ISSN 1810-0708

11

FAO ANIMAL PRODUCTION AND HEALTH

guidelines

PHENOTYPIC CHARACTERIZATION OF ANIMAL GENETIC RESOURCES

COMMISSION ON
GENETIC RESOURCES
FOR FOOD AND
AGRICULTURE

11

FAO ANIMAL PRODUCTION AND HEALTH
guidelines

PHENOTYPIC CHARACTERIZATION OF ANIMAL GENETIC RESOURCES

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2012

Recommended citation

FAO. 2012. *Phenotypic characterization of animal genetic resources.* FAO Animal Production and Health Guidelines No. 11. Rome.

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views of FAO.

ISBN 978-92-5-107199-1

All rights reserved. FAO encourages reproduction and dissemination of material in this information product. Non-commercial uses will be authorized free of charge, upon request. Reproduction for resale or other commercial purposes, including educational purposes, may incur fees. Applications for permission to reproduce or disseminate FAO copyright materials, and all queries concerning rights and licences, should be addressed by e-mail to copyright@fao.org or to the Chief, Publishing Policy and Support Branch, Office of Knowledge Exchange, Research and Extension, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.

© FAO 2012

Contents

BOXES

TABLES

FIGURES

Abbreviations and acronyms

ACSAD	Arab Center for Studies of Arid Zones and Dry Areas
AnGR	animal genetic resources for food and agriculture
AOAD	Arab Organization for Agricultural Development
DAD-IS	Domestic Animal Diversity Information System
DNA	deoxyribonucleic acid
FABISNet	Farm Animal Biodiversity Information System Network
FPC	finite population correction
GPS	global positioning system
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IICA	Inter-American Institute for Cooperation on Agriculture
ILRI	International Livestock Research Institute
ISAG	International Society for Animal Genetics
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
OTU	operational taxonomic unit
PED	production environment descriptor
SADC	Southern Africa Development Community
SAHN	sequential, agglomerative, hierarchic and non-overlapping
SPC	Secretariat of the Pacific Community
STT	Thin-tailed sheep of Sumatra
WB	World Bank

Acknowledgments

The preparation of these guidelines began in 2008 under the supervision of Badi Besbes. Initial work was undertaken by Manuel Luque Cuesta. Workneh Ayalew produced a new draft version of the guidelines, which was presented and discussed at workshops held in Argentina, Senegal and Italy. These workshops were attended by 100 scientists, technicians and policy-makers. A revised and updated draft was prepared by Badi Besbes, Workneh Ayalew and Dafydd Pilling. Text boxes were provided by Luis Iñiguez and Evangelina Rodero Serrano. The illustrations were prepared by Antje Weyhe. FAO would like to express its thanks to all these individuals and to all those not mentioned here who generously contributed their time, energy and expertise. The guidelines were presented to and endorsed by the Commission on Genetic Resources for Food and Agriculture at its Thirteenth Regular Session in July 2011.

Preamble

These guidelines are part of a series of publications produced by FAO to support countries in the implementation of the *Global Plan of Action for Animal Genetic Resources*. While each of these publications addresses a different aspect of the management of animal genetic resources for food and agriculture (AnGR), they should be utilized in conjunction. The guidelines on phenotypic characterization fall within Strategic Priority Area 1 of the *Global Plan of Action*, which is also being addressed by two other guideline publications: one focusing on surveying and monitoring of AnGR and the other on molecular characterization. The guidelines on surveying and monitoring (FAO, 2011a) present the "big picture" – describing how to plan a national strategy for obtaining AnGR-related data and keeping them up to date; they introduce the various types of survey that may form part of such a strategy, and outline the main steps involved in planning and implementing a survey. The guidelines on phenotypic characterization describe how to conduct a study on a specific animal population and its production environment – including details of what to measure, how to take these measurements and how to interpret them. The guidelines on molecular characterization (FAO, 2011b) provide advice on how to obtain and use DNA samples to support the management of AnGR. Despite these differences in focus, there is inevitably some overlap in the subject matter of the three publications.

Introduction

RATIONALE

Characterization of animal genetic resources for food and agriculture (AnGR) involves three types of information: phenotypic, genetic and historical. The weight given to each depends on the country (e.g. whether it is developed or developing) and the objective (e.g. improvement, conservation or breed differentiation). These guidelines focus on the collection and use of phenotypic information.

Phenotypic characterization of AnGR is the process of identifying distinct breed populations and describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors that affect them. The information provided by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels. The *Global Plan of Action for Animal Genetic Resources* (FAO, 2007) recognizes that "A good understanding of breed characteristics is necessary to guide decision-making in livestock development and breeding programmes". The *Global Plan of Action*'s Strategic Priority Area 1 is devoted to "Characterization, Inventory and Monitoring of Trends and Associated Risks".

Assessing the diversity of AnGR is made more difficult by the existence of many animal populations that are not assigned to any recognized breed. Even though parts of these "non-descript" populations are known to be multiple crosses of recognized breeds, some animals may belong to (relatively) homogenous groups distinguishable from neighbouring populations on the basis of identifiable and stable phenotypic characteristics (among which may be unique and valuable attributes) that warrant their being distinguished as separate breeds. Determining whether or not this is the case is one of the roles of phenotypic characterization and is a prerequisite for effective assessment of AnGR diversity and determining whether or not it is being eroded. Phenotypic characterization is therefore fundamental to the establishment of national inventories of AnGR, to effective monitoring of AnGR populations and to the establishment of early-warning and response systems for AnGR.

Phenotypic characterization activities are technically and logistically challenging. Ensuring that they are well targeted (collect data that are important to the country's priority AnGR- and livestock-development activities) and are carried out in an efficient and cost-effective manner requires thorough planning and careful implementation. Valid comparisons among livestock breeds or populations, whether nationally or internationally, require the development and use of standard practices and formats for describing their characteristics. Such standards and protocols are also needed for assessing requests for the recognition of new breeds. The *Global Plan of Action* calls for the development of "international technical standards and protocols for characterization, inventory, and monitoring of trends and associated risks" (Strategic Priority 2).

The main objectives of these guidelines are to provide advice on how to conduct a well-targeted and cost-effective phenotypic characterization study that contributes to the improvement of AnGR management within the context of country-level implementation of the *Global Plan of Action*, and to ensure that such studies provide a sound basis for international breed comparisons and for the preparation of global assessments of the status of AnGR.

BACKGROUND AND DEVELOPMENT OF THE GUIDELINES

The *Global Plan of Action for Animal Genetic Resources* calls on FAO to publish technical guidelines and provide assistance to countries in support of their efforts to improve the management of AnGR. As described in the preamble, these guidelines on phenotypic characterization are part of a series of guideline publications produced by FAO in response to this request. The Commission on Genetic Resources for Food and Agriculture, at its Twelfth Regular Session in 2009, endorsed the first guidelines in the series and "further requested FAO to continue updating and further developing other technical guidelines on the management of animal genetic resources as important support for countries in their implementation of the *Global Plan of Action*" (FAO, 2009a).

The guidelines build upon FAO's earlier work on characterization, which was an important component of the organization's technical programme of work on AnGR, the "Global Strategy for the Management of Farm Animal Genetic Resources" (FAO, 1999), the development of which began in 1993 and which has now been superseded by the *Global Plan of Action*. Even prior to the development of the Global Strategy, methods for characterization of AnGR had been described in several publications in the FAO Animal Production and Health Paper Series (e.g. FAO, 1984a,b; 1992). FAO published a comprehensive list of variables for describing the phenotypic and genetic characteristics of cattle, sheep, goats and chickens as the basis for systematic phenotypic characterization of these species (FAO, 1986a,b,c). It also developed the Domestic Animal Diversity Information System (DAD-IS) to serve as a global data repository and clearing-house facility to support countries in the management of their AnGR-related data and information and in meeting their obligations to report on the status of their national biodiversity within the framework of the Convention on Biological Diversity. The current guidelines are intended to provide practical advice on how to plan and implement phenotypic characterization projects. Draft versions of the guidelines were discussed and evaluated by 100 participants from 28 countries at three workshops, which were held in Argentina (December 2009), Senegal (March 2010) and Italy (June 2010).

USER GUIDANCE

Scope of the guidelines

The guidelines describe the whole process of organizing a phenotypic characterization study from the initial identification of objectives, through planning and implementation of field work, data management and analysis, to reporting the outputs of the study and promoting their full and effective use. Emphasis is given to the importance of collecting data both on the animals themselves and on their production environments; advice relevant to both these aspects of characterization work is included in all the sections of the guidelines.

The guidelines address both "primary" phenotypic characterization activities, which can be undertaken during a single visit and provide a basic picture of the state of AnGR diversity in the study area, and "advanced" characterization activities, which require repeated measurements over an extended period. Advice is provided on the decision as to whether primary or advanced characterization is needed in order to meet the objectives of the study and on how the former can lay the basis for the latter.

The guidelines focus mainly on the low to medium external input production environments of developing countries (where the gaps in AnGR-related knowledge are most substantial and where the "hotspots" of diversity loss are expected to be located in the coming decades). Many valuable traits in these populations probably remain unknown or undocumented. However, much of the activity described is also relevant for developed-country contexts and for high external input production systems, where characterization activities are mainly for the recognition of new breeds. Because of the financial implications of such recognition (e.g. the right to apply for subsidies), more stringent characterization procedures may be required in this context.

The guidelines address situations in which the populations targeted for characterization consist of non-descript animals (not distinguished into recognized breeds) and situations in which the objective is to enhance the state of knowledge of breeds that are already recognized.

The focus of the guidelines is mainly on the five livestock species that are most significant on a global scale – cattle, sheep, goats, chickens and pigs. However, the basic advice on how to plan and implement a survey is relevant to other livestock species. Furthermore, essentially the same key variables can be used to describe closely related animal species. For instance, the descriptors for cattle can be applied to the yak or the buffalo with minimum modifications. Similarly, other avian species can be described using the chicken descriptors.

Target audience

The main target audience for the guidelines comprises individuals involved in planning and implementing characterization studies. Such studies have generally been undertaken by researchers in public research institutions, students doing academic research, and the staff of livestock-development projects. Unfortunately, the outputs of these studies have often ended up gathering dust on book shelves. It is therefore important to emphasize that anyone considering undertaking a phenotypic characterization study should ensure that it addresses a specific "demand" for information. The ideal scenario is that the characterization study is an element within a coherent national strategy for improving knowledge of the country's AnGR as a basis for meeting priority objectives for AnGR management and livestock development. Whatever the circumstances, the contribution of the proposed study to future AnGR management should be clearly thought out, and the potential users of the study outputs should be consulted.

The guidelines may also be useful to decision-makers who wish to obtain a better understanding of the potential contributions of phenotypic characterization studies to national policies and programmes for AnGR and of the practicalities involved in implementing such studies.

BOX 1

A breed improvement scheme based on insufficient characterization information – the case of Bolivian Criollo sheep

In the 1960s Bolivia had about 12 million Criollo sheep but limited knowledge of their potential except for some information related to their zoometric measures and appearance. These animals are a major component of Andean production systems – both mixed crop–livestock systems and grazing systems – and contribute to families' livelihoods through the production of meat, fibre, cheese, milk and manure. Herd sizes ranging from 40 to 60 head.

During the same decade, the Government of Bolivia and the University of Utah established a cooperation programme to investigate ways to improve Andean production systems. Based on poor documentation of the potential of the Criollo sheep, researchers concluded that its small size (average adult weight of 24 kg) and its poor wool production and quality (800 g/sheep/year) should be improved by crossing it with improved breeds. A programme of cross-breeding with Corriedale, Targhee and Rambouillet sheep originating from the United States of America was introduced and lasted until the mid-1980s.

Thirty years later, the highland sheep producer has never become a fine-wool producer. Some producers increased their wool production but, because of the small scale of production, this did not result in substantial increases in revenue. The size of the animals increased, and with it their demand for feed in an environment where feeding is dependent on degraded native pasture. In many cases, the fertility of the native Criollo sheep (> 90 percent) decreased, but lamb mortality remained high. Many producers "returned" to keeping a Criollo type, but of a larger size.

Bolivian researchers acknowledged that they had ignored both the productive potential of Criollo sheep and their particular characteristics (apart from their small size and weight and their "unappealing" appearance). Following this experience, characterization studies of the productive capacity of Criollo sheep under farm conditions, and of market demand, were conducted. They showed that some farmers received a steady income from the sale of sheep cheese made from the small amounts of milk collected from individual animals. There was also an important market demand for Criollo sheep meat, in particular in the main cities located in the country's highlands. Finally, peasants preferred the wool of Criollo sheep for manufacturing felt and for local crafts. None of these features were considered when establishing the breeding programme, which as a consequence did not meet the requirements of the producers.

This example illustrates some of the consequences of an inadequately designed programme based on insufficient characterization of the target population.

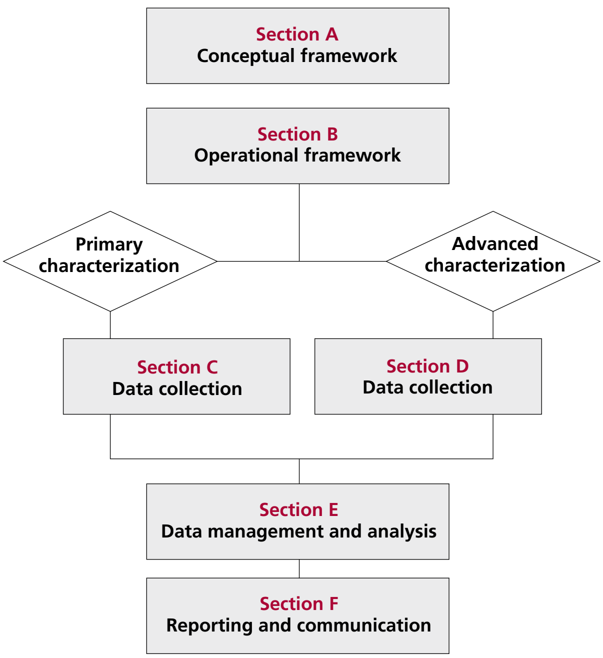
Provided by Luis Iñiguez.

Structure of the guidelines

These guidelines contain six sections (Figure 1). Section A sets out the conceptual and theoretical background to the practical guidance presented in the other sections. It begins by discussing the meaning of the term "phenotypic characterization" along with the concepts of the "breed" and the "non-descript population"; it also addresses the significance of wild relatives of domesticated animals in phenotypic characterization studies. Broad approaches to phenotypic characterization (exploratory vs. confirmatory) are then distinguished. This is followed by an overview of principles and methods for breed identification and of the constituent elements of phenotypic characterization, including the description of production environments and economic valuation of non-production traits.

In Section B, the focus shifts to the preparatory activities for individual phenotypic characterization studies. Emphasis is given to the importance of linking such studies to the requirements of the country's national strategy and action plan for AnGR and (if applicable) national surveying and monitoring strategy. The tasks of constituting the study team, collecting background information and clarifying the objectives and scope of the study (including the fundamental distinction between primary and advanced characterization) are described. Sections C and D describe data collection activities. The former focuses on primary characterization and the latter on advanced characterization. Section E describes

FIGURE 1
Structure of the guidelines



data management (including checking data quality, data entry, data cleaning and processing, and data archiving) and data analysis (including a discussion of the resources required, statistical packages, critical steps in the process of analysis, and interpretation of results). Primary and advanced characterization are here described within a single section. Section F provides advice on reporting the results of the study and communicating them to relevant stakeholders.

The annexes to the guidelines provide check lists for the description of major livestock species and their production environments. These lists are intended as guides that can be adapted, as necessary, to match the objectives and circumstances of specific characterization studies.

The guidelines do not specify standards for quantitative and qualitative variables, data collection tools, precision in data recording or methods for managing and storing the data. Rather they describe options and approaches and provide users with advice on how to tailor them to fit their needs.

SECTION A

Conceptual framework

Conceptual framework

WHAT IS PHENOTYPIC CHARACTERIZATION?

The term "phenotypic characterization of AnGR" generally refers to the process of identifying distinct breed populations and describing their external and production characteristics within a given production environment. In these guidelines, the definition is broadened to include the description of the production environment. The term "production environment" is here taken to include not only the "natural" environment but also management practices and the uses to which the animals are put, as well as social and economic factors such as market orientation, niche-marketing opportunities and gender issues. Recording the geographical distribution of breed populations is here considered to be an integral part of phenotypic characterization. Complementary procedures used to unravel the genetic basis of phenotypes and their patterns of inheritance from one generation to the next, and to establish relationships between breeds, are referred to as molecular genetic characterization (FAO, 2011b). In essence, phenotypic and molecular genetic characterization of AnGR are used to measure and describe genetic diversity in these resources as a basis for understanding them and utilizing them sustainably.

The guidelines distinguish between two phases or levels of characterization. The term "primary characterization" is used to refer to activities that can be carried out in a single visit to the field (e.g. measurement of animals' morphological features, interviews with livestock keepers, observation and measurement of some aspects of the production environment, mapping of geographical distribution). The term "advanced characterization" is used to describe activities that require repeated visits. These activities include the measurement of the productive capacities (e.g. growth rate, milk production) and the adaptive capacities (e.g. resistance or tolerance to specific diseases) of breeds in specified production environments.

NON-DESCRIPT POPULATIONS

Because of a lack of comprehensive information on population fragmentations or sub-structures and geographical distributions, many animal populations in the developing regions of the world are commonly referred to as "non-descript" or "traditional". The inventory of breeds in these regions is thought not to be exhaustive, and new breeds continue to be identified (e.g. Köhler-Rollefson and the LIFE Network, 2007; Wuletaw *et al.*, 2008). It is primarily in these regions that phenotypic characterization studies on AnGR are needed.

Simplified and coherent procedures for phenotypic characterization are needed in order to support countries in establishing more complete inventories of their AnGR. These procedures need to be standardized globally to facilitate valid enumeration, analysis and reporting of breeds nationally and internationally.

THE BREED CONCEPT

The term "breed" is used in phenotypic characterization to identify distinct AnGR populations as units of reference and measurement. Diversity in AnGR populations is measured in three forms: interpopulation diversity (between breeds), intrapopulation diversity (within breeds), and inter-relationships between populations. Phenotypic characterization is used to identify and document diversity within and between distinct breeds, based on their observable attributes. The measurement of genetic relationships between breeds and genetic heterozygosity within breeds is the task of molecular characterization (FAO, 2011b).

The breed concept originated in Europe and was linked to the existence of breeders' organizations. The term is now applied widely in developing countries, but it tends to refer to a sociocultural concept rather than a distinct physical entity. Hence, the use of the term in developing countries, where most of the world's traditional and local livestock populations are located, is different from its use in developed countries. Whereas in developed countries breeds are defined in terms of a set of phenotypic standards, the use of breed herd books and the existence of formalized breed societies that are often supported by legislation, in developing countries livestock-keeping communities and governments apply the term more loosely and identify breeds more with geographic localities, ethnic identities and the traditions of their owners than with their phenotypic attributes. In some cases, the term is used interchangeably with "population", "variety", "strain" or "line" within nationally recognized breeds. Definitions of breed-related terms are provided in Box 2.

FAO uses the following broad definition of the breed concept, which accounts for social, cultural and economic differences between animal populations, and which can therefore be applied globally in the measurement of livestock diversity:

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

These guidelines use the same generic definition.

In addition to the task of characterizing recognized breeds, the guidelines address the task of identifying and characterizing previously unrecognized breeds from among traditional and non-descript populations. This can be done by studying the genetic make-up of the population, its differences with respect to other populations or breeds, its history, and its productive, social and economic merit.

One essential characteristic of a breed is near complete reproductive isolation for many generations (i.e. mating with animals from outside the population has been very restricted), as a consequence of which the population acquires an appearance and capacities that are distinctly different from those of other breeds (FAO, 1992; FAO/UNEP, 1998). In traditional livestock-keeping communities, local indigenous knowledge provides perhaps the best preliminary information available about breed identity; i.e. a particular community may claim to maintain a distinct AnGR population in a specific environment and subject to a common pattern of breeding and utilization. Köhler-Rollefson (1997) provides the following description of how the breed concept can be applied in traditional communities:

BOX 2

Definitions of breed categories and related terms

Traditional populations: mainly local; often exhibit large phenotypic diversity; are managed by farmers and pastoralists at low selection intensity, but may be subject to high natural selection pressure; pedigree may be partially known; genetic structures are mainly influenced by migration events and mutations; population size is generally large (unless subject to erosion).

Standardized breeds: derived from traditional populations by a community of breeders based on a recognized list of "standard" breed descriptors; exhibit less phenotypic diversity as they are selected to meet minimum standards of phenotype; pedigree is partially known; genetic structure may be influenced by important founder effects; population size may be large or small.

Selected breeds or commercial lines: derived from standardized breeds or from traditional populations through the application of an economic selection objective and use of quantitative genetic methods; breeders are organized for pedigree and performance recording, and selected animals are used across flocks or herds; inbreeding increases as a consequence of high selection intensity; molecular markers may be used, for instance for parentage testing and/or for the identification of genes controlling performance; population size is generally large.

Derived lines: arise from the use of specific breeding methods such as close inbreeding; highly specialized inbred lines exhibit low genetic variability; synthetic lines are derived from crossing standardized breeds or selected lines, and exhibit a high level of genetic variability; transgenic and experimental selected lines fall within this category; population size is generally limited, except for synthetic lines.

These different types of population can be identified easily in highly commercialized populations, such as European populations of cattle, pigs and chickens. The classification may be less relevant to other species such as camelids or geese. Nonetheless, it may be used as a general framework covering all types of domesticated populations.

Source: adapted from Tixier-Boichard *et al.* (2007).

> *"A domestic animal population may be regarded as a breed, if the animals fulfil the criteria of (i) being subjected to a common utilization pattern, (ii) sharing a common habitat/distribution area, (iii) representing largely a closed gene pool, and (iv) being regarded as distinct by their breeders".*

What is common in both traditional and industrialized communities is that breed populations are developed, maintained and influenced by humans and hence become the unit of reference for improvement and conservation. It is, therefore, appropriate that AnGR populations are identified by breed and that phenotypic characterization studies involve both the investigation of indigenous knowledge and quantitative classification. Molecular tools can be used to corroborate the classification of populations into breeds.

APPROACHES TO CHARACTERIZATION

In statistical terms, phenotypic characterization can involve either of the following two approaches, depending on the type of background information available:

Exploratory approach – undertaken in situations in which no reliable background information on the existence of breeds in the study area is available; in such circumstances, the objective of phenotypic characterization is to investigate the existence of distinct breeds in the study area.

Confirmatory approach – undertaken in situations in which some basic information on breed identity and distribution is available; in such circumstances, the objective of phenotypic characterization is to validate breed identity and provide systematic descriptions of the breeds.

In situations where available secondary information is insufficient to prepare plans for phenotypic characterization, preliminary field data will need to be collected on the identity, geographical distribution, and relative significance of AnGR populations (nationally or locally recognized breeds, non-descript populations, etc.) in the study area and hence to determine whether an exploratory or confirmatory approach is required. Preliminary data-collection activities may include "mapping expeditions" – journeys within the study area that serve as a means of approximating the geographical distribution of different populations – and "rapid appraisals" – the use of a range of field-based techniques (complemented where relevant with information from secondary sources) to obtain information from local people. Rapid appraisals may include discussions in group meetings and focus groups, semi-structured interviews with individual livestock keepers and other knowledgeable "key informants", and direct observation on the part of the surveyors. A range of specific techniques have been developed for use in rapid appraisals (mapping exercises, seasonal calendars, ranking and scoring exercises, transect walks, progeny histories, etc.) and can be used to discuss the local production system with groups or individuals. Triangulation – the use of several complementary sources of information – is a key characteristic of the approach. Further information on mapping expeditions and rapid appraisals can be found in the guidelines on surveying and monitoring of AnGR published in this series (FAO, 2011a).

Exploratory approach

Once the study area has been designated, the next step is to develop a sampling frame, i.e. a set of criteria to be used in identifying a sample of households and animals for data collection. If the study area is large, it may be necessary to stratify it into more homogenous subunits based on one or more of the following criteria:

- geographical isolation of AnGR populations and their patterns of movement or migration;
- known patterns of morphological and production characteristics in the AnGR populations or the existence of common breeding practices; and

- historical information and indigenous knowledge on the origin of the AnGR.

The exploratory approach to phenotypic characterization also requires estimation of the total livestock population in the study area, as well as the number of livestock keepers who maintain these animals (see Section C).

Secondary information on the livestock populations in the study area should be sought in published and grey literature. The Domestic Animal Diversity Information System (DAD-IS – http://www.fao.org/dad-is) may be a useful source of background information on breed inventory and on the distribution, national population sizes and risk statuses of recognized breeds.

The exploratory approach hypothesizes that the target AnGR population is homogenous and does not have phenotypically distinct subpopulations. It seeks to test this hypothesis by measuring and analysing the pattern of phenotypic diversity within the target population. Standard phenotypic data (see Annexes 1 to 4) are collected from sample animals at the study sites.

Primary characterization (i.e. the collection of data through single field visits) falls within the exploratory approach. For the sake simplicity, primary characterization is used in these guidelines when referring to this approach.

Confirmatory approach

The confirmatory approach to phenotypic characterization aims to validate information on breed identities as recorded in national AnGR inventories, literature and/or local knowledge. It presumes that known breeds have a defined geographical distribution and some common phenotypic characteristics and pattern of utilization. The standard breed descriptors set out in Annexes 1 to 4 provide a framework for collecting detailed phenotypic data. Statistical tools can be used to test whether there are significant multivariate differences among the populations in the study area and hence to validate their identities as distinct breeds. Additional genetic studies are recommended to corroborate such identities.

The confirmatory approach also involves an objective assessment of documented indigenous knowledge and other indicative information. This can reveal important AnGR management issues for closer investigation (e.g. the risk status of existing breeds, emergence of new composite populations, and the perceptions of communities about breed identities). The approach can be used to look more closely at differences among populations identified during primary characterization, with a view to validating the classifications and describing how the distinct groups differ from each other.

The study team may find that additional or more up-to-date information is needed in order to draw up the sampling frame. In such cases, preparatory field work (mapping expeditions and/or rapid appraisals – see above) may need to be conducted in the study area.

The confirmatory approach is applied for breed evaluation and breed comparison under on-station or on-farm management conditions (i.e. advanced characterization). Such studies focus on breeds that have already been identified, and aim to provide a more comprehensive evaluation of their performance and adaptation. For the sake of simplicity, the term advanced characterization is used in these guidelines when referring to the confirmatory approach.

QUANTITATIVE PROCEDURES FOR BREED IDENTIFICATION

Principles of classification

Based on the premise that livestock breeds are distinguishable by differences in appearance, conformation and dimension, quantitative procedures are used to explore breeds from traditional populations by systematically assessing aggregate morphological characteristics in groups of animals, in exactly the same way as taxonomists classify organisms into hierarchical groupings. Known as numerical taxonomy, these procedures are used to explore aggregate morphological resemblances among groups of organisms in order to develop hierarchical groupings, assuming that the groupings may (but not necessarily) represent historical evolutionary processes associated with gross structural diversity (Dobzhansky, 1951). When, in addition to morphological characteristics, sociocultural attributes, such as historical association with particular livestock-keeping communities in well-defined production environments, are used to delineate such animal groups, distinct breeds that are expected to share clearly defined heritable traits and definite areas of distribution, may be identified in line with the broad definition of breed given above. This approach has been applied, for example, among traditional goat populations in Ethiopia (FARM Africa and ILRI, 1996; Ayalew *et al*., 2000) and corroborated by molecular genetic studies (Ticho, 2004). Similar genetic evidence to support phenotypic breed identities has been obtained in sheep (GebreMichael, 2008), cattle (Dadi *et al*., 2008) and chickens (Halima-Hassen, 2007).

Multivariate analyses of variance are used for determining which among the many traits measured are of interests for distinguishing between populations, and for assessing the aggregate morphological characteristics needed for grouping. Numerical taxonomic procedures that use multivariate analysis of variance consider large numbers of observable characteristics of equal value (i.e. not weighted) in a large number of individuals and seek to classify the individuals based on their aggregate similarity. The premise behind this method of classification is that morphological variation among individual organisms is typically discontinuous and forms distinctly separate arrays, with each array comprising a cluster of individuals that possess some common characteristics. The discrete clusters are designated as races (varieties), breeds, species, genera and so forth. The classification arrived at by using this approach is to some extent artificial, but the clusters themselves and the discontinuities observed between them are not abstractions on the part of the classifier (Dobzhansky, 1951; pp. 3–18). In effect, the patterns of morphological variation within species can be used to identify homogenous subgroups of animals, and these subgroups can be considered breeds or varieties.

Methodology

Cluster and discriminant analyses. In this type of analysis, the units of reference (taxonomic units) are referred to as operational taxonomic units (OTU). Depending on the perceived pattern of morphological variation at the population level, the OTUs may be individual animals or sample groups of homogenous animals. In situations where there is high flock/herd-level morphological resemblance, as in the case of pastoral livestock populations, average values of sample animals – otherwise known as centroids – are taken as OTUs. In the absence of such resemblance and in particular when breed identities are less clear, individual sample animals are used as OTUs. Estimating the degree of phenotypic resemblance (morphological, physiological and behavioural) among OTUs is a fundamental step in the analysis. Multivariate cluster analysis is then used to re-organize the heterogeneous set of taxonomic units into more homogenous groups or clusters with respect to the variables (characters) under consideration (Aldenderfer and Blashfield, 1984). If the sample population already includes distinct categories – for instance if local names are given to different populations – discriminant analysis can be used to validate the classification (Klecka, 1980). Both cluster and discriminant analyses assume that the aggregate morphological variation is a linear combination of the individual variables (character states or phenotypic measurements) recorded from OTUs (individual animals or centroids).

Cluster analysis is used to classify OTUs by quantifying aggregate similarity relationships of pairs of OTUs with respect to the characters under consideration (Sneath and Sokal, 1973; p. 116). These relationships can be expressed as relative distance (i.e. resemblance) in a multidimensional Euclidean space, with each character variable defining an axis. In a mathematical sense, the relative distance is, rather, a measure of aggregate differences – the larger the value of this distance the greater is the dissimilarity between the OTUs. Based on the computed values for all the possible pairs of OTUs a hierarchical (classification) tree can be produced (ibid.).

Principal components analyses. The major technical limitation involved in producing clusters directly from morphological variables is that the variables are not independent of each other, because the original variables are recorded on each OTU. The procedure known as principal components analysis (PCA) linearly transforms the original variables into a set of uncorrelated variables, referred to as principal components, which explain essentially the same statistical information (variance) as the original set of variables. Each principal component is a linear combination of all the variables and has a mean of zero and variance of unity (Dunteman, 1989). However, depending on the nature of variation in the original data set, the first (most important) few principal components may account for most of the total variation. As a result, a substantially smaller set of principal components can explain most of the variance in the original variables, thereby reducing dimensionality (number of axes) in the corresponding hyperspace. Furthermore, the independence of the transformed variables will ensure orthogonality between each of the axes. Orthogonality of the axes implies that each of them makes an independent contribution to discrimination between the OTUs or groups of OTUs (i.e. clusters). The computed principal components can then be used to develop a classification tree using cluster analysis.

Method of clustering. There are several contrasting methods of clustering (Sneath and Sokal, 1973; pp. 201–244; Pimentel, 1979; p. 79; Aldenderfer and Blashfield, 1984), but the most widely applied method of clustering in biological systematics, as well as for subspecies-level classification, is one that is sequential, agglomerative, hierarchic and non-overlapping (abbreviated to SAHN). The method starts with t separate OTUs, agglomerates them into successively fewer than t sets, arriving eventually at a single set containing all t OTUs. The resulting taxa at any level (rank) are mutually exclusive (non-overlapping), i.e. OTUs contained within one taxon are not also members of a second taxon of the same rank. An iterative sequence of clustering is used to partition the OTUs into biologically meaningful clusters. This procedure ultimately produces a hierarchical (or classification) tree from which the desired number of homogenous groups (clusters) can be derived. As long as the goal of the analysis is to explore the general pattern of relationships between the OTUs as represented by the classification tree, the number of clusters can be determined by heuristic decisions. The choice that has the most plausible biological interpretation is taken to be the best. Thus, the procedure is prone to biases arising from the opinions of the researchers as to what should be regarded as the most meaningful structure for the data. The following validation techniques should minimize the bias:

- replicating the classification procedure using a separate data set;
- checking the accuracy of the classification using discriminant analysis by the proportion of cases correctly classified – which also confirms indirectly the degree of group separation; and
- checking the stability (internal consistency) of the classification after repeated trials, preferably using another data set from the same sample population.

The results thus obtained are satisfactory as long as they meet two principal aims of numerical taxonomy (Sneath and Sokal, 1973, p. 11):

- repeatability and comparability within an acceptable level of error; and
- objectivity and a degree of unbiasedness from personal feelings and prejudice.

CONSTITUENTS OF PHENOTYPIC CHARACTERIZATION

A phenotypic characterization study will involve collecting a number of different kinds of data:

- the breeds' geographical distribution and if possible their population sizes and structures;
- the breeds' phenotypic characteristics, 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 breeds;
- images of typical adult males and females, as well as herds or flocks in their typical production environments;
- information on the breeds' origin and development;
- any known functional and genetic relationships with other breeds within or outside the country;
- biophysical and management environment(s) in which the breeds are maintained;
- responses of the breeds to environmental stressors, such as disease and parasite challenge, extremes of climate and poor feed quality, along with any other special characteristics related to adaptation; and
- relevant indigenous knowledge (including gender-specific knowledge) of management strategies used by communities to utilize the genetic diversity in their livestock.

While most of these data elements can be collected directly during field work, valuable information may also be obtained from secondary sources in the published and unpublished literature (including electronic data sets related to aspects of the production environment). Most of the elements listed can be collected during primary characterization studies (single visits to field sites); others require advanced characterization studies (repeated measurements and observations). The latter group includes variables that describe economic performance traits (e.g. growth, milk production, egg production, wool production), adaptation (levels of resistance and tolerance to stressors) and trends (e.g. in population size and structure, and phenotypic performance).

Describing breeds in terms of their qualitative and quantitative traits

Qualitative traits. This category of traits covers the external physical form, shape, colour and appearance of animals. These traits are recorded as discrete or categorical variables. Their discrete expression relates to the fact that they are determined by a small set of genes. Relative to the quantitative traits discussed below, some of these traits (e.g. colour of hair coat, feather type, horn shape and ear length) may have less direct relevance to the production and service functions of AnGR. However, they may relate to adaptive attributes. For instance, colour of the skin and hair coat, and size of ears and horns, are known to be relevant to the dissipation of excess body heat. Length of tail or size of switch in cattle is important in areas where there are many biting flies. Other traits may be relevant to the preferences or tastes of livestock keepers and consumers (e.g. colour of hair coat), and some are used for animal identification in situations where permanent identification of individual animals is otherwise impractical. In such contexts, qualitative traits are as important as quantitative traits, and hence they need to be included in phenotypic characterization studies.

Qualitative traits are recorded either as discrete categories of expression (e.g. colour of hair or feathers) or binary variables (e.g. presence or absence of wattles). Collection, management and analysis of data on qualitative traits are therefore different from the equivalent procedures for quantitative traits. Details of these methods are discussed in Section C (Data collection for primary characterization) and Section E (Data management and analysis).

Animal temperament is closely linked to various production and service functions. Temperament is recorded as a subjective measure (either categorical or binary) preferably at herd or flock level. Some breeds (e.g. the Fulani cattle of the Sahel of western–central Africa) have typical features of temperament and attachment to their owners that distinguish them from other populations.

The commonest qualitative traits used in phenotypic characterization of cattle, sheep, goats, chickens and pigs are presented in Annexes 1 to 4. Recording traits such as colour of hair, feathers or shanks, or size of hump involves some level of subjectivity. Steps need to be taken to develop a common understanding of these traits among those collecting such data. Enumerators should be given uniform training on these aspects of data collection. Standardized colour charts can be prepared and taken to the field.

Standardization of the coding of qualitative traits is also essential for ensuring the broad utility of the data, for instance to compare breeds within or between countries. Meta analysis at regional and global levels requires both standardization of breed-descriptor data and access to the relevant data sets. It is therefore important that National Coordinators for the Management of AnGR enter data on the characteristics of their countries' breeds in a consistent manner and as fully as possible into DAD-IS. It is also important that phenotypic characterization studies provide the data that National Coordinators need to complete the task. It is recommended that phenotypic characterization studies should aim to collect the relevant core set of data items – listed in the Annexes to these guidelines – as fully as possible, both for the purpose of international reporting and as a sound basis for national actions to improve AnGR management. The set of data items can be expanded as necessary to address specific objectives and preferences at national or local levels.

In Spanish- and French-speaking countries, some phenotypic characterization studies present qualitative traits in three categories – morphological, morphostructural and cutaneous (*faneropticos*) – but essentially the same set of qualitative traits as those described above is being discussed.

Quantitative traits. This category of traits covers the size and dimensions of animals' bodies or body parts, which are more directly correlated to production traits than qualitative traits are. For instance, body weight and chest girth are directly related to body size and associated production traits. Typically, these variables have a continuous expression. This is because of the numerous genes that determine or influence their expression. While qualitative traits, such as coat colour, are based on a small number of loci and can be precisely recorded and predicted for defined animal populations, economically important quantitative traits require considerable recording of direct and indirect indicators in individual animals. Furthermore, unlike many qualitative traits, most quantitative traits are dependent on the age of the animal and the type of production environment in which they are kept. Consequently, it is imperative to sample only fully adult animals maintained in their typical production environments. The data collected in a single visit can only provide indicative information on economically important quantitative traits. Repeated and more structured data collection is required for systematic characterization of such traits (see Section D for further discussion).

Because of their strong correlations with production traits such as meat and milk production, traits such as body weight, body length and height at withers are used as proxy indicators of the production traits. Body measurements should always be accompanied by explanatory notes on the plane of nutrition, or season of the year and how this affects the availability of feed. In studies that cover large geographical areas and involve the characterization of grazing animals, the objective should be to collect all field data during seasons of the year when feed supplies are similar. Alternatively, body condition scores of sample animals can be collected and used to account for seasonal differences in the plane of nutrition, but this approach requires that the data collectors have the relevant skills.

Traits such as dewlap width, ear length, height at withers and size of preputial sheath are directly related to adaptive attributes of AnGR, and are therefore relevant to phenotypic characterization studies. For instance, AnGR that are well adapted to dry and hot climates, such as the Jamunapari goat of India or the Boran cattle of Ethiopia and Kenya, typically have very long ears and a wide dewlap.

Economically important production traits, such as growth rate, milk yield, egg production and fibre (e.g. wool, cashmere) yield, cannot be adequately assessed by single visits to field sites. They require advanced phenotypic characterization work involving repeated measurements of performance (discussed in more detail in Section D). However, some indicative data on average performance levels can be collected through one-time measurements, interviews with livestock keepers or from available records.

Live body weight at a specific age, combined with available knowledge of meat quality and marketability, can be used as a proxy indicator of suitability for meat production in all the species discussed in these guidelines (cattle, sheep, goats, pigs and chickens). Similarly, average milk off-take records from sample animals on the day of data collection, taking into account the stage of lactation, can indicate milk production capacity in cattle, sheep and goats. Formats for capturing such data are presented in Annexes 1 to 4 for the respective species. A more detailed example is presented in Box 3. Note, however, that such approaches cannot be regarded as substitutes for standard data-collection methods.

If specialized production traits such as the characteristics of wool, cashmere or mohair are considered a priority, direct measurements of fibre quality (e.g. percent wool and hair), length, strength and curliness may be taken during primary characterization studies. Whenever such measures are necessary, however, detailed data collection through advanced characterization studies (on-farm and on-research station) should be planned.

Blood samples can be collected during field work and used for assessing blood parameters, such as haematocrit count or prevalence of blood parasites, or for extracting DNA for molecular genetic analysis. Taking such samples needs careful planning and coordination with the laboratories that will perform the analysis. Detailed information on molecular genetic characterization can be found in the complementary guideline publication devoted to this topic (FAO, 2011b), which is based on a tested set of recommendations for field and

BOX 3

A rapid method of assessing milk production in cattle breeds

As part of a comparative evaluation of the utility value, as perceived by their owners, of four indigenous cattle breeds in southwestern Ethiopia under smallholder management, a semi-structured questionnaire was used to interview 60 cattle-keeping farmers from the home areas of the four breeds, Abigar, Gurage, Horro and Sheko. The questionnaire covered, *inter alia*, reproductive characteristics, breeding practices and milk production. The daily milk off-take was estimated by each farmer for the three trimesters of the lactation period, both for the oldest cow in the herd and for another cow chosen at random from among the herd. Off-take did not include the amount of milk suckled by calves. Milk production was estimated as an average quantity per day in each trimester of the lactation. Based on these figures and the reported lactation length, the total lactation yield was calculated. Lactation length was longest in Sheko cows and shortest in Gurage and Horro. Milk production was significantly higher for Abigar and Sheko compared to Gurage and Horro. The lowest milk production was in the Gurage breed.

Source: Stein *et al.* (2009).

laboratory work. From the perspective of organizing a phenotypic study, the main point to note is that the fieldwork phase of the study is an opportunity to collect blood or tissue samples. Importantly, coordinated approaches allow combined analysis and comparison of phenotypic and genetic data that provides a more comprehensive assessment of AnGR diversity. Such analysis not only facilitates a more definitive identification of distinct breeds in situations where phenotypic differences appear minor (see Box 4), but can also be used for identifying genetic relationships between breeds, which is very useful for planning breed improvement and conservation programmes.

Additional data on resistance to, or tolerance of, biotic (diseases, parasites, etc.) and non-biotic (climate, water scarcity, seasonal feed scarcity, etc.) stressors can be collected during primary phenotypic characterization studies by interviewing individual livestock keepers or through focus-group discussions. Annexes 1 to 5 provide some guidance on traits that can be investigated through interviews. Such data are largely dependent on the perceptions of the interviewees and hence need to be interpreted with caution. Closer investigation through repeated measurements may be necessary.

The traction services provided by cattle are important for many rural populations in Africa and Asia, and hence need to be considered as part of phenotypic characterization

BOX 4

How to complement genetic characterization with phenotypic characterization – an example

An integrated phenotypic and genetic characterization study of three meat-type goat breeds developed in South Africa (Boer, Savanna and Kalahari Red) was conducted in 2007 to determine whether the typical characteristics of the breeds were being maintained and ensure that their unique traits were not being lost. The same populations were sampled for phenotypic and genetic characterization. A set of twelve linear measurements were taken for the phenotypic characterization. Eighteen microsatellite markers selected from a panel of markers recommended by the International Society for Animal Genetics (ISAG) and FAO were used in the genetic characterization. The results showed that morphometric variation within the breeds is greater than between the breeds, and that morphometric differences between the breeds are fairly insignificant. This highlighted the need for genetic characterization to enable the breeds to be distinguished accurately at genotypic level. Results of the genetic studies showed that the three breeds had relatively high heterozygosity values and that each of the populations was clearly distinguishable as a separate breed based on genotyping results with the selected markers. It was concluded that further genetic studies were needed to ensure sufficient diversity within the breeds for long-term conservation of the unique genetic resources.

Source: Pieters *et al.* (2009).

in this species. During primary characterization studies, it is only possible to collect data on trait preferences. If necessary, advanced studies to obtain detailed data on speed and work performed can be implemented.

Limitations of primary characterization for collecting data on traits of economic importance

Despite the high cost and huge effort involved in primary characterization studies, very little can be deduced from them about important production traits such as growth rate (for meat production), lactation milk yield, egg production, wool production or the quality of these products. Some data collection instruments that can be used to capture indicative information on these traits during single field visits are available, but these are not substitutes for advanced characterization based on repeated visits and controlled measurements (see Section D). Resource limitations may mean that it is necessary to choose between covering a large area through primary characterization or conducting advanced characterization in a smaller sample or geographical area.

Investigating feral and wild populations

In some locations and production systems, livestock come into contact and interbreed with wild or feral populations. For example, in the mountainous regions of northern Viet Nam, domesticated chicken populations frequently come into contact with their wild relatives. Similarly, numerous native pig populations in isolated rural communities in Papua New Guinea are known to interbreed freely with feral and wild pig populations. Whenever possible, consideration should be given to collecting some data on these populations during phenotypic characterization studies in such locations. Of particular relevance are estimates of the sizes and geographical distributions of the wild and feral populations, and information on whether, and to what extent, there is interbreeding between them and domestic animals. Apart from genetic introgression, feral and wild populations can be important in the transmission of contagious diseases to domestic populations. The data collected may also be important from the perspective of managing the wild or feral populations themselves, either to help conserve them as important elements of local biodiversity or, if they are "invasive alien species" in the local context, to reduce the problems they cause.

Investigating breed population sizes and threats to genetic diversity

Up-to-date data on the size and structure of breed populations are essential for effective management of AnGR. The task of obtaining a baseline of population (and other) data on a country's breeds and subsequent monitoring of trends is best handled through the development and implementation of a national surveying and monitoring strategy, which is likely to involve sample-based "household" surveys combined with the use of other data gathering tools (for further details, see FAO, 2011a). In countries where AnGR populations are not well characterized, and particularly where they are not distinguished into recognized breeds, phenotypic characterization will be fundamental to the accumulation of a baseline of data on national AnGR.

Many individual phenotypic characterization studies will be too small in scale to allow them to provide precise figures for the population sizes of the breeds covered, particularly if the breeds are widely distributed throughout the country. Nonetheless, such studies represent an opportunity to obtain approximations of the size of breed populations in the study areas. For example, rapid appraisal techniques can be used to collect local knowledge on breed identity and the local distribution of these populations. By mapping these distributions and relating them to available population figures for the relevant species in the relevant administrative units (e.g. from a livestock census) it may be possible to obtain estimates of the sizes of breed populations within these areas (e.g. FARM Africa and ILRI, 1996; Blench, 1999). Additional information from focus-group discussions and key-informant interviews or from secondary sources, such as reports of previous livestock studies, may be useful in further refining crude population estimates.

Consideration should be given to collecting indicative data on threats to AnGR during phenotypic characterization studies as part of the description of breeds' production environments. Interviews and group discussions with livestock keepers and other informants can be used to obtain information on threats related to socio-economic changes, availability of resources, disease epidemics or other disasters. Mapping breed distributions as part of phenotypic characterization studies (see below) can also contribute to the analysis and management of some threats.

Mapping breeds' geographical distributions

Data on the geographical distribution of livestock breeds are important to the development of AnGR management plans both directly (e.g. knowledge of the location of the animals may be necessary to plan responses to emergencies such as disease outbreaks) and indirectly (because of the link between location and the "natural" aspects of the production environment – climate, elevation, terrain, disease epidemiology, etc.). Phenotypic characterization studies should always record the locations where measurements are taken, and map as accurately as possible the distribution of breeds within the areas covered by the study.

Breed distribution maps can be sketched based on global positioning system (GPS) readings taken at study sites combined with information obtained via interviews or mapping exercises conducted with local people. In extensive livestock systems such as those of the pastoral and agropastoral systems of sub-Saharan Africa, the Andes and parts of Asia, breed identities often match the ethnic boundaries of livestock-keeping communities. Such links can be corroborated using information gathered via focus-group discussions and interviews with key informants. Relevant secondary data may also be used to sketch distribution maps, but caution is needed in interpreting data from secondary sources as they may be incorrect or out of date.

Describing production environments

To understand the production and adaptation attributes of livestock breeds or populations, it is essential to describe their production environments. There are several reasons why this is important. If data on production levels are being collected, it is essential that data are also collected on the conditions in which the animals are kept. Without production environment data, performance data are meaningless. Not only do variations in production environments give rise to variations in performance, breeds may be ranked differently in different production environments; i.e. a breed that is the top performer in one production environment may be a poor choice elsewhere. Adaptation traits are complex and difficult to measure, especially in low to medium input production environments. However, they can be characterized indirectly by describing the production environments in which the targeted livestock populations have been maintained over time. Breeds that have had to survive and reproduce in the presence of particular stressors and combinations of stressors (e.g. high or low temperatures, poor-quality feed, specific diseases or parasites) will have been under selective pressure to develop adaptations to these stressors.

Describing the production environment may also be important as a means of identifying potential development opportunities. For instance, the fact that breeds are kept in specific natural environments may be important in the development of niche markets for their products. Descriptions of breeds' production environments are also essential for planning genetic improvement and conservation programmes. Here in particular, it is necessary not only to describe the physical conditions in which the animals are kept but also to describe features of the socio-economic environment, such as the uses and roles of livestock, market orientation and access, specific products and marketing opportunities, and gender-related aspects of livestock keeping.

Meaningful comparisons among breeds require standardized descriptions of their respective production environments. To address this requirement, FAO and the World Association for Animal Production convened an expert workshop (held in 2008) that developed a standard set of production environment descriptors (PEDs) for use in DAD-IS and in phenotypic characterization studies (FAO/WAAP, 2008). Individual phenotypic characterization studies should treat this set of PEDs as a minimum and collect whatever additional production-environment data are relevant to the objectives of the study and for providing a comprehensive description of the conditions in which the animals are kept.

The PEDs framework is presented in Annex 5. Note that the framework includes average climatic data that cannot be obtained in a single visit to a study site (in fact they require several decades of observations). Such data may be obtainable from the records of weather stations situated close to the study site. Moreover, many aspects of the production environment are now recorded electronically in high-resolution maps. If a phenotypic characterization study records the geographical locations of the targeted breeds, it becomes possible to create digitized breed-distribution maps that can be overlaid with any other digitized maps that are available for the respective areas. This approach is being used in the PEDs module of DAD-IS for all aspects of the production environment for which digitized maps are available globally. The global maps incorporated within DAD-IS include not only climatic data, such as temperature, rainfall and relative humidity, but also aspects of terrain and vegetation such as elevation, slope, land cover type, tree cover and soil pH. Data on aspects of the production environment that are not available in mapped form (e.g. management practices) have to be collected directly during field visits. See Sections C and D for further discussion of how to collect production environment data.

Economic valuation of non-production traits

Phenotypic characterization studies may pave the way for genetic improvement or conservation programmes. In the low external input production environments of developing countries, the reasons for raising particular types of livestock include a range of adaptation traits and non-marketable service functions. In stressful environments, tolerance of feed and water scarcity, disease and parasite burden, occasional drought and extremes of temperature may be prioritized over production traits. Similarly, mothering ability, fertility, and capacity to provide traction services or to meet sociocultural roles may be priority traits in some production systems. Unfortunately, these traits are difficult to record during phenotypic characterization studies. Recent advances in the field of economic valuation of AnGR have developed, adapted and tested new data-collection and analysis tools for assessing such traits in ways that can inform genetic improvement and conservation plans or decisions on the import of exotic breeds (Drucker *et al*., 2001; Drucker and Anderson, 2004). Such tools can be applied during phenotypic characterization studies. Two basic examples are:

1. determining the economic importance of the breed under consideration by asking key stakeholders specific questions about breed preferences (i.e. relative importance of the breeds taking into account all relevant economic traits); and
2. identifying all the relevant traits and putting them in priority order based on livestock keepers' trait preferences.

If breeds are being considered for inclusion in genetic improvement or conservation programmes, additional studies that collect detailed data on the levels of inputs and outputs used in their management may be necessary.

The greater significance of non-production traits in the low external input production environments of developing countries means that in these environments it may be particularly important to develop productivity evaluation criteria that take such traits into account and to apply these criteria in assessing and comparing the merits of different AnGR (Ayalew *et al.*, 2003; see Box 5). It also means that non-income functions (e.g. manure, savings, insurance) may need to be included in genetic improvement programmes in such production systems. Unique traits such as resistance or tolerance to endemic diseases or parasites, or to seasonal feed and water scarcity, also need to be identified and valued in economic terms through follow-up studies (Drucker *et al*., 2001). Another important reason for economic valuation of adaptation, service and other non-production traits is the potential role of AnGR in performing public or social functions. As often observed in breeds that are at risk of extinction, these roles attract little market interest.

A common feature of many methods for economic valuation of non-production traits is documentation of the trait preferences of livestock keepers and valuing them in monetary terms. Indeed, livestock keepers can be asked to state their breed preferences and the specific reasons underlying these preferences whenever multiple breeds are under consideration. Such data can be collected during primary phenotypic characterization studies. Analysis of the data may raise more specific economic questions that need investigation through follow-up studies. Economic valuation studies conducted in conjunction with phenotypic characterization can provide useful estimates of the values that society places

BOX 5

Aggregated productivity model for comparative performance evaluation of AnGR

The multiplicity of important production, service and sociocultural functions performed by livestock in smallholder and subsistence production systems cannot be captured by conventional productivity evaluation criteria that focus on production traits. Evaluations based on such criteria are inadequate for evaluating subsistence livestock production because: 1) they fail to capture non-marketable benefits; and 2) the core concept of a single limiting input is inappropriate to subsistence production, as multiple limiting inputs (livestock, labour and land) are involved in the production process. As many of the livestock functions as possible (physical and socio-economic) should thus be aggregated into monetary values and related to the resources used, irrespective of whether the outputs are marketed, home-consumed or kept for later use. A broad evaluation model involving three complementary flock-level productivity indices was developed and used to evaluate subsistence goat production in the eastern Ethiopian highlands. The results showed that indigenous goat flocks generated significantly higher net benefits under improved than under traditional management, which challenges the prevailing notion that indigenous livestock do not respond adequately to improvements in management. Furthermore, the study showed that under the subsistence mode of production considered, the premise that indigenous × exotic cross-bred goats are more productive and beneficial than the indigenous goats is wrong. The model thus provides a more realistic platform upon which to propose improvement interventions.

Source: Ayalew *et al.* (2003).

on particular AnGR. Information on livestock keepers' preferences and perceptions about breeds and their traits is critically important in the design of genetic improvement and conservation programmes. Specific technical input from competent experts should be brought in to assist with the planning and management of economic valuation studies associated with phenotypic characterization work.

SECTION B

Operational framework

Operational framework

This section serves as a transition between the previous more theoretical section, which describes the principles, concepts and elements of phenotypic characterization, and the following sections which deal with the practical planning and execution of phenotypic characterization studies. It addresses the "getting started" phase of such a study. It is a critical section in the sense that it provides advice on forming the study team and guides the team through the process of defining the objectives and the scope of the study.

ESTABLISH AN INVENTORY OF STAKEHOLDERS

Ideally, the study will be initiated within the framework of the country's National Strategy and Action Plan for AnGR (FAO, 2009b) and be part of a national strategy on surveying and monitoring strategy that aims to meet the countries needs for AnGR-related data and information (FAO, 2011a). In other cases the initiative may come from individuals or groups of people, who are aware of the need to characterize particular local AnGR populations. Whatever the institutional framework, it is important that phenotypic characterization studies focus on meeting the priority information needs of AnGR stakeholders locally and/or nationally. Even if the study is not initiated at national level, it is nonetheless essential that the National Coordinator for the Management of AnGR and National Advisory Committee on AnGR (or equivalent body) be informed and consulted.

Once a decision to conduct a study has been taken, it is essential that a balanced and competent team be assembled to plan and implement it. This task will have to be organized by the individual or small group who are initiating the study or who have been delegated

TABLE 1
Examples of national and local, regional and international stakeholders

Category	Organizations
National and local (study area)	Breed associations; farmers' or livestock keepers' associations or unions; livestock conservation organizations; ministries, departments or divisions in national or regional government; service providers (e.g. artificial breeding, performance recording); research establishments; education and training establishments; extension agencies; financing institutions and credit facilitators; rural development agencies; other national or local organizations including NGOs
Regional	Arab Center for Studies of Arid Zones and Dry Areas (ACSAD), Arab Organization for Agricultural Development (AOAD), Inter-American Institute for Cooperation on Agriculture (IICA), Secretariat of the Pacific Community (SPC), Southern Africa Development Community (SADC), other regional organizations including NGOs
International	International Center for Agricultural Research in the Dry Areas (ICARDA), International Livestock Research Institute (ILRI), FAO, International Fund for Agricultural Development (IFAD), Organisation for Economic Co-operation and Development (OECD), World Bank (WB), other international organizations including NGOs

the task by the national authorities. The process may involve a series of consultations with key stakeholders. A first step may be to draw up an inventory of all stakeholders who might contribute to the planning and/or implementation of the characterization study, be interested in the results or contribute to follow-up activities. Representatives of key institutions and stakeholder groups should be identified. Table 1 provides a checklist that may help in identifying relevant stakeholders

ESTABLISH THE STUDY TEAM

Depending on scope of work, the study team that will plan and conduct the phenotypic characterization study may consist of a multidisciplinary team of experts and technicians or a few individual researchers (and their assistants or MSc/PhD students). Studies undertaken by research and academic institutions are likely to be vetted by the respective institutions for the technical competency of the research team.

The following competencies are required in study teams for both primary and advanced characterization studies (additional requirements for advanced studies are discussed below):

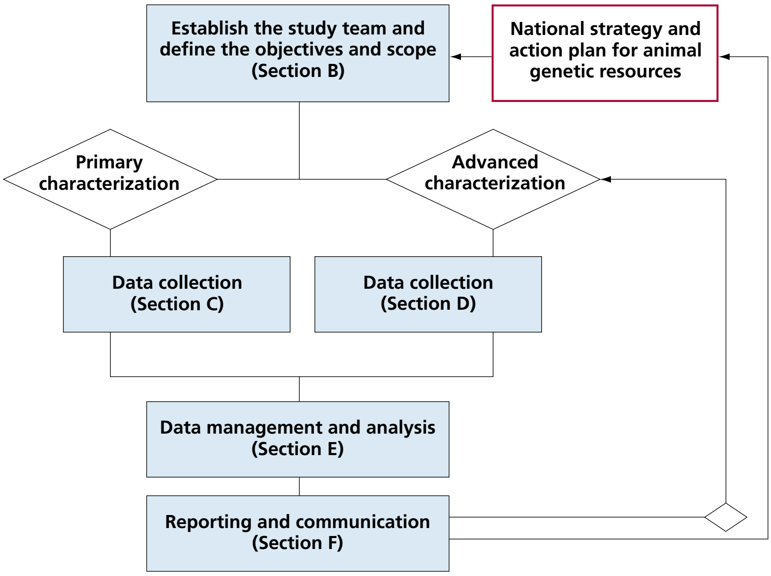
- good knowledge of animal genetics and management of AnGR;
- good knowledge of statistics and data management;
- good knowledge of sociology, and in particular participatory approaches;
- good knowledge of the livestock production systems in the study area and the sociocultural significance of AnGR;
- good skills and experience in organizing field work (particularly phenotypic characterization studies) on the appropriate scale; and
- good insights into the current and potential future contributions of AnGR to the livelihoods of livestock keepers in the study area and to the local economy.

If it is not feasible to assemble all these competencies within the study team itself, expert technical advice from outside the team will need to be sought at various stages during the planning and implementation of the study. It is recommended that the study team be managed by a person with ample experience in characterization studies. The members of the study team should cooperate closely with each other in all the phases of the project (planning, field work, data management and analysis, and writing the report).

A typical study team that meets the above-described criteria might be composed of the following members:

- lead investigator, who may be an expert in any one or more of the desired competencies;
- specialist in livestock production and/or genetics, preferably an expert on the species targeted by the study;
- sociologist or anthropologist;
- data management specialist;
- data entry staff;
- data analyst;
- statistician; and
- enumerators (number depending on the size of the study).

FIGURE 2
Operational framework for phenotypic characterization studies



Note: ◇ = decision.

These members may have multiple competencies and hence responsibilities, but responsibilities should not be shared. The data analyst will ideally be a statistician (in which case there is no need for a separate statistician within the team), but the role may be fulfilled by another competent member of the team (e.g. geneticist or animal scientist) advised as necessary by a statistician.

The study team should contact the local authorities in the area(s) where the study is to take place and seek their support in facilitating the field work and recruiting the enumerators. If there are several separate groups of enumerators, it is critical to appoint a supervisor for each group and to ensure proper coordination among the groups. It is recommended that the different groups have members in common to assure consistency in the methods used. However, this may not be possible if the groups are in the field at the same time.

In the case of advanced characterization, more people may need to be involved. For on-farm evaluation, livestock keepers will need to be contracted and support staff may be needed for data collection and supervision. For on-station evaluation, staff that run the research station's experimental facilities and processes will need to be included in the study team.

Once established, the study team will need to undertake the following tasks:

- collect background information;
- clarify the objectives and the scope of the study;

- plan and execute the field work to collect data on animals and their production environments;
- plan and execute data management and analysis; and
- prepare the report of the study and communicate the main findings to relevant stakeholders.

These tasks are summarized in Figure 2. The first two are described below in this section. The planning and execution of field work to collect data on animals and their production environments are described in Sections C for primary characterization and D for advanced characterization. The planning and execution of data management and analyses are discussed in Section E. Section F deals with communicating the main findings to relevant stakeholders. Note that these sections are arranged by type of activity and do not fully follow a chronological sequence. For example, the study team should plan the data management and analysis before starting the field work.

COLLECT BACKGROUND INFORMATION

In preparing to define the scope of the work, the study team should collect relevant information on the target livestock populations and their production environments and on any past or ongoing activities related to their characterization. This task is simply stated, but it may be time-consuming and should be accounted and budgeted for properly. Information available from published and unpublished literature, official reports and relevant legislation should be reviewed.

The survey team should search for data on the population size of the species of interest, in the areas targeted by the study. The results of the latest livestock or agricultural census are ideal for this purpose and are also likely to be a source of additional valuable information on the agricultural systems and the biophysical and socio-economic environment in the study area. Most censuses do not distinguish animals by breed. However, it may nonetheless be possible to combine census data with information from other sources on breed distribution (FAO, 1996; ACO, 2006). Where census data can be assigned with confidence to particular breeds within the study area, detailed data on the size and structure of these populations can be obtained for use in preparing the sampling frame for the study. The following method may be useful:

- sketch, on a map, the known distribution of breeds within the study area to the lowest possible administrative unit;
- relate the distribution map (the sketch) to the available population figures and try to delineate geographical areas to which the figures can be matched with good confidence;
- aggregate this information to obtain estimates of the size and distribution of the breed populations.

However, caution is needed when using secondary data to develop distribution maps as the data may be out of date or inaccurate.

If the geographical distribution of the breeds targeted by the study can be mapped based on secondary information, it may be possible (depending on what is available) to overlay the distribution maps with a variety of georeferenced datasets, which may provide

BOX 6

Selected surveying tools for collecting AnGR-related data

"Mapping expeditions": a simple set of journeys within the study area that are used to obtain rudimentary information on the geographical distribution of particular breeds and populations.

Transect surveys: a method of estimating the size and composition of the livestock population within a defined area on the basis of counts taken along narrow strips within the area and the use of statistical techniques to obtain estimates for the area as a whole. This tool is only likely to yield useful results in homogenous production environments where livestock are distributed evenly rather than in clusters.

Aerial surveys: essentially aerial mapping expeditions or transect surveys – can be used to locate and count known breeds, but provide little additional information.

Rapid appraisals: the use of a variety of techniques to obtain a range of information from livestock keepers and other local informants individually or in groups.

Household surveys: use of questionnaires to collect data from a random subset of livestock-keeping households in a targeted area. Such surveys are normally major undertakings in terms of time, effort and financial expense.

Obtaining information from breed societies: where they exist, breed societies can provide detailed information on population size and structure, distribution, breed standards, uses and other aspects of the breeds they maintain. However, the information may not cover the entire breed population and may be subject to biases of various kinds.

Source: FAO (2011a).

an insight into aspects of the production environment such as seasonal feed availability, burden of endemic diseases, specific uses of livestock (e.g. traction, milk production), market demand for certain products, cultural preferences and ecological zones. Such information will be useful in developing the sampling frame for the characterization work. Particularly useful, but beyond the scope of these guidelines, would be to create an intelligent database that allowed links between the different datasets.

In situations where available background information is insufficient as a basis for planning the study, preliminary fieldwork and/or consultation with knowledgeable stakeholders will be required. This activity will have to be planned and budgeted for in addition to the main fieldwork. A range of tools can be used to obtain information on the size and distribution of breed populations and on various aspects of their management. Some of these are listed in Box 6. Further details can be found in the complementary guidelines on surveying and monitoring (FAO, 2011a).

Within the framework of a phenotypic characterization study, the most feasible tools for preliminary data collection are likely to be mapping expeditions (e.g. to ground-truth information from secondary sources on breed distributions), rapid appraisals (e.g. to obtain data on breed distribution and other aspects of livestock keeping that may be relevant in developing the sampling frame) and in some circumstances transect methods to obtain data on the size and distribution of breed populations.

CLARIFY THE OBJECTIVES AND SCOPE OF THE STUDY

The study team needs to have a clear understanding of the objective of the study and the key research questions. A preliminary consultation and planning meeting can be organized to clarify the objective(s) of the work, take stock of any ongoing or planned activities that may affect the study, and outline a work plan for the project. The team should review the study objectives and ensure that they are aligned with national priorities for the collection of AnGR-related data, consulting if necessary with the National Coordinator and the National Advisory Committee on AnGR (or other body overseeing such work at national level). Possible objectives and associated research questions for a phenotypic characterization study include:

- To identify new breeds in the study area:
  - Are there distinct new breeds in the study area?
  - Are these breeds known outside the study area?
  - How do the newly identified breeds relate to previously known populations?
- To characterize, phenotypically, newly identified and previously known breeds in the study area:
  - What are the typical phenotypic features of the breeds?
  - Are the breeds associated with particular agro-ecologies or particular socio-economic or cultural groups within the study area?
  - Do the breeds have any specific adaptations or unique traits?
  - How big are the population sizes of the breeds in the study area?
  - What are the geographical distributions of the breeds?
  - Are there any threats to the survival of the breeds or factors that may lead to genetic erosion?

The study team should consider whether and how the envisaged study can meet its objectives. If necessary, further background information should be collected and further consultations conducted with stakeholders. If, given the state of existing knowledge and the amount of resources available for undertaking the study, doubts remain as to whether the objectives can be met, it may be necessary to revise the objectives.

The study team, in consultation with participating stakeholders, should decide whether the study should involve primary or advanced characterization.

Primary characterization studies involve single visits to the targeted study areas. The emphasis is on collecting descriptive data on breeds and their production environments and any additional information relevant to the management of these breeds.

Advanced characterization studies involve repeated visits and longitudinal data collection. The emphasis is on detailed evaluation of production and adaptation traits to provide more comprehensive evidence-based information for AnGR management, in particular for decision-making on breed development and/or conservation.

If it is decided that primary characterization work should be followed by an in-depth longitudinal evaluation, then the whole study can be organized into two phases: Phase I covering the primary characterization and Phase II covering the advanced characterization.

BOX 7

Use of advanced characterization for designing breed improvement – the case of Thin-tailed Sumatra sheep

There are few examples of advanced characterization work that has served the purposes of breed improvement, particularly in which characterization has been conducted with the aim of designing a breeding plan. One example is the case of the Thin-tailed sheep of Sumatra (STT) in Indonesia, a small animal (22 kg adult weight) that is native to Sumatra.

A four-year characterization study revealed that STT has one of the highest reproductive indexes among the world's sheep breeds, with a reproductive rate of 1.54 offspring/lambing, a lambing interval of 201 days and 1.84 lambings/year. This allows the production of up to 3.6 weaned lambs and a total weight of 31.9 kg per ewe per year.

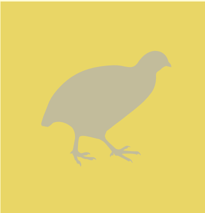
The characterization study was complemented by research that aimed to test the suitability of crosses of STT sheep with other tropical breeds, such as the St Croix sheep from the US Virgin Islands, the Barbados Blackbelly sheep and the Javanese Fat-Tailed sheep form eastern Java. The information obtained was crucial to focusing the crossbreeding scheme on the production of a synthetic population derived from STT and Barbados Blackbelly sheep, which showed better adaptation and performance than crosses between STT and St Croix sheep or STT and Javanese Fat-Tailed sheep.

During the characterization of the STT, the presence of a pancreatic fluke (*Fasciola gigantica*), which attacks both native (Sumatran) breeds and exotic breeds, such as the St Croix and the Javanese Fat-Tailed, was detected. Subsequent studies showed that STT, and Indonesian thin-tailed sheep in general, are more resistant than St Croix to this parasite, and that this resistance probably has simple genetic control.

Provided by Luis Iñiguez.

SECTION C

Data collection for primary characterization


Data collection for primary characterization

DEVELOP THE SAMPLING FRAME

In both primary and advanced phenotypic characterization studies, the study area is likely to be too large to enumerate the whole of the targeted livestock population, making it necessary to sample a representative subset of the population. Whereas in primary characterization studies the geographic distribution of populations will need to be determined as part of the study, in advanced studies existing information on the distribution of the targeted populations can be used as a basis for developing the sampling frame.

As described in Section A, phenotypic characterization is as much about documenting the range of variation and unique features as it is about population-level averages. Therefore, it is important that the sampling does not result in small breed populations being completely missed out of the study.

In a phenotypic characterization study, four levels of sampling may be required:

- region (if applicable, e.g. in a countrywide characterization study);
- study sites or communities within the region targeted by the study;
- households keeping the target species within the targeted study sites or communities; and
- individual animals within the sample households.

Small and isolated communities may maintain unique AnGR. Such animals need to be included in the data collection as they can provide unique historical insights into the management of AnGR (e.g. Wuletaw *et al.*, 2008). Moreover, for cultural, religious or socio-economic reasons, particular AnGR populations may be kept only by subsections of the communities in which they are found. These populations may be missed unless their links to particular social groups are identified (for instance through focus-group discussions) and considered in the sampling.

Genetic diversity of AnGR in traditional communities is associated with the biophysical, socio-economic and management attributes of the production environment (e.g. LPPS and Köhler-Rollefson, 2005). Such factors should be considered when developing the sampling frame for breed identification and characterization studies.

In situations where the AnGR population targeted by the study is distributed across contrasting agro-ecological zones, ethnic groups, sociocultural settings or administrative boundaries, these criteria may need to be included in the sampling frame. They can be used to divide the study area into more homogenous and manageable subunits for more efficient sampling (e.g. Rowlands *et al.*, 2003; Ayalew and Rowlands, 2004). The study team should seek expert statistical advice when developing the sampling frame, especially when the study area or the targeted livestock population is large.

At household level, the involvement of household members in AnGR management and their knowledge of these resources are likely to vary by gender, age or social status. Attempts should be made to collect AnGR-related data from the particular individuals who are involved in livestock keeping.

For breed identification purposes it is the number of individual animals measured, rather than the number of herds or flocks from which measurements are taken, that is important. Conversely, the household is the measurement unit for analysis of many aspects of the production environment, and from this perspective the objective should be to include as many households as possible. However, resources for phenotypic characterization studies are always limited, and trade-off between the number of households visited and the number of animals measured in each household will be one of the challenges faced by study team.

To collect phenotypic data, it is not necessary to record all the selected morphological variables from all animals. It is important to focus only on mature/adult animals. Young animals may not have acquired the features that are typical of adult animals. However, taking measurements on younger animals may be necessary to assess and compare growth trends (see below).

The appropriate size for the sample of individual animals at each study site depends on the precision required and the variability in the sample population. Coefficients of variation in the body measurements of mature animals in traditional livestock populations often range between 10 and 30 percent. For statistical significance (5 percent) 100 to 300 mature females and about 30 mature males from each sample site are required. In other words, if the desired confidence interval is 10 units for a 5 percent level of significance, the target sample size should be about 100 mature animals.[1]

BOX 8

Estimating the of age of sheep and goats from their dentition

In traditional livestock populations, for example in pastoral areas, recording animals' dentition is essential for identifying mature females, calculating the population pyramid, assessing sex ratios and, where relevant, for comparing generalized growth curves. Natural patterns of eruption of deciduous and permanent incisors in sheep and goats are strongly related to the age of the animals and the quality of the roughage feed (FAO, 1991). The common eight dental classes (see Annex 6) are too broad for estimating animals' age with sufficient precision, especially at two stages of maturity – one between the eruption of the fourth pair of milk teeth and that of the first pair of permanent incisors, and the other after the full-mouth stage. Six additional classes were introduced and tested in several studies in Ethiopia (FARM Africa and ILRI, 1996) and despite their vulnerability to biases on the part of the observer proved to be very helpful in producing more comparable age classes.

[1] See http://www.gmi-mr.com/solutions/sample-size-calculator.php

In all livestock species, the number of mature breeding males is always very limited. Thus, the focus, especially in breed-identification studies, will be on mature females, the males being included for breed description, especially in the case of known sex dimorphism, and for genetic characterization. In traditional populations of, for instance, cattle and small ruminants in sub-Saharan Africa, mature females typically constitute about 40 percent of the animals in a herd or flock. To identify and sample mature females, it may be necessary to combine information provided by the livestock keepers with information obtained by examining the dentition of the animals (see Box 8).

Note that the figures quoted above are guides; the study team should seek specific technical advice from a statistician if the relevant expertise is not available within the team itself. Box 9 presents a generic method for determining sample size.

PREPARE THE DATA-COLLECTION EQUIPMENT AND METHODS

A combination of quantitative and qualitative data needs to be collected, in simplified formats, from sample animals, livestock keepers and the production environment. The study team will need to prepare equipment and tools for taking animal body measurements, questionnaires for interviews and guides for focus-group discussions and other informal interviews. Annexes 1 to 5 provide outlines that can be customized, as necessary, to meet the specific needs of the study. If the study includes molecular genetic characterization, tools and protocols for blood or tissue collection will need to be prepared.

Equipment

Even when standardized measuring devices are employed, some subjectivity is involved in taking quantitative body measurements from animals. Similarly, collection of data on qualitative or categorical traits may be affected by inconsistencies and errors in judgement on the part of the observer. This review of equipment and tools includes advice on how to address such problems.

For quantitative data collection, the following instruments may be needed:

- **Measuring tapes** are used for linear body measurements such as body length, chest girth and horn length. They can be made of textile or plastic material. Textile tapes are preferable to plastic because they are less affected by variations in temperature.
- **Sliding rulers** (metallic or wooden rulers fitted with sliding height bars) are preferable to tapes for measuring vertical heights (e.g. wither heights) to avoid subjectivity associated with gauging the top line.
- **Callipers** are used for measuring distances between two symmetrically opposing sides of an animal or other object (e.g. pelvic width or egg diameter). Metallic callipers are less prone to measuring error than are measuring tapes. The tips of the callipers can be adjusted to fit the points to be measured and the distance read either from the graduated callipers themselves or by measuring the distance between the tips of the callipers with a separate measuring tool.
- **Altimeters** are used to record the elevation of study sites.
- **Compasses** are used in mapping exercises and to guide enumerators during visits to new sites.

BOX 9

Simple example for determining sample size

At last three factors determine the sample size for simple random sampling:

1. *The margin of error (also referred to as the confidence interval):* which measures the precision with which an estimate from a single sample approximates the population value. The margin of error (e.g. + or - 5 percent) is closely related to sample size, and decreases as the sample size increases. It depends on the precision needed in making population estimates from the sample.
2. *The confidence level:* which is the estimated probability that a population parameter lies within a given margin of error. The confidence level is also closely related to sample size, and increases as the sample size increases. Generally, the confidence level is 95 percent.
3. *The proportion (or percentage) of a sample that will choose a given answer to a survey question:* which is generally unknown, but needs to be estimated as it is required for calculating the sample size. A proportion of 50 percent is most commonly used as it considered the most conservative estimate.

The formula for calculating the sample size for a simple random sample is then:

$$n = \left(\frac{z}{m}\right)^2 p(1 - p)$$

where z is the z value (e.g. 1.96 for 95 percent confidence level); m is the margin of error (e.g. 0.05 = + or – 5 percent); and p is the estimated value for the proportion of the sample that will respond a given way to a survey question (e.g. 0.50 for 50 percent).

Using the above values, and without using the finite population correction factor (explained below), the sample size is:

$$n = \left(\frac{1.96}{0.05}\right)^2 0.5(1 - 0.5) = (39.2)^2(0.25) = 1536.64(0.25) = 384$$

The finite population correction (FPC) factor is routinely used in calculating sample sizes for simple random samples. It has very little effect on the sample size when the sample is small relative to the population, but it is important to apply the FPC when the sample is large (10 percent or more) relative to the population. The sample size equation for n' (new sample size) when taking the FPC into account is:

$$n' = \frac{n}{1 + \frac{n}{N}}$$

where n is the sample size based on the calculations above and N is population size.

(cont.)

This formula is presented only for illustration and should be customized by the statistician in the study team.

Using the formula above, and for N = 16 450, the new sample size is:

$$n' = \frac{384}{1 + \frac{384}{16\,450}} = \frac{384}{1.023} = 375.37$$

Examples of sample size calculators can be found at:

- http://www.raosoft.com/samplesize.html;
- http://surveysystem.com/sscalc.htm#ssneeded;
- http://calculators.stat.ucla.edu/

Source: Adapted from Cochran (1977) and http://grants.nih.gov/grants/funding/modular/eval/Sample_MGAP.doc (accessed March 2012).

- **Weighing scales** – for sheep, goats and chickens, mobile weight measuring sets consisting of a tripod, a spring balance and a hanging canvas sling can be used. For larger animals, measuring body weights in the field is often difficult because of a lack of mobile weighing bridges or scales. In primary characterization studies on cattle or pigs in widely dispersed communities, indirect methods of estimating body weight can be considered. Options include tested regression equations of body weight on body length and chest girth, which in general are highly correlated with body weight. Such equations are, however, population specific; i.e. they can be developed in a first study of the target population and later applied in other studies of the same population (Ribeiro *et al.*, 2004), provided their levels of accuracy are known. Weighing bridges and spring balances always need to be calibrated before data collection starts. In the case of spring balances, the weight of carrying slings should be accounted for when reading body-weight measurements, either by subtracting the weight of the carrying sling from the total weight reading or by adjusting the weight reading to zero with the sling set on the spring balance.

For data collection on qualitative or categorical traits, the instruments described below may be needed:

- **Coding sheets and guides for enumerators** – the study team should develop data codes for categorical variables, ideally with the help of customized illustrations.
- **Colour charts** – these are essential for ensuring uniform treatment of traits such as type and pattern of coat colour, plumage colour, shank colour and skin colour.
- **Pictorial body conformation guides** – the study team should set verifiable standards for all qualitative indicators of the size and shape of body parts. For instance, the method for classifying head profiles as straight, concave, convex or markedly convex should be clear-cut and without ambiguities. The same is true for classifying ear orientation as prick, lateral, drooping, pendulous or semi-pendulous.

Other items of equipment that will be needed in the field include:

- gear for sampling blood, hair root or tissue (if material for molecular genetic characterization is to be collected);
- digital photo and video cameras, which are needed to capture images of animals and can also be used to record subjective qualitative data (e.g. shape, appearance and colour) for comparison and standardization;
- GPS apparatus;
- writing materials and bags;
- communication equipment; and
- means of transport (field vehicle, motorcycles, bicycles, etc.).

Methods for obtaining indicative measurement of production traits

Primary phenotypic characterization reveals very little about important production traits such as growth rate, milk yield, egg production, wool production or the quality of these products. Evaluation of these traits requires more in-depth studies. Relevant methods are described in Section D. However, it is possible to collect indicative information on these key economic traits during primary characterization studies. The following examples illustrate methods that can be used in smallholder settings.

Milk production: ask livestock keepers, preferably the members of the household who milk the animals, to identify two of their milking animals that have completed at least one lactation: the cow that has most recently completed its lactation (to be the random cow) and the cow that is known to be the most productive. Then ask the livestock keepers to recall the lactation length in each of these cows, divide it into three trimesters, and then estimate the volume of the average daily yield for each trimester separately. This can be done in terms of volume measures that are familiar to the livestock keepers, such as cups or gourds, and later converted into litres. Aggregating figures obtained in this way can provide more realistic estimates of lactation milk off-take than can be obtained by direct estimates of the whole off-take (e.g. Stein *et al.*, 2009). See also Box 3.

Growth rate of animals (cattle, sheep, goats, pigs, chickens) destined for meat production: First ask livestock keepers to identify a meat animal that is about ready for sale, and then record the weight and estimated age (as recalled by owner or judged by dentition) of this animal. Then randomly select three or four other animals of the same sex and progressively younger ages. Weigh these animals and record their ages. These data can be used to derive an estimated average growth rate from an early age to market weight for marketable animals in the sample flocks/herds. The method only provides rather crude estimates, but can give a quick indication of weight gain for the period covered. If consistently applied, the method can be used to compare growth rates across flocks/herds. In circumstances where live body weights cannot be directly recorded, weight estimator measuring tapes can be developed in advance based on known regression of, for instance, body weight on chest girth.

Reproduction rate and frequency of multiple births in cattle, sheep, goats and pigs: Ask livestock keepers to recall the parturition histories (number and type of births) of all the female animals sampled in the study. This enables average litter size and frequency of multiple births to be estimated at the level of the sample population. If the animals are identified by source (i.e. home-bred or purchased) and their ages are estimated, it is possible to estimate the probable number of parturitions for a given age group, either by production system or by breed (see for instance, FARM-Africa and ILRI, 1996).

Egg production: Once the number of hens in the sample flock has been determined and recorded, ask the chicken owners to recall the number of eggs laid by all hens in the flock during the last three days. Aggregate the figures at household and village levels to get an estimate of: 1) average egg production for the period covered; and 2) hen-day production, i.e. total number of eggs laid by the flock in the three-day period divided by the hen-days covered (the sum of the number of hens in the flock on each of the three days).

If they are considered priorities, specialized traits such as those associated with the production of wool, cashmere and mohair can be investigated during primary characterization studies, for example, by taking direct measurements of fibre quality (e.g. percent wool and hair), length, strength and curliness.

Describing production environments

The field work phase of a phenotypic characterization study is an opportunity both to directly collect data on the production environments of the targeted AnGR populations and to collect data on their geographical distribution which can be related to mapped datasets obtained from other sources (see Section A).

Most data items related to animal management and to the socio-economic, marketing and gender aspects of the production environment need to be collected directly in the field. This can be done via interviews with livestock keepers or other local people (individually or in groups) and through the use of "participatory" data collection tools. Basic data items that need to be collected in order to describe these aspects of the production environment are listed under "management environment" in Annex 5. These can be supplemented with whatever additional production-environment data the study team considers relevant to the objectives of the study and to providing a comprehensive description of the conditions in which the animals are kept.

The presence of diseases and parasites is another aspect of the production environment that requires investigation through fieldwork unless the relevant data are available from previous studies in the area targeted. High-resolution global maps of disease distribution are currently unavailable. Detailed advice on how to record the disease and parasite challenge facing a livestock population is beyond the scope of these guidelines. If it is necessary to collect data on this aspect of the production environment, advice should be sought from experts in conventional and/or participatory epidemiology.

Field data to complement georeferenced data on terrain and vegetation may also be useful (e.g. to record the nature of the terrain – substrate, slope, etc – in the specific areas where the animals actually graze rather than averages for the area as a whole). Such matters can be explored via interviews with local people, but some aspects of terrain can also be directly observed and/or measured by the study team even during single visits to the field.

Most kinds of quantitative climatic data (e.g. long-term average temperatures measured in °C) are impossible to collect during the fieldwork phase of an individual phenotypic characterization study. The mapping-based approach described in Section A is the only feasible means of describing such aspects of the production environment. However, it is likely to be useful to complement georeferenced climatic data with data collected in the field from livestock keepers or other local people. This might be done, for example, to obtain some information on aspects of the climate that are not available in global georeferenced datasets (e.g. snow fall and snow cover – see Annex 5). Interview data might also shed light on local people's perceptions of recent climatic trends and their effects on livestock production.

Prepare questionnaires for individual and group interviews

Structured, semi-structured and open-ended questionnaires can be used to capture data systematically through interviews. Interviews can be conducted with individuals or selected groups of individuals. Apart from livestock keepers, individual interviews may be conducted with government officials, service providers, livestock traders, community leaders or development/extension agents. Focus-group discussions can be held with livestock keepers, community representatives or other stakeholders. Data generated through questionnaires may include descriptions of production environments, management practices, historical origin and evolution of AnGR, and data on the perceptions of livestock keepers (or other people) regarding AnGR and their management. Key descriptors for AnGR management and for breed attributes are listed in Annex 5. These can be supplemented or customized to suit the circumstances of specific individual studies.

It is important that the scope and depth of the questionnaires be guided by the specific requirements of the study. The time and resources required for data collection and processing can be substantial and the focus should be on collecting only the data that are needed to complete the analysis and meet the objectives of the study.

Verbal interviews entail interaction and information sharing between interviewers and respondents within a limited period of time. Location and timing may limit the participation of particular individuals, groups or communities. Group facilitation skills are needed to manage group discussions. For instance, the potential effects of social structures and group dynamics in participatory discussions need to be recognized (LDG, 2003).

PREPARE THE PROTOCOL FOR DATA COLLECTION

To ensure consistency in data collection, the study team should elaborate a protocol for enumerators detailing the sampling frame, the equipment and tools to be used, along with instructions on how to administer the questionnaires, and how to take measurements from sample animals. The protocol can be based on the material presented in this section and in the annexes, adapted as necessary to the specific circumstances of the study. The protocol can be used as support material during the training of the enumerators.

In particular, potential sources of systematic error in measurement and recording should be highlighted. All data codes and acronyms should be clearly described in the protocol. The protocol should emphasize that instead of introducing new data codes for unexpected types of data, enumerators should gather as much explanatory information as possible so that the study team will later be able to make an appropriate decision on how to code the data in question.

TRAIN THE ENUMERATORS AND THEIR SUPERVISORS

It is critically important that enumerators and their supervisors be trained in the use of the whole set of data-collection instruments. Training should include both formal lessons and practical exercises. It should promote common understanding of the data-collection process, reporting relationships, and how queries that emerge during data collection should be handled. Training should continue during the pre-testing and the pilot study.

The training should establish good communication channels and working relationships between the specialist members of the study team (who will provide the training) and the enumerators and their supervisors. This will favour a higher sense of responsibility and ownership of the data and results among the enumerators and their supervisors, which, in turn, will lead to greater accuracy in data collection. Communication between supervisors and the enumerators is also very important. Good communication will ensure that support is provided to the enumerators when they need it and that data collection is supervised effectively. Supervisors should be trained in:

- ensuring consistency in the collection of interview data and in the measurement of sample animals. Data collection methods should be as consistent as possible from one enumerator to another and from one production environment to another, and
- checking raw data in questionnaires and other data-collection formats to identify obvious errors and missing data. Instructions should be provided on how to address these errors, if necessary by going back to data sources. Checks should be made as soon as possible after the data are collected. Checked questionnaires should then be signed by both enumerators and supervisors. All such procedures should be set out in the protocols for the fieldwork.

If the study involves more than one field team it is advisable, if circumstances allow, that they have members in common to promote homogeneity in data collection.

PILOT AND PRE-TEST THE STUDY INSTRUMENTS

The protocol and all data-collection instruments should be pre-tested at a few selected sites within the study area to:

- minimize variation among the enumerators;
- identify inconsistencies and sensitive issues in the questionnaire;
- determine whether each question is properly worded and understood by the enumerators and the respondents;
- determine whether all questions are relevant and whether additional ones may be needed;
- test the layout and sequence of questions in the questionnaire and the coding system; and
- determine the expected duration of each interview and hence of the whole study (if the interviews are too long, the respondents may lose interest, which will affect the quality of the responses).

Subsequently, a full pilot study needs to be conducted in the study area. This will allow the following aspects of field work to be assessed:

- the pace of data collection and checking;
- interactions with livestock keepers; and
- supervision relationships within the team.

The lessons learned from the pilot study will allow more realistic planning of the actual data collection: particularly the number of enumerators and supervisors needed, the type and quantity of support services needed, the timeframe and the budget. The data collected during the pilot study should be used to refine the coding of nominal, textual and, where relevant, numerical data into precisely defined discrete categories that can be used for analysis.

ORGANIZE THE LOGISTICS OF THE FIELD WORK

While the technical preparations are being finalized, the study team should start preparing the agenda and the logistics for the field work, in collaboration with the enumerators and supervisors. Before deciding on the dates for the field work, the following questions should be considered:

- May the season of the year (heavy rains, drought, etc.) affect data collection at particular sample sites or across the whole study?
- May peak agricultural activities (land preparation, harvesting, etc) affect data collection?
- May sociocultural events (e.g. religious holidays) affect data collection?

Supervisors and the study team should visit the study sites to inform local authorities and the selected study communities formally about the planned data collection. The date, time and location of field visits should be agreed with community representatives. This may involve consulting village chiefs, local officials or service providers (e.g. vets) to identify the most convenient times for data collection. It may be appropriate to involve such stakeholders directly in organizing field activities.

Logistical issues such as booking vehicles, purchasing consumables (fuel, paper, batteries, etc), travel authorizations, and arranging accommodation for the field teams should be addressed in advance.

FINALIZE THE PLAN FOR DATA COLLECTION

The final plan for the data collection should include the sampling frame, and details of all the data-collection instruments, guides and protocols, as well as a timetable for the field work. The plan should be accompanied by a budget report which accounts for all logistical issues and human-resource requirements.

SECTION D

Data collection for advanced characterization

Data collection for advanced characterization

As explained in Sections A and B, advanced characterization is the term used in these guidelines to describe aspects of phenotypic characterization that cannot be addressed by single visits to a study site, i.e. which require taking repeated measurements over a substantial period of time. Effective planning of advanced characterization, including defining the specific objectives and scope of the study, depends on the availability of background data on the targeted breeds and their production environments, either from earlier phases of the study or from the outputs of previous studies documented in the literature.

Both this and the previous section describe data collection, and there is therefore some unavoidable overlap between the two. However, they are also complementary, especially with respect to repeated surveys. Therefore, it is recommended that readers read both sections even if their specific interest is in advanced characterization.

REVIEW OBJECTIVES AND SCOPE

The study team should identify the particular traits to be targeted, along with the production-environment data that need to be recorded. This will help in defining the scope of the work and the approach to be taken. The following aspects of the study will need to be reviewed at this stage:

- the size and geographical distribution of the base population from which representative sample study herds or flocks are to be selected;
- the timeframe of the study, including planning, data collection, data analysis and reporting; and
- the decision as to whether data are to be collected in the animals' usual production environment (i.e. on-farm) or at a research station where key environmental variables can be controlled.

On-farm performance evaluation

Evaluation of production and adaptation traits in the animals' normal production environment reflects the true levels of performance in the base population. In such studies, representative sample flocks or herds are selected for continuous monitoring of these traits over a period long enough to allow estimation of the mean and dispersion of performance levels, as well as documentation of attributes of the production environment that influence animal performance. Depending on resource availability and the level of detail needed to meet the objectives of the study, on-farm evaluation can be organized either as a set of repeated visits to sample livestock holdings, or as a comprehensive monitoring process involving repeated measurements of performance in the target animal populations over a defined period of time, usually covering a few full production cycles. Both approaches have the objective of generating performance data on the priority production and adaptation traits.

On-farm performance studies can be designed to estimate genetic parameters as part of genetic improvement programmes (e.g. nucleus breeding schemes for Djallonke sheep in Côte d'Ivoire: Yapi-Gnaore *et al*., 1997a,b) or to monitor overall herd/flock productivity at site level, along with the effects of specific interventions (e.g. Agyemang *et al*., 1997; Osaer *et al*., 2000). If conducted over sufficiently long periods, such studies allow herd/flock structures and population trends to be monitored and identification of the associated causes and drivers.

On-station performance evaluation

On-station studies allow evaluation of breed performance and potential in a relatively defined and controlled production environment. This allows more precise measurement of individual performance, including the ability to respond to improved levels of management, and possibly to specific levels of stress (parasite load, water deprivation, poor quality of feed, etc.). A key advantage of on-station studies is that they allow comparison of multiple breeds under alternative management environments at the same time, thus enabling assessment of genotype × environment interactions. Another positive aspect of on-station evaluation is that it may pave the way for the establishment of a nucleus population and contribute to the conservation of the population being characterized and to its genetic improvement in the longer term. The limitations of such studies are that animals may not be adapted to the controlled environment and that some traits, such as grazing behaviour and responses to environmental stressors present in the animals' usual production environments, cannot be expressed and measured. Thus, the specific advantages of a local population may not be recognized, and the conclusions drawn from the study may be misleading because they do not account for the relevant genotype × environment interactions.

DEVELOP THE SAMPLING FRAME

A different set of statistical tools from those employed for primary characterization may need to be used to identify study populations for advanced phenotypic characterization. While it is still important to select animal populations and farms/holdings that are representative, local circumstances may dictate that purposive sampling has to be used to select populations for advanced characterization. Such constraints may include:

- unwillingness of livestock owners to allow repeated data collection on their animals; and
- natural and human-induced constraints on access to the study area for repeated visits.

Similarly, for on-station evaluations, purposive rather than random sampling procedures may be needed when:

- random selection of experimental animals is constrained by a lack of background information on the base population;
- livestock keepers are not willing to part with their animals for the study; or
- only animals that meet certain minimum requirements can be selected for the study.

PREPARE THE TOOLS FOR DATA COLLECTION

Advanced phenotypic characterization studies, whether on-farm or on-station, require the collection, in simplified formats, of a combination of quantitative and qualitative data over a relatively long period of time. It is important to ensure that the necessary equipment and tools are prepared and remain available throughout the study. Advanced characterization mainly involves the collection of data on production and adaptation traits, but physical characteristics can also be measured. For the latter category of trait, the relevant measurements and tools are described in Section C.

Identification of animals

An essential element of repeated data collection is reliable identification of individual animals in order to ensure that the data collected over time are consistently attributed to the correct animals in the data analysis. All animals in the experimental unit should be identified using double ear tags. If a livestock owner objects to having ear tags attached to his or her animals, the study team may either select another owner or try to convince him or her to cooperate. In the latter case, specific advice should be sought from a sociologist if the relevant expertise is not already available within the team. Where the use of ear tags is not possible, alternative methods of identification need to be sought. In pastoral communities, for example, livestock owners give names to individual animals. These combined with distinct external features of animals can be used for animal identification.

Trait measurements and tools

Customized tools and data-collection formats will need to be developed for the specific traits and control variables targeted by the advanced characterization study. Some traits and control variables need specialized equipment and data loggers. Requirements should be identified and their costs evaluated during the planning phase of the study.

In addition to collecting data on milk production, meat production, egg production, reproduction, adaptation, etc. within the experimental unit (the herds/flocks of the research station, holding or village), the pedigree of each animal should be recorded and samples of biological material collected for laboratory analyses. The cost and complexity of data collection schemes vary depending on the type of traits targeted and the methods used for measurement and recording. In general, they increase with the level of precision and automation involved. This section focuses on techniques that are simple and low cost but will not compromise the outcomes of the study.

Even when standardized measuring devices are used, there is some subjectivity in taking measurements. This review of traits and tools includes some recommendations that can help address such problems:

Milk off-take: all or a selected set of lactating animals should be identified for weekly recording of all (morning and evening) milk off-take on a nominated day of the week for a set period of time (e.g. one month or the whole lactation period). The following tools are needed: standard sanitary milking utensils; a graduated measuring cylinder or jug to measure the volume of the milk or a digital weighing scale to measure the weight of the milk; and data record sheets.

Milk quality: milk samples can be analysed on site or sent to a laboratory to determine fat and protein content, and if required the number of somatic cells. Fat percentage in milk can be detailed in terms of fatty-acid composition, and protein percentage in terms of the different types of caseins. Standard milk sampling bottles and a cool box are needed to take fresh milk samples for chemical analysis in the laboratory. Similarly, sampling kits are needed for taking fresh milk samples and checking the microbiological quality of the milk.

Growth rate or curve: can be derived from live body weights at different ages. Regular (monthly) body weights of growing meat animals should be measured and recorded for a set period of time (three or four consecutive months). Combined with measurements of feed consumption in a sample of animals for a set number of days (e.g. three weeks for poultry and much longer for ruminants), they allow feed conversion efficiency to be calculated for the observation period. Individual measurement of feed consumption requires isolation of each animal (e.g. in a box) and may be possible only on-station and for estimating genetic parameters. Mobile weighing bridges, spring balances or tested body-weight-estimating measuring tapes can be used for recording body weight.

Carcass and meat quality: carcass yield, bone/meat ratio or fat content measurements require slaughtering animals, and may be possible only on-station and for small animals. Indirect evaluation can be done by taking morphological measurements (see Section C) that provide information on the conformation of the animal. Advanced techniques, such as magnetic resonance, radioisotopes, tomography, radiography and ultrasound, can be used to assess carcass composition and quality (e.g. quantity and distribution of specific tissues). For example, for back-fat thickness in pigs and other animals raised for meat production, the specialized ultrasound equipment widely used for commercial purposes can provide accurate measurements. Meat-quality traits (e.g. tenderness, juiciness) are seldom reported in characterization studies (particularly in animals other than chickens) but may be important traits for valuing local breeds.

Egg production: the number of eggs laid and the mortality should be recorded daily for a limited period of time (three months). On-station, the recording period can be much longer (e.g. one year). Hens should be weighed at the start and at the end of the laying period. Combined with measurements of feed consumption in a sample of hens for a set number of days (e.g. three weeks), egg production recording allows feed conversion efficiency to be calculated for the observation period.

Egg quality: two samples of eggs (e.g. 10 to 20 eggs) should be taken at the beginning and at the end of the laying period. The eggs should be weighed to determine the average egg weight. The same samples can be used to estimate shell quantity, either directly (by weighing the shell after separating it from the albumen and the yolk) or indirectly based on egg density (using different water recipients with increasing levels of salinity). Shell strength can be measured either directly (measure of fracture force) or indirectly (measure of deformation). To measure internal egg quality, the dry-matter content, the yolk and albumen weights, or the albumen height can be measured in the same samples of eggs. Many of these measurements (e.g. egg weight, egg density, yolk to albumen ratio) can be taken using simple devices, but others (deformation, fracture force, dry-matter content and albumen height) require more sophisticated tools and may not be necessary in all studies.

Wool production: can be measured correctly only during the shearing season, which is usually during the spring. The timing of data collection should be planned accordingly. All the wool shorn should be weighed to obtain the greasy fleece (wool) weight. The fleece should then be washed (scoured) thoroughly and weighed to determine the clean wool yield. Manual shears or motor-driven shearing devices and a weighing scale are the tools needed.

Wool quality: wool quality is expressed in terms of fibre length, diameter, strength, curliness and colour. All of these require precision measuring devises, and such data cannot be collected in the field. Wool samples can be taken during shearing for laboratory analysis. Tools needed in the field are shears and sample bottles.

Reproduction: for sheep, goats and pigs, cases of parturition and mortality of young animals can be monitored for a set period of time (e.g. a few months). In temperate and subtropical environments where reproduction often has a seasonal pattern, more targeted recording periods may be required. Numbers of births recorded during the observation period can be related to the total number of breeding females in the flock to estimate the reproduction rate during that period. For cattle, lactation length and parturition interval also need to be recorded.

Adaptation: specific adaptive attributes such as heat tolerance can be measured via body temperature, but it will not be possible in such a study to rigorously assess resistance or tolerance to local endemic diseases. Blood parameter measurements as proxy indicators of adaptation traits can be obtained by taking blood samples and sending them to a laboratory for analyses. To measure tolerance to parasites such as trypanosomes or gastro-intestinal parasites, successive blood and faeces samples can be collected during the peak challenge season and sent to a laboratory for analysis to detect the presence of parasites and quantify the load. If the focus of the study is on disease or parasite incidence and prevalence, it may be appropriate, where feasible, to organize mobile laboratory facilities. Animal restraining tools and blood sampling gear (vacutainers, slides, light microscope, sample tubes) are needed. Longevity is probably the best indicator of adaptation, but may not be possible to measure in characterization studies. When data on the age of individual animals can be obtained from available records, the average age of mature animals in sample herds and flocks can be used as a proxy indicator. Livestock keepers can also provide information on the ages of home-born animals. Liveability (or its reverse, mortality) and production levels are easily obtainable, but indirect, measures of adaptation.

Describing production environments

The production environment descriptors (PEDs) framework devised for use in DAD-IS is presented in Annex 5. The study team should treat this set of PEDs as a minimum and collect whatever additional production-environment data are relevant to the objectives of the study and to providing a comprehensive description of the conditions in which the animals are kept.

In the case of advanced characterization studies that record production traits in a limited group of animals, the focus is less on recording a general description of the production environment of the breed as a whole and more on recording the precise conditions in which the study animals are maintained during the period covered by the recording. The restricted focus of such studies and the close attention paid to the targeted animals mean that it should be possible to record all significant aspects of the production environment in detail.

Questionnaires

Questionnaires are used either in repeated surveys or long-term on-farm studies to collect information about production environments, to monitor herd or flock structures and population trends, and identify the causes behind such changes. In both types of study, structured, semi-structured and, in some cases, open-ended questionnaires can be used to capture data systematically through interviews. However, if livestock keepers are interviewed repeatedly, care should be taken to avoid interview fatigue. The scope and depth of the questionnaires should be guided by the specific data requirements of the study. See Section C for further advice and discussion.

PREPARE THE PROTOCOL FOR DATA COLLECTION

To ensure consistency in data collection, the study team should elaborate a protocol detailing the sampling frame, the measurements, and the equipment and tools to be used. This can be based on the material presented in this and the preceding sections and in the annexes, adapted as necessary to the specific circumstances. This protocol could be used as support material in the training of enumerators, livestock keepers and other support staff.

In particular, potential sources of systematic error in measurement and recording should be highlighted. All data codes and acronyms should be clearly described in the protocol. For qualitative descriptive traits and production environment descriptors, the protocol should emphasize that instead of introducing new data codes for unexpected types of data, enumerators should gather as much explanatory information as possible so that the study team will later be able to make an appropriate decision on how to code the data in question.

TRAIN LIVESTOCK KEEPERS OR ENUMERATORS AND THEIR SUPERVISORS

Repeated measurements from sample village herds and flocks require contractual arrangements with the livestock owners to specify the type, scope and modalities of data collection. It is important to be aware that such contractual arrangements are limited in time and to a few holdings, and hence should not be equated to a national identification and performance recording programme, the establishment of which is an institutional issue requiring action at national level. In some circumstances, household members themselves can be recruited and trained to collect data, instead of having external enumerators visit the households. Recruiting enumerators and supervisors is, however, needed in the case of repeated surveys.

It is critical that the contracted livestock keepers, or the enumerators and their supervisors, are trained in the use of the whole set of data-collection instruments both in formal lessons and through practical exercises. The training should promote common understanding of the data-collection process, reporting procedures, and how queries that emerge during data collection should be handled. The training should continue during the pre-testing and pilot study.

The training should lead to the establishment of a good working environment and good communication between everyone involved in the study. This will favour a stronger sense of responsibility and ownership of the data and results on the part of the contracted livestock keepers or the enumerators and supervisors, which in turn will lead to better accuracy in data collection. Good communication will ensure that support is available to the livestock keepers or enumerators when they need it. It also promotes effective supervision of data collection. Guidance should be provided to the supervisors on:

- ensuring consistency in the measurements taken on the sample animals. Data collection methods should be as consistent as possible from one livestock keeper/enumerator to another and from one production environment to another;
- checking raw data soon after data collection to identify missing data and address obvious errors. Clear guidance should be provided on how to deal with such errors, if necessary by going back to data sources or even repeating the measurements.

If repeated surveys involve more than one field team it is advisable that they have members in common to promote homogeneity in data collection. Likewise, livestock keepers who are involved in taking measurements should, if possible, be supervised by the same person.

PILOT AND PRE-TEST THE STUDY INSTRUMENTS

As in the case of primary characterization, the protocol and all data measurement and recording instruments should be pre-tested. Subsequently, a full pilot survey needs to be conducted in the study area. The reasons for this are discussed in Section C.

For on-farm or on-station repeated measurements, recording instruments should be pre-tested in order to minimize variation among operators (livestock keepers, research technicians or enumerators).

ORGANIZE THE LOGISTICS OF THE FIELDWORK

While the technical preparations are being finalized, the study team should start preparing the agenda and the logistics for the field work, in collaboration with the livestock keepers and/or the enumerators and supervisors. Before deciding on the dates for the fieldwork, the following points should be considered:

- May the season of the year (e.g. heavy rains, drought) affect data collection at particular sample sites or across the whole study?
- May peak agricultural activities (e.g. land preparation, harvesting) affect data collection?
- May sociocultural events (e.g. religious holidays) affect data collection?

In the case of repeated surveys, as for primary characterization, supervisors and the study team should visit the study sites to formally inform local authorities and the target communities about the planned data collection. The date, time and location of field visits should be agreed with community representatives. This may involve consulting village chiefs, local officials or service providers (e.g. vets) to identify the most convenient times for data collection. It may be appropriate to involve these stakeholders directly in organizing field activities.

For on-station evaluation, the study team should ensure that research facilities are not only able to provide a predefined physical and management environment, but also allow monitoring and recording of animal responses to given production environments. The study team should determine whether the staff of the research station will be able to cope with the additional workload involved in the characterization study, and if necessary recruit additional staff.

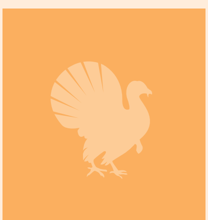
Logistical issues such as booking vehicles, purchasing consumables (fuel, paper, batteries, etc), travel authorizations and accommodation for field teams should be addressed in advance.

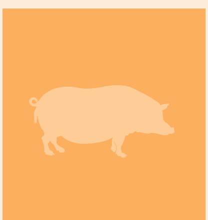
FINALIZE THE PLAN FOR THE DATA COLLECTION

The final plan for the data collection should include the sampling frame, details of all data collection instruments, guides and protocols, as well as a timetable for the field work. This plan should be accompanied by a budget report accounting for all logistical issues and human resource requirements.

SECTION E

Data management and analysis





Data management and analysis

Phenotypic characterization studies often involve the collection of a large volume of data. These data have to be processed and analysed, and the results published to provide guidance on AnGR-related decision-making. Data management and analysis should be addressed thoroughly during the planning phase of the study. This section reviews the activities and tools required.

DATA MANAGEMENT

Data management involves a series of activities – designing a data-capture system (database), setting up the database structure, checking the data, entering data into the database, and storing and archiving the data. Plans for data management should be drawn up in conjunction with the plans for data collection and data analysis. For example, data management should be accounted for in the design of the study questionnaire, which should have a layout and structure that facilitate data collection and allow data entry and data analysis to follow smoothly. It is important to assess whether the resources needed to handle the outputs of the proposed fieldwork are available and whether the proposed data-management activities are logistically feasible. The data management plans also need to ensure that the data collected are maintained safely, completely and accessibly (both as hard copies and as electronic versions).

The choice of software for data management will depend on the resources available for the study. Simple spreadsheets, such as Microsoft Excel, should be used with strict care and only for simple data structures (University of Reading, 2001). Hierarchical and relational data require the use of real database management systems, such as Microsoft Access or CSPro[2] (free open source from the US Census Bureau) that have custom-made facilities for data entry, filtering and retrieval. Data-entry staff should be experienced in working with the specific packages used or provided with adequate training. It is essential that data are backed up regularly and that copies are stored at separate locations.

Well-defined data-management procedures are prerequisites for a successful phenotypic characterization study. The following elements need to be planned for:

- data-checking procedures;
- data-capture system (database) for entering the data into computers;
- data-cleaning procedures;
- procedures for processing the data into an appropriate form for analysis; and
- procedures for archiving the data so that they remain available throughout the subsequent phases of the project and afterwards.

[2] See http://www.gmi-mr.com/resources/sample-size-calculator.php

Checking the quality of the data

The raw data collected in the field should be checked to ensure that the quality of the data used in the analysis is as high as possible. Checks by supervisors should be incorporated into the data-collection routine in the field. Each questionnaire should be checked for completeness and consistency. Any problems that come to light should be documented by the supervisor. The questionnaires that reach the desks of the data-entry staff should have been signed by the enumerator and the supervisor.

Data entry

It is important to ensure that the data collected during the field work are completely and accurately transferred from paper to computer. The data should be entered in their raw form (i.e. directly from the original questionnaires) as soon as possible after they are collected in the field. A manual detailing the data-entry procedures should be prepared and the data-entry staff should be thoroughly trained.

Data entry can be handled using customized data-capture and checking software, general statistical packages (e.g. GenStat, NCSS, R, SAS, SPSS, XLStat), or specialized commercial or free survey data management software, such as CSPro. If resources allow, enumerators may be able to enter data directly during the field work using hand-held computers with a customized data-capture system. This is particularly useful for repeated measurement of performance during advanced characterization studies.

Data-entry screens should, as far as possible, match the questionnaire visually. If possible, any skips in the questionnaire (e.g. "if no, go to question 15") should be programmed into the data-entry screens. The units of measurement used for all quantitative variables and their precision (number of significant digits) should be clearly defined and should match the real precision of the measuring instruments or recording devices.

Data entry should be organized systematically, i.e. all the data from one study site should be entered before moving on to enter data from other study sites. Depending on the type of data-entry system being used, it may be more efficient to enter data section by section rather than to complete data entry for each questionnaire in turn. Key variables that can be used to merge data stored in different files or tables should be identified.

Data entry should be checked for accuracy both as the data are keyed into the computers and afterwards, at which point checks for completeness should be made to ensure data-entry staff have not missed any questions. Where possible, use software that includes facilities for data checking and validation. Consider using double entry, i.e. have the data entered independently by two people into separate copies of the database.

Data cleaning

The objective should be to build an electronic data set that reflects the data originally collected in the field as closely as possible. If double entry (see above) has been used, the two versions of the database can be compared and, if necessary, discrepancies can be checked against the original questionnaires or data sheets.

An attempt should be made to correct any errors that are detected. If this is not possible, the data can be declared missing. Such decisions should be taken by the study team's data analyst. It is essential to ensure that the data-management system produces automatic reports documenting all such changes and corrections. Corrected versions of the database should be stored under new names. There should be a single "master copy" of the database, and subsequent analyses should be performed using data extracted from the master copy. Data-cleaning provides an opportunity to run preliminary analyses and obtain first summaries of the data (see below). Finally, it is very important to back up and store the data in separate storage systems located in separate safe locations. The backup procedures should be thoroughly documented.

Data processing

The activities described in this subsection are a very important part of preparing the data for analysis. The data analyst should take responsibility for ensuring that they are carried out. Data processing will – depending on the precise requirements of the study – involve all or some of the following activities:

- using the selected statistical software to import the data set stored in the database;
- writing and running a program to label variables and values;
- merging or subsetting data sets;
- generating derived or composite variables for further analysis;
- transforming the data for checking or further analysis. For example, it may be easier to see whether values are unusual if they are transformed into familiar units such as kilograms or hectares. The data set may include different types of data (ordinal, nominal, discrete text codes, free text, images, video files, audio files, etc.). These data need to be coded and recategorized before data analysis; and
- writing and running a program that produces descriptive statistics from the data set – frequency for qualitative data (e.g. coat colour) and simple average and variation for quantitative data (e.g. body length) – as a further data cleaning exercise. The descriptive statistics will allow the data analyst to obtain a broad overview of the data set and its distribution and, in particular, to identify strange values (outliers) that appear out of range when data are plotted or elementary statistics (e.g. minimum and maximum values) are calculated.

Data checking and any subsequent editing of inconsistencies or outliers should be based on expert guidance from a statistician if the relevant expertise is not available within the team. Inconsistencies and outliers should be investigated and handled carefully; extreme outlying values may be important to the outcomes of the study.

The terms to be used for describing missing data should be clarified. Data may be missing because they have been lost after collection, because they have been declared unreliable or doubtful, or because the item of data was not collected for some reason. Each of these types of missing data needs to be precisely defined before the start of data analysis. It is better to label data items "missing" than to discard the whole record of which they form a part.

Data archiving

Archiving and analysis require full documentation (metadata) of the data set. After the study is completed, the completed data files and questionnaires – whether in paper or electronic format – will need to be transferred to a central repository. The archive should include all the information collected during the study (including photographs, maps, etc.) and key communications and reports written during the planning and implementation of the study. The archive should be made available (e.g. on a CD-ROM) to all members of the study team and to the organization or institutions vested by the national authorities with the custodianship of the data collected. Other stakeholders that are partners in the study should receive reports only. Any use of the data that is not within the framework of the study should be subject to a material transfer agreement – in which intellectual property rights and benefit-sharing arrangements are clearly specified – between the recipient organization and the organization that is the custodian of the data.

DATA ANALYSIS

This subsection provides an overview of the elements that contribute to good-quality analytical results.

Personnel and resources

Data analysis is a highly technical field that requires expert professional knowledge. Although statistical packages can handle routine chores in data management and analysis, expert advice on the choice of model and on efficient data processing is essential. More importantly, expert advice is needed to guide the data analysis and ensure that it addresses the specific objectives and research questions of the study while also ensuring the validity of the assumptions in the analytical model. The need for expert support should have been identified during the planning phase of the study and addressed by including a statistician among the members of the study team or, if this is not possible, ensuring that advice from a statistician can be accessed whenever needed.

Statistical packages

Data analysis requires suitable computer hardware and statistical packages. The packages used should be appropriate to the objectives of the study and to the level of competence of the data analyst. As indicated above, a range of general statistical software is commercially available for use in data analysis (e.g. SAS, GenStat, SPSS, STATA, S-Plus, XLStat, NCSS, Statistica, Systat). Public domain software such as "R"[3] is not only freely distributed, but also allows customized development of tools for analysis. An earlier version of "GenStat"[4] is available for use free of charge by some developing countries. Specialized statistical packages geared towards the analysis of survey data are also available. In general, the statistical packages chosen for the analysis should provide the following:

- sufficient capacity to cope with the size and diversity of the data that will be collected;
- user-friendly algorithms;
- sufficient tabular and graphical capabilities;
- options for analysing multiple-response data;

[3] http://www.R-project.org/

[4] www.genstat.co.uk

- means of diagnosing whether the data are consistent with the assumptions of the model; and
- means of presenting the results in forms that assist the study team in interpreting the data.

Check whether the software packages under consideration allow quantitative and qualitative variables to be considered simultaneously in the data analysis; for instance, SAS cannot handle this. Software that can process both types of data together is preferable as it allows more comprehensive analysis.

The availability of resources (e.g. to pay for the use of commercial software) will also have to be taken into account in the choice of statistical package. Options for, and implications of, future use of the software (such as mandatory annual license renewal fees) should be considered. If the study team does not include a statistician, it may be necessary to seek external professional advice on the selection of appropriate software. The apparent ease with which software processes data and generates outputs does not guarantee efficiency or effectiveness in data processing, model selection or in obtaining results.

Time needed for analysis

A less obvious, but equally important, resource is the time needed for the data analysis. The analysis should start with minimum delay after data collection is completed, so that any data checks that are needed can be done while the memories of the field team are still fresh, and so that results can be communicated promptly to stakeholders. The time needed to analyse a completed database will depend on the complexity of the sampling frame and the number of questions the study is addressing. Given the speed of modern computers, the amount of time needed does not, in principle, depend heavily upon the size of the sample. For planning purposes, it is reasonable to expect that management and analysis of phenotypic characterization data may take about the same amount of time as the actual data collection.

Reviewing objectives

The analysis should be preceded by a detailed review of the objectives of the study and examination of the data that have been collected, as these will determine the type of statistical analysis that needs to be undertaken. The objectives should be broken down into specific questions or hypotheses that can be answered or tested during the analysis. Some examples of questions that might be answered by a phenotypic characterization study are listed in Section B. The next task is to select variables associated with the specified questions and use them in the analysis. These variables may already be available in the database or may be new ones constructed by recoding or combining existing variables. It can be helpful to combine variables if there are many variables that seem to measure similar things. In order to enable the data analyst to complete the work quickly and efficiently, a list of the techniques to be used and the tables or graphs that need to be produced should be prepared. The list should be accompanied by a common standard for table layout, headings, font sizes, spacing, etc.

Critical steps in data analysis

Before starting the analysis, make sure that the data analyst is familiar with the data sources and collection methods, and has a clear understanding of the objectives of the study and the questions derived from them. He/she should understand the exact meaning of the variables, especially the coded variables. The analysis should begin with data exploration (summarizing and becoming acquainted with the data) using different approaches for different types of variable; this should be followed by confirmatory analysis guided by the results obtained during the exploratory phase. Plans should be made for how to handle missing values – either including or omitting them from the analysis – in full awareness of how this will affect the results obtained.

Exploratory data analysis. The use of simple descriptive statistics – average, minimum, maximum, median and standard deviation for quantitative data, or frequencies and tabulations for qualitative data – is recommended. This will allow evaluation of the major patterns in the variables and facilitate progress to confirmatory data analysis. The exploratory phase of the analysis is an opportunity to answer questions such as "Who are the livestock keepers that own animals belonging to the newly identified breed?"

Confirmatory data analysis. The major objectives of confirmatory data analysis are estimation and hypothesis testing. The data analyst should describe the factors and parameters that are to be estimated and state the hypothesis that is to be tested.

It is important to ensure that estimations account for the sample weights. If sampling is multistage (stratified), observations will not be sampled with equal probability. In such cases, a weighted mean ($\hat{x} = \Sigma wx / \Sigma w$ with weights w) can be used instead of x to compensate for the unequal probabilities. If a weighted mean is not used, it is important to justify the validity of the estimates by explaining why they were computed without weighting. Ensure, at this point, that sampling errors (estimates of standard errors and confidence intervals – see Box 9) are computed.

In phenotypic characterization, multivariate data (cluster) analysis techniques are used to assess the aggregate morphological similarities among groups of animals based on a selected set of quantitative and qualitative phenotypic data. These techniques are introduced in Section A. The reader is advised to review these techniques before reading the rest of this section.

In primary phenotypic characterization studies (when the objective is to identify distinct breeds) the analysis will need to include the following actions:

- Determine the operational taxonomic unit (OTU) for classification. OTUs may be individual animals or they may be means of the measurements taken on a sample of animals from a particular site (centroids).
- Use analysis of variance tools to screen the variables in order to select those that significantly contribute to observed phenotypic variation.
- Determine whether data analysis should be done by sex group (females and males separately). Some phenotypic traits are dependent on the sex of the animal. If such traits significantly contribute to the total observed variation, they need to be included in the multivariate analysis of the data. It may be appropriate to analyse the data for male and female animals separately and compare the results. If the results suggest

significant sex dimorphism, then the final cluster analysis should be done separately for females and males.

- Check for, and avoid, collinearity in the set of variables selected for analysis; i.e. avoid situations in which the classification variables themselves are highly correlated, such as the use of traits that are derived from others (combination) along with the component traits.
- Transform the raw data into standardized and independent principal components.
- Decide what type of clustering technique to use for developing the classification tree (dendrogram); the most common method is sequential, agglomerative, hierarchic and non-overlapping (SAHN).
- Seek the most logical biological interpretation of the classification tree.
- Consider how to validate the classification; i.e. by replicating the classification procedure using separate data sets or by checking the accuracy of the classification using discriminant analysis.
- Consider discussing preliminary results with key stakeholders. This may provide additional insights into the analytical model employed.

In advanced phenotypic characterization, statistical tools are used to validate multivariate differences between known groups. Both general statistical software and specialized multivariate statistical software can be used for discriminant analysis.

Results of the multivariate analysis of phenotypic data provide the framework for analysing data describing production environments. The objective should be to describe comprehensively the physical and management environment of the identified breeds (key descriptors are listed in Annex 5). Exploring the associations between breeds' features and the various attributes of their production environments may draw attention to production and adaptation characteristics that merit follow-up investigation.

Table 2 summarizes statistical methods used in characterization studies. Note that some of the methods presented in the table are used for several purposes. Box 10 illustrates how the appropriate choice of statistical method depends on the objective of the study.

Interpreting the results

The primary aim in interpreting the results should be to address conclusively the specific objectives of the study and the questions derived from them. However, there should also be scope for reporting unforeseen outcomes. The results should be compared to the body of knowledge (theoretical as well as empirical) obtained during the literature review (see Section B). This may provide evidence to support the answers offered to the study questions.

In so far as it is possible, the data analysis and its interpretation should go beyond mere description of AnGR and their production environments. For example, different types of results (e.g. phenotypic features and production system attributes) should be combined to answer questions such as: "Why is this particular breed the only breed population that is found in this particular region?" or "Why is this breed population at risk?" Consider presenting a critical analysis of the data set itself. This should indicate the limitations of the data set as well as its potential. The latter may include opportunities to explore relationships and trends within the respective agro-ecosystem and identify next steps in AnGR management. Data on production environments are vital for analysis of this kind.

TABLE 2
Statistical methods for characterization studies

Method*	Type of variable	Application
Multivariate analysis of variance	Quantitative	To determine the most interesting traits from a set of traits, in order to differentiate populations
Multivariate cluster analysis	Quantitative	To reorganize a heterogeneous set of taxonomic units (individuals or populations) into more homogeneous groups or clusters according to the relevant variables
Discriminant analysis	Quantitative	To validate the differences between different breeds according to morphological or morphostructural models
Bonferroni test	Quantitative	A multiple comparison of a variable in different populations or breeds, after an analysis of variance
Principal component analysis	Quantitative	To study the linear relationships between characters. To correct a cluster analysis when the variables are not independent, by transforming them into uncorrelated variables
Factor analysis	Quantitative	To report on the most important underlying factors
Correspondence factor analysis	Qualitative	To estimate variability and purity of a breed
Multiple correspondence analysis	Qualitative	To determine the similarity between individuals or breeds
Heuristic methods (Neural networks)	Quantitative	To determine the degree of differentiation of one breed from others
x^2 test for least squares estimates	Qualitative	(Non-parametric test) to estimate the association between qualitative characteristics
Mahalanobis distance	Quantitative	To determine the degree of differentiation between breeds by using continuous or normally distributed phenotypic traits
Parameters for measurement of genetic variability (allelic richness, effective number of alleles, heterozygosity, polymorphic information content)	Genetic (identification of alleles)	To genetically characterize the population and its genetic profile
Wright's F-statistics	Genetic (identification of alleles)	To estimate inbreeding, the deficiency or excess of heterozygotes, the migration rate and differences between populations
Genetic distances (Nei, Reynolds, Cavalli-Sforza and Edward)	Genetic (identification of alleles)	To measures the genetic relationship between breeds and populations, in phylogenetic studies
Weitzman's analysis	Genetic (identification of alleles)	Phylogenetic studies of breeds

* The final four rows of the table describe methods for use in genetic studies. These methods do not strictly fall within the scope of these guidelines, but are included as complementary information.

It may be necessary to share preliminary results with some stakeholders in order to obtain further input that will be useful in interpreting unexpected findings. Once the interpretation of the results has been finalized and approved by the study team, a final study report should be produced and circulated widely (see Section F).

BOX 10

Choosing the statistical methods according to the purpose of the characterization study

Increasing numbers of studies use morphometric traits derived from body measurements in the classification and differentiation of breeds. Below are some examples:

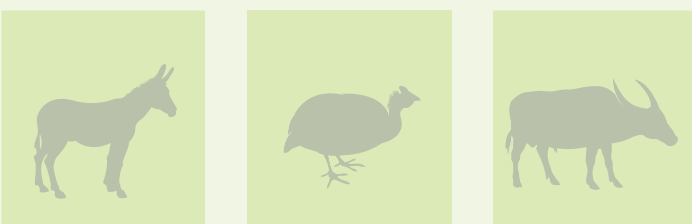
1. The phenotypic characterization studies of Herrera *et al.* (1996) and Zaitoun *et al.* (2005) aimed to identify and differentiate goat breeds in Spain and Jordan, respectively, and to determine which variables, among 13 zoometric variables, were most effective for this purpose. The statistical methods used in the first study were simple discriminant analysis, canonical discriminant analysis and step-wise discriminant analysis. The second study used the same methods plus a cluster analysis. The conclusion differed for each objective, highlighting the need to standardize the statistical methods according to the objective. Both studies estimated breed differentiation from Mahalanobis distances and constructed phylogenetic trees of breed relationships.
2. Ndumu *et al.* (2008) followed the same procedures used in the previous examples to characterize and identify cattle populations of the Great Lakes Region of Africa. However, Rodero *et al.* (in press) showed the superiority of heuristic statistical methods (multilayer perceptrons, probabilistic neural networks and support vector machines) over discriminant analyses in achieving the correct differentiation of minor Andalusian breeds.

These examples show the need to clarify the objectives of the characterization study and to choose the appropriate statistical method to achieve these objectives.

Provided by Evangelina Rodero.

SECTION F

Reporting and communication



Reporting and communication

As emphasized throughout the guidelines, phenotypic characterization is ideally conducted within the framework of the country's National Strategy and Action Plan for AnGR or other livestock development strategies and programmes, to supply AnGR-related data that are needed by policy makers, development practitioners and researchers for planning and implementing sustainable management programmes for these resources. A communications and reporting strategy should be developed during the planning phase of the study. An effective strategy that addresses communication during all phases of the study as well as the final reporting of outputs will enable the study team to:

- maintain partners' interest in the study;
- develop and report on key performance indicators for monitoring and evaluating the study;
- demonstrate transparency and accountability;
- ensure appropriate public visibility for the study;
- enhance awareness and engage stakeholders in constructive dialogue; and
- share lessons learned and good practices with all those who are planning or undertaking similar work.

Reporting and communication should start during the inception phase and continue throughout the study. The study team should prepare regular interim reports on progress and a final report. The latter will constitute the main tool for communicating the study findings to relevant stakeholders. This section provides guidance on the structure and the content of interim and final reports. It also discusses other methods that may be used to communicate the results of the study, and the need to consider the potential impact of communication activities. Consideration is also given to how the outputs of the characterization study can be linked to other ongoing activities in AnGR management.

It is important that the study's reporting and communication strategy pays close attention to ensuring effective communication among the members of the study team and with the partners in the project. This can be described as "communicating for results" (da Costa, 2009) in contrast to the "communicating about results" that will be the objective of the final report and related communications products. "Communicating for results" is essential for ensuring the effective delivery of the intended outputs of the study. Communication should be harnessed as a tool for internal learning and for developing more coherent team action.

INTERIM PROGRESS REPORTS

Interim reports should be prepared regularly to update the project partners on progress in the implementation of the study. The reports should address all activities undertaken, documenting the degree to which the objectives set out in the plan have been achieved. If objectives are not being met or not being met on time, clear explanations of the problems should be obtained from the people involved in the relevant aspects of the work, options for overcoming the problems should be identified and evaluated, and a decision should be taken on the best way to address them. Reports that contain preliminary results should always include prominent caveats stating that the results are preliminary and subject to change. They should be marked "confidential" and circulated only to the relevant key partners.

Interim reports facilitate communication between the members of the study team and improve mutual comprehension of individual strengths and weaknesses within the team. Where disputes over responsibilities arise, areas of ambiguity should be identified and clarified. If necessary, the work plan and schedule should be amended.

THE FINAL REPORT

The objectives and the specific questions targeted by the characterization study should have been clarified at the start of the planning process (see Section B). The final report must provide answers to these questions. It is highly recommended that the final report be made available to the country's National Coordinator for the Management of AnGR, National Advisory Committee on AnGR (if such exists), relevant ministries and all partners who have been involved in the study. The research community should also be informed. A good way to reach an international audience is to send the report to FAO for inclusion in the library of DAD-IS and distribution via the DAD-Net e-mail discussion network.

As well as providing answers to the study questions, a well-prepared final report will also provide a basis for planning future studies, indicate whether there is a need to conduct additional or complementary studies, and draw attention to opportunities to improve the methodology. The report should document the characterization process from beginning to end and set out the findings of the study. The whole of the study team should be involved in its preparation. If the steps outlined in these guidelines have been followed (i.e. if all plans and phases of work have been documented thoroughly), much of the report will already have been prepared.

The study team should decide whether it is necessary to produce separate reports for different target audiences (see below for further discussion of differentiated communications projects). The structure of the report(s) should be appropriate to the target audiences. For researchers, who are interested in detailed data that they can work with, the report should follow the standard structure of a scientific publication. Policy-makers and development practitioners, who are looking for strategies and ideas to help them in their planning, will be more interested in concise reports that specifically address questions such as:

- whether there are previously unidentified breeds in the study area;
- whether the breeds in the study area have any unique features;
- estimated population size and current distribution of the breeds and their risk status;
- whether there are any threats that merit immediate attention; and
- whether there are any ongoing or planned management activities for the breeds.

The results of a survey of 100 users of research data, indicating what they look for in research reports (Hague, 2006), are presented in Table 3.

The report of a phenotypic characterization study may include the following elements:

- Executive summary;

TABLE 3
What makes a good research report?

What makes a good research report?	Percentage of respondents mentioning*
Answers brief	33
Clear structure	29
Interpretation/conclusions	27
Recommendations/action points	21
Concise	21
Well-presented	19
Good executive summary	18
Sample size	100

* Responses to an open-ended question. Individual respondents mentioned several factors so the total does not add up to 100.

Source: Hague (2006).

- Introduction, which should include a statement of the objectives, questions to be answered and the scope of the study;
- Methodology, with further details available in annexes;
- Results;
- Discussion of the results and their implications;
- Recommendations for further work to address unresolved issues, including lessons learned on the process of conducting the study: what might have been done better and how?
- References;
- Annexes, which should include:
  - The original detailed plans for field operations, data management and data analysis, including documentation of any amendments to these plans;
  - Description of the data archive;
  - Technical annexes providing details of the statistical analysis;
  - A list of the persons and institutions involved.

In addition to the text, results should be presented – as appropriate – in charts and tables. Charts have more impact than tables because they simplify the data and pull out key findings in pictorial form. Conversely, a table can hold far more information than a chart while remaining intelligible. Attention needs to be paid to the way tables are laid out, as this affects how easy or difficult they are to read. It is recommended that the tables present not just mean values of phenotypic measurements from the sample populations, but also the range and extent of variation around the means. The figures in the tables should be presented in a standardized format to facilitate meta-analyses and comparison between studies.

The core of the report should be the presentation of the methodology and the results of the analysis and their interpretation. Box 11 provides a checklist that will help ensure that

BOX 11

A checklist for reporting on the data analysis

1. Are the objectives of the study listed?
2. Are the sampling frame and other field methodology adequately described?
3. Is the description of the statistical methods adequate, including the methods used for any data cleaning or transformation, so that they could be repeated unaided by another data analyst?
4. Is the choice of statistical models justified?
5. Are the assumptions underpinning the models listed?
6. Do the models fitted address the stated objectives and recognize all the design variables?
7. Do the results described in the report:
   - address the objectives of the study and the questions raised;
   - provide measures of confidence for the estimates and predictions made;
   - assess possible biases and their potential magnitude;
   - assess the effects that invalid model assumptions would have on the results;
   - identify significant sources of experimental error and, if appropriate, how these may be better controlled in future studies;
   - flag unexplained results that may merit further investigation to determine whether they are artefacts of a design flaw or an unexpected but "real" findings; and
   - identify emergency actions that may be required as a result of the analysis?
8. Has consideration been given to how the presentation of results may be customized for a range of stakeholders?

Source: adapted from FAO (2011a).

this part of the report serves its purpose. As far as possible, the report should contribute to the identification of logical next steps in the management of the AnGR.

The report should state where and how electronic and hard copies of the raw data are safely archived for future use. With rapid advances in statistical-analysis tools and computing capacity, breed characterization data from different sources can be combined to analyse long-term trends in the attributes of AnGR populations, for instance in the face of environmental degradation and climate change.

Consideration should be given to how the outputs of the study can be used to improve the country's breed and production environment data records in DAD-IS. The entry of data into DAD-IS (or an associated FABISnet information system) is the responsibility of the National Coordinators for the Management of AnGR (or nominated co-workers). The study team should seek to ensure that the way the data are presented in the final report allows for their efficient transfer into such information systems (e.g. results tables that mirror the data-entry screens in DAD-IS).

ADDITIONAL COMMUNICATIONS PRODUCTS

The study team should attempt to identify specific messages that are relevant to particular groups of stakeholders. One exercise that may be useful is to prepare a table in which the rows represent the various outputs of the study and the columns represent different groups of stakeholders (livestock-keeping communities, policy-makers, extension services, animal health services, educators, international partners, the general public, etc). For each cell in the table, the study team can then consider whether and how the respective project outcomes are relevant to the respective stakeholder group. After matching the study outputs to stakeholder groups, specific messages addressing each relevant stakeholder group should be developed. This might be done by preparing another table of stakeholder groups and listing the range of relevant messages for each of them. Further discussion of these methods can be found in FAO (2011a).

Once messages for each stakeholder group have been defined, appropriate communication methods need to be chosen, taking into account the costs involved, the coverage that can be achieved and the likely impact on the recipients. Some of the strengths and weaknesses of different communication methods are summarized in Table 4.

Television, radio, e-mail or the web can be used to disseminate audio material, visual images or textual information. Some countries may have national information systems for AnGR in which summary data and images can be published. Printed and reproduced materials (CD-ROMs, DVDs) need to be developed, designed, produced and distributed in appropriate numbers. The costs involved and the expertise required for each step of product development need to be identified and planned for.

Whatever communication media are chosen, the results should be summarized and presented in a simple and understandable manner, taking the objectives of the study into consideration. Attractive graphics, tables, boxes and images will catch the attention of the audience and help them to recall key messages.

Before finalizing and implementing the communication strategy, consideration should be given to the potential impacts on various groups of stakeholders. For example, publicizing the discovery of "new" breeds via the mass media may lead to unwanted attention and disruption for the livestock-keeping communities concerned. If such impacts are foreseen, the people likely to be affected should be consulted about what they think is appropriate and how they would like the process to be managed[5].

THE WAY FORWARD – INCORPORATING THE OUTPUTS INTO FUTURE WORK

As well as preparing communications materials for different groups of stakeholders, the study team should consider whether specific stakeholders involved in planned or ongoing AnGR-management or livestock-development activities need to be engaged actively in promoting the use of the study results and planning next steps.

The links between the characterization study and relevant national strategies should have been clarified during the planning phase, but opportunities to use the outputs of

[5] Note that in any event, the designation and reporting of new breeds requires consultation and endorsement by the relevant national authorities or mandated body such as the National Advisory Committee for AnGR.

TABLE 4
Communication methods – strengths and weaknesses

Communication method	Strengths	Weaknesses
Face-to-face events: - conferences - workshops - field days - shows, markets - extension activities - training and demonstration activities	- interactive - encourage collaboration - more direct impact - opportunity to distribute printed and other communication materials	- higher costs - more difficult to organize - time bound - lower outreach - one-time events
Printed material: - policy briefs - leaflets, brochures - reports - books - scientific journals (national, international)* - farming press - local newspapers - national newspapers	- lower costs - wider outreach - permanent	- not interactive - less direct impact
Audio: - radio - CD-ROM - internet audio streams	- lower costs - wider outreach - permanent	- not interactive - high technology requirement - less direct impact
Film: - television - DVD - internet video streams	- wider outreach - permanent	- high initial costs - not interactive - high technology requirement - less direct impact
Web-based information system: - national - international (e.g. DAD-IS)	- low running costs - wide outreach - permanent	- high initial costs to establish a national system** - high technology requirement to establish a national system** - less direct impact

* FAO oversees the publication of the journal *Animal Genetic Resources* (for further information send an e-mail to AnGR-Journal@fao.org).

**DAD-IS and related FABISnet information systems have already been established and so additional costs and technology requirements are low.

Source: adapted from FAO (2011a).

the study should also be reviewed at the end of the process in discussion with relevant stakeholders. Candidates for participation in this discussion should have been identified in the inventory of the stakeholders drawn up during the planning phase of the study (see Section B) and include people involved in:

- genetic improvement projects targeting the AnGR population covered by the study;
- rural development projects with AnGR management components;
- livestock restocking schemes implemented in the wake of disasters;
- delivery of animal health services and disease surveillance;
- organization of agricultural or livestock censuses and surveys; and
- conservation programmes for AnGR.

One good way to promote the uptake of the outputs of the study is to organize a workshop at which the results are presented and implications for future work discussed with a range of stakeholders. Should immediate follow-up actions be necessary, the workshop will be an opportunity for the study team to alert and consult relevant stakeholders.

In defining the scope of the phenotypic characterization study (Section B), the study team, in consultation with participating stakeholders, will have decided on whether to conduct a primary or an advanced characterization study. In the former case, one question that should be considered when reviewing possible follow-up actions is whether to go forward and implement an advanced characterization study on the targeted livestock populations. This decision should be taken in collaboration with the various stakeholders who might use the outcomes or be involved in the implementation. The committees or working groups overseeing relevant national plans and strategies for livestock development and AnGR management should be consulted.

References and annexes

References

ACO. 2006. *Pakistan Livestock Census 2006*. Lahore, Pakistan. Agricultural Census Organization of the Government of Pakistan.

Agyemang, K., Dwinger, R.H., Little, D.A. & Rowlands, G.J. 1997. *Village N'Dama cattle production in West Africa. Six years of research in the Gambia*. Nairobi, International Livestock Research Institute.

Aldenderfer, M.S. & Blashfield, R.K. 1984. *Cluster analysis*. Sage University Paper Series on Quantitative Applications in the Social Sciences, 07-044. Beverly Hills, USA and London, Sage Publications.

Ayalew, W., King, J., Bruns, E. & Rischkowsky, B. 2003. Economic evaluation of smallholder subsistence livestock production: lessons from an Ethiopian goat development program. *Ecological Economics*, 45(3): 331–339.

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

Ayalew, W., Peacock, C., Alemayehu, N., Reda, A. & Rey, B. 2000. The characterization of indigenous goat types of Ethiopia and Eritrea. *In* R. Blench & K. MacDonald, eds. *The origins and development of African livestock: archaeology, linguistics and ethnography*, pp. 280–289. London, University College London Press, Taylor & Francis Group.

Blench, R. 1999. *Traditional livestock breeds: geographical distribution and dynamics in relation to the ecology of West Africa*. Working Paper 122. London, Overseas Development Institute.

Cochran, W.G. 1977. *Sampling techniques,* 3rd edition. New York, Wiley and Sons.

da Costa, P. 2009. *Study on communicating development results*. Commissioned by the OECD DAC Development Co-operation Directorate & DevCom Network. The 2009 Annual Meeting of the Informal Network of DAC Development Communicators, 8–10 November, Dublin, Ireland.

Dadi, H., Tibbo, M., Takahashi, Y., Nomura, K., Hanada, H. & Amano, T. 2008. Microsatellite analysis reveals high genetic diversity but low genetic structure in Ethiopian indigenous cattle populations. *Animal Genetics*, 39(4): 425–431.

Dobzhansky, T. 1951. *Genetics and origin of species*. 3rd ed. New York, USA, Columbia University Press.

Drucker, A., Gomez, V. & Anderson, S. 2001. The economic valuation of farm animal genetic resources: a survey of available methods. *Ecological Economics*, 36(1): 1–18.

Drucker, A.G. & Anderson, S. 2004. Economic analysis of animal genetic resources and the use of rural appraisal methods: lessons from South-East Mexico. *International Journal of Sustainable Agriculture*, 2(2): 77–97.

Dunteman, G.H. 1989. *Principal components analysis*. Sage University Paper Series on Quantitative Applications in Social Sciences, 07-069. Thousand Oaks, California, USA, Sage Publications Inc.

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

FAO. 1984b. *Animal genetic resources conservation by management, data banks and training. Part 2*. FAO Animal Production and Health Paper No. 44/2. Rome.

FAO. 1986a. *Animal genetic resource data banks. 1. Computer systems study for regional data banks*. Animal Production and Health Paper No. 59/1. Rome.

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

FAO. 1986c. *Animal genetic resource data banks. 3. Descriptor lists poultry*. Animal Production and Health Paper No. 59/3. Rome.

FAO. 1991. *Small ruminant production and the small ruminant genetic resource in tropical Africa*, by R. T. Wilson, Animal Production and Health Paper No. 88. Rome.

FAO. 1992. *The management of global animal genetic resources*. FAO Animal Production and Health Paper No. 104. Rome.

FAO. 1996. *Conducting agricultural censuses and surveys*. Rome.

FAO. 1999. *The global strategy for the management of animal genetic resources: executive brief.* Initiative for Domestic Animal Diversity. Rome.

FAO. 2007. *Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration.* Rome (available at http://www.fao.org/docrep/010/a1404e/a1404e00.htm).

FAO. 2009a**.** *Report of the Twelfth Regular Session of Commission on Genetic Resources for Food and Agriculture, Rome, 19–23 October 2009 (CGRFA-12/09/Report).* Rome (available at ftp://ftp.fao.org/docrep/fao/meeting/017/k6536e.pdf).

FAO. 2009b. *Preparation of national strategies and action plans for animal genetic resources*. FAO Animal Production and Health Guidelines. No. 2. Rome (available at http://www.fao.org/docrep/012/i0770e/i0770e00.htm).

FAO. 2011a. *Surveying and monitoring of animal genetic resources.* FAO Animal Production and Health Guidelines. No. 7. Rome (available at http://www.fao.org/docrep/014/ba0055e/ba0055e00.htm).

FAO. 2011b. *Molecular genetic characterization of animal genetic resources.* FAO Animal Production and Health Guidelines. No. 9. Rome (available at http://www.fao.org/docrep/014/i2413e/i2413e00.htm).

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

FAO/WAAP. 2008. *Report of the FAO/WAAP Workshop on Production Environment Descriptors for Animal Genetic Resources, held Capralola, Italy, 6–8 May 2008*, edited by D. Pilling, B. Rischkowsky & B. Scherf. Rome.

FARM Africa & ILRI. 1996. *Goat types of Ethiopia and Eritrea. Physical description and management systems.* London, FARM-Africa and Nairobi, International Livestock Research Institute.

GebreMichael, S. 2008. *Sheep resources of Ethiopia: genetic diversity and breeding strategy*. Wageningen University, Animal Genetics and Genomics Centre. Wageningen, the Netherlands. (PhD Thesis)

Hague, P. 2006. *A practical guide to market research*. Free e-book (available at http://www.b2binternational.com/library/books/pub_free2.php).

Halima-Hassen, M. 2007. *Phenotypic and genetic characterization of indigenous chicken populations in northwest Ethiopia*. Faculty of Natural and Agricultural Sciences, Department of Animal, Wildlife and Grassland Sciences. University of the Free State, Bloemfontein, South Africa. (PhD Thesis)

Herrera, M., Rodero, E., Gutierrez, M.J., Peña, F. & Rodero, J.M. 1996. Application of multifactorial discriminant analysis in the morphostructural differentiation of Andalusian caprine breeds. *Small Ruminant Research,* 22: 39–47.

Klecka, W.P. 1980. *Discriminant analysis*. Sage University Paper Series on Quantitative Applications in the Social sciences, 07-019. Beverly Hills, USA and London, Sage Publications.

Köhler-Rollefson, I. 1997. Indigenous practices of animal genetic resource management and their relevance for the conservation of domestic animal diversity in developing countries. *Journal of Animal Breeding and Genetics*, 114: 231–238.

Köhler-Rollefson, I. & the LIFE Network. 2007. *Keepers of genes. The interdependence between pastoralists, breeds, access to the commons, and livelihoods*. Sadri, Rajasthan, India, The Life Network (available at www.pastoralpeoples.org/docs/keepersofgenes_web.pdf).

LDG. 2003. *The livestock and poverty assessment methodology. A toolkit for practitioners*. Reading, UK, Livestock Development Group, University of Reading (available at http://www.smallstock.info/research/reports/R7359/LivestockPA_Manual.pdf).

LPPS & Köhler-Rollefson, I. 2005. *Indigenous breeds, local communities: Documenting animal breeds and breeding from a community perspective.* Sadri, Rajasthan, India, Lokhit Pashu-Palak Sansthan.

Ndumu, D.B., Baumung, R., Hanotte, O., Wurzinger, M., Okeyo, M.A., Jianlin, H., Kibogo, H. & Solkner, J. 2008. Genetic and morphological characterization of the Ankole Longhorn cattle in the African Great Lakes region. *Genetics Selection Evolution,* 40: 467–490.

Osaer, S., Goossens, B., Eysker, M. & Geerts, S. 2000. The effects of prophylactic anthelmintic treatment on the productivity of traditionally managed Djallonke sheep and West African Dwarf goats kept under high trypanosomosis risk. *Acta Tropica*, 74(1): 13–24.

Pieters, A., Van Marle-Koester, E., Visser, C. & Kotze, A. 2009. South African developed meat type goats: a forgotten animal genetic resource? *Animal Genetic Resources Information*, 44: 33–43.

Pimentel, R.A. 1979. *Morphometrics: the multivariate analysis of biological data.* Dubuque, USA, Kendall/Hunt Publishing Co.

Ribeiro, N.L., Medeiros, A.N., Ribeiro, M.N. & Pimenta filho, E.C. 2004**.** Estimativas del peso vivo de caprinos de razas autóctonas brasileñas a través de medidas morfológicas. *Archivos de Zootecnia da Universidad de Córdoba*, *Córdoba España*, 53(203): 341–344.

Rodero, E., González, A., Luque, M., Herrera, M. & Gutiérrez-Estrada, J.C. in press. Classification of Spanish autochthonous bovine breeds. Morphometric study using classical and heuristic techniques. *Livestock science.*

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. *A report to FAO on the design, execution and analysis of livestock breed surveys – a case study in Zimbabwe*. Nairobi, International Livestock Research Institute.

Sneath, P.H.A. & Sokal, R.R. 1973. *Numerical taxonomy*. San Francisco, USA, WH Freeman & Co.

Stein, J., Ayalew, W., Rege, J.E.O., Mulatu, W., Malmfors, B., Dessie, T. & Philipsson, J. 2009. Livestock keeper perceptions of four indigenous cattle breeds in tsetse infested areas of Ethiopia. *Tropical Animal Health and Production*, 41(7): 1335–1346.

Tixier-Boichard, M., Ayalew, W. & Jianlin, H. 2007. Inventory, characterization and monitoring. *Animal Genetic Resources Information*, 42: 29–47.

Tucho, T.A. 2004. *Genetic characterization of indigenous goat populations of Ethiopia using microsatellite DNA markers*. The National Dairy Research Institute (deemed University). Karnal, Haryana, India. (PhD Thesis)

University of Reading. 2001. *Disciplined use of spreadsheet packages for data entry*. Reading, UK, Statistical Services Centre, University of Reading.

Wuletaw, Z., Ayalew, W. & Soelkner, J. 2008. The Mahibere-Silassie composite: a new cattle breed type in north-western Ethiopia. *Ethiopian Journal of Animal Production*, 8(1): 39–51.

Yapi-Gnaore, C.V. Rege, J.E.O. & Alemayehu, N. 1997a. Analysis of an open nucleus-breeding programme for Djallonke sheep in the Ivory Coast. 2. Response to selection on body weights. *Animal Science (UK),* 64(2): 301–307.

Yapi-Gnaore C.V., Rege, J.E.O. & Dagnogo, B. 1997b. Analysis of an open nucleus-breeding programme for Djallonke sheep in the Ivory Coast. 1. Examination of non-genetic factors. *Animal Science (UK)*, 64(2): 291–300.

Zaitoun, I.S., Tabbaa, M. & Bdour, S. 2005. Differentation of native goats breeds of Jordan on the basis of morphostructural characteristics. *Small Ruminant Research,* 56: 173–182.

Annex 1
Checklist for phenotypic characterization of cattle

GENERAL GUIDELINES

- This checklist is intended as a guide. It should be adapted to your situation and transformed into a questionnaire. It is recommended to record classes using a suitable set of codes (e.g. for sex: 1 = male, 2 = female, 3 = castrate).
- Physical measurements should be taken only from a representative set of adult animals (as judged by dentition): about 100 - 300 females and 10 - 30 males.
- The linear measurements on mature animals should include at least body length, height at withers, heart (chest) girth, ear length, horn length, muzzle circumference, and hock circumference, which can be taken using a textile measuring tape to the nearest unit centimetre. Measurement of body weight is limited by availability of weighing bridges. However, when it is taken, an attempt should be made to identify animals by age, or at least dentition.
- Measurements should be taken early in the morning to avoid the effect of feeding and watering on the animal's size and conformation.
- Descriptive information should be collected on common herd sizes and structures, as well as on the uses of the animals.
- Measurements should be taken when animals are in barns or kraals or in a tethered position, but not when they are nervous.

DISCRETE OR QUALITATIVE VARIABLES

- Sex: female, male, castrate
- Estimated age or dentition class
- Body hair coat colour pattern: plain, patchy/pied, spotted
- Body hair coat colour: black, dark red, light red, fawn, grey
- Body skin colour: pigmented, not pigmented
- Muzzle colour: pigmented, not pigmented
- Eyelid colour: pigmented, not pigmented
- Hoof colour: pigmented, not pigmented
- Horn presence: absent, present
- Horn colour: black, brown, white
- Horn presence (at herd level; separately for males and females): percent of polled animals, percent of horned animals
- Horn attachment (at herd level; separately for males and females): percent of loose horns, percent of fixed horns

- Horn shape: straight, curved, lyre-shape, loose, stumps, polled
- Horn orientation (at herd level, separately for males and females): tips pointing laterally, upward, downward, forward, backward (indicate also if animal is polled, or horns are loose or just stumps)
- Hair type:
  - sheen: glossy, dull
  - curl: curly, straight
- Hair length: medium (1–2 mm), long (>2 mm)
- Ear shape: rounded; straight-edged
- Ear orientation: erect, lateral, drooping
- Hump size: absent, small, medium, large
- Hump shape: absent, erect, drooping (backwards, sideways)
- Hump position: thoracic, cervico-thoracic
- Facial (head) profile: straight, concave, convex ultra convex
- Dewlap size: absent, small, medium, large
- Backline profile: straight, slopes up towards the rump, slopes down from withers, dipped (curved)
- Rump profile: flat, sloping, roofy
- Navel flap (for cows): absent, small, medium, large.
- Preputial sheath (for bulls): absent, small, medium, large
- Tail length: short (above the hocks), medium (about the hocks), long (below the hocks)

QUANTITATIVE VARIABLES

- Body weight (if weighing bridge is available) with age specified
- Body size for adult males and females (to the nearest 0.5 cm):
  - chest girth
  - body length
  - height at withers
  - muzzle circumference
  - hock circumference

HERD-LEVEL DATA

- Basic temperament: docile, moderately tractable, wild
- Any known adaptability traits[6]:
  - tolerance or resistance to diseases and parasites
  - drought tolerance
  - heat tolerance
- Type of holding: peasant farm, breeding centre, commercial farm, experimental station, multiplication station
- Mating practice:
  - uncontrolled, non-seasonal, natural mating
  - uncontrolled, seasonal, natural mating (multiple sire)

[6] For more detailed variables on adaptability traits, see Annex 5 Part V.

  - uncontrolled, seasonal, natural mating (1 sire per herd)
  - hand mating
  - artificial insemination used for at least part of the herd
- Herd size
- Herd composition (proportion in the herd of):
  - breeding females
  - replacement females
  - breeding males
  - males not used for breeding
  - steers (castrated males)
  - female calves
  - male calves
- Typical image of adult breeding cow and bull with a comparator background
- Typical image of herd with its usual production environment in the background
- Uses of the animals in order of importance (milk, meat, traction, manure, sociocultural, etc.)[7]
- Type of traction: ploughing in dry land, ploughing in paddy, haulage, back-packing, other traction (specify: for pumping, milling, etc.)

DATA RELATED TO ORIGIN AND DEVELOPMENT[8]

- Name of the breed of the sample animal(s)
- Synonyms and local names
- Background for such names
- Breeds known to be most closely related to this breed
- Origin of the breed
- Source of the animals, if imported (name of country and year(s) of importation)
- Original geographic distribution of the breed (if possible georeferenced)
- Approximate area of distribution (km^2) of the breed or in terms of administrative boundaries
- Names of geographical areas where this breed is known to exist
- Estimated total population size, including year of estimate and source/reference
- Types of communities or holdings maintaining the breed population: commercial farmers, subsistence farmers; pastoralists; breeding centres; experimental stations
- Known or reported breed improvement activities
- Known or reported breed admixtures or (planned or random) cross-breeding

DATA COLLECTED ON TRAITS THAT REQUIRE REPEATED MEASUREMENTS[9]

Dairy and reproductive performance indicators on a randomly selected cow and the cow that has the latest completed lactation:

- Lactation length
- Daily average milk off-take over three trimesters

---

[7] For more detailed variables on uses, see Annex 5 Part IV.

[8] Ideally generated through focus-group discussion.

[9] From recollection by owners.

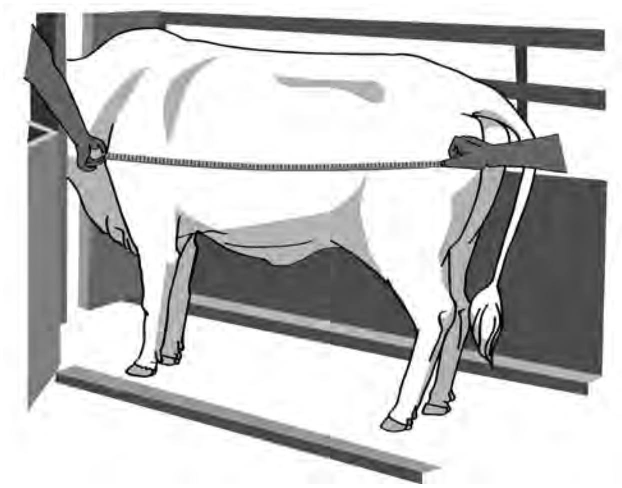
- Milking system practised: hand milking with calf, hand milking without calf, machine milking with calf, machine milking without calf, combinations of these (specify)
- Total number of calves born
- Age of the cow (may be estimated)
- Age of the cow when first calf was born (may be estimated)
- Number of abortions

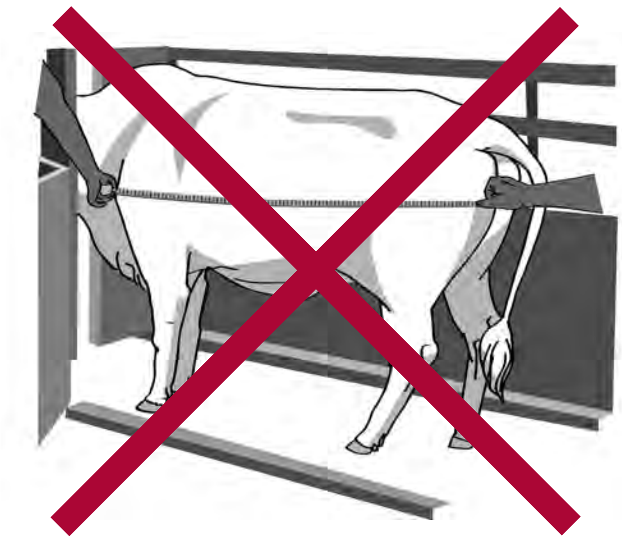
Carcass characteristics (when available):

- Slaughter weight of a meat animal (typically a grown-out male, otherwise specify)
- Hot carcass weight
- Cold carcass weight
- Dressing percentage

ILLUSTRATIONS

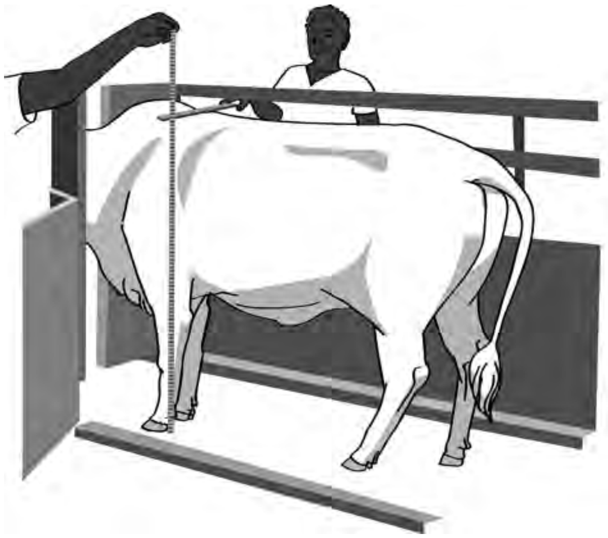
Body length





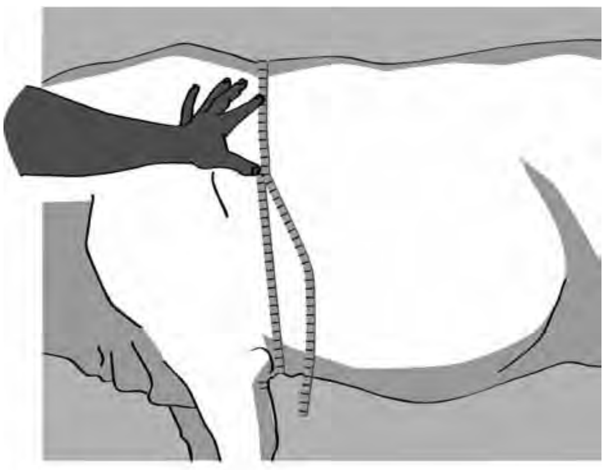
Note: The correct standing position for the animal, with the hind legs close together. If one hind leg is in front of the other, the measurement will be inaccurate. Measure from shoulder point to pin bone. Both points have a protruding bone that can be located for correct measurement.

Height at withers



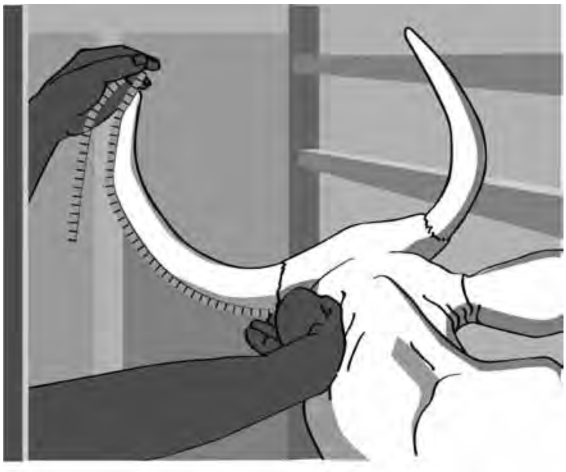
Note: The use of the bar at the shoulder to allow correct measurement of vertical height.

Heart girth



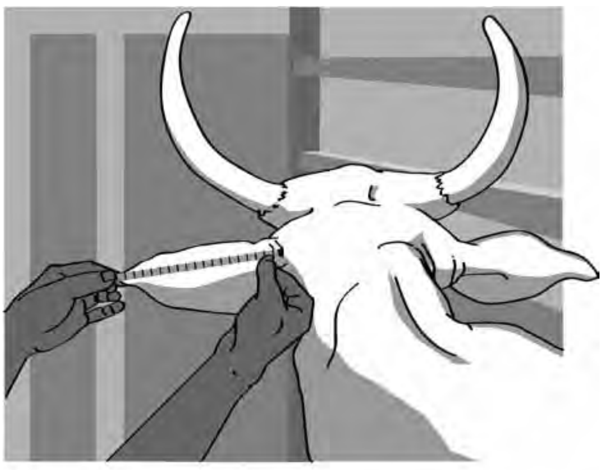
Note: Take the measurement right behind the animal's front legs.

Horn length



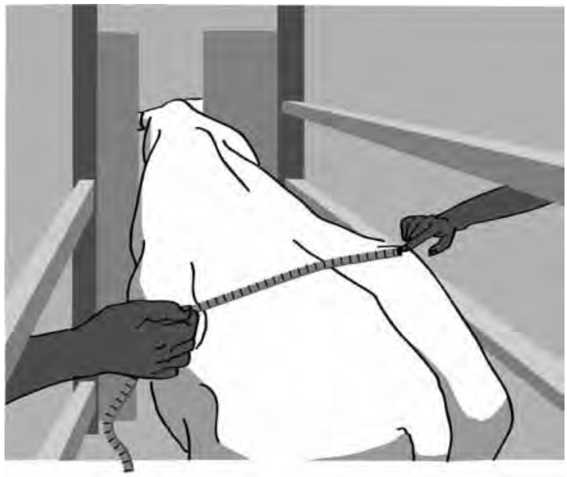
Note: Measure the longest distance from the root of the horn to its tip along the outer curvature.

Ear length



Note: Measure the length on the back side of ear from the root to the tip.

Pelvic width



Muzzle circumference

Note: Take the measurement a little above the nostrils and around the point where the dewlap meets the chin.

Annex 2

Checklist for phenotypic characterization of sheep and goats

GENERAL GUIDELINES

- This checklist is intended as a guide. It should be adapted to your situation and transformed into a questionnaire. It is recommended to record classes using a suitable set of codes (e.g. for sex: 1 = male, 2 = female, 3 = castrate).
- Physical measurements should be taken only from a representative set of adult animals (as judged by dentition): about 100 - 300 females and 10 - 30 males.
- The linear measurements should include at least body length, height at withers, heart girth, ear length and horn length, which can be taken using a textile measuring tape to the nearest unit centimetre. Measurement of the body weight is limited by availability of weighing scales (spring balance or weigh bridge), but when it is taken, an attempt should be made to identify animals by age, or at least dentition.
- Measurements should be taken early in the morning to avoid the effect of feeding and watering on the animal's size and conformation.
- Descriptive information should be recorded on the common flock sizes and structures, as well as on the uses of the animals.
- Measurements should be taken when animals are in barns or kraals or in a tethered position, but not when they are nervous.

DISCRETE OR QUALITATIVE VARIABLES

- Sex: female, male, castrate
- Estimated age or dentition class
- Body hair coat colour pattern: plain, patchy/pied, spotted
- Body hair coat colour: black, dark red, light red, fawn, grey
- Body skin colour: pigmented, not pigmented
- Fibre type (sheep):
  - hair sheep
  - wool sheep
    - coarse/carpet (about 100 microns)
    - medium wool (20 - 40 microns)
    - fine wool (about 15 microns)
- Fibre type (goat): Mohair/Angora, Cashmere
- Hair type (goat): glossy, smooth hair, straight long hair, curly rough hair, dull
- Hair length: medium (1–2mm); long (>2 mm)

- Horn presence (at flock level; separately for males and females): percent of polled animals, percent of horned animals
- Horn shape: scurs, straight, curved, spiral, corkscrew
- Horn orientation (at flock level, separately for males and females): lateral, obliquely upward, backward (indicate also if animal is polled or if horns are loose or just stumps)
- Ear orientation: erect, semi-pendulous, pendulous, carried horizontally
- Facial (head) profile: straight, concave, convex, ultra convex
- Wattles (goats): absent, present
- Beard (goats): absent, present
- Ruff: absent present
- Tail type (sheep): thin, fat rump, thick at base, fat
- Tail shape (sheep): cylindrical & straight, cylindrical & turned up at end, bi-lobbed without appendage, broad without lobe
- Back profile: straight, slopes up towards the rump, slopes down from withers, dipped (curved)
- Rump profile: flat, sloping, roofy

QUANTITATIVE VARIABLES

- Body weight (if spring balance or weighing bridge is available) with age specified
- Body size for adult males and females (to the nearest 0.5 cm):
  - body length
  - height at withers
  - chest girth
  - chest depth
  - shoulder point width
  - rump length
  - rump width
  - head length
  - head width
  - shin circumference
  - horn length
  - ear length
  - tail length (sheep)
  - hair/wool length (on the backline, at the rump)

FLOCK-LEVEL DATA

- Basic temperament: docile, moderately tractable, wild
- Any known adaptability traits[10]:
  - tolerance or resistance to diseases and parasites
  - drought tolerance
  - heat tolerance

[10] For more detailed questions on adaptability traits, see Annex 5 Part V.

- Type of holding: peasant farm, breeding centre, commercial farm, experimental station, multiplication station
- Mating practice:
  - uncontrolled, non-seasonal, natural mating
  - uncontrolled, seasonal, natural mating (multiple sire)
  - uncontrolled, seasonal, natural mating (1 ram/buck per herd)
  - hand mating
  - artificial insemination used for at least part of the flock
- Flock size
- Flock composition (proportion in the flock of):
  - breeding females.
  - replacement females
  - breeding males
  - males not used for breeding
  - castrated males
  - female lambs/kids
  - male lambs/kids
- Typical image of adult breeding ewe (doe) and ram (buck) with a comparator background
- Typical image of flock with its usual production environment in the background
- Uses of the animals in order of importance (milk, meat, fibre, traction, manure, sociocultural, etc.)[11]

DATA RELATED TO ORIGIN AND DEVELOPMENT[12]

- Name of the breed of the sample animals
- Synonyms and local names
- Background for such names
- Breeds known to be most closely related to this breed
- Origin of breed
- Source of the animals, if imported (name of country and year(s) of importation)
- Original geographic distribution of the breed (if possible georeferenced)
- Approximate area of distribution (km^2) of the breed or in terms of administrative boundaries
- Names of geographical areas where this breed type is known to exist
- Estimated total population size, including year of estimate and source/reference
- Types of communities or holdings maintaining the breed population: commercial farmers, subsistence farmers; pastoralists; breeding centres; experimental stations
- Known or reported breed improvement activities
- Known or reported breed admixtures or (planned or random) cross-breeding

[11] For more detailed questions on uses, see Annex 5 Part IV.

[12] Ideally generated through focus-group discussion.

DATA COLLECTED ON TRAITS THAT REQUIRE REPEATED MEASUREMENTS[13]

Dairy (if the sheep/goats are milked) and reproductive performance indicators on a randomly selected adult female and the female that has most recently completed a lactation:

- Lactation length
- Daily average milk off-take over three trimesters
- Milking system practised: hand milking with lamb/kid, hand milking without lamb/kid, machine milking with lamb/kid, machine milking without lamb/kid, combinations of these (specify)
- Total number of kids/lambs born
- Age of the ewe/doe (may be estimated)
- Age when first lamb/kid was born (may be estimated)
- Number of abortions

Carcass characteristics (when available):

- Slaughter weight of a meat animal (typically a grown-out male, otherwise specify)
- Hot carcass weight
- Cold carcass weight
- Dressing percentage

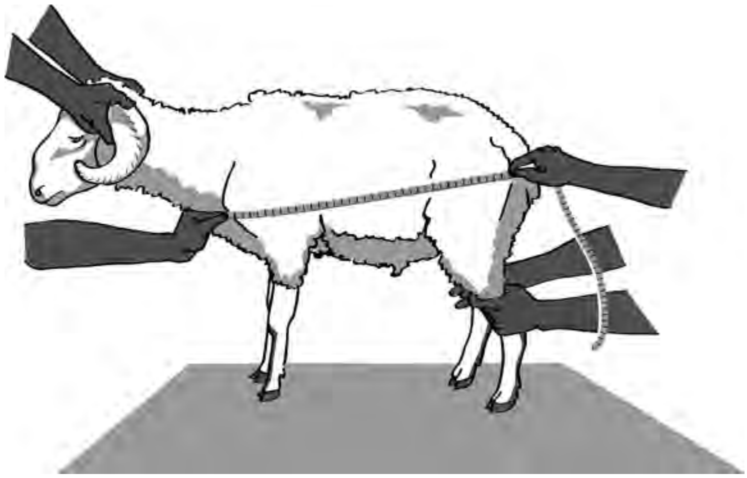
Reproductive performance estimates from two ewes or does, one random and one that recently gave birth:

- Age of ewe/doe at first lambing/kidding (may be estimated)
- Current age of ewe/doe (may be estimated)
- Number of lambings/kiddings observed and the size of litter for each (number of lambs/kids born)
- Number of abortions
- Number of lambs/kids weaned from last lambing/kidding

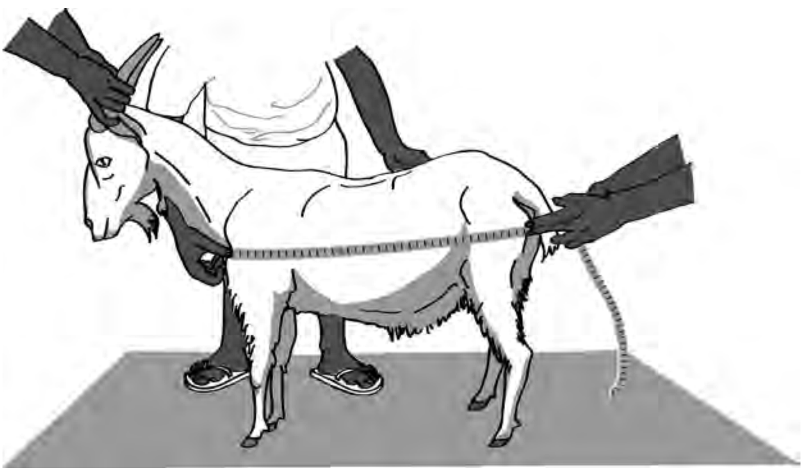
[13] From recollection by owners.

ILLUSTRATIONS

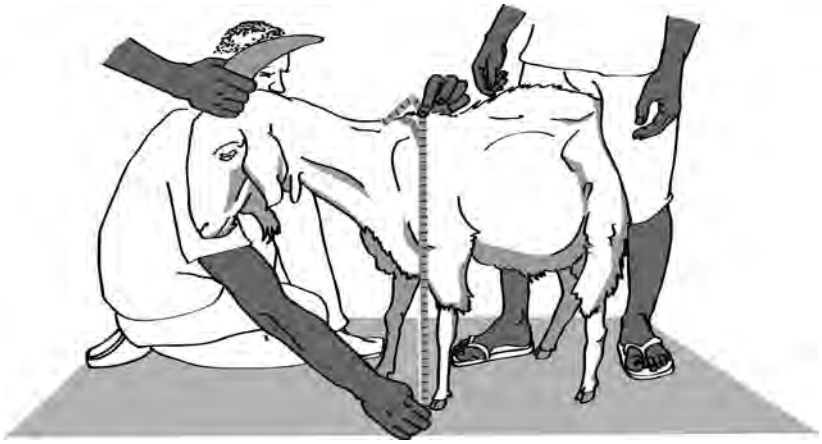
Body length – sheep



Body length – goat

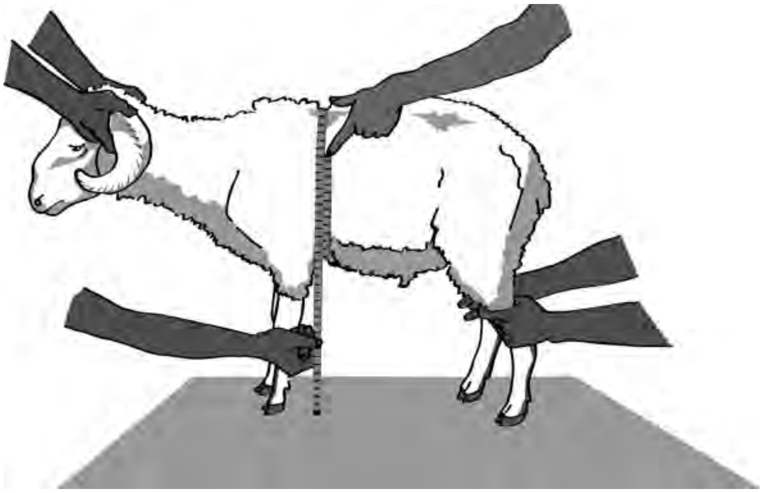


Height at withers



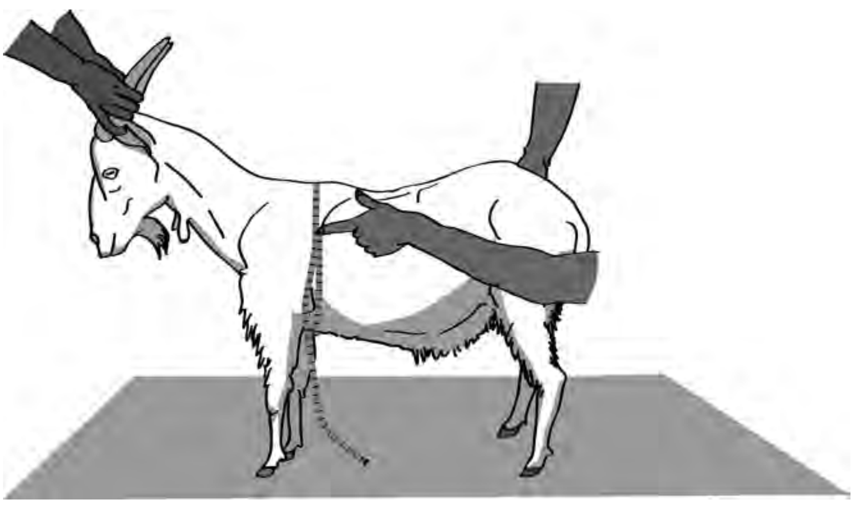
Note: The tape should be held vertically and not curved round the animal's shoulders.

Heart girth – sheep

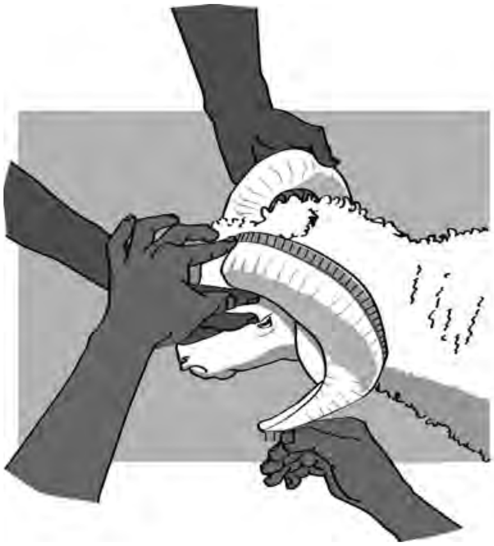


Note: Press gently to ensure that the wool cover does not increase the measurement.

Heart girth – goat

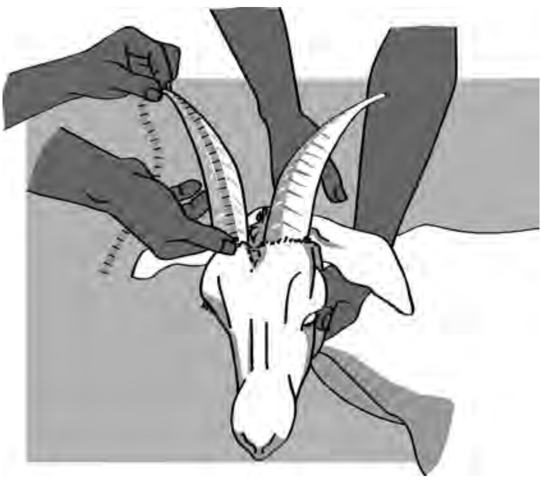


Horn length – sheep



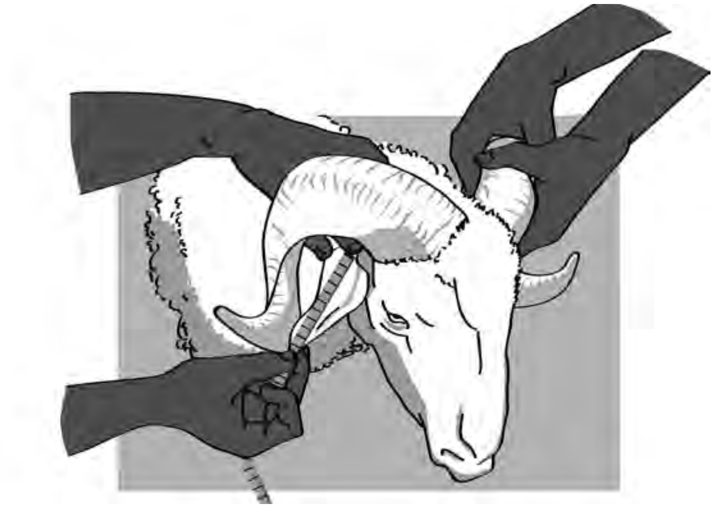
Note: Measure the longest distance from root of horn to the tip along the outer curvature.

Horn length – goat



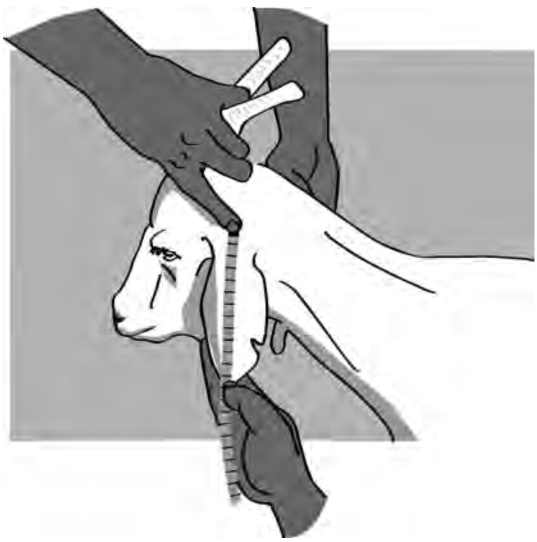
Note: Measure the longest distance from root of horn to the tip along the outer curvature.

Ear length – sheep



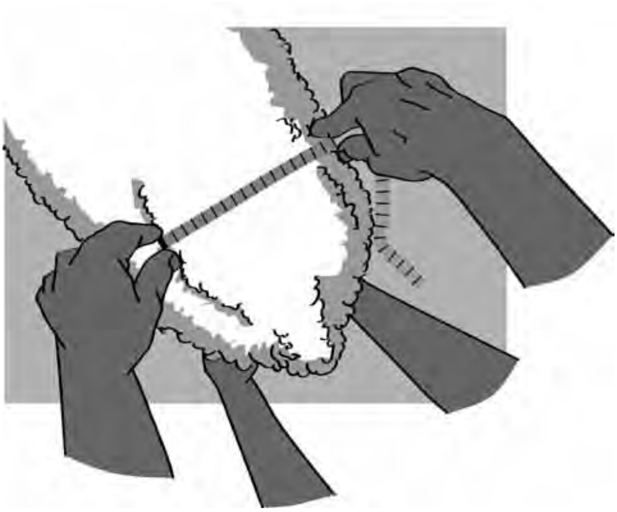
Note: Measure the length on the back side of ear from the root to the tip.

Ear length – goat



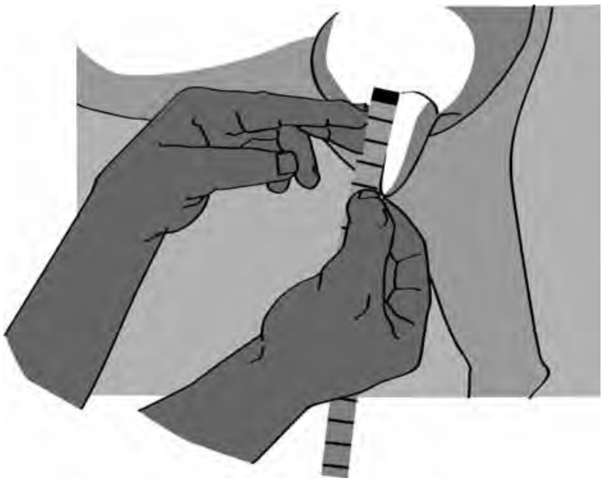
Note: Measure the length on the back side of ear from the root to the tip.

Pelvic width – sheep



Pelvic width – goat

Teat length (for milking goats)



Annex 3
Checklist for phenotypic characterization of chickens

GENERAL GUIDELINES

- This checklist is intended as a guide. It should be adapted to your situation and transformed into a questionnaire. It is recommended to record classes using a suitable set of codes (e.g. for sex: 1 = male, 2 = female).
- Physical measurements should be taken only from a representative set of adult animals (as judged by comb and wattle size): about 100 - 300 females and 10 - 30 males.
- The linear measurements on mature animals should include at least body length, shank length, wing span and chest circumference, which can be taken using a textile measuring tape to the nearest unit centimetre. Measurement of the body weight should be taken along with available information on the age of the animals.
- Descriptive information should be collected on common flock sizes and structures, as well as on the uses of the animals.

DISCRETE OR QUALITATIVE VARIABLES

- Feather morphology: normal, frizzle, silky,
- Feather distribution: normal, naked neck, feathered shanks and feet, muffs and beard, crest, vulture hocks (long stiff feathers protruding down and back from the hock joint)
- Plumage pattern (the colour pattern of feathers, if necessary stating the specific location on the body of the birds): plain, barred (specify if sex linked or autosomal), laced, mottled
- Plumage colour: white, black, blue, red, wheaten
- Skin colour: not pigmented (white), yellow, blue-black
- Shank colour: white, yellow, blue, green, black, brown
- Ear-lobe colour: not pigmented (white), red, white and red
- Comb type: single, pea, rose, walnut, cushion, strawberry, duplex, V-shaped, double
- Comb size: small, medium, large
- Eye colour (phenotypic frequency, %)
- Skeletal variants (phenotypic frequency, %): normal, crested, polydactyl, extra toes, creeper, dwarf, rumples, multiple spurs
- Other specific and distinct visible traits

QUANTITATIVE VARIABLES

- Body weight, if spring balance or weigh bridge is available

- Body size for adult males and females (to the nearest 0.5 cm):
  - body length (length between the tip of the *rostrum maxillare* (beak) and that of the *cauda* (tail, without feathers); the bird's body should be completely drawn throughout its length
  - circumference of the chest (taken at the tip of the *pectus* [hind breast])
  - shank length (length in cm of the shank from the hock joint to the spur of either leg)
  - wing span (length in cm between tips of right and left wings after both are stretched out in full)

FLOCK-LEVEL DATA

- Any known adaptability traits[14]:
  - tolerance or resistance to diseases and parasites
  - tolerance to extremes of temperature
- Type of holding: peasant farm, breeding centre, commercial farm, experimental station, multiplication station
- Flock size
- Flock composition (proportion in the flock of):
  - hens
  - pullets
  - cockerels
  - chicks
- Typical images of adult cockerel and hen with a comparator background
- Typical image of flock with its usual production environment in the background
- Notes on reported uses of the animals in order of importance (e.g. meat, egg, feathers, sociocultural)[15].

DATA RELATED TO ORIGIN AND DEVELOPMENT[16]

- Name of the breed of the sample chickens
- Synonyms and local names
- Background for such names
- Breeds known to be most closely related to this breed
- Origin of breed
- Source of the animals, if imported (name of country and year(s) of importation)
- Geographic distribution of the breed (if possible georeferenced)
- Types of communities or holdings maintaining the breed population: commercial farmers; subsistence farmers, breeding centres, experimental stations
- Estimated total population size, including year of estimate and source/reference
- Any other information specific to the breed

---

[14] For more detailed questions on adaptability traits, see Annex 5 Part V.

[15] For more detailed questions on uses, see Annex 5 Part IV.

[16] Ideally generated through focus-group discussion.

DATA COLLECTED ON TRAITS THAT REQUIRE REPEATED MEASUREMENTS[17]

Egg production characteristics (N, mean, range and standard deviation):

- Age at first egg (months)
- Annual egg production
- Clutch sizes
- Clutch interval (days)

Egg-quality traits (N, mean, range and standard deviation):
- Egg weight (g)
- Shell weight (g)
- Albumin weight (g)
- Yolk weight (g)
- Specific gravity
- Shell colour (white/brown/cream or tinted/other)
- Egg shape index[18]

Reproduction characteristics:
- Broodiness: usual, sometimes, rare
- Fertility and hatchability (%) (N, mean, range and standard deviation):
  · fertility (percent fertility is the percentage of fertile eggs among eggs produced)
  · hatchability on fertile egg basis
  · hatchability on total egg basis

Body weight and growth characteristics:

Body Weight at	Male			Female		
	Average	Range	N	Average	Range	N
Hatching (g)						
8 weeks (g)						
12 weeks (g)						
Adult weight (kg)						

Mortality (%) (N, mean, range and standard deviation):
- 0 – 1 week
- 1 – 8 weeks
- 8 – 20 weeks
- 20 – n weeks

- Carcass characters (N, mean, range and standard deviation) for males and females separately:
  - age at slaughter
  - live weight at slaughter
  - carcass weight (eviscerated)
- Dressing percentage[19]

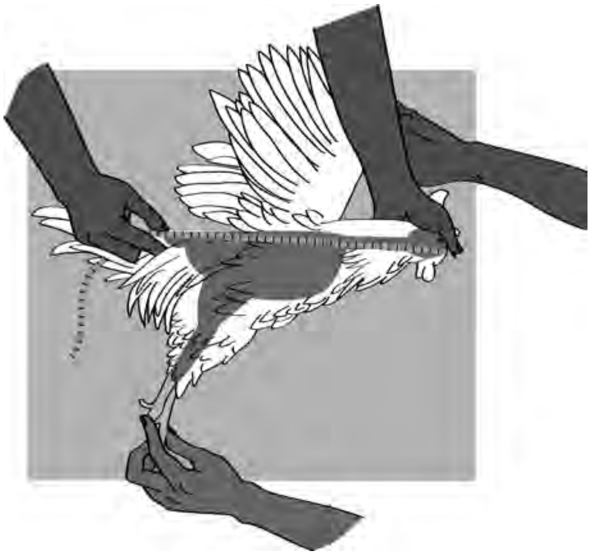
[17] From recollection by owners.

[18] Egg shape index is defined as the average width of the egg/average length of the egg * 100.

[19] Dressing out percentage is the proportion, in percent, of the carcass to the animal's live weight, specifying whether or not the slaughter weight was fasted, and whether the carcass was hot or cold during measurement.

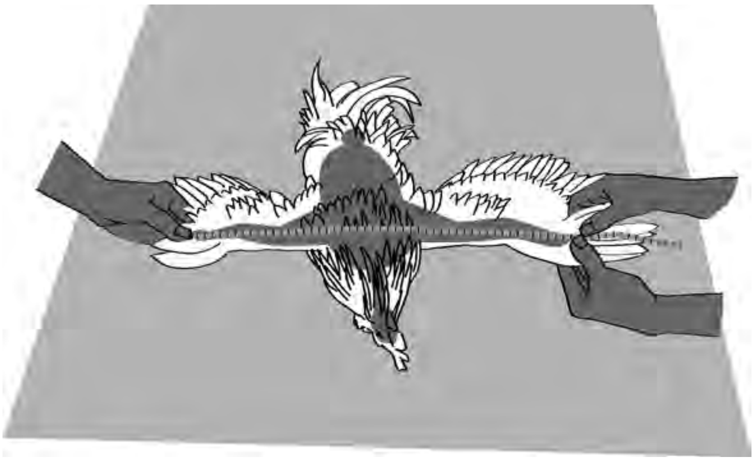
ILLUSTRATIONS

Body length



Note: Measure from the tip of the beak to the tip of the tail (excluding feathers). Note the need to fully stretch the sigmoid neck, with the chicken in a lying position.

Wing span (view from top side)

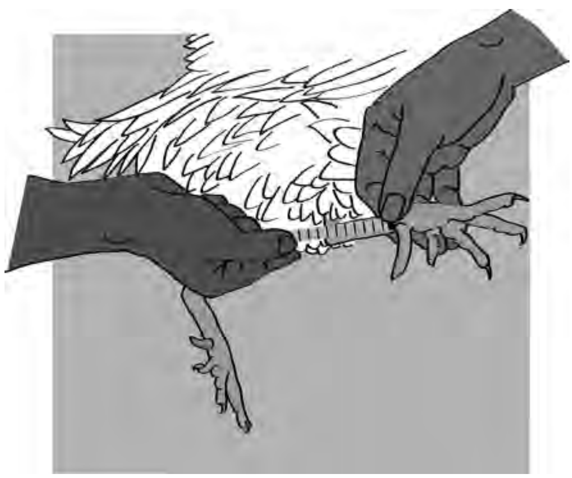


Wing span (view from under side)

Note: The measurement is taken across the back of the bird.

Circumference of the chest

Shank length



Body weight (using hanging spring balance)

Annex 4
Checklist for phenotypic characterization of pigs

GENERAL GUIDELINES

- This checklist is intended as a guide. It should be adapted to your situation and transformed into a questionnaire. It is recommended to record classes using a suitable set of codes (e.g. for sex: 1 = male, 2 = female, 3 = castrate).
- Physical measurements should be taken only from a representative set of adult animals (as judged by dentition): about 100 - 300 females and 10 - 30 males.
- The linear measurements should include at least body length, head length, height at withers, chest girth, ear length and tail length, which can be taken using a textile measuring tape to the nearest unit centimetre. Measurement of the body weight is limited by availability of weighing bridges, but when it is taken, an attempt should be made to identify animals by age, or at least dentition.
- Measurements should be taken early in the morning to avoid the effect of feeding and watering on the animal's size and conformation.
- Descriptive information should be recorded on the common herd sizes and structures, as well as on the uses of the animals.
- Measurements should be taken when animals are in barns or kraals or in a tethered position, but not when they are nervous.

DISCRETE OR QUALITATIVE VARIABLES

- Hair: curly, straight, short, long, dense, sparse
- Tusks: present, absent
- Snout: long and thin, short and cylindrical
- Coat colour pattern: plain, patchy, spotted
- Coat colour type: white, black, dark red, light red, fawn, grey
- Head profile: concave (dished), straight, convex
- Ear type: droopy (pendulous), semi-lop (e.g. Pietrain), lop, prick (erect)
- Ear orientation: project forwards, backwards, upwards
- Skin: smooth, wrinkled
- Tail type: straight, curly (kinked)
- Backline: straight, swaybacked (i.e. markedly convex ventrally)

QUANTITATIVE VARIABLES

- Body weight (if spring balance or weighing bridge is available) with age specified

- Body size for adult boar and sow (to the nearest 0.5 cm):
  - body length
  - head length
  - tail length
  - ear length: measure length or classify into large, medium or small
  - chest girth
  - height at withers
  - teat numbers: numbers of normal and rudimentary teats counted on the sow or gilt

HERD-LEVEL DATA

- Basic temperament: placid and friendly, moderately tractable, aggressive (wild)
- Any known adaptability traits[20]:
  tolerance or resistance to diseases and parasites
  - drought tolerance
  - heat tolerance
- Type of holding (general description of the production environment): peasant agriculture, pig breeding centre, experimental station, multiplication centre, commercial production unit
- Mating practice:
  - uncontrolled, non-seasonal, natural mating,
  - uncontrolled, seasonal, natural mating (multiple sire),
  - uncontrolled, seasonal, natural mating (1 sire per herd),
  - hand mating, artificial insemination used for at least part of the herd
- Herd size
- Herd composition (proportion in the herd of):
  - breeding sows
  - boars
  - growing male pigs
  - replacement gilts
  - piglets
- Typical images of adult boar and sow with a comparator background
- Typical images of a herd with its usual environment in the background
- Uses of the animals in order of importance (e.g. meat, income, manure, sociocultural)[21]

DATA RELATED TO ORIGIN AND DEVELOPMENT[22]

- Name of the breed of the sample animals
- Synonyms and local names
- Background for such names

[20] For more detailed questions on adaptability traits, see Annex 5 Part V.

[21] For more detailed questions on uses, see Annex 5 Part IV.

[22] Ideally generated through focus-group discussion.

- Breeds known to be most closely related to this breed
- Origin of breed type
- Source of the animals, if imported (name of country and year(s) of importation)
- Original geographic distribution of the breed (if possible georeferenced)
- Approximate area of distribution (km^2) of the breed or in terms of administrative boundaries
- Names of geographical areas where this breed type is known to exist
- Estimated total population size, including year of estimate and source/reference
- Types of communities or holdings maintaining the breed population: commercial farmers, subsistence farmers, breeding centres, experimental stations
- Known or reported breed improvement activities
- Known or reported breed admixtures or (planned or random) cross-breeding

DATA COLLECTED ON TRAITS THAT REQUIRE REPEATED MEASUREMENTS[23]

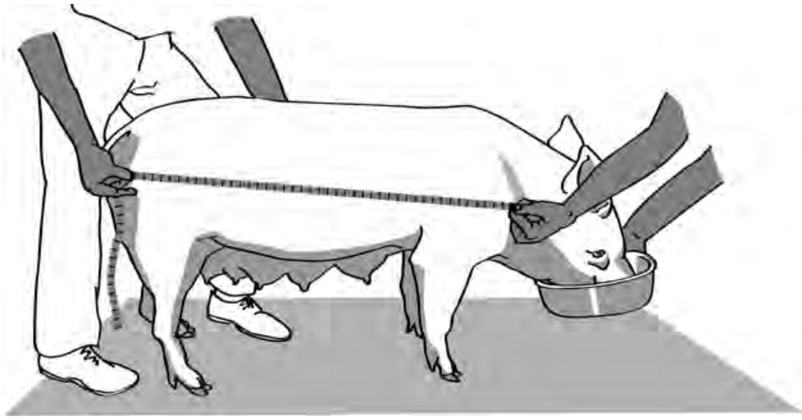
Reproductive performance estimates from two sows, one random and one just recently farrowed:

- Estimated age of sow at first farrowing
- Current estimated age of sow
- Number of farrowings observed and the size of litter for each (number of piglets)
- Number of abortions
- Number of piglets weaned from last farrowing

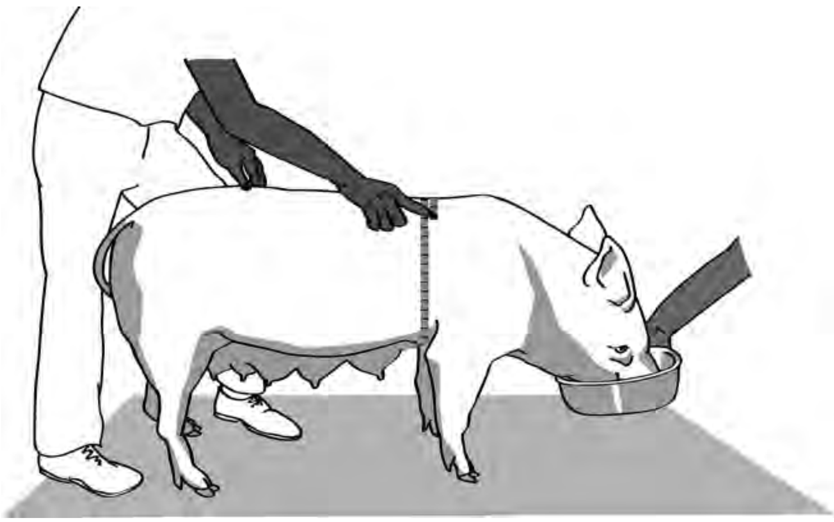
[23] From recollection by owners.

ILLUSTRATIONS

Body length



Heart girth



Note: Ensure the skin is not pressed too deep.

Height at withers

Note: Hold the tape in a straight line to the high point of the pig's shoulder. Do not curve the tape round the shoulder.

Ear length

Pelvic width

Tail length

Note: Ensure that the tail is fully stretched.

Hock circumference

Note: Taking this measurement is particularly difficult as pigs can easily get nervous when their legs are handled.

Annex 5
Production environment descriptors[24]

PART I: GENERAL

- Species
- Most common name of the breed or population
- Other names or synonyms or local names of the breed or population
- Name of the study area including the name(s) of the relevant administrative area(s)
- Geographic locations of the study site(s) (georeferences)
- Map (as complete and precise as possible) of the geographic distribution of the breed population
- Names of other administrative areas where the breed population is known to exist
- Is this breed population known to be kept in more than one production environment?
- Is the production environment being described part of a seasonal transhumant system?
- If yes, provide the time period the animals spend in each production environment
- Length of time that the breed has been present in this particular production environment:
  - Start year: provide a rough estimate of the year the breed was first present in this production environment, or indicate that breed emerged in, or was introduced to, this production environment at some distant and unknown time in the past.
  - End year: provide a rough estimate of the last year the breed was present in this production environment[25], or indicate that the breed is still present in this production environment.
- Proportion of the total breed population[26] that is in this particular production environment in percent

PART II: NATURAL ENVIRONMENT

Climate

- Temperature
  - Mean daily maximum temperature (°C)
  - Mean daily minimum temperature (°C)
  - Mean daily maximum temperature of the hottest month of the year (°C)
  - Mean daily minimum temperature for the coldest month of the year (°C)

---

[24] Adapted from FAO/WAAP (2010).

[25] This option is relevant to historical investigations rather than conventional phenotypic characterization studies focusing on breeds in their current production environments.

[26] Calculating this proportion requires data for the whole country. It may not be possible on the basis of the outputs of an individual phenotypic characterization study.

- Relative Humidity
  - Mean daily relative humidity (%)
  - Mean daily relative humidity of the hottest month of the year (%)
  - Mean daily relative humidity of the coldest month of the year (%)
- Precipitation:
  - Monthly mean precipitation (mm)
  - Annual mean (mm)
  - Between-year variation in precipitation:
    - large variation in rainfall
    - medium variation in rainfall
    - little variation in rainfall
    - normally little variation in rainfall but subject to "sporadic" droughts
  - Between-year variation in:
    - occasional deep snow
    - frequent deep snow
    - little or no variation in snowfall between years
    - no snowfall
  - Wind conditions – frequency and type of winds
    - occasional high winds
    - frequent high winds
    - occasional high wind-chill values
    - frequent high wind-chill values
    - occasional warm dry winds (conditions that cause rapid water loss)
    - frequent warm dry winds (conditions that cause rapid water loss)
    - average wind speed for the hottest month of the year: (km/hour)
    - average wind speed for the coldest month of the year: (km/hour)
  - Day length period:
    - Hours of daylight on the longest day of the year
    - Hours of daylight on the shortest day of the year
  - Solar radiation:
    - UV index – annual average (local solar noon)
    - UV index – above 5 (high/very high/extreme) (number of days per year)
    - Total annual hours of sunshine
    - Solar radiation (intensity) (kW/m^2)

Terrain features

- Elevation
  - Mean elevation for this production environment (m above sea level)
  - Lowest elevation for this production environment (m above sea level)
  - Highest elevation for this production environment (m above sea level)
- Slope: The terrain in this production environment is generally – choose one:
  - flat
  - hilly

- steep and mountainous
- very variable

- Soil pH – the soil in this production environment is generally:
  - very alkaline (pH > 8.5)
  - neutral (pH between 5.5 and 8.5)
  - very acidic (pH < 5.5)
- Surface conditions – indicate the main substrate conditions on which animals are generally maintained:
  - natural vegetation
  - stony/rocky
  - sandy
  - commonly wet – with very swampy substrate conditions
  - Regularly and/or frequently flooded
  - Regularly and/or frequently covered by snow/ice during winter
  - Highly variable substrate types
- Tree cover: provide the percentage tree cover in this production environment

Diseases, parasites[27] and other threats to animal health:
List the diseases and parasites that present, or have presented, a significant challenge to animals of this *species* in this production environment and indicate their pattern of occurrence. Note that the breed itself might be resistant or tolerant, and therefore show little or no ill-effect despite being challenged by the disease or parasite.
Consider the following disease categories, ectoparasites, endoparasites and other threats:

- Disease categories
  - bacterial
  - rickettsial
  - viral
  - fungal
  - prion
- Disease occurrence – select the most appropriate choice for each disease listed:
  - eradicated
  - rare
  - frequent
  - continuously present
  - emerging
- Ectoparasites
  - insects
  - mites
  - ticks

[27] Lists of diseases and parasites that may be entered in the PEDs module of DAD-IS are provided as an annex to the report of the FAO/WAAP Expert Meeting on Production Environment Descriptors (FAO/WAAP, 2008). Individual phenotypic characterization studies should attempt to describe the local disease and parasite challenge as comprehensively as is feasible.

- Endoparasites
  - helminths
  - protozoa
- Parasite occurrence – select the most appropriate choice for each ectoparasite and endoparasite listed:
  - eradicated
  - seasonal
  - occasional
  - continuously present
  - emerging
- Other threats including feed and water toxins, predators and other harmful animals

PART III: MANAGEMENT ENVIRONMENT

- Livestock production system type
  - grassland-based systems:
    - ranching
    - pastoralist
  - mixed systems:
    - crop–livestock
    - agropastoralist
    - agroforestry–livestock
  - landless systems:
    - industrial
    - backyard/scavenger
- Level of confinement (refers to whether or not and for what periods animals are confined in a shed/cage/ pen, etc.):
  - most animals are continuously unconfined
  - most animals are confined only at night
  - most animals are confined on a seasonal basis
  - most animals are continuously confined
- Climate modifiers:
  - basic heat protection (shelters, shading trees, etc.)
  - basic cold protection (shelters, windbreaks, etc.)
  - housing – not completely climate controlled
  - housing – completely climate controlled
  - cooling facilities (wallows, water sprays, etc.)
- Control of diseases, parasites and other threats to health
  - For each disease listed as presenting a challenge in the local production environment, choose one of the following – most animals are vaccinated:
    - never
    - occasionally
    - regularly
  - Most animals are subject to preventive ectoparasite or vector control:
    - never

- occasionally
- regularly

- Most animals are subject to preventive endoparasite control:
    - never
    - occasionally
    - regularly
- Most animals are provided with veterinary treatment when they are sick:
    - never
    - occasionally
    - whenever needed
- Most animals are subject to traditional treatments:
    - never
    - occasionally
    - regularly

- Feed and water availability and management
  - Access to drinking water is:
    - normally not restricted
    - occasionally restricted
    - frequently restricted
  - Salt content of drinking water
    Drinking water has a high salt content: yes/no
  - Feed availability (quantity and quality):
    - not restricted
    - frequently restricted during periods of the year
    - restricted throughout the year
    - feed type and proportion and seasonality

Feed type	**Types of feed fed to the animals**	**Estimate the percentage % of dry matter fed to the animals that is contributed by each feed type**		
		Vegetation growing period	**Outside the vegetation growing period**	**Whole year***
Natural pastures, including browse type vegetation	☐			
Sown pastures	☐			
Forage crops	☐			
Crop residues (straws, stovers, etc.)	☐			
Concentrates	☐			
Industrial by-products with low nutrient density	☐			
Mineral supplements	☐			
Vitamins and trace elements	☐			

* if there is no distinct vegetation growing period

- Between-year variability in feed availability
  Is there high year to year variation in feed availability? yes/no
- Reproduction strategies
  - List the months during which mating occurs
  - Type of reproductive control generally employed by livestock keepers for breeding stock of the breed:
    - uncontrolled mating
    - controlled mating
  - Methods employed for controlled mating:
    - hand or pen mating
    - artificial insemination
    - embryo transfer

PART IV: SOCIO-ECONOMIC CHARACTERISTICS

- Market orientation for animals and products:
  - fully market oriented
  - mixed market/subsistence orientation
  - subsistence oriented
- Markets targeted:
  - international market
  - regional market
  - national market
  - local market
- Products targeted at niche markets? yes/no
- If products targeted at niche markets, describe the niche products
- Established market for breeding animals and genetic material? Yes/no
- Main uses and roles of the breed in this production environment – prioritize from the list below (1 for most important use, 2 for second most important, etc.):
  - food:
    - milk
    - eggs
    - meat
    - lard
    - production of offspring for slaughter as young animals
    - fatty liver
    - blood
  - fibre and skins:
    - wool
    - hair
    - pelt/fur
    - skin/hides
  - work:
    - draught power (field work)
    - draught power (transport)
    - pack/baggage
    - herding (include herding for fighting bulls)
    - riding for work or general transport
  - manure:
    - fertilizer
    - fuel
  - plumage:
    - feathers
    - down feathers
    - feathers for fishing
  sociocultural:
    - general
    - savings/insurance

- prestige
- social and/or religious ceremonies
- maintaining social networks
- fighting

- cross-breeding:
  - general cross-breeding
  - sire line
  - dam line
  - interspecies crossing
- special uses:
  - guard
  - hatching foreign eggs
  - horns
  - pest control
  - medical or pharmaceutical purposes
  - research
  - vegetation management
  - velvet
  - wool for fishing lures
  - spanish horse school
- fancy and hobby:
  - sport
  - fancy
  - sport (general)
  - hobby (general)
  - racing
  - riding (sports/leisure)
  - riding (by children)
  - carting
  - dressage
  - tourist attraction
  - hunting

- Gender aspects of decision taking (note: only for non-industrial systems)

Decision-taking	**Household**		**Community/cooperative**
	Women	**Men**	
Scale of operation	☐	☐	☐
Sales/purchases	☐	☐	☐
Intensity of production	☐	☐	☐
Markets targeted	☐	☐	☐
Breeding objectives	☐	☐	☐

- Gender aspects of work sharing – mark one or more boxes in each row

Work-sharing	**Household**			**Community/cooperative**
	Women	Men	Children	
Feeding	☐	☐	☐	☐
Watering	☐	☐	☐	☐
Herding	☐	☐	☐	☐
Cleaning	☐	☐	☐	☐
Health management	☐	☐	☐	☐
Reproductive management	☐	☐	☐	☐
Harvesting products	☐	☐	☐	☐
Marketing products and animals	☐	☐	☐	☐

PART V: BREEDS' SPECIAL QUALITIES[28]

- Breed characteristics relevant to climate:
  - tolerant of heat – low humidity
  - tolerant of heat – high humidity
  - tolerant of cold – low humidity
  - tolerant of cold – high humidity
  - adapted to heavy snowfall
  - adapted to high solar radiation
- Breed characteristics relevant to terrain:
  - adapted to high elevations
  - adapted to steep terrain
  - adapted to extremely stony/rocky substrates
  - adapted to extremely sandy substrates
  - adapted to snowy and icy substrate conditions
  - adapted to walking long distances
- Breed characteristics relevant to health

  List all relevant diseases, ectoparasites and endoparasites and indicate whether they are:
  - resistant
  - tolerant
  - subsceptible
- Other animal health-related adaptations, including to feed and water toxins and predators
- Breed tolerance relevant to feed and water availability:
  - tolerant of long intervals between watering
  - tolerant of highly saline drinking water
  - tolerant of high ph drinking water
  - tolerant of low ph drinking water
  - tolerant of long intervals between feeding
  - tolerant of low-quality feed
  - tolerant of high variations in feed quality
- Other feed- or water-related adaptations
- Specific quality of products

[28] Note that the items in this worksheet describe to the adaptations of animals to the production environments rather than the characteristics of production environments per se. In primary phenotypic characterization studies, the principle means of collecting such data are individual or group interviews with livestock keepers and other key informants. More detailed information can be obtained through advanced characterization studies.

Annex 6
Definition of terms

QUANTITATIVE VARIABLES FOR BODY MEASUREMENTS[29]

Ear length: length (in centimetres) of the external ear from its root on the poll to the tip.

Horn length: length of the horn (in centimetres) on its exterior side from its root at the poll to the tip.

Height at withers: the (vertical) height (in centimetres) from the bottom of the front foot to the highest point of the shoulder between the withers. Measurement is preferably taken with a sliding ruler.

Chest girth: the circumference of the body (in centimetres) immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body.

Body length: the horizontal distance (in centimetres) from the point of shoulder to the pin bone.

Pelvis width: the horizontal distance (in centimetres) between the extreme lateral points of the hook bone (tuber coxae) of the pelvis.

Body weight: the fasted live body weight (in kilograms).

DENTITION CLASSES OF GOATS[30]

0 – a kid without teeth, often a newborn animal
1 – with erupted and growing first pair of milk teeth
2 – with erupted and growing second pair of milk teeth
3 – with erupted and growing third pair of milk teeth
4 – with erupted and growing fourth pair of milk teeth
5 – with fully grown milk teeth that have started to spread apart
6 – the milk teeth have started to wear down, or are fully spread apart
7 – with erupted and growing first pair of permanent incisors
8 – with erupted and growing second pair of permanent incisors
9 – with erupted and growing third pair of permanent incisors
10 – with erupted and growing fourth pair of permanent incisors
11 – the four pairs of permanent incisors have started to wear down
12 – the incisors are worn down and have started to spread apart
13 – worn down incisors are spread apart and a few are lost (broken-mouth)
14 – most of the incisors have been lost (smooth-mouth) or worn down to the level of the dental pad

---

[29] Adapted from Edey, T.N. (ed.) 1983. *A course manual in tropical sheep and goat production. assessment and measurement of the normal animal.* Canberra, Australian Vice-Chancellor's Committee, Australian Universities' International Development Programme.

[30] As employed in phenotypic survey in Ethiopia (FARM-Africa and ILRI, 1996; Ayalew *et al.,* 2000).

ESTIMATES OF AGE OF SHEEP AND GOATS FROM DENTITION

Stage	Age (year)	Characteristic change on teeth
lamb	under 1 year	8 sharp milk incisors
yearling	1–2 years	central pair of permanent incisors
young adult	2–3 years	2 pairs of permanent incisors
adult	3–4 years	3 pairs of permanent incisors
mature	4–5 years	4 pairs of permanent incisors
old	over 5 years	without teeth and some missing

DESCRIPTION OF BODY CONDITION SCORES (BCS)

BCS	Characteristic change of the body (lumbar vertebrae and tail)
0	• highly emaciated • no muscle and fat between the skin and bone in the lumbar region • used up tail fat reserve and coccygeal bones felt from inner and outer sides
1	• sharp and prominent dorsal and transverse processes • fingers easily pushed below the transverse processes • fat-tail reserve almost used up and coccygeal vertebrae prominent
2	• dorsal processes prominent and felt as corrugation • transverse processes smooth and round and fingers can easily pass under them • fat tail is slightly heavy and fine to the touch.
3	• dorsal processes are smooth and rounded and their bones can be felt with pressure • transverse processes are smooth and well covered • pressure is required to pass fingers under the transverse processes • fat tail is more rounded and firm and the coccygeal bones are not easily felt
4	• dorsal processes are detected as a line • transverse processes are well covered and can not be felt • coccygeal bones can only be felt with pressure from the inner side of the tail
5	• not possible to detect the dorsal processes • requires very strong pressure pass fingers under transverse processes • coccygeal bones not felt with strong pressure

CHICKEN PLUMAGE DESCRIPTORS[31]

Frizzle feather: Feathers that are curled and which curve outward and forward.

Crest: Almost globular tuft of feathers on the top of the head of some fowl and waterfowl, as in Polish, Houdans, Crevecoeurs, Silkies, Sultans and White Crested Ducks. Full expression is partially dependent on the knob.

Split crest: Crest in which there is a division, with feathers falling to either side; a serious defect.

Beard: Cluster of feathers pendent from the upper throat of some fowl. Found only in combination with muffs.

Hackle: Rear and side neck plumage of a fowl. Feathers on male and female differ in shape and structure except in breeds having hen-feathered males.

[31] *Source:* http://216.92.143.243/eureka/index.php/Category:Chicken_Plumage.

Stripe: Usually refers to a contrasting stripe of colour in the web of hackle feathers of both sexes, and the saddle of males of some parti-coloured varieties. In most instances the stripe should extend through the web, running parallel with the outer edges of the feather and tapering to a point near the lower extremity of the feather.

Cape: Short feathers at the juncture of the back and neck underneath the hackle and between the shoulders, collectively shaped like a cape.

Feather legged (shank-feathering): Fowls having feathers on the outer sides of shanks, and on the outer, or the outer and middle, toes.

Cushion: Profuse mass of feathers over the back and base of the tail of a fowl giving it a rounded effect.

Booted: Fowls that are feathered on shanks and toes and having vulture hocks are said to be booted, as in Booted and Sultans.

Sex-linkage: Connection between colour and sex in certain poultry breeds (e.g. when a Black Leghorn cock is mated with a barred Plymouth Rock hen, all the cockerels will be barred, and all the pullets black).

Sex feathers: Pointed feathers in the hackle, back, saddle, sickles and wing-bow of a male fowl, which differ from the oval shape feathers in the same sections of the female.

Hen-feathered: Male having feathers like a female; i.e. oval instead of pointed sex feathers in hackle, saddle, wingbow and sickles.

Columbian: A plumage colour pattern in chickens. The main body plumage is white, but certain feathers in the neck, tail and wing sections are variously tinged with black. It is the plumage pattern of the Light Brahma, Columbian Plymouth Rock, and Columbian Wyandotte.

Barred (cuckoo): Poultry feathers having a side-to-side pattern of black and white stripes (bars). Where the bars are white with another colour, such as gold or buff, the colour description is gold-barred or buff-barred.

Self-colour: Single uniform colour throughout the plumage, as in black and white varieties.

Solid-colour: All of one tone; i.e. one hue, tint or shade.

Surface colour: Colour of the portion of the plumage that is exposed when the feathers are in natural position.

Ground colour: Basic or predominating colour of the web of a feather. In laced, pencilled, barred, spangled and mottled varieties, it is the basic or predominating colour on which the markings are delineated.

Undercolour: Colour of the lower or fluff portion of feathers, not visible when the feathers are in natural position.

Foreign colour: Colour in any part of a fowl that differs greatly from the colour prescribed by the standard.

Mossy: Confused, indistinct, irregular or disarranged colour markings which destroy the desired colour contrast or pattern.

Mealy: Applies to buff or red plumage flecked with a lighter colour, as if dusted with flour or meal.

Pencilling: Alternate collared crosswise markings in Silver and Golden Pencilled Hamburg females.

Barring: Transverse purple markings in black feathers.
Peppered (peppering): Feathers sprinkled with small dots of black or grey.
Ticking: Specks or small spots of black colour on the tips of the lower neck-feathers.
Laced (lacing): Border of contrasting colour around the entire web of a feather.
Frosting: Faded margin on a black lacing or spangle.
Tipped (with white): Loosely used in describing the white markings at the tips of feathers in mottled and spangled breeds.
Spangle (spangling): Distinct marking of contrasting colour at the extremity of a feather, proximally shaped like a well-defined V with a rounded end. Always black in colour and found in combination with silver or gold ground colour.
Mottled (mottling): Plumage in which a variable percentage of the feathers are tipped. Note that mottling differs mainly from spangling in that markings are always white and found only on a variable percentage of the feathers, whereas in spangling the markings may be either black or white and are located on the tip of each feather.
Parti-coloured: Fowls having feathers of two or more colours, or shades of one colour.
Bay: Light golden-brown.
Buff: Medium shade of orange-yellow colour with a rich golden cast.
Chestnut: Dark red-brown plumage colour, darker than bay.
Creaminess: White feathers in which the shafts and webs are tinged with a light yellow or creamy colour, not the same as brassiness. Characteristic of new feathers, due to immaturity.
Dark slate: Very dark bluish grey, approaching black.
Khaki: Light brown.
Mulberry (gypsy colour): Very dark purple approaching black.
Pure white: Opaque white, generally applied to the unblemished white in female-type feathers of white or parti-white varieties. The complement of silvery white in male sex feathers of the same varieties.
Salmon: Medium shade of reddish ochre colour used to describe the colour of the breast of some breeds (e.g. Light Brown Leghorn females).
Silkie: Semiplume character of the feathers of the Silkie fowl in which the shafts are very thin and the barbs are very long, very soft and fluffy, which have no holding power and no locking arrangement; structurally similar to the fluff of a normal feather.
Slate: Shade of grey having a bluish cast sometimes approaching black, sometimes of lighter shades.
Wheaten: Various shades of the colour of wheat. The term is used to describe the plumage colour of the females of certain varieties.

PRODUCTION ENVIRONMENT DESCRIPTORS[32]

General terms

Production environment: comprises the natural environment and the management environment in which a breed population is kept.

[32] *Source:* adapted from FAO/WAAP (2008).

The natural environment: can be specified by describing the climate, soil quality, terrain elevation and surface type, and disease and parasite challenge that prevail in the location where a breed population is kept.

The management environment: refers to any interventions or actions that affect the conditions under which the breed population is kept. It can be specified by describing the livestock production system type, the level of confinement, climate modifiers, control of diseases and parasites, feed and water management, reproductive strategies and socio-economic characteristics including the main uses and roles of the breed population.

Transhumant system: transhumant livestock keepers follow a seasonal cycle of movement with their herds or flocks to find feed and water or to avoid unsuitable climatic conditions. Movement may be within a single production environment or between two or more production environments.

Terms related to the natural environment

Temperature: refers to the ambient temperature measured at a nearby weather station that accurately reflects conditions within the production environment being described.

Relative humidity: refers the humidity measured at a nearby weather station that accurately reflects conditions within the production environment.

Precipitation: refers to rain and snowfall measured at a nearby weather station that accurately reflects conditions within the production environment.

Drought: the naturally-occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems[33].

Large variation in rainfall: less than 75 percent of long-term average in two or more of six consecutive years.

Medium variation in rainfall: less than 75 percent of long-term average in fewer than two in six consecutive year.

Little variation in rainfall: Less than 75 percent of long-term average in fewer than two in ten consecutive years.

Sporadic droughts: normally little variation in rainfall (see above), but occasionally three to four consecutive years with less than 75 percent of long-term average.

Deep snowfall: abnormally severe snowfall that seriously disrupts livestock production for an extended period.

Occasional deep snowfall: deep snowfall occurs on average less than twice in ten years.

Frequent deep snowfall: deep snowfall occurs on average more than twice in ten years.

High winds[34]: winds in excess of 62 km/hour.

---

[33] *Source:* United Nations Convention to Combat Desertification, Article 1. (http://www.unccd.int/convention/text/convention.php?annexNo=-1).

[34] No definition of what should be considered "frequent" and "occasional" in the context of describing the wind conditions in a production environment was established by the FAO/WAAP Expert Meeting.

Wind chill[35]: refers to conditions in which the air temperature perceived by the body is lowered by the effect of the wind. Wind-chill index is commonly calculated in terms of the effect on exposed human skin. Livestock species will be affected differently from humans and from each other according the characteristics of their coats/plumage. In the absence of a separate index for each species, a high wind-chill index (i.e. low felt temperature) as calculated for humans is taken as a proxy for conditions in which livestock species are likely to be adversely affected by a combination of cold and wind.

Warm dry winds: refers to conditions in which water loss from the animals is significantly exacerbated by the effect of the wind.

UV Index: refers to the global solar ultraviolet index (UVI) which is a simple measure of the ultraviolet radiation level at the earth's surface [36]. The values of the index range from zero upward. The higher the index value, the greater the potential for damage to the skin and eye, and the less time it takes for harm to occur.

In the absence of separate UVI for livestock species, the human UVI is taken as a proxy for conditions in which livestock species are likely to be adversely affected by high levels of ultraviolet radiation.

The following harmonized exposure categories and colours are associated with various values of the UVI [37]:

Category	UVI range	Colour
Low	0 to 2	Green
Moderate	3 to 5	Yellow
High	6 to 7	Orange
Very high	8 to 10	Red
Extreme	≥ 11	Purple

Elevation: refers to the height above sea level of the production environment.

Slope: refers to the steepness of the terrain generally found in the production environment.

Surface conditions: refers to the condition of the ground (on which the animals walk and rest) generally found in the production environment.

Diseases and parasites: refers to the diseases and parasites that are found in the production environment and are likely to affect breed performance and/or adaptedness. The effects of a disease or parasite may be manifested in terms of poorer performance (reduced levels of survival, production or reproduction), increased requirements for management interventions (e.g. use of veterinary drugs), restrictions on the choice of breeds (e.g. susceptible breeds cannot be used), or a combination of these effects.

Note that a specific breed population may be resistant or tolerant to a given disease or parasite and therefore show little or no ill-effect. The presence of such diseases and parasites

---

[35] No definition of what should be considered "high" wind chill for the purposes of describing a production environment was established by the FAO/WAAP Expert Meeting.

[36] The UVI was developed by the World Health Organization (WHO) in collaboration with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the German Federal Office for Radiation Protection.

[37] *Source:* WHO. 2002. *Global Solar UV Index: a practical guide.* Geneva.

in the production environment should nonetheless be recorded, as they may over time have affected the breed's adaptedness, and are likely to affect the performance of newly introduced breeds.

Diseases and parasites that were formerly present but have now been eradicated from the production environment no longer affect performance, but may have affected the breed's levels of resistance or tolerance. Such diseases and parasites should therefore be recorded if possible. Information may be available from previous studies. It may also be possible to obtain timelines[38] of disease history through conducting participatory exercises with livestock keepers or other local informants.

Occurrence of disease is categorized as:

- eradicated from this production environment (but was formerly present)
- rare – outbreaks occur on average less than or once in an animal's lifetime
- frequent – outbreaks occur on average more than once in an animal's lifetime
- ever present in the production environment
- emerging – new in the production environment.

Ectoparasites: are parasites that live on the exterior parts of the body of the host.

Endoparasites: are parasites that spend some part of their life cycle inside the body of the host.

Occurrence of endoparasites and ectoparasites is categorized as:

- eradicated from this production environment (but were formerly present)
- ever present in the production environment
- seasonal – regularly present over specific period(s) of the year
- occasional – sometimes present without clear seasonal pattern
- emerging – new in the production environment.

Nutritional toxins: are substances found in feeds or water that are known to cause physiological disorders in livestock and may be lethal.

Predators: are animals that consume other animals (the prey). Typically, the predator catches, kills and eats its prey.

Terms related to the management environment

Livestock production systems: are classified in terms of their relation to land, integration with crops, and the mode of production.

- **grassland-based systems:** are those in which the animals obtain a large proportion of their forage intake by grazing natural or sown pastures.
    - **ranching systems:** are grassland-based systems in which livestock is kept on privately owned rangeland.
    - **pastoralist systems:** are grassland-based systems in which the livestock keepers move with their herds or flocks in an opportunistic way on communal land to find feed and water for their animals (either from or not from a fixed home base).

[38] FAO. 2000. *Manual on participatory epidemiology – method for the collection of action-oriented epidemiological intelligence,* by J.C. Mariner and R. Paskin. Animal Health Manual No. 10. Rome (available at http://www.fao.org/docrep/003/X8833E/x8833e00.htm).

- **mixed systems:** are those in which livestock keeping is integrated with other agricultural activities, together forming a whole.
  - **crop–livestock systems:** are those in which livestock production is integrated with crop production.
  - **agropastoralist systems:** are livestock-oriented systems that involve some crop production in addition to keeping grazing livestock on rangelands; they may involve migration with the livestock away from the cropland for part of the year; in some areas, agropastoral systems emerged from pastoral systems.
  - **agroforestry–livestock systems:** are those in which livestock production is integrated with the production of trees and shrubs.
- **landless systems:** livestock production is separated from the land where the feed given to the animals is produced.
  - **industrial systems:** are large-scale landless production systems in which the production environment is highly controlled by management interventions.
  - **backyard/scavenger systems:** are small-scale landless production systems in which the animals are kept in backyards and fed on household waste and/or other feeds, or fend for themselves with little feeding from their keepers.

Level of confinement: refers to whether or not, and for what periods, animals are confined. Confinement may refer to housing, confinement out of doors in a pen or cage, or a combination of indoor and outdoor confinement (e.g. a pen or cage with access to a shelter); it refers to situations in which the animals are largely protected from predators that are present in the local area, and the animals can be easily accessed for management purposes. When animals are unconfined, they may be more able to express their instinctive behaviours.

Housing: is classified either as completely climate controlled or not completely climate controlled.

- **Completely climate controlled:** refers to situations in which animals are kept within buildings where all significant aspects of the climate to which the animals are exposed (including lighting) are fully controlled by humans.
- **Not completely climate controlled:** refers to situations in which animals are kept within buildings that provide protection from adverse aspects of the local climate but do not provide complete climate control.

Cooling facilities: refers to equipment used to keep animals cool (e.g. water sprays).

Vaccination: the administration of antigenic material to induce immunity to a disease.

- **Regular vaccination:** refers to a vaccination schedule that meets veterinary recommendations for disease prevention (in terms of frequency and coverage in the herd or flock, etc.).
- **Occasional vaccination:** refers to situations in which some vaccination is applied, but where animals are unlikely to be adequately protected from the disease at all times.

Preventive vector or ectoparasite control: refers to measures taken to kill ectoparasites or disease vectors (e.g. application of insecticides or acaricides by dipping, spraying, as pour-ons or by hand).

- **Regular ectoparasite or vector control:** refers to situations in which control measures are applied according to a schedule that removes or minimizes the harmful effects of the parasites or vectors.

- **Occasional ectoparasite of vector control:** refers to situations in which some control measures are applied, but animals are unlikely to be adequately protected from the harmful effects of the ectoparasites or vectors.

Preventive endoparasite control: refers to the use of veterinary drugs as a preventive measure against endoparasites (e.g. a programme of dosing with anthelmintics).

- **Regular endoparasite control:** refers to situations in which control measures are applied according to a schedule that removes or minimizes the harmful effects of the endoparasites.
- **Occasional endoparasite control:** refers to situations in which some endoparasite control measures are applied, but animals are unlikely to be adequately protected from the harmful effects of the endoparasites.

Veterinary treatment: refers to the use of drugs or other interventions, as appropriate, to cure animals when they are sick.

- **Veterinary treatment "whenever needed":** refers to situations in which sick animals always, or usually, receive the appropriate veterinary treatment (such as might be recommended by a competent veterinarian familiar with the production system).
- **Occasional veterinary treatment:** refers to situations in which sick animals only sometimes receive appropriate veterinary treatment.

Traditional treatment: application of treatments based on indigenous knowledge to control or reduce the spread of diseases and parasites and/or their effects on animal production.

Drinking water access: refers to the amount of drinking water available to livestock.

High levels of salt: refers to the presence of salt in the water at concentrations that would normally adversely affect the health or performance of animals of the species in question.

Feed availability (quantity and quality): refers to the extent to which the available feed (grazed/browsed vegetation and feed provided by the livestock keeper) can meet the animals' nutritional needs. Both quantity and quality of the feed need to be taken into consideration when answering this question – nutritional insufficiency, may be the result of insufficient quantity, poor quality or a combination of both. The objective of this question is to obtain a general overview of the nutritional status of the animals (whether they face continuous or seasonal nutritional stresses, or are well fed all year round).

Feed type, proportion and seasonality: refers to the main components of the animals' diets (see list), their approximate proportions (on a dry-matter basis) and how this varies between the seasons of the year.

Concentrates: are feeds that contain a high density of nutrients; they are usually low in crude fibre content (less than 18 percent of dry matter) and high in total digestible nutrients. Concentrates may be high in energy – "energy concentrates" such as cereals and milling by-products – or high in protein (over 20 percent crude protein), referred to as "protein concentrates"[39].

---

[39] *Source:* Hendy, C.R.C., Kleih, U., Crawshaw, R. & Phillips, M. 1995. *Interactions between livestock production systems and the environment – impact domain: concentrate feed demand. Livestock and the environment finding a balance.* Chatham, UK, Natural Resources Institute (available at http://www.fao.org/WAIRDOCS/LEAD/X6123E/x6123e00.htm#Contents).

Industrial by-products with low nutrient density: are by-products of processing industries that have low nutrient density and therefore cannot be described as concentrates, i.e. those with high crude fibre contents (over 18 percent of dry matter) and low crude protein contents (less than 20 percent). Note that many industrial by-products fed to animals qualify as concentrates according to these definitions.

Forages: are edible parts of plants, other than separated grain, that can serve as feed for grazing and/or browsing animals or that can be harvested for feeding in fresh or conserved condition (e.g. hay, silage).

Mineral supplements: are used to complement diets which are otherwise deficient in minerals.

Vitamins or trace elements: supplements used to complement diets that are otherwise deficient in vitamins or trace elements.

Mating season: the period of the year in which females are impregnated.

Uncontrolled mating: is haphazard mating with no regard to the genetic makeup (genotype) of the individuals.

Controlled mating: is planned mating that takes the genetic makeup (genotype) of the individuals into consideration.

Hand mating: is mating in which the female is detected to be in oestrus and is then hand held while she is mated or is let into a paddock or pen with a male, where she is the only female. Mating is observed and can be guaranteed to have occurred. It also allows accurate recording of the day of mating and the genetics of the animals involved – in contrast to pen mating.

Pen mating: is a form of mating in which a group of females is placed in a pen with one male for mating. Not all females may be bred and the day of mating may not be known (cf. hand mating).

Artificial insemination: is the process by which sperm is placed into a female's uterus (intrauterine), or cervix (intracervical) using artificial means and with the intention of impregnating the female, rather than by natural sexual intercourse.

Embryo transfer: is the process whereby one or several embryos are placed into the uterus of the female with the intent to establish a pregnancy.

Terms related to the socio-economic characteristics of the production environment

Market orientation for animals and products: is expressed as proportion of the value of production (live animals and products) that is marketed rather than used for subsistence:

- Fully market oriented >90 percent
- Mixed market/subsistence orientation 10–90 percent
- Subsistence oriented <10 percent

Markets targeted: are the main markets that the producers of the breed population generally target when they sell the animals or their products.

International markets: operate on a worldwide scale and demand uniform products of guaranteed quality.

Regional markets: refers to a specific geographic region of the world that has specific demands. There are formal regional markets that demand uniform products of guaranteed product quality, but there may also be informal markets that accept less uniform products where product quality is not always guaranteed.

National markets: operate within the national boundaries of a specific country and generally demand uniform products of guaranteed quality.

Local markets: operate at subnational level within a specific country. Generally, they do not have such high demands for product uniformity as national markets, and product quality is not always guaranteed. Local markets may be formal or informal markets.

Niche markets: are targetable subsets of a market sector. They can be thought of as a narrowly defined group of potential customers. Because of the benefits of specialization and focusing on identifiable market segments, niche-market ventures may be profitable even though they are by nature small relative to the mainstream market. A niche market may be a subset of a local, national, regional or international market.

Gender aspects: Considering gender aspects and obtaining data that are disaggregated by gender provides a better understanding of the economic, social and political differences that exist between men and women; informs efforts to overcome disparities between men's and women's participation in the development process; allows for the planning of development programmes that take the specific situation of both sexes into account; and helps to create an enabling environment for the sustainable development of the country as a whole. In certain socio-economic environments, men and women are differently involved in livestock-related work and decision-taking. In some cultures, work may be done by children. Gender groups may take different decisions and do the work differently. Such differences might influence the adaptedness and performance of the breed population. It is also important that they are adequately accounted for when planning AnGR management activities or livestock development more broadly.

The major areas of decision-taking relevant for animal production are: scale of operation, intensity of production, sales/purchases, markets targeted, and breeding objectives. The major areas of livestock-related work are: feeding, watering, herding, cleaning, health management, reproductive management, harvesting products and marketing products and animals.

Scale of operation: refers to the decision as to the size of the household's herd or flock (in so far as this can be determined by the livestock keepers).

Intensity of production: refers to decisions as to the type and quantity of external and internal inputs, including labour and land, used for the herd or flock.

Sales/purchases: refers to decisions as to when and which animals are purchased or sold.

Markets targeted: refers to decisions as to which markets to target with animal products and services (e.g. niche vs. mass markets; local vs. national vs. regional vs. international markets; seasonal vs. year-round markets).

Breeding objectives: refers to decisions as to which traits the livestock keepers want to improve, maintain or introduce in their herds or flocks.

Watering: work required to provide water for the animals to drink (note that herding the animals to a watering point is included under "herding").

Herding: taking the animals to a grazing area or watering point, guarding them if necessary, and moving them as and when required.

Cleaning: cleaning the shed, pen, cage or the animals themselves.

Health management: all activities that maintain or improve animal health (other than basic feeding, watering and cleaning).

Reproductive management: all activities that control reproduction (e.g. castration, mating, insemination).

Harvesting products: all activities undertaken to extract, collect or take-off animal products (e.g. egg collection, milking, shearing).

Marketing products and animals: all activities involved in the sale of animals or animal products to an intermediary or consumer.

FAO ANIMAL PRODUCTION AND HEALTH GUIDELINES

1. Collection of entomological baseline data for tsetse area-wide integrated pest management programmes, 2009 (E)
2. Preparation of national strategies and action plans for animal genetic resources, 2009 (E, F, S, R, C**)
3. Breeding strategies for sustainable management of animal genetic resources, 2010 (E, F, S, R, Ar)
4. A value chain approach to animal diseases risk management – Technical foundations and practical framework for field application, 2011 (E)
5. Guidelines for the preparation of livestock sector reviews, 2011 (E)
6. Developing the institutional framework for the management of animal genetic resources, 2011 (E, F, S)
7. Surveying and monitoring of animal genetic resources, 2011 (E, F, S)
8. Guide to good dairy farming practice, 2011 (E, S, R*, AR*)
9. Molecular genetic characterization of animal genetic resources, 2011 (E)
10. Designing and implementing livestock value chain studies, 2012 (E)
11. Phenotypic characterization of animal genetic resources, 2012 (E)

Availability: April 2012

Ar	–	Arabic	Multil	–	Multilingual
C	–	Chinese	*		Out of print
E	–	English	**		In preparation
F	–	French	e		E-publication
S	–	Spanish			
R	–	Russian			

The *FAO Animal Production and Health Guidelines* are available through the authorized FAO Sales Agents or directly from Sales and Marketing Group, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.

Find more publications at
http://www.fao.org/ag/againfo/resources/en/publications.html

The *Global Plan of Action for Animal Genetic Resources*, adopted in 2007, is the first internationally agreed framework for the management of biodiversity in the livestock sector. It calls for the development of technical guidelines to support countries in their implementation efforts. Guidelines on the *Preparation of national strategies and action plans for animal genetic resources* were published by FAO in 2009 and are being complemented by a series of guideline publications addressing specific technical subjects.

These guidelines on *Phenotypic characterization of animal genetic resources* address Strategic Priority Area 1 of the *Global Plan of Action* – "Characterization, inventory and monitoring of trends and associated risks". They complement, in particular, the guidelines on molecular genetic characterization and on surveying and monitoring of animal genetic resources. They have been endorsed by the Commission on Genetic Resources for Food and Agriculture.

The guidelines offer advice on how to conduct a well-targeted and cost-effective phenotypic characterization study that contributes to the improvement of animal genetic resources management in the context of country-level implementation of the *Global Plan of Action*. An overview of the concepts and approaches that underpin phenotypic characterization is followed by practical guidance on planning and implementing field work, data management and data analysis. The annexes include generic data collection formats for phenotypic characterization of major livestock species, as well as a framework for recording data on breeds' production environments.

ISBN 978-92-5-107199-1 ISSN 1810-0708

9 789251 071991

I2686E/1/03.12