goat, 72 pig, 8 donkey, 8 buffalo, 6 camel, 4 reindeer, 1 llama, 1 yak, 64 chicken, 10 duck, 7 turkey, 7 goose, 1 guinea fowl and 1 black swan breeds. It also provides links to relevant information in its virtual livestock library. The aim is to expand the scope of the system, in terms of the number of breeds and the educational and scientific information it contains, through collaboration with individuals and universities from around the world. The submission of information (written material or images) on breeds not included in the list, or additional information on those already included, is welcome.

4 Conclusions

Adequate characterization of AnGR is a prerequisite for successful management programmes and for informed decision-making in national livestock development. Tools developed in the field of characterization should allow a strategic and coherent approach to identification, description and documentation of breed populations. Interest in such an approach is slowly emerging. Some aspects of characterization are increasingly being addressed. Molecular characterization has received particular attention. However, there is still a need for methods and tools to organize surveying and monitoring.

An important missing element in breed descriptions in many countries/regions, is a clear definition of the respective breeds to give them unique identity, and a description of the production environments to which they are adapted. A basic structure for the definition of production environments has been proposed, but needs to be reviewed and implemented. The existing breed-related information systems need to be further developed to allow easy information capture, processing, accessibility and interconnectivity.

Ideally, tools and methods for decision-making on AnGR management, as well as early warning and response tools, would be based on comprehensive information obtained using the methods described above. However, given that immediate action is required, there is a need for tools and methods that make effective use of incomplete information.

References

Ayalew, W., Rege, J.E.O., Getahun, E., Tibbo, M. & Mamo, Y. 2003. Delivering systematic information on indigenous animal genetic resources – the development and prospects of DAGRIS. *In* Proceedings of the Deutscher Tropentag 2003, *Technological and Institutional Innovations for Sustainable Rural Development,* held 8–10 October 2003. Göttingen, Germany. (also available at www.tropentag.de/2003/abstracts/full/28.pdf).

Ayalew, W., van Dorland, A. & Rowlands, J. 2004. *Design, execution and analysis of the livestock breed survey in Oromia Regional State, Ethiopia*. Addis Ababa and Nairobi. OADB (Oromia Agricultural Development Bureau) and ILRI (International Livestock Research Institute).

DAGRIS. 2004. *Domestic Animal Genetic Resources Information System (DAGRIS).* J.E.O. Rege, W. Ayalew & E. Getahun, eds. Addis Ababa. International Livestock Research Institute.

FAO. 1984. *Animal genetic resource conservation by management, databanks and training.* Animal Production and Health Paper No. 44/1. Rome.

FAO. 1986a. *Animal genetic resources data banks - 1. Computer systems study for regional data banks.* Animal Production and Health Paper No. 59, Volume 1. Rome.

FAO. 1986b. *Animal genetic resources data banks - 2. Descriptor lists for cattle, buffalo, pigs, sheep and goats.* Animal Production and Health Paper No. 59, Volume 2. Rome.

FAO. 1986c. *Animal genetic resources data banks - 3. Descriptor lists for poultry.* Animal Production and Health Paper No. 59, Volume 3. Rome.

FAO. 1992. *The management of global animal genetic resources. Proceedings of an Expert Consultation,* Rome, Italy, April 1992. Edited by J. Hodges. Animal Production and Health Paper No.104. Rome.

FAO. 1998. *Report: Working group on production environment descriptors for farm animal genetic resources.* Report of a Working Group, held in Armidale, Australia, 19 – 21 January 1998. Rome.

FAO. 2005. Genetic characterization of livestock populations and its use in conservation decision making, by O. Hannotte & H. Jianlin. *In* J. Ruane & A. Sonnino, eds. *The role of biotechnology in exploring and protecting agricultural genetic resources*, pp. 89–96. Rome. (also available at www.fao.org/docrep/009/a0399e/a0399e00.htm).

FAO. 2006. *A system of integrated agricultural censuses and surveys, volume 1, World Programme for the Census of Agriculture 2010.* Statistical Development Series No. 11. (also available at www.fao.org/es/ess/census/default.asp).

FAO/UNEP. 1998. *Primary guidelines for development of national farm animal genetic resources management plans.* Rome.

FAO/UNEP. 2000. *World watch list for domestic animal diversity*, 3rd edition. Edited by B.D. Scherf. Rome.

Gibson, J.P., Ayalew, W. & Hanotte, O. 2007. Measures of diversity as inputs for decisions in conservation of livestock genetic resources. *In* D.I. Jarvis, C. Padoch & D. Cooper, eds. *Managing biodiversity in agroecosystems.* New York, USA. Columbia University Press.

Oklahoma State University. 2005. *Breeds of livestock*. Stillwater, Oklahoma, USA. Department of Animal Science, Oklahoma State University. (available at http://www.ansi.okstate.edu/breeds/).

Rege, J.E.O. 1992. Background to ILCA's animal genetic resources characterization project, objectives and agenda for the research planning workshop. *In* J.E.O. Rege & M.E. Lipner, eds. *Animal genetic resources: their characterization, conservation and utilization.* Research planning workshop, ILCA, Addis Ababa, Ethiopia, 19-21 February, 1992, pp. 55–59. Addis Ababa. International Livestock Centre for Africa.

Rowlands, J., Nagda, S., Rege, E., Mhlanga, F., Dzama, K., Gandiya, F., Hamudikwanda, H., Makuza, S., Moyo, S., Matika, O., Nangomasha, E. & Sikosana, J. 2003. *The design, execution and analysis of livestock breed surveys - a case study in Zimbabwe.* A report to FAO. Nairobi. International Livestock Research Institute.