THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Section 3 - ICAR Guidelines for Beef Cattle Production Recording

Section 3 – Beef Cattle

Version March, 2018

Network. Guidelines. Certification.

Table of Contents

Change Summary

Date of Change	Nature of Change
July 2017	Reformated using new template.
July 2017	Table of contents added.
July 2017	Heading numbers and heading text edited for clarity and removal of redundant text.
August 2017	Stopped Track change sand accepted all previous changes.
August 2017	Moved the file to the new template (v2017_08_29).
August 2017	Version updated to August, 2017.
September 2017	Version updated to September, 2017.

September 2017	Fix link to OMIA website and add examples of non-heritable genetic defects.
September 2017	Remove blank page 67.
March 2018	Correct units for growth rates in section 3.5.9 page 34 and 35 to grams per day in two places.
Feb 2020	Formula on page 33 corrected from $WR = \{[(W_t - W_B)/ A_t]*(AR - A_t)]\} + W_t$ to $WR = \{[(W_t - W_B)/ A_t]*(AR - A_t)]\} - W_t$
Jan 2021	Formula on page 33 corrected from $RW = \{[(W_{t-2} - W_{t-1})/(A_{t-2} - A_{t-1})]*(A_{t-1} -RA)\} - W_{t-1}$ to $RW = \{[(W_{t-2} - W_{t-1})/(A_{t-2} - A_{t-1})]*(A_{t-1} -RA)\} - W_{t-1}$

1 Introduction

Beef recording is a basic tool for herd management as well as for genetic evaluation and breeding. It aim is to collect information about economically relevant traits that show genetic variation and that are used for the calculation of genetic proofs.

1.1 Objectives

As shown in the ICAR survey of 2001, many countries have been involved in beef recording for decades and independently developed national approaches of their own. As a consequence, a huge diversity of national recording schemes can now be observed at present. In view of this background the present guideline aim to provide:

a. A common understanding of beef recording schemes that enables producers and breeders to communicate efficiently across countries.

b. Global standards in beef recording.

c. Advice and help for the establishment of new national beef recording schemes.

d. A solid data interface for genetic evaluation of beef characteristics.

e. For the improvement in the reliability of genetic proofs, by implementing appropriate data structures.

f. For the improvement in the accuracy of genetic proofs, by the identification and recording of the important non-genetic effects.

g. For the establishment of an international data dictionary for beef cattle which allows for efficient national and international data exchange.

h. Assistance to recording and breeding organizations involved in genetic evaluation programmes.

i. A reliable code of practice.

1.2 Scope

The present guideline aims to provide guidelines for the relevant matters which must be undertaken in the routine execution of beef recording schemes.

Beef production is predominantly based on specialised beef breeds that use natural mating, the rearing of calves by their mothers and the finishing of the young animals in specialized finishing units. On the other hand, dual purpose and dairy breeds that mainly use artificial insemination and separate the young calf from the mother immediately after birth, also contribute significantly to beef production in many countries. Therefore, the present guideline aims to provide for the recording of all cattle used for meat production.

Genetic evaluation is not considered in detail in these guidelines, as this field of activity is subject to highly sophisticated approaches which are continually enhanced by teams of specialists. Standardisation would be inappropriate, as it would impede future developments.

The ICAR survey clearly indicated two main beef recording traditions. The European type approaches on the one hand and North American type approaches, as represented by the Beef Improvement Federation (BIF), on the other hand. The differences between them can in the main be traced back to substantial differences in consumer’s demand impacting the pricing system and consequently the selection objectives and also the significant differences in the production environment and in particular herd sizes.

The present guideline aims to combine recording standards of all regions in as much as this is possible. However, overall uniformity can not be fully accomplished. For example no agreement about weight standardisation in weaner calves has been achieved todate. Most European countries use a standard age of 210 days whereas 205 days are applied in North America. Differences such as this should not be viewed as failures in developing international standards. It matters little when weaner calf weights are recorded or to what age they are adjusted, as long as all of the pertinent information is furnished, such as weight, date of recording and contemporary group information.

Documenting differences enables the person interpreting data to see that “weaning weight” from different sources may not mean the same thing, but with the appropriate information it may be possible for the values to be adjusted and used to compute a meaningful comparison or evaluation.

The guideline recommends basic procedures. However, there will be situations where national organizations will develop more refined procedures that are more suitable for their members. Furthermore there might be national or legal restrictions in the use of proposed or recommended units of measurements (e.g. non use of metric units) thus preventing a body from using uniform international standards.

2 General

2.1 Applied beef recording schemes

Beef recording requires recording schemes that can accommodate beef production as implemented in practice. The recording procedures must account for all important effects including the existence of genotype by environment interactions. Beef recording may be undertaken in:

a. Breeding farms.

b. Finishing farms.

c. Individual test stations.

d. Progeny test stations.

e. Abattoirs.

In accordance with existing ICAR terminology recording methods “A”, “B” and “C” may be used to describe the following methods of recording.

a. The A method means recording done by a technician.

b. The B method means recording done by the farmer.

c. The C method means recording done by a mixed system of recording by farmers and technicians.

2.2 Factors to be considered

The following factors should be considered as basic requirements in beef recording:

a. A contemporary group may comprise of animals of the same breed, sex and age range kept under the same or at least similar management conditions. Its definition should be carefully established.

b. Tests on animals should be organised in such a way that maximum information can be obtained. This particularly relates to the composition of contemporary groups. This applies especially in relation to the degree of relationship within the contemporary group. The contemporary group animals should be as unrelated as is practically possible.

c. The animals must be identified permanently by a unique number that is always retained with all individual records or documents relating to the animal.

d. Invariant or permanent animal data and further basic information on the animal should be stored in a centralised database. All performance data on an animal should be verified and correct on loading to the database.

e. National cattle databases used to identify, register and monitor birth, movements and the death of animals should be used in the beef recording schemes as far as this is possible.

f. All personnel charged with data collection duties must understand the need for accurate and dated records, which should also include the identification of the recorder. Data may be collected by farm personnel or trained technicians depending on the trait. Complex traits such as conformation assessment using a linear scale or ultrasound measures of fat and muscle must be collected by trained personnel that undergo routine evaluation and retraining procedures when necessary.

g. Data verification systems must be in place which undertake thorough record checks and identify and reject inconsistent or unacceptable data.

h. The contemporary group should include the progeny of at least two sires.

2.3 Principles of beef data recording

It is essential that some basic principles should be taken into account in beef recording practices to improve recording efficiency, data storage, data exchange and usability of the animal's performance data.

Throughout the whole recording process, there are four essential key pieces of information which should be included in any animal's data record:

a. Identification number of the animal.

b. Date of recording.

c. Identification number of the location (farm, station).

d. Identification number of the recorder (recording person).

It is desirable therefore for practical reasons to allocate standardized unique identification codes or numbers not only to the animal but also to locations (holding ID) and to recording personnel. The animal's holding identification together with recorder identification provides information which allows for the correction for environmental effects and therefore is needed for statistical analysis and genetic evaluation. Furthermore the information in respect of the recorder (recording technician) allows for identification of recording methods (A = recording by official technicians; B = recording by the keeper; C = mixed systems), in accordance with the general ICAR standards.

In general, details relating to an animal can be categorised into four different types as follows.

2.3.1 Invariable data

There are 3 groups of invariable data:

2.3.1.1 Invariant animal data

This includes all data that are specific to an animal, are available at the birth of the animal and do not change during its lifetime. This set of data comprises at least:

a. The ID no.

b. Birth date.

c. Birth location.

d. Birth type (single, twins, triplets etc.).

e. If the animal is an identical twin or a clone, the ID no(s) of the other genetically identical animal(s).

f. Sex.

g. The breed or breed composition.

h. The ID no. of the animal's genetic parents.

i. Information in respect of embryo transfer if applicable.

j. ID number of recipient dam in case of embryo transfer.

k. Information in respect of fostering if applicable.

l. ID no. of foster mother case of fostering

2.3.1.2 Invariant location data

All holdings should have a permanent unique ID to identify correctly fixed effects in genetic evaluation and to study the evolution of these fixed effects (specially herd effects) over time. Furthermore this fixed location ID allows for tracing the origin and later locations of the animal as it moves through the whole production chain.

2.3.1.3 Invariant recording personnel data

Many records are influenced by an operator or recorder effect. This applies not only for subjective assessments such as linear scoring but also to some degree to measured traits like weights, as the accuracy of the recording and other individual influences differ significantly between recording persons. Therefore, in the case of data recorded by technicians, the operator's ID number should be included in each record.

2.3.2 Life history data

This class of animal data includes information on the status of the animal (alive or dead, suckling or weaned etc.) and the farm or management conditions the animal is kept in. These data are time-critical in that, for a given animal and a given date, it should be possible to retrieve all relevant information pertaining to management condition, reproduction status etc.

There are two main areas of information that have to be collected and permanently updated in this class of data.

2.3.3 Physical location of the animal

Many animals change location during their lifetime. Records may start in the birth herd, continue in a finishing herd or test station and then be completed in an abattoir. The date of arrival and date of departure from each establishment must be recorded so that data collected during each period can be verified if necessary from the recording herd.

The identity of an animal must not change between locations. The original identification must be checked before it leaves one location for the next and then checked again on arrival.

The standard format for recording a change of location or status may include the following:

a. Animal ID.
b. Date of change of status/location.
c. Recording person.
d. Current location: farm ID (management-group within farm if applicable).
e. New location: farm ID (management-group within farm if applicable).
f. Range of codes to describe such events as weighed, weaned, died, sold for breeding, sold for slaughter etc.

Animal movements from one herd to another or between management groups within herd, should be recorded as soon as possible.

2.3.4 Reproductive status of the animal

The reproductive status describes the standing of the animal in respect of its breeding cycle/status. It includes such events as mating, insemination, embryo transfer and birth/calving for females, and castration for males. If females are kept with one or several bulls during the mating period, then all possible mates in the mating time window should be recorded. Where natural service is used, then the dates of introduction and withdrawal of sires should be recorded.

The relevant data can also be collected in a standardized format:

a. Animal ID.
b. Date.
c. Recording person.
d. Actual location: farm ID (management-group within farm if applicable).
e. Code to describe the reproductive event.
f. ID of other animal(s) involved (e.g. mating partner, calf, foster calf etc.; if applicable).

Having these two types of data of an animal's life history, it should be possible to access all relevant information for the calculation of and statistical analysis of performance data.

2.3.5 Recorded data

Recorded data are those details directly recorded on an animal or animal group. It includes both objective measures and subjective assessments.

A number of general principles apply in respect of this data.

a. Provided there is no conflict to legal national units of measurement the data should be recorded in metric units (meters or centimetres, kilogram).

b. All recorded data should be stored as raw data without any adjustment or transformation.

c. Recorded data should include information about all known non-genetic effects and circumstances affecting the level of recorded performance.

It should be noted that a 'recorded trait' should strictly be the actual measurement, count or subjective score. If a trait. has to be standardized for a given age or for environmental factors, the resulting adjusted weight is a calculated or derived trait. Adjusted weight may be a function of the recorded weight and age derived from the weighing date and the birth date. Thus, 'weight' is a recorded trait, whereas 'weight at 200 days' is a calculated or derived trait. In principle, 4 different types of data records can arise.

2.3.5.1 Objective measurements

Measurements like weights, heights etc. which are assessed with the use of some technical equipment. These measurements, if recorded properly have a high degree of accuracy and are relatively easy to standardize if the definition is clear. However, it should be mentioned that some recording device (e.g. ultrasound measurements) needs careful training and supervision of the operator as otherwise the accuracy of measurement is not guaranteed.

2.3.5.2 Date /Time

It is strongly recommended that for recording purposes, the recording date should be used rather than the animal's age. The reason is, that additional information is required to derive the age of an animal, and this may lead to erroneous recordings, arising from different formats (age in years, months, or days) or just deficient or inaccurate information which can subsequently be corrected.

The recording date allows for the calculation of age when combined with the birth date. The birth date should be recorded in the database for every animal.

The date of recording also provides information on the month or season in which the recording has been undertaken in. This information may be useful for the further interpretation or statistical/genetic analyses of the recorded data.

Where date of data collection is recorded then the date should be stored as an 8-digit number using the format

- YYYYMMDD.

For most performance traits the date of data collection is sufficient information, the time not normally being necessary unless needed for management reasons. However, where recording time is collected then the 24-hour clock should be used. The time should be stored as an 6-digit number using the format

- hhmmss.

2.3.5.3 Nominal classification

This occurs where observations are recorded in discrete, unordered classes, like breed or reason for disposal. Well defined and comprehensive categories are required to gain as much information as possible. The classes should be mutually exclusive, i.e. no overlapping of classes should occur. There may be a need for an additional open class for all cases, that cannot be attributed to one of the defined classes. This class should be as small as possible and should include a brief description in order to facilitate the creation of additional classes if necessary.

2.3.5.4 Subjective scores

This type of recording classifies animals, using a finite ordinal scale, into one of a number of possible classes. Often the classes are an ordered sequence of numeric scores, where the lowest and the highest numbers represent extreme phenotypes expressed in the population under consideration.

It is desirable that descriptions of the different classes be provided in text and where appropriate as pictures/drawings.

As outlined later, the main problem with subjective scores is to ensure that values are comparable, even if they are assessed by different persons or by the same person at different points of time and at different locations. This requires clear definitions, ongoing and systematic training as well as the permanent supervision of the recording process. It is essential that periodic verification of the aptitude of the recording technicians be undertaken.

Regardless of the type of recorded trait, it is possible to use a standard format:

a. Animal ID (or group of animals if applicable).
b. Date of recording.
c. Recording person.
d. Actual location: farm ID (management-group within farm if applicable).
e. Trait name/trait code.
f. Trait value.
g. Additional information pertaining to the animal.
h. Additional information pertaining to the recording procedure.

It is essential, that for all recorded traits in a given recording scheme, the trait be sufficiently well defined. Additionally unique two or three letter trait codes may be specified (e.g. one code for "shoulder width", another code for "roundness of thighs" etc.) where it is not practical to use the full name. It is strongly recommended to use trait definitions and/or trait codes in accordance with international standards where available from an international breed umbrella organisation.

2.3.6 Calculated traits

This type of trait is different from the other categories, as calculated traits are derived from the 'raw' data information. These traits are calculated according to clearly defined rules. Where the calculated trait requires complex computing procedures or is frequently used, the results may be stored rather than re-calculated each time.

In general, calculated traits may be divided into three different classes of traits.

2.3.6.1 Counts

This category include summarized information from recordings such as the number of inseminations or matings per mating period, the number of calves born and the number of ticks observed per unit area.

2.3.6.2 Adjusted or derived traits

Raw data will often have to be adjusted to a defined age, weight, or length of testing period, to comply with the defined standard. If, for example, the weight at 365 days is defined as a standard beef trait, but an animal which is born on March 1, 2000 is weighed on March 15, 2001, the recorded weight is taken at 380 days. Therefore, it has to be adjusted to the standard age by using a linear or other adjustment procedure.

For these classes of traits it makes sense to use a similar data format as for the unadjusted recorded trait. Distinct trait codes should be used in order to avoid confusion. Information that already has been accounted for in any adjusting procedure is omitted.

2.3.6.3 Functions of several recorded traits

A number of interesting performance traits are derived from a combination of recorded traits. Daily gain in the test period for example is the difference between weight at end and weight at start of the test period, divided by the difference of age at end and age at start of test period, expressed as grams per day. This type of data can be derived both from raw recorded data and from adjusted traits.

With these kind of traits, one often has several overlapping additional pieces of information. For example combined traits are recorded by different recorders, at different dates, and at different locations. Combined traits therefore should be defined to be largely independent of this type of additional information. A daily gain in a test period should pertain to a standardized test length.

The trait definitions given in the following section will specify which additional information is needed in detail.

The resulting general data format for calculated traits may be as follows:

a. Animal ID (or group of animals if applicable).
b. Date of recording (start/end of test period etc.).
c. Age of animal.
d. Relevant location.
e. Trait code of calculated trait – where applicable.
f. Value of calculated trait.
g. Additional information pertaining to the animal (e.g. contemporary group).

Note that in this case the age (as a calculated trait) is included, while for recording purposes, it is strongly recommended to record actual dates of events.

2.3.7 Genetic proofs and other population-related indices

This type of data applies, if an animal's performance is related to the performance of other animals in the same population. Genetic evaluation includes trait information (raw or adjusted), pedigree information, classification of fixed environmental effects and covariables etc. Typically such analyses are done for all animals of a population simultaneously.

Results of genetic proofs are by definition independent of any environmental factors, but values may change over time. Therefore they should be stored with the animal's identification number, the date of estimation together with a definition of the reference base used in the particular genetic evaluation.

2.3.8 Data requirements for the calculation of genetic proofs

In most cases the required data formats for trait information, fixed and random effects and pedigree information are clearly defined in the genetic evaluation system. The data file should be provided in a standard format. Where raw data is subjected to ongoing maintenance which allows for changes of historical data (e.g. change of parentage, fixed effects etc.), submitted data for genetic evaluation should include all animals of the relevant population rather than just a subset of new or recently recorded animals.

Data for the calculation of genetic proofs should comprehensively account for management conditions and other non-genetic effects affecting the animal's performance. Much attention should be paid in the definition of contemporary groups held under similar management conditions. However, the definition of contemporary groups frequently will be a compromise between a precise specification of the group with possibly loss of contemporaries on the one hand and a wider specification with loss of information accounting for fixed effects.

Usually the pedigree file is a separate file containing the animal identification number and that of its parents together with breed sex and birth date. The pedigree file should contain all animals contributing to the genetic structure of the breeding population. Where pedigree data originates from separate regional or historical sub-populations or separate databases, it may happen that different ID numbers and/or different names of identical animals occur. Therefore special consideration should be given to identifying and attaching unique ID numbers to the relevant animals.

There are some special situations which need to be taken into account:

a. In case of identical twinning and cloning, it is necessary to record the fact that two or more individuals are genetically identical, since on the basis of pedigree information alone (identical parent IDs), these animals would be falsely identified as full sibs.
b. In genetic evaluation systems it is common practice to include 'genetic groups' for founder animals. Animals with unknown parents are grouped according to age (year born), country of origin and/or breed composition (if more than one breed is included). Therefore, it is essential to record this data especially for older animals in the pedigree file.

2.3.9 Data storage and management

Given that genetic proofs will be used for the assessment of the production or breeding potential of an animal, it is essential that data are stored in a centralized form, which typically would be a national database, but also may be a database at the level of regions, large farms, commercial breeding companies or breed associations etc. The necessity for a database results from the fact, that performance data of different animals or the same animal at different ages might be combined to retrieve the relevant information.

Ideally, data from one 'breeding population' are stored in one database or in databases following a common structure with well established links and defined interfaces for data exchange.

The data structure should be defined in such a way, that flexible and efficient use of the relevant data for a variety of purposes is enabled. 'Structure' means both the hierarchy of different types of data and the general format, in which data should be recorded and stored.

3 Specific recommendations for data collection

3.1 Identification

3.1.1 Animals

Animal identification is outlined in detail in section 1.1. of ICAR's International Agreement on Recording Practices. The following chapter therefore only provides a brief overview on the most important aspects for identification issues. More details can be found in the relevant International Agreement.

Having decided on which performance traits are to be measured, it is then vital that a system is adopted that successfully records data relating to an individual animal and allows it to be transferred to the body responsible for genetic evaluation. The key to this success is an individual animal identification number.

The recorded animal identity must be unique to that animal. The approach taken in the EC is to have a two-character code for the country and then a numeric code for the individual that may incorporate geographic and herd information in addition to the animal number. Within Breeds Associations, a numbering system may be used allied to ear tags or tattoos. This may be in addition to the official governmental numbering system or it may be a stand alone system. Where both systems are in use then one numbering system must be agreed as the definitive identifier and used in all data collection, communications and evaluations concerning an animal.

Where an official governmental identification system is in place, it is recommended that this identification system be the primary identifier for each animal.

The internationally accepted standard for an animal identity number is a maximum of 12 digits (including a check digit where used) together with the alphabetic ISO country code if the country of origin needs to be identified. Each newly born calf must be tagged with its unique identifier as close to birth as possible. Ideally this should be within 24 hours of birth but could be up to 30 days provided some temporary measure is taken to ensure its identity is not confused with cohorts. The animal's identity number may be attached to it by, a tag, tattoo, sketch, photo, brand or electronic device. The preferred methods of attachments are those least likely to be confused or lost. Dual identification with a combination of methods or duplication of one method (for example two tags – one in each ear) are recommended for insurance.

Compared to the visible animal ID, a 3-digit ISO country code may replace the alpha country code for data storage and data transfer. In accordance with ISO 3166, the resulting number is composed of 15-digits where the first 3 digits represent the country of birth and the remaining 12 digits represent a unique number within the country of origin. Leading zeros are recommended to fill up to 12 digits.

Animals that lose their identity must be re-identified, wherever possible using their original number If doubt over the identity exists then all possible efforts should be taken to determine the true identity. The use of DNA genotyping from known (or suspected) relatives should be considered.

For the purposes of performance recording it is essential that the records of calves that are born dead or, die shortly after birth are entered in the system. This can be done without identification of the dead calf if the relevant calving is seen as an event of the appropriate dam.

Cattle that move from one country to another or become parents to offspring in another country (through AI or ET) should continue to be identified using their original identity number (and name if appropriate).

In the case of imported animals, where the number has been changed, the official records should also show the original name and number. The original name and number must be reported on Export Certificates, AI catalogues and show and sale catalogues.

The responsible organisation must maintain a data base that links the animal's identity to its performance records and its parents identities. In the case of embryo transfer the genetic parents and the surrogate dam identities should all be recorded.

3.1.2 Parentage recording

Parentage recording is outlined in detail in section 1.2. of ICAR's International Agreement on Recording Practices. Again. the following section only aims to provide a brief overview on this subject.

The identity of the animals served and the service sire must be recorded on the farm on the day of service for AI. For groups of cows bred by natural service the expected parents should be noted and confirmed or deleted at pregnancy diagnosis. The record must contain the identity numbers of the sire and dam including names where available, the breed or breed cross and the date of mating where AI is used or the natural mating was witnessed. If the mating was not witnessed a record of the period the dam and sire were kept together should be made.

To verify the parentage record the cow served and the service bull must be properly identified and exist in or be entered on to the database. The gestation length, where it can be calculated should be within +/- 6% of the average gestation length for the breed of the service sire. The service bull must be verified by an AI record or evidence that the sire was on the farm on the day of service or, in the case of ET, a declaration by the supervising Veterinary Surgeon should be available in respect of the required information.

It is recommended that all mating details be notified to the database as soon as possible after the mating event. This will provide the basic information needed to evaluate a range of fertility traits and may help to identify fertility problems early. It is recommended that the mating details should be reported at least within sixty days after the mating. This will help to minimise errors in pedigree and provide useful fertility and gestation information.

Visual inspection or DNA analysis of the progeny may be carried out to confirm parentage.

3.1.3 Farms/Herds

The data collected for specific animals must relate to the birth herd, finishing herd, test station or abattoir in which it was collected. One animal may have data from a number of sources contributing to its performance record so the source must be acknowledged. Farms and herds must be uniquely identified by the organisation responsible for the data collection. This identification may use an existing Government or nationally recognised farm identification system or may be generated specifically for the purpose of data collection.

Within farms or herds differential management of cohorts must be clearly identified. Differentiation may occur through deliberately different feeding regimes or through use of pastures with different herbage type and hence nutritional value.

The herd or farm identification codes may be formulated to include geographical location in a country. This may provide the basis for improving the design of the contemporary groups to be used.

3.2 Life history

3.2.1 Introduction

Life history refers to the full cycle of an animal's reproductive and productive herd life. There are many more breeding females and young animals destined for beef production than breeding males. Efficient beef production depends upon three component elements, female reproduction, viability and growth of the young and culled female production. In the production system, the breeding male may be regarded as an overhead.

The reproductive life of an animal is determined by age at puberty (or sexual maturity) and stayability. Age at puberty is the time at which the animal acquires the ability to reproduce offspring and stayability refers to the ability of a breeding animal to remain in the breeding herd. The definition of puberty by precise events in both the male and the female (see Annex) allows for the calculation of age at puberty. In cattle this is between 9 and 15 months of age. But age at puberty is of little practical relevance due to the difficulty to accurately determine the date of these events.

The productive life refers to the period of growth of the young and to the period of fattening of slaughter animals and culled cows.

Reproductive and productive lifetimes are influenced by a wide range of genetic, environmental, nutritional and management factors.

3.2.2 Synopsis of life history recording events

Table 3.1. Recording requirements

State	**Recording requirements [1)]**	
Calf	Conception	Outcome of a breeding, success or failure Date of the relevant breeding
	Birth	Date, identification, sex, weight [2)]
	Pre-weaning period	Date of weight, measurements [3)]
	Weaning	Date, weight, measurements
	Post Weaning period	Date of weight, measurements
	Death/Disposal	Date, reason
Breeding female	Puberty	Date
	First and Subsequent Breeding (s)	Type (AI, natural service, multiple sires) Rank of AI Sire identification Date (AI, mating, mating period) Measurements, Weight [1)]
	Calving	Date, parity Calving ease, Measurements [2)], Weight
	Death/Disposal	Date, Reason

State	Recording requirements [1]	
Breeding male	Puberty	Date
	Mating/Semen collection	Date, Measurements, Weight, Semen characteristics
	Death/Disposal	Date, Reason
Slaughter animal	Finishing	Date (Start/Finish) Measurements, Weights
	Slaughter	Date, Carcass, Measurements, Weight; Meat quality measurements

[1] The location where each of these events occurs should always be recorded according to the rules given in the section relating to physical location of the animal. Herd identification and slaughter identification are at stake.

[2] Weight means live weight or carcass weight.

[3] Measurement refers to any body measurement on the live animal or carcass measurement.

3.3 Reproduction and fertility of male and females

3.3.1 Introduction

Fertility is the most important economic trait in beef cattle. The recording and use of reproductive traits are of major importance in beef cattle breeding because they are directly connected with the birth of animals and the cycle in which animals are born. Environmental effects have a significant impact on reproductive performances, for example season of breeding and diseases. Fertility also can be influenced by management, for example, grouping of calvings and the ability of the breeder to detect oestrus and the system of production. Management treatments which increase the growth rate in growing animals or the production levels in high production cows can also greatly influence fertility.

Some reproductive traits are simple attributes of an individual animal (i.e. age at puberty, gametes production) and others are complex traits because they are related to reproductive peculiarities of the female, the male and the embryo or foetus (i.e. conception, production of a developing embryo).

Basically, most male and female reproduction traits are physiological traits recorded on the animal (sperm production in bulls and oestrus or pregnancy in females) and calculated traits from life history records as for instance dates and outcome of breeding.

Calculated traits from recorded life history information provide ages at various stages of the reproductive cycle and facilitate the calculation of time intervals between various reproductive stages. This information also facilitates the calculation of conception rates.

3.3.2 Male reproduction

Male reproductive performances can be assessed by traits measured on the male itself (semen production and libido) or by the outcome of breeding recorded in mates (conception rate). Moreover, AI bulls also can be genetically evaluated for any sex-limited fertility traits recorded on their female’s relatives (e.g. age at calving, calving interval).

With AI bulls all that is required is a source of fertile sperm and with natural service bulls, libido and mating ability are most important.

Furthermore, some experiments show that male reproductive traits are genetically related to female reproduction and to body growth. For example, testis size is related to age at puberty and ovulation rate of female's to body weight in the male.

3.3.2.1 Semen production

After collection, semen can be examined generally and microscopically and quantity and quality assessed by measuring or by scoring several criteria. These examinations include the volume of ejaculate, the spermatozoa concentration, the proportion of live spermatozoa, the sperm percent forward motility, the proportion of spermatozoa with morphological abnormalities and the semen freezeability. Procedures for semen evaluation have been developed by the Society of Theriogenology (www.therio.org). Semen examination can facilitate the calculation of age at puberty. After semen processing, the number of straws produced in a specified period can assess the bull's fecundity.

Moreover, it has been established that total sperm cells production, testicular size and scrotal circumference (SC) are highly correlated in young bulls. Therefore, SC can be used as an indicator of the sperm producing capacity of a bull until about 5 years of age. SC varies with the bred, size and age of the bull. Yearling bulls of different breeds have SC of about 30-36 cm.

Recording Scrotal Circumference

a. Recorded Scrotal Circumference
b. The Scrotal Circumference (cm) should be taken at the largest diameter of the scrotum with a flexible tape placed around the scrotum after both testicles has been positioned beside each other in the scrotum.
c. Calculated yearling Scrotal Circumference

   Adjustment should be done by breed for age or weight.

   Adjusted 365 days SC = actual SC + (365 – days of age) x breed adjustment factor.

3.3.2.2 Sexual behaviour

The male reproductive behaviour is of particular importance in natural service, but the hereditary component of these traits should not be disregarded in AI.

a. Recorded behaviour traits
b. Libido or sex drive: defined as the "willingness and eagerness" of a bull to attempt to mount and service of a female. A libido score system has been developed to assess both sex drive and mating ability (Chenoweth, 1981)
c. Mating ability: the physical ability of bull to complete service
d. Serving capacity: a measure of the number of services achieved by a bull under stipulated conditions and thus includes aspects of both libido and mating ability (Blockey, 1976, 1981).

3.3.2.3 Calculated conception rates/breeding index

The conception rate and breeding index are calculated from the outcome of a single breeding, i.e. whether a female conceives (code=1) or not (code=0) or whether a zygote develops into an embryo or not. The outcome of a single breeding can be assessed at different times of the gestation cycle according to the methods of pregnancy diagnosis applied.

When recorded on female mates, conception rate may be a practical measure of the fertilizing ability of the sperm cells and as such can be regarded as a fertility trait of the service bull.

To avoid dependencies or complications associated with successive inseminations (variation in cow fertility owing to the rank of oestrus, use of fertile bulls or natural mating for the second and latter mating, varying payment systems related to repeated AI services) only the first inseminations should be used as valid records.

Recorded traits

a. Breeding index: number of matings / conception, gestation or calving.

b. It is of practical use only when the same (only one) bull is used to breed each cow and to obtain a conception, gestation or calving.

c. Conception rate after first breeding: proportion of cows, a bull had been mated to or inseminated with one bulls semen, which conceived or was pregnant at a defined stage of gestation or subsequently calved (calving rate).

3.3.2.4 Calculated non-return rates (NRR)

Non-return rate (NRR) is a particular expression of conception rate mainly used in AI industry. NRR is based on the observation that a bred/mated cow has not returned for another service within a defined number of days. In order to facilitate the understanding of the NRR and to facilitate the harmonization of calculations between countries, ICAR recommended a precise description for the expression of NRR.

The real value of the non-return rates is to the artificial insemination industry since they can be calculated on a large number of inseminations.

In AI, non-return rates are usually calculated as an index of the fertility of the bulls and the efficiency of the inseminators. These indices are based on the assumption that a cow is pregnant to first insemination if she has not been submitted for a second insemination within a specified interval.

Non-return rate generally overestimate the calving rate due to loss of cows from the herd (sale, death), to embryonic or foetal loss, to failure to detect any subsequent heat and also returns to service that occur later than the specified interval. Furthermore, in some cases up to 10% of pregnant cows may show signs of behavioural oestrus.

Refer to Section 6 of the ICAR Guidelines for the expression on non-return rates for the purposes of AI organisations.

Non-return rate after first insemination (NRR) is the proportion of cows inseminated for the first time during a given period of time (such as a month) that have not been recorded as having returned for another service within a specified number of days, and so are presumed pregnant.

Only first inseminations should be considered. This means that first insemination to breed a heifer or first insemination to breed a cow after the end of each pregnancy should only be used

The interval within which the cows are observed for return after insemination should be specified (e.g. 56 day NRR).

The females with short returns only, can be considered either as non-returned females and are as such considered pregnant (included in the calculation) or alternatively as non-inseminated females (and excluded from the calculation).

As a recommendation, short returns, within 3 days after Ai, should be considered like non-inseminated females and both limits of the considered interval should be indicated (e.g. 3-56 day NRR) and these limits should be inclusive. Any other chosen option should be mentioned.

NNR Trait Details

a. The NRR related to the date of each AI
Each of n cow inseminated for the first time within a specified period is observed for return during the same interval (3-24, 18-24) after the date of each AI.

- Recommended ICAR NNR expression
Specified period' (n=): 'start of interval'-'end of interval' = day NRR

b. The 60 to 90-day NRR
The cows inseminated for the first time within a specified month are observed for return during a 90 days interval from the first day of the month of insemination. In this case, the cows inseminated the first day of the month of insemination will have 90 days in which to be recorded for a subsequent service, while those inseminated the last day of the month of insemination will have only 60 days??

c. Additional information to record

- The specific period in which cows have been inseminated.
- The number of females inseminated for the first time, (n=).
- The treatment of cows with short returns, either like non-returned and pregnant (included in the calculation) or like non-inseminated (excluded from the calculation).
- The return interval this side of which a return is considered short return, the start of interval in the expressions given above.
- The interval during which the returns for another service have been recorded after the first insemination.
- Factors which NRR have been corrected for such as parity and season.

3.3.2.5 Additional information about the male

In order to identify the reproduction and the environmental effects, which have an impact on reproductive performances of both male and female, some additional information related to the male, should be recorded. Some additional information about the mate to which the mating is made may also be pertinent to the reproductive performances of the bull (see additional information about the female).

a. The mode of fertilisation (artificial insemination with frozen or fresh semen, natural ating).

b. In case of artificial insemination

- Semen processing (e.g. dilution) in case of AI.
- Date of semen collection, collection or ejaculate identification on straws.
- AI by an inseminator or by Do It Yourself (DIY).
- Identification of the inseminator.
- AI day of the week.

- Time interval from heat detection until AI completed.

3.3.3 Female reproduction

The female reproductive performance refers not only to her capacity to produce developing embryos but also to her capacity to give birth to a live calf and to ensure a proper postnatal maternal environment for normal calf growth. Female reproductive traits include fertility traits calculated from life history dates and from the outcome of lifetime events such as breeding, pregnancy, parturition and weaning.

Furthermore, sires breeding values can be predicted from most female reproductive traits recorded on relatives.

It should be recognised that some reproductive traits depend on the farmer's arbitrary decisions such as breeding dates or culling decisions.

3.3.3.1 Oestrus / Breeding / Conception / Calving dates

The recording of reproductive life history dates in respect of each cow allows for the calculation of the ages at various reproductive events and time intervals between reproductive stages.

Important events include:

a. Date of heifer first oestrus (puberty).
b. Dates of first oestrus postpartum.
c. Breeding dates:
   - Date of first breeding in heifer or dates of first breeding postpartum in cow. This date is needed to calculate NRR.
   - Date(s) of subsequent or repeated AI.
   - Dates of observed natural mating.
   - Pasture natural mating exposure dates (start and end of breeding season).
d. Fertilizing breeding date, conception date.
   If several consecutive breeding or matings occurred, the last breeding date before calving is considered as the conception date. Moreover, the last breeding identifies the putative or assumed sire of the calf. The last breeding date should be compatible with the gestation length.
e. Calving date as a trait of the female.

3.3.3.2 Calculated ages at various reproductive events

Many ways of calculating ages and intervals as measures of reproductive performances are reported. In order therefore to provide a comprehensive picture of the trait, the details of the animals involved and of the elements included in the calculation are required.

a. Age at puberty.
b. Age at first breeding (in days or months).
c. Age at first successful breeding (in days or months).
d. Age at first calving (in days or months).

e. The first calving of the animal should be checked against normal biological criteria and with reported calving number.

f. Age at nth calving (in days or months).

3.3.3.3 Calculated interval between various reproductive events

a. Calving to first oestrus postpartum interval (days), measures the precocity of postpartum oestrus cycle resumption

b. Calving to first breeding interval (days)

c. Calving to conception interval (days open), can be computed for previous breeding cycles (days)

d. Interval between services, assessment of the current breeding efficiency (days)??

e. Calving interval, the calving numbers involved should be specified, it can be computed for previous breeding cycles (days). Calving events have to be consistent with calving number.

f. Average lifetime calving interval. This is the number of days between first and last calving divided by the number of calving (days). The number of the last calving should be specified.

g. Average days to calving = days from bull in to calving when pasture natural mating exposure is practised during a breeding season

h. Gestation length. The number of days between known conception date and subsequent calving date. In case of several consecutive breeding the last one is considered to be the conception date.

3.3.3.4 Pregnancy diagnosis, recording of the result of a breeding in female

The pregnancy diagnosis allows the determination of the outcome of a mating, its success or failure can be recorded as a binary trait (pregnant = yes not pregnant = no).

a. Methods of pregnancy diagnosis:

- Observation of failure to return to oestrus in a specified return interval (e.g. between 18 and 24 days after breeding).
- Palpation of ovaries, persistence of the corpus luteum (day 18-24).
- Progesterone essay (at day 24).
- Palpation of amniotic vesicle (from day 30-65).
- Ultrasonic method to detect the embryo (from about day 20), (see Kastelic *et al.*, 1988)
- Calf birth.

b. The date of pregnancy diagnosis

3.3.3.5 Calculated conception rates or indices

Conception rate calculated from the outcome of a mating (whether a cow conceives or not), can be a measure of her capacity to ovulate and to produce a properly fertilizable ovum and her capacity to complete the implantation of the conceptus. As such, conception rate can be regarded as a fertility trait of the female. Moreover, conception is little if any influenced by the farmer because once he decided to breed a cow, success is always the desired outcome. As a female trait, conception rate can also be used to genetically evaluate sires.

Given hereafter are the basic definition of the main conception rates and indices used, but there are various ways of calculating such conception rates and indices. So it is important to define clearly the animals involved in numerator and denominator, the time or the interval at conception diagnostic from breeding date and the breeding number.

a. Female breeding index: number of matings / conception or gestation or calving. This measure of female fertility is often influenced by farmer's decisions, for example elite cows may be bred more times than other ones that are likely to be culled earlier.

b. Number of calves produced per cow and per year at herd level

The outcome of a single breeding can be assessed at different times of the gestation according to the method of pregnancy diagnosis applied. So conception rate should be calculated at a defined day or interval from the date of breeding and could be calculated at the herd or progeny group level. The breeding ranks and parities also should be recorded.

a. Conception rate: proportion of cows bred in a herd or in a progeny group, which conceived or was pregnant at a defined stage of gestation (day or interval) or which calved (calving rate).

b. Non return rate at a given interval (see guidelines from ICAR for calculations NRR in male reproduction section).

3.3.3.6 Number of calves per gestation, prolificacy

The number of calves per gestation is important in so far as it may affect calving mode, birth weight, weaning weight and growth during pre-weaning period. Moreover, in the case of suckling of both twins by the mother pre-weaning growth and maternal ability assessment also are influenced.

a. Code for number of calves: (1) single calf, (2) twins, (3) triplets or more.

b. Additional information: suckling of both twins by the mother or fostering of one calf or artificial rearing of one or both.

When prolificacy is a trait of interest, the number of embryos, foetuses or calves could be an indicator of the ovulation rate for one oestrus cycle but dizygotic twins should only be considered. Blood groups or DNA polymorphism can assess the zygotic status. Dizygotic twins are considered full sibs.

3.3.3.7 Additional information about the female

To define at best the management of reproduction and the environmental effects, which have an impact on reproductive performances of both male and female, some additional information related to the female, should be recorded. Some additional information about the male is also pertinent to the reproductive performances of the cow (see additional information about the male).

a. Time of service with respect to the onset of oestrus.

b. Mode of oestrus detection (visual, devices, teaser bulls).

c. The hormonal treatments of the dam if any (induction of oestrus).

d. The previous calving mode of the dam.

e. The postpartum pathology of the dam (metritis, retained placenta).

f. Fertility problems in the dam (anoestrus, anovulation, ovarian cysts).

g. Cow disposal for infertility / sterility in case of unsuccessful breeding.

h. Type of calf rearing (suckling calf or fostering of the calf or artificial rearing), which may affect the moment of the resumption of oestrus cycles postpartum. Suckling delays the onset of postpartum oestrus.

i. Abortion.

3.3.3.8 Mothering aptitude (see temperament/behaviour)

The maternal behaviour may affect the viability of the calf and can require fostering.

a. Production trait, the milk yield the cow produces to allow pre-weaning growth of the calf, usually assessed by the weaning weight.

b. Behavioural trait of the mother towards her calves, i.e. the way the mother takes care of her calves after birth.

3.3.3.9 Embryo transfer and ovum pickup

In some breeds, Multiple Ovulation and Egg Transfer (MOET) is used as a breeding technique or/and in selection program. Ovum Pick Up technique (OPU) is an alternative source of cattle embryos that required in vitro maturation of oocytes and their in vitro fecundation and culture to the stage of blastocyst before egg transfer.

In order to fulfil the standard data for an animal and to properly use records, the following information should be recorded:

a. Identification of the embryo and of its genetic parents.

b. Date of transfer.

c. Coding of the calves produced by egg transfer.

d. Identification of the recipient cow.

e. Coding of donor and recipient dams to identify cows which did not raise a natural calf.

To specifically analyse the efficiency of the multiple ovulation technique, the traits to be recorded are:

a. Number of unfertilised oocytes/flushing.

b. Number of degenerate embryos/flushing.

c. Number of transferable embryos/flushing.

Moreover some environmental factors may influence the results and particular information should be recorded in the donor cow including the multiple ovulation treatment used and date, the dates of AI and of flushing and the identification of the technician.

As for the result of the egg transfer, the following information should be recorded:

a. The date of eggs transfer.

b. The mode of transfer as fresh or thawed embryos.

c. The type of oestrus of the recipients as natural or by hormone treatment and

d. The identification of the technician.

3.3.3.10 Calving ease or difficulty, calving mode

Difficult calvings lead to increased calf and cow mortality and could impair the health of the calf, the health of the dam, her subsequent fertility and her production performances.

Dystocia can be of maternal or foetal origin.

Maternal factors are:

a. Anatomical or pathological defects in the pelvic canal (variation in pelvic opening area, pelvis immaturity, and fibrosis of the reproductive tract).

b. Insufficient preparation for parturition or expulsive contractions.

Foetal factors are:

a. Oversize (relative, absolute or pathological).

b. Faulty position.

c. Dead calf.

d. Twinning.

For breeding purposes, the most relevant causes of dystocia are oversized calf and narrow pelvic area in relation with dam's age. The presence of a veterinarian at calving is not necessarily associated with these causes, but may have been requested for any of the other causes of dystocia. So the description of a calving mode class by the veterinary assistance is meaningless in so far as breeding is concerned.

Recommended codes for calving mode or ease

a. Easy calving without assistance

b. Easy calving with some assistance

c. Difficult calving (hard pulling, assistance by 2 or more persons, mechanical assistance)

d. Caesarean section

e. Embryotomy

Other additional information to be recorded: calving date, parity and age of the dam, sex of calf, calf presentation at parturition, twinning, breed of dam and ID of dam.

3.3.3.11 Birth weight

The most common cause of dystocia is foetal oversize and the most interesting cause in connection with the breeding ability of the sire for calving ease is the birth weight.

3.3.3.12 Pelvic opening

Most calving difficulty or dystocia occurs in first-calf heifers. Research indicates that disproportion between calf size (birth weight) and size of the female pelvic inlet (pelvic area) is a major contributor to calving difficulty. As a result, the yearling pelvic measurements can be used as a culling tool to reduce the potential incidence and severity of calving difficulty among first-calf heifers.

a. Pelvic measurements:

- Sacropubic (vertical) diameter (cm).
- Transilial (horizontal) diameter (cm).

b. Calculated pelvic area (cm2)
Estimated pelvic area is the product of vertical and horizontal measurements

c. Yearling calculated pelvic area
Pelvic measurements should be taken between 320 and 410 days of age and adjusted to 365 days of age to accurately evaluate yearling bulls and heifers. BIF proposed formulas for male and female (see annex calculated traits definition), but the adjustment should be breed specific.

3.3.3.13 Mortality from birth

The time of death can be recorded as date or/and code. Generally, the codes are connected to live history events (birth, weaning, post-weaning) or to time period from such events which should be specified. The usual times of death are given hereafter.

a. Date of death

b. Code for time of death:

- Stillbirth, still-born: dead-born full term.
- Death during parturition.
- Perinatal death generally defined as death within first 48H.
- Death within a specified time from birth.
- Death in any specified interval.
- Death after weaning.

From those records, various mortality or viability rates can be calculated, so the animals involved in numerator and denominator and the time or the interval from lifetime event considered should be clearly defined. These rates also could be calculated at herd or sire levels and separated according to different causes of mortality that should be specified.

a. Calculated calf mortality rate
Dead calves, within a time period or towards a defined event, as a % of cows exposed, pregnancies, calvings or calves born alive

b. Calculated viability rate
Alive calves, within a time period or towards a defined event, as a % of cows exposed, pregnancies, calvings or calves born alive

c. Weaning rate: proportion of calves weaned for a specified denominator

d. Causes of mortality:

- Congenital defects.
- Dystocic calving.
- Accident.
- Disease (respiratory, digestive, infectious, metabolic….).
- Other.

3.3.3.14 Disposal from birth

The time of disposal can be recorded as date or/and code. Generally, the codes are connected to live history events or time period from such events that should be specified.

a. Date of disposal.

b. Code for time of disposal.

- Postnatal, preweaning, postweaning, other.

c. Causes of disposal.
There are numerous causes of disposal, which can vary from one production system to another. So, an exhaustive list of causes is difficult to establish. Moreover breeders may decide upon an animal‘s disposal based on more than one reason. On can generally classify these causes into voluntary and involuntary decision of the breeder.

- Voluntary: sale for fattening, sale for breeding, sale for slaughtering.
- Involuntary: culling for defects, diseases, infertility, sterility, production deficiency, mothering ability, temperament, other.

d. Calculated age at disposal, at culling.
From those records, various disposal statistics or rates can be calculated, The animals involved in numerator and denominator, the time or the interval from lifetime events should be clearly defined. These rates also could be calculated at herd or sire levels and separated according to different causes of disposal that should be specified.

e. Calculated rates of disposal, for a specified type of animals at a specified age or event or within specified period.

3.4 Longevity traits

3.4.1 General

Longevity is an essential part of any breeding goal, reflecting the ability of an animal to cope successfully with the environmental conditions that arise in the production system. The length of the life of an animal can be calculated from its life history data as any survival trait may be defined as the length of time between two events. Longevity may be measured, from birth or from onset of production to the date of measurement of the specific trait for the last time in an animal's life.

Life history data which are essential for longevity traits (see elsewhere in these guidelines) are birth date, calving dates and date of disposal. In addition for the calculation of longevity traits the cause of disposal needs to be recorded.

3.4.2 Calculated longevity traits

The trait generally suggested to describe the longevity of an animal is the productive life span (or also sometimes referred to as productive herd life). Length of productive life is the period of time between the start of production and the end of productive life. As detailed in these guidelines, this trait may be calculated if the recommendations for recording life history data are followed. The endpoints for the calculation of the length of productive life need to be defined. Typically the productive life of a cow starts at her first calving and ends with her death. In using this data in a genetic evaluation, however, two problems have to be taken into account.

Firstly, incomplete records have to be considered in calculating the length of productive life where a different endpoint than the death of an animal is available. Examples are longevity data of animals which are still alive or which were sold for commercial use. To exclude incomplete records from the evaluation or consider them as dead would lead to biased results. One way to deal with this problem is to use indirect longevity indicators such as whether a cow is still alive at a certain age ('Stayability'). This method is however associated with a great loss of information. Therefore, it is suggested, that incomplete data are treated as censored and special statistical tools are designed for coping with such data used in analysis. For the latter case, the correct code for cause of disposal is mandatory.

Secondly, for genetic evaluation the 'functional longevity' should be the trait of interest, i.e. longevity corrected for performance. In this context, culling for low productivity is disregarded since performance is used as a different selection criterion. Only culling for health problems or other non-production causes is taken into account. As for dairy cattle, the performance being corrected for may be milk yield assessed by weaning weight or a weight at a fixed age.

In many cases, early predictors of productive herd life is used for breeding value predictions in young animals. These predictors are usually associated with linear type traits, body measurements and production records.

3.5 Live animal weights

The collection of live animal weights is critical to the analysis of productivity in the beef herd. Typical weights collected by producers are birth, weaning and yearling weights. It is important that these weights are collected consistently to ensure an informative analysis. Animals are typically weighed using suspension scales or electronic load cells. It is important to ensure that the weighing equipment particularly mobile scales are suitably located on a level surface. Scales should be regularly calibrated to ensure the accuracy of the recorded data. As a minimum, a scale that measures to an accuracy of 1kg/2lb should be used for birth weights and 2kg/5lb for later weights.

When weighing cattle several aspects must be considered. Birth weights are typically recorded on suspension scales. It is imperative that the calf is completely off the ground and is not obstructed in any way. It is best if the scale is mounted on a stand so that an accurate measure can be recorded. For weighing cattle on platform or suspension scales it is necessary that the scales are checked regularly for obstructions and that they are cleaned and balanced frequently.

3.5.1 Birth weight

Birth weight is the major contributor to dystocia in cattle. Therefore, collecting and analysing birth weight information is useful for many beef breeding programs. Birth weights should be collected within 48 hours of birth. Data that should be collected at birth include: Dam ID; Calf ID; birth date; birth weight; date of weighing and calving ease score. The calf should be dry and should be allowed to nurse the cow.

3.5.2 Weaning weight

Weaning weights are important to beef producers for several reasons. Weaning weights are an indication of the productivity of the dam and the genetic potential of the calf for pre-weaning growth. Weaning weights serve as the initial weight for determining post-weaning growth. Additionally, many producers market their calves at weaning based on the calves' weights; therefore, weaning weights can have a significant influence on farm income. Genetic evaluations account for the environmental contribution to weaning weight and separate maternal and growth genetic components. Weaning weights should be collected at the time the calf is weaned. All calves in the contemporary group should be weighed at the same time. The age of the calf at this time may vary depending on the country of origin. For correct adjustment purposes the average age of the calves should be as close as possible to the age adjustment standard for that country or accepted management system. For example, the weaning adjustment age in the United States is 205 days of age, therefore, it is recommended that weaning weights should be taken when the average age of the calves is close to 205 days. If weights are taken at ages considerably different from this age the adjusted weights will not be as accurate.

3.5.3 Post-weaning growth

Weaning weights typically serve as the initial weight and yearling weights serve as the end-point for evaluating post-weaning growth. In situations where official weaning weights are collected prior to actual removal of the calf from the dam, the initial weight should be collected at the time of removal. Genetic evaluation of post-weaning growth may be reported different. This will either be reported as post-weaning growth or as yearling weight (which is typically the genetic value for weaning weight plus the genetic value for post-weaning growth). In either case the maternal component that influences the trait is accounted for so that the evaluation is on growth potential. Final weights for post weaning growth are traditionally taken as close to 365 days as possible. However, there are exceptions depending on country and management systems. For example, in the United States there are three accepted ages for yearling weights: 365 days; 452 days; and 550 days. Post-weaning weights should be collected when the average age of the calves is close to the appropriate age. All calves in the contemporary group should be weighed at the same time.

3.5.4 Finish weights

Collected live finish weights at time of harvest or slaughter is often used as the sale weight and is also critical to assessing dressing percentages. Determining the appropriate time to harvest animals and collect finished weights varies greatly depending on the country and expected utilization of the carcass. For genetic evaluation purposes these weights will be adjusted to a consistent end-point (i.e. age, fat thickness, etc.). Empty weights (no feed or water for minimum 12 hours) should be taken at time of harvest. A scale that measures in increments of 2 kg or 5 lb, or less, should be used for finished weights.

3.5.5 Test weights

Initial and final test weights to compute growth rate may be either full or shrunk (empty) weights. If full weights are utilized, initial and final weights should be an average of weights taken on two consecutive days to minimize fill effects. Otherwise, a single weight after a 12-hour shrink (no feed or water) is adequate. Weights may be collected at various points during the test to ensure that appropriate gains are being achieved. A scale that measures in increments of 2 kg or 5 lb, or less, should be used for test weights.

3.5.6 Chest girth circumference as a predictor of growth

In certain beef cattle management systems, where live weight cannot be recorded directly, chest circumference of animals may be recorded as indicator trait for growth rate in beef performance recording.

Chest girth can be recorded using a measuring tape; alternatively, it is possible to record chest girth using dedicated devices that can predict chest girth from the processing of digital images of the animal. Such devices must be composed by a digital - optical part that is in charge to take digital images of the animal and by a software that must interpret digital images and, using dedicated software, produce animal's chest girth estimate.

The device precision in chest girth estimation must be periodically verified by field calibrations where the average difference between tape and predicted chest girth should not exceed 2,5% of tape chest girth.

Live weight, a direct beef performance trait, can be estimated from chest circumference using a transformation formula that includes both:

a. The age of the animal, and
b. Its chest circumference.

The age of the animal is calculated as the difference in days between date of recording and animal's birth date. Transformation formulas may be specific to breed and sex.

It is suggested that use be made of transformation formulas derived from sufficiently large datasets where both chest circumference and live weight were recorded on the same animal, and collected on animals at different ages. Where transformation formula derived from a multiple regression approach are used then the relative R2 should be at least 0.90.

Where chest circumference data is used to estimate live weight, it is recommended:

a. That the recorded trait of chest circumference is specified, and that the appropriate units (centimetres, inches, meters, etc.) are specified.
b. That the actual chest circumference is recorded.
c. That chest circumference is stored in the central database and used to estimate live weight using appropriate and approved conversion formulae.
d. That estimated live weight derived from chest circumference together with original chest circumference be recorded together on the database.
e. That a code be recorded on the database with the animal record to indicate the procedure used to estimate growth from the chest measurement.

3.5.7 Adjusted growths and weights

Weights are recorded as raw weights together with the weighing date. In order to make live weights comparable among animals of the same breed and sex, and to allow data and information exchanges among countries, it is common practice to express live weights adjusted to specific reference ages. For instance, live weight at 365 days of age of the animal ("yearling weight") makes it possible to rank animals of same breed, sex or herd for their growth aptitude.

Reference ages are defined according to specific breeding events; for instance, 200 days of age refers to weaning of the calves. Weights at reference age are important because they allow comparative analyses for animals in different environments and countries. Usually, recording activity in a herd requires weights on all the animals that are present in that day to be recorded. It may not be possible to make the required measurements on the exact date required. If for example the yearling weight is to be recorded, but only monthly, bimonthly or tri-monthly weightings are technically possible, the expected weight at day 365 can only be calculated using an adjustment procedure and will be stored as a 'calculated trait'.

When a recorded trait such as live weight is standardized for a given age, the resulting adjusted weight becomes a calculated or derived trait, which is a function of the recorded weight and of the age of the animal. Thus, 'weight' is a directly recorded trait, while 'weight at 200 days' will be a calculated trait. For the international exchange of data, a standardization of time intervals is strongly recommended, and each national organization should define reference ages for its beef cattle breeds. When storing such weights, it is necessary to specify that these are calculated traits derived from raw data.

Live weight measurements, both from direct (scale) recording and from transformation of biometric measures (e.g., chest circumference) are of primary importance in monitoring an animal's growth. As already mentioned, weights are recorded as raw weights together with the weighing date and can be adjusted to the reference age of choice. However, such data can be used to calculate other traits that can more easily provide information on the growth potential of the animal.

This type of data refers to live growth rate in a specific time interval and expresses the growth potential of an animal in a specific time period. While live weight specifies an animal's weight in a single day, growth traits can refer to two weights recorded on two dates and describes an animal's growth performance in the specific period. The resulting information can be useful for management and comparison among animal growth potentials at differing stages of growth.

Growth traits are of primary importance in beef breeding and the beef industry since growth is highly correlated to the economic value of retail product. These traits are usually expressed as daily gain in g per day. These growth traits are calculated traits and can be divided into two categories:

a. Growth rate from birth to a specific age such as 365 days.
b. Growth rate between defined periods in the animal's life.

3.5.8 Recommendation for weight correction to standardized age

The usual method for calculating standard age weight is based on determining average daily gain between two weight recordings; then, assuming growth to be linear between the recordings, estimate live weight increase from the day of first recording and reference day and add it to weight on first recording. It is preferable that the age to which weight is being adjusted occurs between two successive recordings. If this is not possible, an extrapolation is possible if age at last recording falls within a specific time interval from the standard age. The time interval has to be determined by each recording organization based on recording frequencies.

3.5.8.1 Calculation method

Different situations can occur:

a. Where with the exception of birth weight, there is only one weight record available after birth:

let AR be reference age

let WR be weight at reference age

let D_B be birth date

let D_t be recording date t

let W_B be birth weight

let W_t be recorded weight at date t

let A_t be age of animal at recording date (= D_t - D_B)

If AR < A_t then

$$WR = [(W_t - W_B)/ A_t]*AR + W_B$$

If AR > A_t then

$$WR = \{[(W_t - W_B)/ A_t]*(AR - A_t)]\} - W_t$$

b. Where there is more than one weight recordings are carried out after the birth is recorded.

The following formula refers to the case of two recordings (n = 2). The procedure can be applied to any number n of recordings, noting that the reference age in this case should be comprised of the age intervals from two successive recordings, or, if this is not possible, should be closest to the last available record. The age range tolerance or limitation values should be specified by the recording organization, based on recording frequencies etc.

let RA be reference age

let RW be weight at reference age

let D_B be birth date

let D_{t-1} be recording date 1

let D_{t-2} be recording date 2

let W_{t-1} be recorded weight at date 1

let W_{t-2} be recorded weight at date 2

let A_{t-1} be age of animal at recording date 1 (= Dt-1 - DB)

let A_{t-2} be age of animal at recording date 2 (= Dt-2 - DB)

If RA < A_{t-1} then

$$RW = \{[(W_{t-2} - W_{t-1})/(A_{t-2} - A_{t-1})]*(A_{t-1} -RA)\} + W_{t-1}$$

If A_{t-1} < RA < A_{t-2} then

$$RW = \{[(W_{t-2} - W_{t-1})/(A_{t-2} - A_{t-1})]*(RA - A_{t-1})\}+ W_{t-1}$$

If RA > A_{t-2} then

$$RW = \{[(W_{t-2} - W_{t-1})/(A_{t-2} - A_{t-1})]*(RA - A_{t-2})\} + W_{t-2}$$

c. In suckler herds participating in birth to weaning recording scheme, where the reference performance trait is weight adjusted for 200 days, the recommended calculation method is as follows:

let At be the age at weighing in days

let Wt be the weight in kilograms

let WB be the recorded birth weight or a breed standard,

then reference performance is calculated as:

$$RW = ((W_t - WB)/A_t) * 200 + WB$$

d. Where it is necessary to extrapolate to an age outside the lower and higher recording ages, a maximum allowable interval should be specified between the standard adjustment age and the available recording ages. This interval can be related to animal's breed sex and growth potential in the period under consideration. Intervals greater than such threshold should not be used. For example, it may be decided that weight at 365 days can only be calculated if records are within a time period of ± 45 days. Useful weights to calculate 365 days weight should then only be recorded in the age range 320 and 410 days of age. Considering the variation in these parameters throughout recording schemes, the decision of threshold period for determining weight at standard age for each breed is left to member countries. Generally, computational method used are standard linear interpolations. However, if threshold periods are very large, a non-linear standardization may also be necessary within a recording scheme. For the international exchange, it is recommended that raw weights and dates of recording be provided as a minimum.

3.5.9 Recommendation for growth traits calculation

A number of weight gains definitions can be defined:

a. **Average daily weight gain**: This is total live weight increase between two weight recordings, divided by the number of days between the two weighing records. The trait is expressed in grams per day.

b. **Live weight gain per day of age**: Given a specific weight record, taken at a specific age of the animal, and given an actual or default birth weight of an animal, a live weight gain from birth may be calculated. For the calculation of this trait, birth weight and birth date of the animal should be mandatory data. In the case of missing or invalid birth weights the average birth weight for the breed and sex can be used. The trait is expressed in grams per day.

c. **Net weight gain per day of age**: This is the commercial carcass weight divided by days of age at slaughter. Birth date is mandatory in order to calculate age at slaughter. Net gain is expressed in grams per day. It is important to record the trim specification of the carcass as this can vary significantly.

The above-mentioned performance traits are calculated from a combination of recorded traits (weight recording and corresponding dates). This type of trait can be derived both from raw recorded data and from adjusted weights

Calculation method

Refer to current ICAR guidelines for the method.

a. Suckler herds from birth to weaning

Weight gain may be calculated as follows:

let WW be the corrected live weight at weaning, expressed in kilograms

let BW be the birth weight, expressed in kilograms

let AW be the age at weaning, expressed in days

Then, weight gain from birth to weaning is calculated as:

$$(WW - BW)*1000 / AW$$

and is expressed in grams per day.

b. Test stations

The reference performance trait in test stations is average daily weight gain:

let AS be the age at test start, expressed in days

let AF be the age at test end, expressed in days

let SW be the live weight at test start, expressed in kilograms

let FW be the live weight at end of test, expressed in kilograms

Then, average daily weight gain is calculated as:

$$(FW-SW)*1000 / (AF - AS)$$

and is expressed in grams per day.

c. Finishing herds after weaning to slaughter

The reference performance trait is average daily weight gain.

let n weight recordings be performed during the period

let A_{n-1} be the age at weight recording n-1, expressed in days

let A_n be the age at weight recording n, expressed in days

let W_{n-1} be the live weight at weight recording n-1, expressed in kilograms

let W_n be the live weight at weight recording n, expressed in kilograms

Then, average daily weight gain is calculated as:

$$(W_{n-1}-W_n)*1000 / (A_{n-1} - A_n)$$

and is expressed in grams per day.

3.6 Live animal assessments

3.6.1 Assessment of muscularity

Linear scoring is a technique which allows a systematic description of an animal's morphology. Linear scoring reveals part of the animal's economic value and, if the scored traits are heritable, part of its genetic value. Economic and environmental conditions vary over time and between countries so the economic importance of each scored trait may differ depending on the circumstances. The specific relative importance has to be determined by the responsible breeding organisations.

As well as the description of a single animal, data from linear scorings are used for genetic evaluation of dairy, dual purpose and specialised beef breeds.

Many breeders, breed societies and those in the AI industry use linear scoring in routinely performed animal recording. In beef breeds linear scoring of muscle shape is particularly important as an indicator of saleable beef yield per animal, and thus is an indispensable part of the beef recording system.

To meet the need for an efficient world wide, genetic exchange, international comparison of breeds, and demand for more comparability of individual cattle between countries, procedures for linear scoring of muscularity should be harmonised. This need is best served by an internationally recognised set of recommendations.

The following recommendation may help organisations design a linear scoring system for beef performance recording which suits their market conditions, and which may lead to more homogeneous and comparable scores between different countries.

The present recommendation refers only to linear scoring of muscularity, which is usually part of a complete integrated scoring system within breed. It does not deal with the full spectrum of linear scoring. A complete linear scoring system for a given breed often includes further items such as skeletal traits, udder, legs etc.

The following recommendation may be used both for dual-purpose breeds as well as for specialised beef breeds. Linear scoring can be conducted on any category of animals, such as male and female calves, heifers, cows, bulls and steers.

3.6.2 Recommended approach to be taken in organising Linear Scoring

Linear scoring has the following characteristics:

a. Linear scoring is a systematic description of an animal's morphology.

b. It is usual for a linear scoring scheme to takes several anatomical sites into account.

c. The anatomical sites must be precisely defined.

d. Within one single anatomical site, linear scoring provides a description of the biological extremes and a number of intermediates.

e. The scores represent an ordinal scale, which should allow for sufficient discrimination in the degree of expression of the linear trait.

f. The extremes and the intermediates are ordered according to the degree of expression of the trait. For example, thin and thick, long and short etc.

g. A high or a low score has no particular meaning and it is not necessarily desirable or undesirable.

h. By convention one of the extremes receives the score '1'; the other levels receive a number in ascending order which describes the expression of the trait.

i. A scale from 1-9 points is recommended for most traits.

j. Where the range of biological extremes is large in the population of animals under consideration, (e.g. double muscling or an across breed recording scheme) the scale may need to be extended. A 1 to 15-point scale is recommended in such circumstances.

k. The scoring system should be consistent across contemporary groups, i.e. breeds/breed groups.

l. Linear scoring should if possible be conducted on animals which belong to the same category in terms of sex and age.

m. For each category of animals, the scoring scale for muscle shape should be the same.

n. Scoring for muscularity relates to muscle shape only.

The traits which should, as a minimum, be taken into account in a muscularity linear scoring scheme are:

a. Shoulder width.

b. Loin width.

c. Rump length.

d. Rump width.

e. Thighs width.

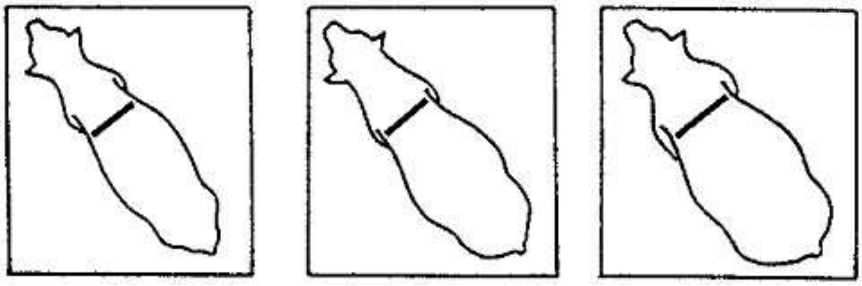
f. Thighs depth.

g. Thighs inside.

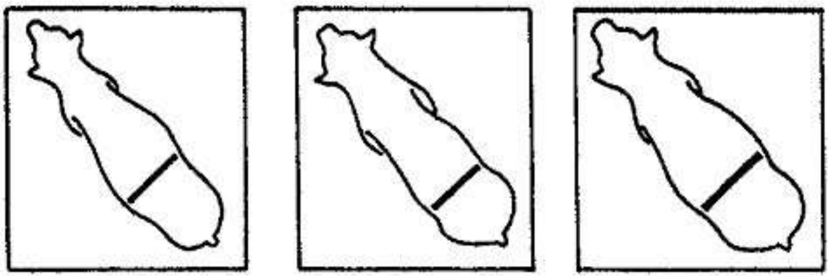
h. Thighs rounding.

The following is a graphical representation of the linear muscular anatomical sites.

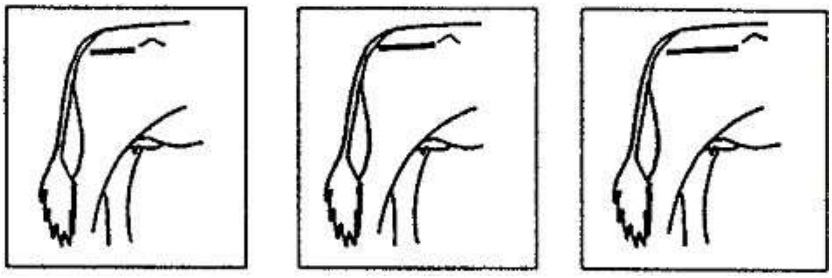
a. Shoulder width



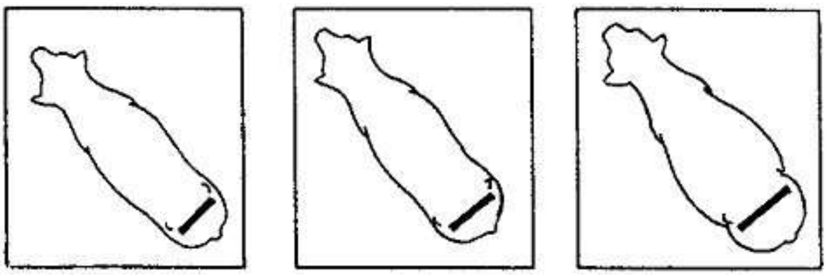
b. Loin width/ development



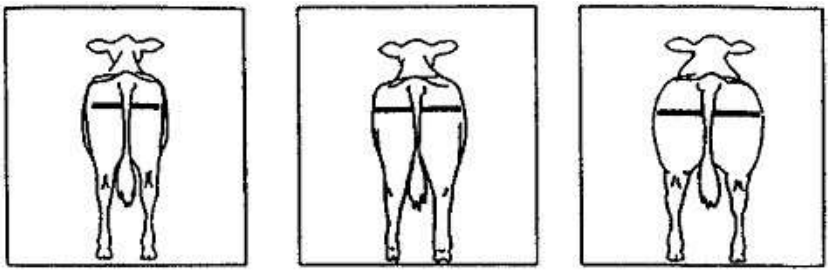
c. Rump/pelvic length



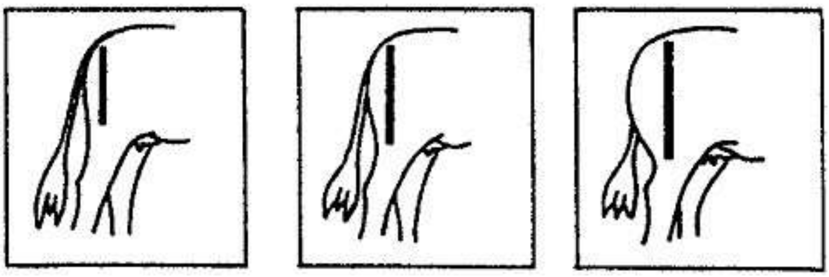
d. Rump width



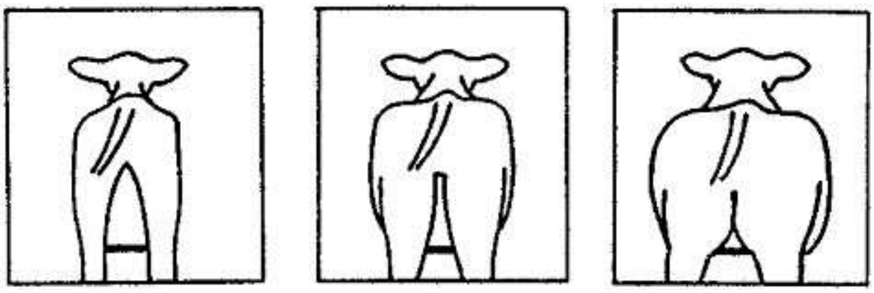
e. Thighs width



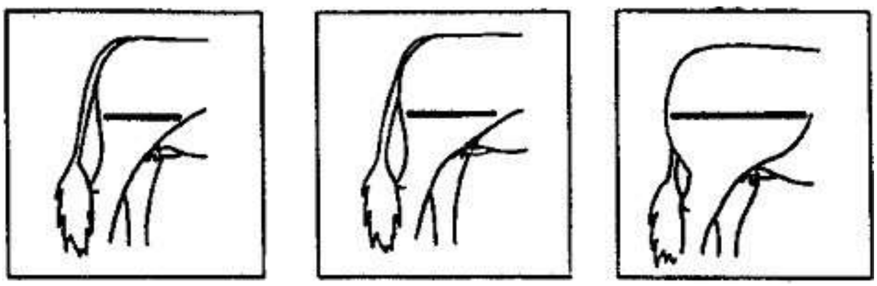
f. Thighs depth



g. Inside thighs



h. Rounding/Development of the thighs



3.6.3 Requirements for linear scoring

All factors accounting for any non-genetic variance should be recorded., e. g.

a. Scorer's identification.

b. Scoring date/time.

c. Management group.

d. Nutritional status etc.

All information should be recorded in accordance with ICAR recommendations where they apply.

Within contemporary group (e.g. animals of one scoring season within farm) all animals of the same category should be scored according to the standard of the appropriate category.

In order to prevent any pre-adjustments by the scorer, it is necessary that no information other than the animal's identification should be provided when scoring. No other information, particularly in relation to the ancestors of the animal, or its age should be available.

Linear scoring requires well trained technicians. The practical and theoretical knowledge of the scorer should be tested after receiving appropriate training. The training should allow the scorer to:

a. Make full use of the scale within the category of animals being recorded.

b. Attain a minimum level of repeatability within scorer.

c. Attain a minimum level of repeatability across scorer.

If possible, a routine regional rotation of the scorers is recommended as this facilitates and improves the statistical evaluation of data from linear scoring in different herds by giving a better estimation of the scorer's effect.

The responsible breeding organisation should establish a routine supervision procedure for the scorers. The competency of all scorers should be monitored and training should be provided annually or more often if necessary.

3.6.4 Assessment of body condition

Condition scoring can be defined as an objective attempt to describe the body condition or degree of fatness of cattle by visual assessment. By adjusting the plane of nutrition, body condition can, to a large extent be controlled.

3.6.4.1 Purpose

Condition scoring provides a means of attaining the desired target condition scores for optimum production and reproduction, whilst simultaneously making optimum use of available feed sources.

Differences in condition can also be recorded within contemporary groups as a means of quantifying differences among animals or for consideration in models for genetic evaluations.

3.6.4.2 Recommended methods

Different scoring systems have been developed through the years. For example, one such system has been developed by the East of Scotland College of Agriculture in 1973. In this instance, the score range between 1 (extremely thin) and 5 (extremely fat) with half scores sometimes used between the main scores.

The method recommended is based on the nine-point system developed for zebu cattle by Nicholson and Butterworth (1985) or similar systems. A nine-point system gives distinguishable steps that can be described and used to account for the wide range of body conditions that are shown by cattle from temperate to tropical areas. It avoids the use of half-points, which can be common when applying a five-point system. An arrangement in which three main categories are first defined, and which are then each sub-divided into three to give nine possible options gave repeatable results as well as being easy to teach and explain to others. Units of three worked well where subjective assessment was required. There is always one unit at each end and one in the middle, making decisions easier.

3.6.4.3 How to condition score

Condition scoring is primarily concerned with two specific areas in assessing fat cover (Figure 3.1).

The first is the loin area (between the hip bone and the last rib) which incorporates the spinous and transverse processes of the lumbar vertebrae. The area surrounding the tail head and pin bones is the second.

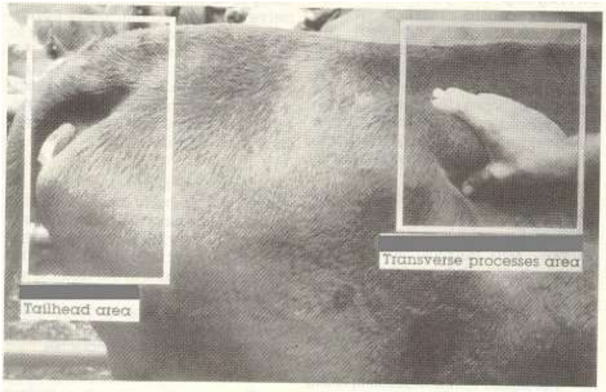


Figure 3.1. Areas on the body where fat cover is assessed for body condition scoring.

The fat cover over the loin area (transverse and spinous processes) is the most important scoring area since changes in fat deposition can be clearly felt and assessed particularly in thinner animals (Scores 1 to 5 on the 9-point scale). The deposition of fat in cattle with a score greater than 5 is such that the transverse processes become increasingly difficult to feel. Fat deposition over the pin bones and the surrounding tail head area becomes increasingly excessive in cows with scores of 7, 8 and 9. The difference between a score of 6 and 7 is the actual deposition of fat on either side of the tail-head which must be clearly visible.

Ideally, the weighing of animals and condition scoring should be carried out simultaneously so that the relevant assessing areas can be felt. Continuous practicing in condition scoring of cattle will increase the accuracy of assessment and the speed at which it is carried out by the operator.

Table 3.2. Description of the body condition scores for cattle on a scale from 1 to 9.

Score		Description
1	Very thin (Emaciated)	Animal markedly emaciated; bone structure easily seen over body; little muscle present; animal weak, lethargic.
2	Thin	Animal emaciated; individual spinous processes, ribs, hooks (tuber coxae), pins (tuber ischii), shoulder blades and spine all prominent, sharply defined; some muscle development; neck thin; prominent withers; shoulders sharply angular. Area around the tail-head completely sunken.

Score		Description
3	Less thin	Vertebral column prominent and individual spinous processes can be felt; little fat, but superspinous muscle over spinous processes apparent; ribs, pins, (tuber ischii) and hooks (tuber coxae) prominent; loin area and rump concave; little muscle or fat covering over withers and shoulders.
4	Less than moderate	Vertebral column prominent and individual spinous processes can be felt; little fat, but superspinous muscle over spinous processes apparent; ribs, pins, (tuber ischii) and hooks (tuber coxae) prominent; loin area and rump concave; little muscle or fat covering over withers and shoulders.
5	Moderate	Superspinous muscles developed and readily apparent; vertebral column can be felt; hooks (tuber coxae) rounded; rump rounded, convex; pins (tuber ischii) not visible; some fat can be felt in shoulder area region and at base of neck; can feel ribs, but not visible.
6	More than moderate	Cannot feel spinous processes easily; back becoming flat well covered; rump convex and well muscled; some fat can be felt on neck, base of neck and shoulder area; neck filled into shoulder; hooks (tuber coxae) just visible.

The following series of illustrations can serve as a guide in scoring cattle for condition (Figure 3.2).

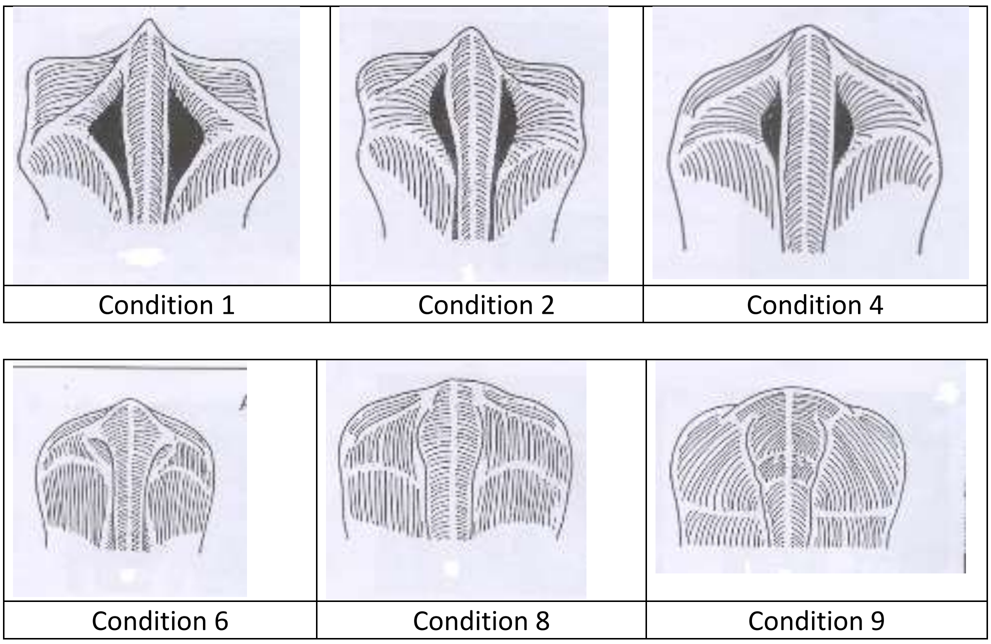


Figure 3.2. Illustration of bode condition scores.

Condition scoring does not eliminate the need for weighing animals. Ideally these two operations should be carried out simultaneously. Condition scores should not be affected by weight, age or breed.

More accurate alternatives exist to compare differences in animals for body condition, such as subcutanious fat thickness measurements by using Real Time Ultrasound methods. Visual condition score, however is a cheap and quick alternative.

3.7 Ultrasound measurements

3.7.1 Introduction

Real time ultrasound imaging equipment to record carcass characteristics in live animals for livestock improvement programs has been in use for more than two decades. Its usefulness in beef cattle has been well demonstrated e.g. Brethour (1994), Wilson *et al.* (1998).

Ultrasound scanning has been used since the late 1980's in many beef cattle breeding programs to overcome the inherent difficulty of recording carcass data from progeny tests under extensive production systems and in performance test situations where access to carcass information is not possible. A number of genetic evaluation programs have now included scan data in their routine analysis.

3.7.2 Practical Application of ultrasound imaging

The application of ultrasound is highly technical and requires:

a. The use of sophisticated equipment.

b. Strict adherence to proper equipment calibration.

c. Proper animal preparation.

d. Adherence to a standard scanning protocol.

e. Adherence to a standard image interpretation protocol.

f. Suitable animal handling facilities.

3.7.3 Animals to be scanned

3.7.3.1 Scanning for genetic evaluation

It is important for genetic evaluation that animals are allowed to express their inherent genetic potential. As fat measurements are directly related to the nutritional state of the animals it is essential to record only groups of animals which are on a reasonable level of nutrition. Otherwise too many animals will be recorded with minimum fat levels and no intramuscular fat thus generating information of little value since the true genetic potential will not have been expressed. Such data is useless for genetic evaluation where the intention is to identify genetic differences.

As ultrasound measurements are used to provide an insight into a number of carcass characteristics and to a limited extent into meat quality, the most valuable records will come from young animals undergoing selection for breeding and on which no direct carcass information can be collected. Yearling bulls and yearling heifers are the most obvious animals to scan. In many commercial production systems a progeny test through steers or bulls is also possible.

In summary scanning can provide useful information for the estimation of carcass EBVs or EPDs using records from

a. Yearling bulls.
b. Yearling heifers.
c. Groups of progeny fed for slaughter.

The most common age window for young breeding stock is between 320 to 500 days. It may vary depending on production system.

The development of body composition EBVs or EPDs requires that scanned animals be associated with a well-defined contemporary group.

For animals scanned on the farm of birth a contemporary group is comprised of all animals of the same sex that are reared and managed together. A 60 days birth window is recommended. Where herd sizes are small and calving season extended the contemporary group may cover a longer birth season window. A typical contemporary group definition would include herd code, birth season, weaning group (date, location, and management), operator (if scanned by more than one operator) and scanning group (date, location, and management).

For animals scanned at a central station test, the contemporary group should include animals from the same sex born within 60-90 days age window and the same test end. The herd of origin and other birth and weaning group information may also be included.

The practise of harvesting/slaughtering animals from groups when they reach market target weights reduces the management group size as records from animals slaughtered on different days and in particular in different abattoirs should not be directly compared. Scanning for carcass traits of all animals prior to the first selection of any animals to be slaughtered will provide a basis for direct comparison of all animals in the group.

3.7.3.2 Scanning of slaughter animals

Real time ultrasound scanning for subcutaneous fat can also be used to determine market suitability of commercial slaughter animals. However, scanning of animals that have reached target market specifications should not be compared with the use of the same technology for performance recording purposes.

Special care must be taken to avoid any bias in the mean of the observations. Such a bias could have severe financial implication if animals are slaughtered and found to be outside market specifications. For the purpose of genetic evaluation a consistent bias will be part of the management group effect and will not affect the accuracy of genetic evaluation.

3.7.4 Technical requirements

3.7.4.1 Recording device

A number of real time ultrasound recording devices are on the market. Most of them have been developed for human health or veterinary purposes (e.g. pregnancy testing). The small transducer used for medical purpose is of limited use for scanning of carcass characteristics and so special transducers are required when scanning for carcass traits.

For a list of scanning devices used in animal recording see Appendix 1 following. Ultrasound equipment is undergoing continuous improvement resulting in smaller and more sophisticated models being developed and marketed on an ongoing basis.

3.7.4.2 Facilities

Efficient ultrasound scanning of large groups of animals requires well designed yards, races and chutes to hold the animals in a stress free and secure manner and release them as soon as all necessary information has been recorded. The operator should insure that the cattle handling facilities for scanning are adequate in respect of health and safety considerations before he commences scanning. A squeeze chute with fold-down side panels is best for scanning beef cattle.

A shaded area is required to allow the operator a good view of the monitor, as direct sunlight will make it difficult to see the images on the screen. Therefore, the chute should be located under a roof that can block direct sunlight and provide protection from rain or other inclement weather conditions. A clean and grounded power signal is required at the chute-side. It is best if the electrical circuit is a dedicated line to the chute, free from the interference of other electrical equipment such as motors etc.

Most ultrasound equipment does not operate efficiently and accurately when the ambient air temperature falls below 8 degrees Celsius or 45 degrees Fahrenheit. The breeder should make provisions to keep the facility heated in these situations. The operator should provide some portable supplemental heating systems to keep the ultrasound equipment warm if required.

3.7.4.3 Preparation of the animal

Animals should be cleaned and clipped particularly in winter or early spring when their hair is too long to get quality images. The requirement for clipping is even higher if scanning is used to determine intramuscular fat % (IMF%) as the lack of complete contact between the ultrasound transducer and the animal's skin can have a direct effect on the predicted IMF%. In general the length of hair coat should be no more than 1,5 cm or 1/2 inches. Prior to scanning a liquid, commonly vegetable oil, should to be applied to the scan site to provide maximum contact between transducer and skin. The temperature of the oil applied to the skin should be above 20 degrees Celsius or 68 degrees Fahrenheit for best results. This might require a warm water bath for the bottle containing the oil during times of lower temperatures.

Wet animals can be scanned successfully as the water can easily be removed from the scan area.

For the scanning of eye muscle area a curved guide or offset made from super-flap will help and will allow a curved image to be recorded without the need to apply excessive pressure to maintain good contact as this would result in distortions of the muscle or fat measurements resulting.

3.7.4.4 Recorded Traits

Real Time ultrasound imaging has so far been used for the measurement of subcutaneous fat cover as well as for Eye Muscle Area and Muscle Depth and the Intramuscular Fat Percent in the longissimus dorsi. The appropriate areas of interest are shown in Figure 3.3.

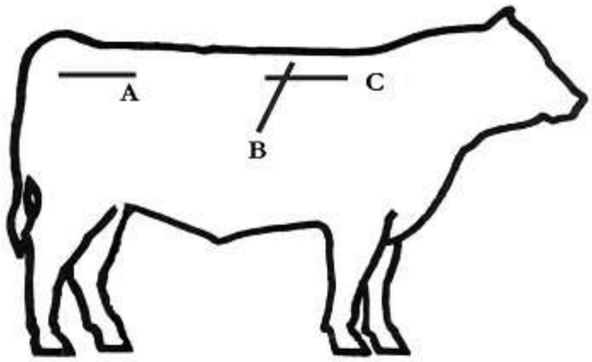


Figure 3.3. Areas of interest for ultrasound evaluation of carcase characteristics.

where: A – Rump fat image
B – Cross-sectional image for ribeye area/depth and 12th-13th rib fat thickness
C – Longitudinal image for intramuscular fat

3.7.4.5 Rump fat thickness

Rump fat thickness or P8 scan is an indicator of fatness and can be used to improve the overall accuracy of external fat measurements. This measurement can be particularly beneficial when scanning leaner animals such as yearling bulls.

For measurements, the ultrasound transducer is aligned directly between the hook- and pin bones without a standoff guide to collect this image. Rump fat thickness is measured at the apex of the biceps femoris muscle. The site is located at the perpendicular intersection of the line from the high bone (third sacral vertebra) with a line from the inside of the pin bone (Tuber ischii) (see Appendix 2, Figure 2 and 3). Rump fat thickness should be reported to the nearest millimeter or 1/25 of an inch. Operators may report to a higher degree of accuracy if desired.

3.7.4.6 Rib fat thickness

The selection of the site for rib fat and eye muscle depth or area may coincide with the traditional quartering site of beef carcasses in the country. In general the records on different sites are genetically highly correlated, however they might show different variation and are more or less easy to record as different muscles might interfere.

A common site assessed in a number of countries (e.g. Australia, Canada, New Zealand, US) is located ¾ of the distance from the medial to the dorsal end of the longissimus dorsi at a lateral point between the 12th and 13th rib. Rib fat thickness will be reported to the nearest millimeter or 1/25 of an inch. As with Rump fat thickness recordings may be reported to a higher degree of accuracy. Rib and rump fat thickness are well correlated (genetic correlation exceeding 0.70) with rib fat commonly having a lower mean. However, interactions between breed, management system and environment exist.

3.7.4.7 Eye Muscle Area (EMA)/ Eye Muscle Depth

Carcass ribeye usually is measured between the 12th -13th ribs of the ribbed carcass. The ultrasound ribeye measurement commonly is made from the same image used to measure 12th 13th rib fat thickness.

Eye Muscle Area/Eye Muscle Depth is measured as the cross sectional area of the longissimus dorsi muscle. Care should be taken not to include other muscles that occur at this site. Similarly, the image should be taken between the ribs not over a rib as the latter will cause distortion.

The presence of well-defined intercostal muscles under the Longissimus dorsi is an indication that the transducer is properly aligned directly between the 12th and 13th rib for this measurement.

3.7.4.8 Intramuscular fat percent (IMF%)

Intramuscular fat percent or marbling is an important meat quality characteristic in certain high-priced markets, because consumer equate it with outstanding eating quality. The carcase benchmark for intramuscular fat is the chemical extraction of all fat from a meat sample taken as a slice off the longissimus dorsi. Most analytical software for IMF% use a longitudinal image in the region of the 11th, 12th and 13th ribs approximately 2/3rds of the distance from the medial to the dorsal end of the longissimus dorsi.

In experiments, it has been demonstrated that the correlation between a longitudinal sample and a cross sectional sample is very high. Research has shown that variation between images on the same side is larger than variation within an image selecting different but overlapping areas for the analysis.

The IMF% trait is the most difficult of all ultrasound traits to measure accurately. Equipment calibration, animal preparation, electrical power signal noise, existence of atmospheric radio waves, and transducer-animal contact are just some of the factors that can influence the measurement accuracy. Therefore, it is strongly recommended that the IMF% result be reported as the average of at least three images and even better, the average of five images to increase the accuracy.

Most machines do not provide a direct measure of IMF% and thus there is a requirement for specialised PC software. An image frame from the ultrasound scan is digitised and analysed on a computer. Such analysis software is normally designed specifically for a particular ultrasound machine (Hassen *et al.*, 2001).

3.7.4.9 Scanning weight

The scanning weight of each animal should be measured within +/- 7 days of the scanning date.

3.7.5 Recorded data

Recorded data should comprise as a minimum:

a. Identification of the operator.

b. Type of scanner used.

c. Scanning date.

d. Farm/Herd identification.

e. Animal number.

f. Trait definition.

g. Actual recorded measurement.

h. Unit of measurement.

3.7.6 Qualification of the operator

3.7.6.1 Image Interpretation

The accurate interpretation of real-time ultrasound images for fat thickness, eye muscle area and IMF% requires a high degree of skill. A number of training programs are currently recognised within the beef cattle industry. Ultrasound scanning operators should participate in and satisfactorily complete such a course in ultrasound methodology before undertaking scanning activities.

3.7.6.2 Certification of commercially operating operators

To guarantee high quality data for genetic evaluation and research purposes Real Time Ultrasound Scanners should be regularly tested for their proficiency (e.g. annually). Successful completion of such proficiency tests can be made a prerequisite for the acceptance of data into national genetic evaluation systems by those organisations, which control access and input to beef cattle data bases (e.g. recording organisations or breed societies).

3.7.7 Training and Testing Protocol

3.7.7.1 Test design

Attempts should be made to select a group of about 30 animals with a range of values for the traits of interest, namely fat depth, eye muscle area, muscle depth and intramuscular fat. All animals should be clipped with some oil applied to the measurement site prior to the test.

As each operator will measure the animals twice, all animals should be tagged with numbers (best on their backs) and these numbers have to be changed between runs.

All operators should have a scanning station to themselves and will be allowed fixed time (e.g. 6 minutes per animal) to complete all measurements on the animals. All crushes should be sequentially aligned so that any time delay by one operator will delay the whole team. Note no two machines should take power from the same power plug to avoid interference between machines, which can particularly influence the prediction of intramuscular fat.

3.7.7.2 Testing protocol

Official sheets should be provided to record measurements. Sheets should be customised for operators with different machines. No other recording is to be permitted. These sheets are to be collected at the end of each run with at least fat depths recorded. They will be photocopied and returned to those who need them to submit eye muscle area, muscle depth or intramuscular fat.

Other measurement, e.g. eye muscle area should be submitted within 48 hours of completing the test. Operators recording images for eye muscle areas will be required to submit tapes when submitting the EMA records. Operators who wish to submit EMA measurements on the spot can do so.

Intramuscular fat measurements will be submitted within 48 hours of completing the test.

Test animals should be killed between 24 and 48 hours after the completion of the test and after allowing for a settling down period to overcome any stress related downgrading of the carcasses.

Carcass data should be recorded by at least two experienced staff independently to allow for measurement error correction. It has to be remembered that recording of carcass data in the chiller is not error free and also requires skills. Care must be taken to identify carcasses whose physical attributes have been changed through the slaughter process e.g. commonly used hide pullers can remove some of the subcutaneous fat on rump or rib. Tightly packed carcasses can deform and reduce muscle area. Left or right-handed quartering of carcasses can affect the surface area and may bias the results for the eye muscle measurement.

3.7.7.3 Criteria for certification

The criteria for a pass in the proficiency test has to be established. The standards established by the Performance Beef Breeders Association (PBBA) in Australia, Table 1 and the Beef Improvement Federation in the USA, Table 2 are presented as examples. These criteria may be adjusted if the mean and standard deviation of the carcass traits are found to be different to the values in the test that were used to establish these criteria. There does not need to be a requirement to achieve a minimum bias. As bias affects all animals in a similar way it is an effect confounded with the management group of the animal. However, note that a comparison of scanned records and real carcass records which reveal large biases will undermine the confidence of breeders in the technique.

Mean and standard deviations between animals and between carcass graders have to be recorded to monitor quality recording of carcass data and a consistent variation between the test animals.

A number of different statistics should be calculated to show the proficiency of the scanner.

a. Standard deviation of the difference between first and second scans of the same animals together with the correlation. For this, animals don't have to be slaughtered and this statistic can be used to evaluate scanners during a training phase. Only scanners reaching minimum standards here, that means those that are consistent in what they are measuring will be allowed to attempt the expensive accreditation involving carcase data.

b. Standard deviation of difference between scan results and mean carcase value and the correlation between scan and carcase results.

c. The bias between scan and carcase measurement.

Table 3.3. Recommended standards for Proficiency Testing of Real Time Ultrasound Assessment of Live Cattle used in Australia.

Rib Fat Thickness (12/13th rib)		
Maximum Standard error of repeatability	1.0 mm	0.04 inches
Maximum Standard error of measurement (prediction)	1.0 mm	0.04 inches
Correlation with carcase measurement	0.9	0.9
Rump Fat Thickness (12/13th rib)		
Maximum Standard error of repeatability	1.5 mm	0.06 inches
Maximum Standard error of measurement (prediction)	1.5 mm	0.06 inches
Correlation with carcase measurement	0.9	0.9
Eye Muscle Area (EMA		
Maximum Standard error of repeatability	6.0 cm^2	0.90 $inches^2$
Maximum Standard error of measurement (prediction)	5.5 cm^2	0.80 $inches^2$
Correlation with carcase measurement	0.8	0.8
Intramuscular fat percent (IMF%)		
Maximum Standard error of repeatability	1.0 %	1.0 %
Maximum Standard error of measurement (prediction)	0.9 %	0.9 %
Correlation with carcase measurement	0.75	0.75

Table 3.4. Guidelines on the minimum requirements for operators as set by the Beef Improvement Federation of the United States of America.

Trait	Standard error of prediction	Standard error of repeated measures	Bias
Fat thickness	≤ 0.10	≤ 0.10	≤ 0.10
Ribeye area	≤ 1.20	≤ 1.20	≤ 1.20
% IMF	≤ 1.20	≤ 1.10	≤ 0.70

Alternative statistical methods, like goodness to fit, can also be considered when the proficiency of operators (scanners) are evaluated.

3.7.7.4 Supervision of the operator

The responsible breeding organisation should establish a routine supervision procedure for the operator. The competency of all operators should be monitored and training should be provided at regular intervals.

3.7.8 Ultrasound scanner

Table 3.5. Ultrasound scanners used in Beef cattle performance recording

Model	Manufacturer	Used by	Comments
SSD 210 DX II	Aloka	Kansas State	Requires Software for IMF
SSD 500V	Aloka	Iowa State	Requires software (Iowa State)
Pie 200 Vet	Pie	Australia, US	Includes software for IMF
Scanner 200 SLC	Tequesta	US	Requires Software for IMF

3.7.9 Location of P8 Site

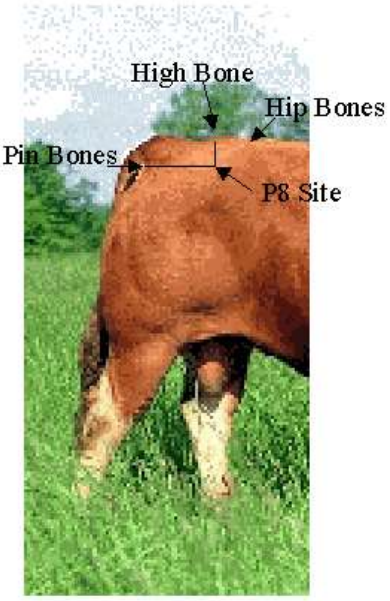


Figure 3.4. Location of P8 Site (Rump fat thickness).

Figure 3.5. Ultrasound rump fat image with typical landmarks identified. Notice how the point of biceps femoris is near the 2/3 position of the image, and the fat lines are very defined and not blurred. Additionally, the pelvic bone is absorbing the ultrasound waves on the lower right portion of the image. The transducer is placed above a straight line between the hooks and the pins. The animal's head is to the right side of the image, and the tail is to the left of the image.

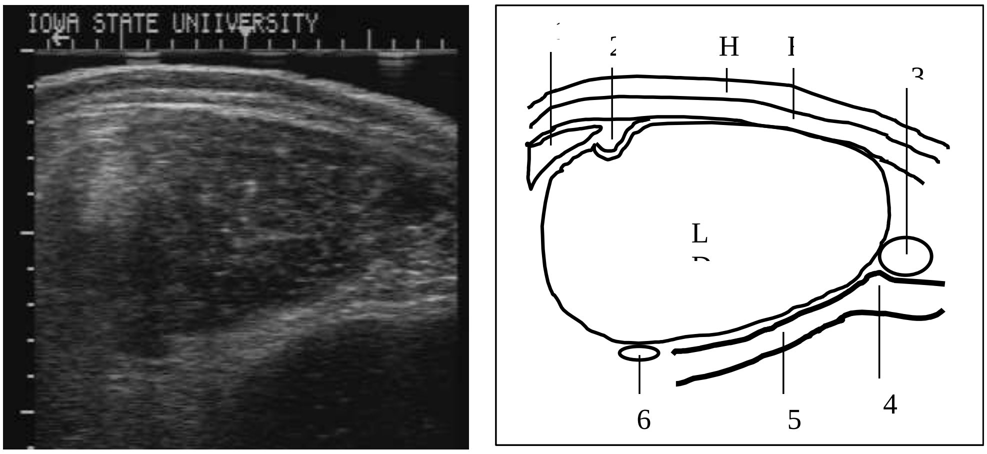


Figure 3.6. Cross-sectional ultrasound image and outline of important landmarks @ 12-13 rib, where a carcass would be broken into quarters.

1 – Spinalis Dorsi
2 – Acorn Fat or the "Hook" of the ribeye
3 – Longissimus Costarum
4 – "Break" in the intercostals
5 – Intercostal muscle boundaries or "Railroad Tracks"

Figure 3.7. Longitudinal ultrasound image taken over the 13th, 12th, and 11th ribs. The first uniform layer of is the hide of the animal. The second layer is the subcutaneous fat layer. Notice also the triangular shaped section of spinalis dorsi under the fat layer above the 11th rib, and the added brightness of the image under the spinalis dorsi.

3.8 Test period feeding and test arrangements

3.8.1 Feed intake

Recording feed intake and the calculation of EBV's for feed conversion efficiency or Net Feed Efficiency is a goal of many breeding programmes. Clearly defined procedures are a prerequisite in the recording of feed intakes and feed efficiencies. The ultimate objective, however, is to generate EBVs having removed non-genetic variation as much as is possible. Standardizing the test procedures within and between locations will reduce non-genetic variation, and with adequate genetic linkages between tests centres, data from different tests both in time and location can be used for estimating BVs.

3.8.2 Feed efficiency

Efficiency of gain in beef production can be defined as the ratio of nutrient input to beef output. It is normally expressed as the kg of feed consumed per kg of live weight gain. However, the definition of feed conversion efficiency needs to be clearly defined for any particular animal recording scheme. Test animals may be fed in varying forms. The ration may be a fully formulated to include roughage and concentrate and fed in cube or loose form. Alternatively, the test animals may be fed with a standard ration supplemented with some form of roughage such as hay or straw. The nutritional contribution of the roughage element may not in some efficiency tests be included in the calculations. Feed consumed may also be expressed in units of dry matter. This will be important where the dry matter content of the ration may vary. Beef output is normally recorded as the total live animal gain. Carcass gain for example may be an alternative measure of beef output.

Recommendations:

a. Nutrition of test animals and definition of beef output should be clearly detailed in the test description.

b. A standardised feeding regime should be adopted which minimizes dry matter variation in the ration fed within and over the tests.

3.8.2.1 Testing facilities

Feed conversion efficiency recording may be undertaken on farm or in a central test station. The test facilities should be approved in respect of satisfying the minimum standards for such tests and should be monitored from time to time to ensure compliance with these minimum standards. Any modifications of the testing procedures of facilities should be notified to the body responsible for genetic evaluation.

3.8.2.2 Eligibility of animals for testing

3.8.2.2.1 Age and age range of test group

It is desirable that the tests be conducted earlier in the animals' life to minimize pre-test non-genetic effects. The range in age within a contemporary group should be kept as low as possible. However, for many reasons such as the population size of the breed and birth pattern through the year, it may not be feasible to set a very restrictive age range within a contemporary group. It is recommended that the age range within the contemporary group should not exceed 90 days.

The age over which a feed conversion efficiency determination is made varies considerably between test programmes being normally influenced by production systems. The test may commence soon after birth and continue until the later stages of their growth phase which would normally not extend to greater than two years of age. As the test can be expensive to run, a more restricted test period is normally conducted to facilitate the testing of larger numbers of animals and to minimise costs.

3.8.2.2.2 Sex

Bulls, steers or heifers may be tested. Where resources are limited it is recommended that bulls only should be tested, especially at Central Test facilities.

3.8.2.3 Length of test period

Most feed conversion efficiency tests begin after weaning at about six months of age and should be sufficiently long to facilitate an accurate estimation of feed conversion efficiency or net feed efficiency. The test period should provide for a sufficient adjustment period to allow any pre-test environmental effects to be minimised and to ensure that all animals have adjusted to the conditions and the diet.

3.8.2.3.1 Recommendation for the test period

It is recommended that the minimum period over which feed conversion efficiency should be determined is at least 60 days together with an adjustment period of at least 21 days.

3.8.2.4 Pre-test treatment

Animals destined for entry to a performance test station should be identified in sufficient time to facilitate all of the necessary health tests to be completed. Animals entered for feed conversion efficiency evaluation should not be given any special treatment prior to entry but should be fed on a normal plane of nutrition. They should have been introduced to concentrate feeding and be weaned in sufficient time such that the stress on entering the performance test station is minimized and they can be confidently expected to adapt to the test conditions within the adjustment period.

3.8.2.5 Animal health

All animals within a test shall be subjected to identical health treatments.

All animals entering a test should receive standard health treatments that allow each animal to achieve its potential growth performance in that environment.

Records of any remedial health treatments administered to individual animals on test should be maintained.

3.8.2.6 Withdrawal of animals from test

Where an animal on test has encountered any condition or circumstance, which has had a significant influence on its performance and for which there is insufficient time for the animal to recover, then such animals should be withdrawn from test.

3.8.2.7 Allocating animals to groups

A "group" may consist of any number of animals in individual pens. These pens should be adjacent to each other and have the same physical environment.

The test facilities under which feed conversion efficiency determinations are made can vary considerably. Test facilities designs include:

a. Individual pens.

b. Group pens of similar size with individual feed boxes.

c. Group penning with automated feed stations.

Where an animal is temporarily withdrawn from a pen for any reason, it should upon recovery be returned to the same pen if possible.

Recommendation

In the case of individual penning, all animals should be randomly allocated to the pens. Where animals are group penned, it will normally be necessary for management reasons to assign animals to pens based on animal size. These groups should be randomly assigned to the pens.

All animals in the same test must be fed and maintained under similar physical conditions, and must be fed a ration containing ingredients from the same batch.

3.8.2.8 Feeding regimes and rations

A well-organised feeding system using reliable equipment is essential. Variation in ration and feeding procedures is a significant source of variation between contemporary groups and test centres. Feeding systems vary from simple manually based systems where feed is manually weighed, recorded and dispensed to varying levels of automation including mechanically dispensed to fully computer controlled systems where feed is dispensed under full control to electronically identified animals kept in group pens.

Many test programmes calculate feed conversion efficiency on the basis of ad-libitum feeding. Some evaluation schemes determine feed conversion efficiency based on a restricted level of feeding which is set to achieve a pre-determined level of performance for the group. Such systems need careful monitoring to ensure that the average performance targets are being attained.

Where ad-libitum feeding is being practised, the level of feeding given to the animals should be increased to appetite as soon as possible after the beginning of the test.

In the event of a mechanical failure or any disruption to the feeding system, alternative procedures should be in place to enable all cattle to have access to their normal allocation of ration within 24 hours. If for any reason the feed dispensed on any day cannot be accurately weighed or recorded then that days data must be examined and appropriate adjustments made to the database records. Where feed intake for a day is lost the estimated feed intake for that day should be based on the average intake of the previous 7 days. Automated dispensing systems should be monitored to ensure that feeding levels are being achieved and animals are not reluctant to use the equipment.

The dispensing and recording systems should be checked on a routine basis to ensure the accuracy of all recorded data.

Recommendation

The feeding system used must incorporate accurate measurement and recording of daily individual animal feed intake.

3.8.2.9 Feeding

A balanced ration appropriate to the biological needs of the animal should be fed in a form which minimises any ingredient selection by the test animal. The ration formulation may change in the course of the test as the nutritional needs of the animal change. All animals within the contemporary group should be fed the same ration. Feeding of roughage may not be a requirement depending on the ration formulation. It may be fed as an aid to rumen function. Access to roughage should be controlled in order to avoid interference with ration intake. Roughage in such quantities as are required to maintain good rumen function should be fed. The pen construction and bedding material should be such as not to interfere with the ration or roughage consumption of the test animals.

Commercially available feed additives or supplements may be included in a ration to minimise health risks, or to ensure that the ration meets the minimum standards for metabolisable energy and crude protein, provided they are included within the manufacturers recommendations and to accepted industry standards.

Recommendations

Consignments of ration should be sampled and analysed on a random basis by an approved feed analytical service to ensure that the ration satisfies the pre-defined specification.

Where more than one test centre is involved in a joint evaluation, the specification of the ration fed should, as far as is possible, be similar. Care should be taken to ensure the ration is suitable for the class of stock.

It is strongly recommended that feed analyses performed before the commencement of test are conducted in sufficient time to modify the intended ration if there is a risk that the ration could fall outside the stipulated levels and cause the data generated to be rejected.

3.8.2.10 Adjustment period

A sufficiently long adjustment period is necessary in order to allow animals in the test to adjust to the test conditions. In ad-libitum tests the intake of animals should be gradually increased during this period until the animals are eating to appetite. Assessments should be made during this period to determine intake level as a proportion of theoretical intake potential of the animal.

Recommendation

A minimum of 21 days should be provided to facilitate full adjustment to the station conditions.

3.8.2.11 Data recording

Comprehensive and accurate data recording systems should be established.

Details should be recorded in respect of the following.

3.8.2.11.1 The individual test details

As a minimum, this should include:

a. Station ID where a number of test centres are involved.
b. Test year.
c. Test number.
d. Test type.
e. Date start (beginning of adaptation period).
f. Date start of test for feed conversion efficiency.
g. Date end of test.

3.8.2.11.2 Animals within the test

a. ID number of station.
b. Test year.
c. Test number.
d. Animal ID.
e. Station working number of animal if different from the permanent ID.
f. Pen number.

3.8.2.11.3 Intake details of animals on test

The recording of intake details is determined to some degree by the feeding procedures used. With computer based fully automated systems it is possible to record daily feed intake together with average daily weight derived from weighings taken from each visit to the feed station.

In non-computer controlled systems the feed record will hold the accumulated daily feed intake data since the previous intake information was recorded. The period over which feed intakes will be accumulated will normally be determined by the weigh period.

As a minimum each intake record should include:

a. Animal identification.
b. Date of record.
c. Quantity of feed eaten in this period.

3.8.2.11.4 Weight details of animals on test

This record will store the weight of the animal. Weighings should be taken on a routine basis while minimising gut-fill variation. Weighing the test animals on a regular basis facilitates the close monitoring of performance and early diagnosis of any difficulties within the test. Routine weighings together with a matching feed intake record facilitates the computation of within weigh period daily gains and feed efficiencies together with cumulative daily gains on test and feed conversion efficiency statistics. Depending on the design of the test it may be possible to combine the weight and feed intake details on a single record.

As a minimum the record should record:

a. Animal ID.

b. Date of weighing.

c. Weight.

3.9 Health traits

3.9.1 General

Healthiness of the animals is an essential prerequisite for any production system. Animal health is an increasingly important subject for beef recording schemes. Diseases may affect level of production, shorten length of productive life of animals and be the cause of confiscation of parts or of the whole carcass. Confiscation may be based on the risk to consumers' health and/or on the effect on the quality of carcass or meat. In all cases, profitability of the beef production system is affected because of veterinary treatment, loss of value of carcasses or of the value of the final meat product, increasing costs of slaughtering animals and the potential impact on consumers' demand.

Compilation of health data provides a mechanism of control of health status that may affect the profit of the beef enterprise, animal welfare and public health. Recording of animal health data is a tool for monitoring and controlling animals' diseases. It is also a useful tool for national and international trade in animals and their products as well as for the control of the epidemiology of diseases with special interest for zoonoses.

Disease resistance traits are among the most difficult to include in genetic improvement programs. They require good field measurements of the disease status of the animals under selection. In particular, infectious diseases depend very much upon environmental factors such as the degree of exposure to pathogen agent. In this context, molecular information may be a key tool for breeding purposes. Another approach in considering animal health as a whole is to include functional longevity in the set of breeding goals. Molecular information could provide and important tool for selection of genetic resistance to diseases.

3.9.2 Condition for data recording

Immunizations and screening tests are an important part of preventive veterinary services. Prevention has an strong impact diminishing morbidity and mortality in animal population. Most health service systems create population immunity from vaccination campaign or seasonal treatments. However, there is a number of diseases with a high prevalence in the beef cattle populations whose impact may be reduced through selection for diseases resistance. Recording of health traits allows for improvement in disease resistance. In countries where veterinary services are directly linked to performance recording schemes, there is an ideal environment to obtain information on health traits for breeding or/and epidemiological purposes. In other situations, it will be necessary to generate the need of systematic recording of animals health status among those professionals responsible for animals health and farmers. It is required at least a compromise solution of systematic recording of diseases which are obliged to be declared. The International Office of Epizooties (www.oie.int/eng/normes/mcode/a_summry.htm) provides information each year on the most significant epidemiological events with particular attention to contagious and economically significant diseases. OIE publishes two lists of disease, A and B. Diseases on list A are assumed to be either highly contagious and/or with significant economic effect (OIE list A). Diseases on list B (OIE list B) are less contagious than those on List A, but pose a significant threat to national economies or public health.

A systematic recording and storing of data at slaughter as a regular practices in abattoirs may be an important source of information for diseases at post mortem meat inspection. It is of particular interest for cases when non visible clinical signs has been detected. It is also of great interest when data is linked to on farm recording systems to identify risk factors.

Data recording need to be done on individual basis. It is also necessary to compile information that allows the establishment of the 'environmental conditions', timing, transmission factors etc.

3.9.3 Data recording

a. Animal Identification: this will link the animal to its invariable animal data such as sex, birth date pedigree and herd of birth or/and changes of location.

b. Code for disease.

c. Clinical signs or not: False or True. If true:
   - Date of visual appraisal of clinical signs.
   - Person responsible.

d. Type of diagnostic:
   - Clinical: symptoms.
   - Patognomonic lesions.
   - Laboratory Techniques: T or F. If true:
     - Technique: Direct (detection of the agent): Faecal counts (eggs or larvae counts), Inmunohistochemistry, PCR, Antigens, Culture and Isolation.Indirect: Delaged hypersensitivity: Antibodies, Others.
     - Lab.
     - Specificity or sensitivity of the technique.

e. Sample.

f. Date of sample.

g. Vaccination: T or F. If true:
   - Vaccine
   - Date of vaccination.

h. Treatment: T or F. If true:
   - Treatment.

- Date of treatment.

i. Relapse.

j. Date of relapse.

3.9.4 Classification of diseases and injuries

For data recording and storing is necessary to establish a systematic classification of diseases. As a first approach, there is an international classification of diseases from the World Health Organization (WHO). Thus, firstly, disease could be grouped as in the following list which is based on that classification (www.who.int):

a. Infectious and parasitic diseases.

b. Systemic diseases.

c. Endocrine, metabolic and nutritional diseases and immunity disorders.

d. Diseases of the nervous system or neurological diseases.

e. Diseases of respiratory system.

f. Diseases of circulatory system.

g. Diseases of digestive system.

h. Diseases of genitourinary system.

i. Diseases of skin and subcutaneus tissue.

j. Diseases of the musculoskeletal system and connective tissue.

k. Traumatism, injury and poisoning.

l. Genetic disorders.

m. Disease of blood and blood forming organs.

n. Complication of pregnancy and delivery.

3.9.5 Annex I - Diseases included in list A and B of the OIE

The following diseases are included in List A:

a. Foot and mouth disease.

b. Bluetongue.

c. Vesicular stomatitis.

d. Rinderpest.

e. Contagious bovine pleuropneumonia.

f. Rift Valley fever.

The following diseases are included in List B, within the category of multiple species diseases:

a. Anthrax.

b. Aujeszky's diseases.

c. Echinococcosis/hydatidosis.

d. Leptospirosis.

e. Q fever.
f. Rabies.
g. Paratuberculosis.
h. Trichinellosis.
i. New world screwworm (Cochliomyia hominivorax).
j. Old world screwworm (Chrysomya bezziana).

The following diseases are included in List B, within the category of cattle diseases:

a. Bovine anaplasmosis.
b. Bovine babesiosis.
c. Bovine brucellosis.
d. Bovine genital campylobacteriosis.
e. Bovine tuberculosis.
f. Bovine cysticercosis.
g. Dermatophilosis.
h. Enzootic bovine leukosis.
i. Haemorrhagic septicaemia.
j. Infectious bovine rhinotracheitis(IBR)/infectious pustular vulvovaginitis.
k. Theileriosis.
l. Trichomonosis.
m. Trypanosomosis (tsetse-transmitted).
n. Malignant catarrhal fever.
o. Bovine spongiform encephalopathy (BSE).

3.9.6 Annex II - Single –Locus genetic diseases

Single –Locus genetic diseases, refer to OMIA database for all species here and specifically for cattle here.

The following is a partial list of known defects:

- Anhidrotic ectodermal dysplasia.
- Cardiomyopathy.
- Cardiomyopathy, dilated.
- Ceroid lipofuscinosis.
- Chediak-higashi syndrome.
- Chondrodysplasia.
- Chronic interstitial nephritis with diffuse zonal fibrosis.
- Citrullinaemia.
- Coat colour, albinism.

- Complex vertebral malformation.
- Deficiency of uridine monophosphate synthase.
- Dwarfism, dexter.
- Dwarfism, growth-hormone-receptor deficiency.
- Dwarfism, snorter.
- Dyserythropoiesis.
- Ehlers-danlos syndrome.
- Ehlers-danlos syndrome, type vii.
- Epitheliogenesis imperfecta.
- Factor xi deficiency.
- Gangliosidosis, gm1.
- Glycogen storage disease ii.
- Glycogen storage disease v.
- Goitre, familial.
- Hyperbilirubinaemia, unclassified.
- Hypotrichosis.
- Lethal trait a46.
- Leukocyte adhesion deficiency.
- Mannosidosis, alpha.
- Mannosidosis, beta.
- Maple syrup urine disease.
- Mucopolysaccharidosis i.
- Muscular hypertrophy.
- Myoclonus.
- Porphyria, congenital erythropoietic.
- Progressive degenerative myeloencephalopathy.
- Protamine-2 deficiency.
- Protoporphyria.
- Renal dysplasia.
- Sex reversal: xy female.
- Spastic lethal.
- Spherocytosis.
- Spinal dysmyelination.
- Spinal muscular atrophy.
- Syndactyly.

- Testicular feminization.
- Testicular hypoplasia.
- Tibial hemimelia.
- Trimethylaminuria.
- Vertical fibre hide defect.

There are also a numbr of non-heritable genetic defects including: Turner Syndrome (XO) and Klinefelter (XXY) both are non-heritable genetic defects that result in sterile animals.

3.10 Tick count recording

3.10.1 Management aspects

The aim with the recording of tick counts is the evaluation of the genetic variation between animals for tick susceptibility. For this reason, it serves no purpose to do tick counts on animals that are not exposed to tick infestation.

3.10.2 Guidelines

a. Tick counts should be done on groups of animals that are kept in their natural environment (e.g. natural pastures), where they are exposed to ticks. (There is normally little or no exposure to tick infestation in feedlots, resulting in little or no variation in tick loads between animals).

b. Tick-control measures:

- The ideal is not to apply dipping or other tick-control measures on the particular group of animals for the testing period. However, this is not always possible if the tick infestation is severe.
- If dipping or other tick-control measures is needed during the testing period, the following guidelines should be followed:
    - Record tick counts immediately before dipping or the application of other tick-control measures. The ideal is not to dip or to use other tick-control measures on the to-be-recorded animals for at least three weeks prior to the tick count recording date.
- This period should be selected based on:
    - The effective period of the particular dip or other tick-control measure(s) being used. (A minimum of two weeks for long-acting remedies and a minimum of one week for short acting remedies is recommended).
    - The dominant or major tick species in the specific region/area. (The one-host blue ticks which have a three-week life cycle and a shorter than three-week dipping interval would allow only infestation of immature blue ticks. Because the immature ticks are very small, they may easily be missed during counting. An ideal dipping interval would therefore be three weeks. This is of course not always possible in situations of heavy multi-host tick challenge, but is essential if any data is to be obtained in areas where the one-host blue ticks are the only or major tick species present).

c. The general degree of tick infestation of that particular group of animals at the specific location and point in time.

- Tick count recordings should preferably be done during the season or period of expected high tick infestation - usually the warm (summer) months. The reason is that heavier tick infestation will increase the expression of genetic variation in tick resistance of individual animals, which in turn will be beneficial for genetic evaluation of tick resistance.
- Tick counts should preferably be done at a minimum of three or more occasions during the test period, with ideally at least three weeks between any two consecutive dates. This will increase the accuracy of the genetic evaluations.
- Each date during the test period on which tick counts are taken, should be recorded as a separate count or record for each animal.
- All tick species and types irrespective of sex and stage of maturity at a specific counting site should be counted at each event date on which counts are done during the test period.
- Each site on the animal where tick counts are done, should be recorded as a separate count (record) per animal.

Site	**Description**
Anus area	Observed from the rear of an animal, the area under the tail, around the anus
Scrotum/udder	Observed from the rear of an animal, the area below the anus down to and including the scrotum/udder
Ear	The inside area of the left or the right ear
Other	Non-specified area (Only for use of historical non-specified data)

3.10.3 Contemporary groups

Apart from the general requirements for contemporary groups, the following is recommended. For young animals, a contemporary group should be subjected to the same tick control measures and the tick counts should be recorded at the same dates. The animals should be born within a period of maximum 100 days of each other.

For older animals (cows and breeding bulls), different birth years and seasons may be evaluated in the same group, provided they are managed alike and they are in the same production stage. (Dry cows and cows suckling calves should, for example, be handled as separate groups).

The same person (recorder) should record tick counts on all animals in a contemporary group on the same date(s).

3.11 Carcass assessments

The ultimate goal of all beef cattle production systems is to efficiently produce a high yield of palatable beef. Meat quality and the quantity of edible portion are basic factors used to assess carcass merit. However, the relative emphasis to be placed on quality and quantity are subject to change with changing market demands.

Not all beef producers need complete carcass data. Careful thought should be given to the specific information that will be useful. Increasing the amount of traits to be recorded on large numbers of carcasses adds to the time required, costs, and likelihood of errors and may reduce beef processors' interest in cooperating. Only trained personnel should be contracted to do this in the large processing plants. Carcass weight, composition and quality are essential traits to be recorded at the slaughterhouse.

An essential prerequisite for gaining records in the slaughterhouse is that the ID of the live animal stays with the carcass or that a system is used, that allows the reporting carcass data with the ID of the corresponding live animal.

The following traits, as illustrated in table 4, are recommended as mandatory traits for breeding purposes.

Table 4. Mandatory traits for breeding purposes.

Trait	**Recorded as ….**
Carcass weight	Weight
Estimated meat yield	Percent; score
Carcass classification/Scoring system	Score

3.11.1 Carcass weight

Carcass weights are unaffected by variation in shrinking and therefore – apart from the scaling effect - show less variation than live weights. Compared to live weights they relate more to meat yield and to the consumers endpoint. Calculation of net gain is based on slaughter weight.

Typically, carcass weights are collected by commercial abattoirs; additionally experimental abattoirs come into consideration. Carcass weights should be collected consistently to ensure an informative data analysis.

Usually, carcass weight is defined by appropriate national legislation which clearly specifies which parts of the carcass are to be removed prior to taking the weight.

In the case of no legal definition, carcass weight should be defined as the hot weight of both half carcasses after removal of skin, bled and eviscerated and after removal of external genitalia, the limbs at the carpus and tarsus, head, tail, kidneys and kidney fats and the udder.

Preferably the unit of measurement should be metric to the nearest of 500 grams.

3.11.2 Carcass grade

Carcass grades significantly affect the market value of the carcass. Therefore they form a trait with big economic impact and should be used for the analysis of progeny productivity. Grading mostly is done according to national standards that frequently are based on appropriate legislation.

a. However, according to different market demands, national grading schemes frequently target different objectives and therefore are composed of different traits. On a global level there are two predominant types of grading schemes:

b. USDA grading scheme including the following components

- Class (steer, bullock, bull, heifer, cow)
- Maturity
    - Meat colour
    - Texture of lean meat

- Quality grade: 8 levels (Prime; Choice; Select; Standard; Commercial; Utility; Cutter; Canner)
  - Marbling
  - Firmness
- Yield grade
  - External fat
  - Kidney, pelvic and heart fat
  - Ribeye area
  - Carcass weight

c. EU grading scheme including the following components
- Class (calf, young bull (=bullock), bull, steer, heifer, cow)
- Conformation grade: 6 levels (S-E-U-R-O-P)
- Fat grade: 5 levels (1-2-3-4-5)

As a consequence meat reports are almost incomparable across big market regions like e.g. North America, Europe and other continents. Therefore the grading system should be clearly indicated on reports provided for use outside the country where the grading scheme is applied. In order to provide useful information that might be used outside the market region, it is recommended additionally to record each of natural components forming the grade.

3.11.3 Dressing percentage

Dressing percentage describes the percent ratio between carcass weight and the live weight taken immediately before slaughter. Although dressing percentage mainly is used for the estimation of carcass weights of live animals, it provides additional information on the animal's type even if carcass weight is measured directly.

A scale that measures in increments of 1 kg or 2 lb., or less, should be used for taking the live weight immediately before slaughter.

As live weight is largely influenced by shrinking, dressing percentage should account for this effect, by standardisation of the live weight to 12-hours shrinking time. The correction factors should apply in the special production environment of the animals.

Dressing percentage should be described as percentage with 1 decimal place.

3.11.4 Meat yield

Meat yield means the percentage of lean meat in the beef carcass as obtained by dissection. However, - with regard to high costs arising from carcass dissection - meat yield frequently is estimated on the base of surrogate traits, that can be easily measured in the course of the slaughter process.

In some areas meat yield refers to the whole lean meat contained in the carcass, whereas other regions account for specified retail cuts forming the most evident part of the carcass value.

Meat yield should be described as percentage with 1 decimal place.

Some areas apply yield grades rather than meat yield itself; e.g. the USDA yield grade is a numerical score from 1 to 5 expressed as a whole number. It represents the yield of the boneless, closely trimmed retail cuts from the round, loin, rib and chuck. These cuts represent about 75% of the carcass weight and about 90% of the carcass value.

Y.G.=2.5 + (2.5 X adjusted fat thickness, in inches)
+ (0.2 X per cent kidney-, pelvic-, heart fat)
+ (0.0038 X hot carcass weight, in pounds)
- (0.32 X Ribeye area)

The relation between yield grade and meat yield is described in table 3.5.

Table 3.5. USDA yield grade and meat yield.

Yield grade	Boneless, closely trimmed retail cuts
1	> 53.3
2	52.3 - 50.0
3	50.0 - 47.7
4	47.7 - 45.4
5	< 45.4

3.11.5 Meat quality

3.11.5.1 Definition of meat quality

In broader terms, quality refers to palatability, appearance, nutritional value and food safety. In practice, quality refers to the overall appearance and palatability of the edible portion of the carcass. Quality can be determined by evaluation of animal maturity, tenderness, subcutaneous fat, intramuscular fat (marbling), meat colour, fat colour, firmness of meat (lean) and texture of meat. Factors such as juiciness, flavour, aroma and undesirable flavours (off-flavours), are also quality traits, but can only be assessed through sensory taste panels and are therefore rarely recorded and evaluated.

Meat quality can be assessed on the basis of a subjective score (including e.g. a marbling score), through taste panels, or by using technical devices to measure the meat colour, tenderness, intramuscular fat, physiological parameters like the pH at different points of time, etc.

Meat quality can probably be defined as comprising four aspects of importance:

a. Visual quality:
Factors evaluated in classifying carcasses and/or factors that affect consumers' decisions when purchasing meat (e.g. subcutaneous fat cover, bone content and meat and fat colour).

b. Eating quality.
Tenderness, juiciness, odour and flavour intensity of the cooked product.

c. Nutritional quality.
Proportions of proteins, vitamins and minerals relative to energy density.

d. Safety.
Negligible risk from food-borne illness or poisoning and absence of drug, chemical, antibiotic or hormone residues. (Dikeman, 1990).

In this section, the focus will be on visual quality and eating quality (palatability).

3.11.5.2 Maturity

Maturity can be defined as an estimation of the physiological age of the carcass, which can be determined by evaluating the size, shape, and ossification of the bones and cartilage, the number of permanent incisors and the colour and texture of the lean. Alternatively, the chronological age of the animal may be used although physiological and chronological age are not necessarily the same.

Where the chronological age of the animal is unknown, maturity score is a useful unit of measurement. Maturity is usually classified according to the percentage ossification of the cartilage of thoracic buttons. In case maturity scoring, the following scores apply (Table 3.6).

Table 3.6. Numerical scores and maturity/age groupings.

Maturity	Score	Chronological age	Percentage ossification of the cartilage of thoracic buttons
A	1.0 – 1.9	9 – 30 months	<10
B	2.0 – 2.9	30 – 42 months	10
C	-	-	35
D	-	-	70
E	-	-	90

In some maturity classifications, numerical scores are given within the chronological age groupings, for a more accurate approximation of maturity. A numerical score of 1.5 would suggest that the carcass was in the middle of "A" maturity, while a score of 1.9 would be appropriate for a carcass at the upper end of "A" maturity but not quite into "B" maturity.

Initial maturity score is determined by the skeletal characteristics with adjustments made according to characteristics of the lean tissue. However, lean characteristics cannot be used to adjust final maturity of the carcass more than one full maturity group.

3.11.5.3 Marbling

Marbling can be defined as the flecks of fat in the lean. Marbling is usually evaluated visually in the rib-eye muscle, which is exposed between the 12th and 13th ribs. Marbling contributes to meat tenderness and is also associated with the palatability traits of juiciness and flavour.

Marbling is usually assessed by classification (e.g. 9 degrees of marbling, ranging from Practically Devoid to Abundant) related to the estimated percentage of intramuscular fat. Marbling scores and intramuscular fat percentages are specific to carcass assessments performed in North America and are not necessarily applicable to other countries.

As a consequence, marbling should be recorded according to BIF standards, where each degree of marbling is divided into tenths within each degree of marbling as in the table 3.7.

Table 3.7. Descriptive and numerical marbling scores for quality grades of "A" maturity carcasses.

Quality grade[1]	Marbling	Score
Prime	Abundant	10.0 – 10.9
Prime	Moderately abundant	9.0 – 9.9
Prime	Slightly abundant	8.0 – 8.9

Quality grade[1]	Marbling	Score
Choice	Moderate	7.0 – 7.9
Choice	Modest	6.0 – 6.9
Choice	Small	5.0 – 5.9
Select	Slight	4.0 – 4.9
Standard	Traces	3.0 – 3.9
Standard	Practically devoid	2.0 – 2.9

[1]B-maturity carcasses with Small or lower degrees of marbling cannot be graded Choice or Select.

Quality grades may vary in the number of degrees of marbling within a grade. If marbling is the primary determinant of quality grade, the numerical scores for grade should be the same as the marbling scores, except in cases in which they are discounted for maturity, colour, firmness of lean, or texture of lean.

The average relationship between marbling scores and intramuscular fat percentages is shown in the table 3.8.

Table 3.8. Marbling and intramuscular fat.

Marbling score	Intramuscular fat, %
Slightly abundant	10.13
Moderate	7.25
Modest	6.72
Small	5.04
Slight	3.83
Traces	2.76

It is recommended that a highly trained and certified person be used to assess quality grade factors when collecting carcass data.

3.11.5.4 Colour firmness and texture of lean

Colour of the rib eye muscle is used as an additional indicator of maturity or physiological age. The visual appeal of beef at the retail counter is highly dependent on desirable colour. Dark cutters are carcasses that produce lean tissue that is dark red to almost black and often result from cattle that have been stressed prior to slaughter. Dark cutters are safe to eat and their palatability is not seriously affected. However, the colour reduces consumer acceptability and lowers carcass value dramatically

Firmness of lean refers to the relative firmness or softness of the rib-eye muscle, whereas texture of lean refers to the apparent fineness or coarseness of muscle fibres within the rib-eye muscle.

Colour, firmness, and texture of lean are widely used in North America, and are not necessarily applicable to other countries. Accordingly, those traits should be recorded according to the following BIF standards reported in table 3.9.

Table 3.9. Scores for lean tissue.

Score	Colour	Firmness	Texture
7	Light cherry red	Very firm	Very Fine
6	Cherry red	Firm	Fine
5	Slightly dark red	Moderately firm	Moderately fine
4	Moderately dark red	Slightly soft	Slightly fine
3	Dark red	Soft	Slightly coarse
2	Very dark red	Very soft	Coarse
1	Black	Extremely soft	Very coarse

3.11.5.5 Standardized Warner- Bratzler shear force procedures for sire evaluation

More direct measures of palatability than quality grade include Warner-Bratzler shear tests for tenderness assessment, and trained sensory panel evaluation for tenderness, flavour, and juiciness. However, cost and availability will restrict usage of these alternative methods.

An initiative to standardize the protocol for Warner-Bratzler shear force determinations was identified at the National Beef Tenderness Plan Conference in April, 1994. The purpose of this protocol is to facilitate consistent collection of Warner-Bratzler shear force determinations across institutions for comparative evaluation. These data can be used in progeny testing and in the development of carcass breeding values to improve meat tenderness. Any institution abiding by these guidelines can be certified to collect Warner-Bratzler shear force determinations for the beef industry.

3.11.5.5.1 Conversion of live animals to carcasses

The process of conversion of the live animal to the carcass can have a significant effect on meat tenderness; therefore, the slaughter process and the environmental conditions during slaughter should be controlled as closely as possible. Conditions that should be monitored and that could affect Warner-Bratzler shear force values include electrical stimulation and post mortem chilling. Although these factors can affect the ultimate tenderness of beef, these variables are probably not controllable by the researcher. Whenever feasible, chilling temperatures and the type of electrical stimulation used (if any) should be noted.

3.11.5.5.2 Sample preparation

Consistent sample collection and preparation are critical to obtaining repeatable and consistent Warner-Bratzler shear force determinations. The following procedures are to be utilized when preparing steaks for shear force determinations:

a. Steaks, 25 mm thick, should be removed from the longissimus lumborum between the 12th rib and the 5th lumbar vertebrae of the carcass. Only one steak per animal is needed for evaluation. Steaks should be trimmed free of fat and bone.

b. After removal from the carcass, steaks should be vacuum-packaged, aged 14 days then frozen at day 14 post mortem to -20 °C or lower until they can be evaluated at a later date. Steaks should be stored at 0 to 3 °C during the 14-day aging process. All steaks should be vacuum-packaged during refrigerated storage after removal from the carcass (assuming that they are cut from sub primals before the end of the 14-day period) and during frozen storage. Steaks should be frozen individually without stacking (rather than after boxing) to ensure uniform, rapid freezing.

c. Internal temperature of the sample at the initiation of cooking can affect tenderness; thus, this variable must be standardized. Frozen samples should be thawed at 2 to 5 °C until an internal temperature of 2 to 5 °C is reached. For steaks, 1.0 in. thick, the time frame is approximately 24 to 36 hours (thawing time depends largely on the ratio of frozen meat to refrigerator/cooler size). During thawing, avoid steak overlap and stacking to improve the consistency of the thawing process.

d. Internal temperature of steaks will be determined prior to cooking. Steaks should not be cooked until a temperature of 2 to 5 °C is obtained throughout each steak. Steaks should not be thawed at room temperature.

e. To enhance consistency among institutions, steaks must be broiled on a Farberware Open Hearth Electric broiler (Kidde, Inc., Bronx, NY) or oven-broiled. Samples should be cooked to an internal temperature of 40 °C, turned and cooked to a final internal temperature of 71 °C (removed from the heat at 71 °C). For consistency in cooking, do not cook more than four steaks at a time on each Farberware grill.

f. Temperature will be monitored with iron- or cooper-constantan thermocouple wires with diameters less than 0.02 cm., and special limits or error of less than 2 °C. A metal probe, such as a 15-gauge spinal needle with a stylet (plunger), should be used to insert the thermocouple into the geometric center of the steak. Push the probe (with the stylet inside) completely through the meat, remove the stylet and thread the thermocouple wire into the needle through the pointed end. Remove the needle and pull the end of the thermocouple back into the center of the meat. Temperature can be monitored using a potentiometer or hand-held temperature recorder.

g. Steaks should not be held in foil or other types of containers prior to chilling because these processes affect chilling and cooling rates.

3.11.5.5.3 Core preparation

a. Cooling temperature and time after cooking, before coring, should be standardized. Two methods of cooling are recommended. Either chill samples overnight at 2 to 5 °C before coring (wrap with plastic wrap to prevent dehydration) or cool samples to room temperature prior to coring. Cooling samples to room temperature should be conducted so that a uniform temperature is obtained throughout the sample before coring. At least a 4-hour cooling time is required for 25 mm -thick steaks. Both procedures will remove variation in shear force caused by core temperature at shearing. Laboratories should intermittently check to assure that the chilling or cooling method they are using is providing an even temperature throughout the steak prior to cooling. Adjustment by lengthening the cooling or chilling time should be implemented if the previous time intervals are not long enough.

b. Cores should be 1.27 cm. in diameter and removed parallel to the longitudinal orientation of the muscle fibres so that the shearing action is perpendicular to the longitudinal orientation of the muscle fibres. Cores can be obtained using a hand-held coring device or an automated coring device. Coring devices must be in good condition and sharp; otherwise the core diameters will vary, causing an increase in variation of shear values.

c. A minimum of six and maximum of eight cores will be obtained from each steak. Cores that are not uniform in diameter, that have obvious connective tissue defects, or that otherwise would not be representative of the sample, should be discarded. If samples are chilled before coring, cores should be kept refrigerated (2 to 5 °C) until they are sheared. All values obtained should be used for mean calculation, unless visual observation indicates that a value should be discarded (e.g., a piece of connective tissue).

d. Shear each core once in the centre to avoid the hardening that occurs toward the outside of the sample.

e. Shearing must be done by using a Warner-Bratzler shear machine or an automated testing machine with a WBS attachment and crosshead speed set at 20 cm./min.

3.11.5.5.4 Certification of Warner-Bratzler shear force

Certification of institutions that perform Warner- Bratzler shear force measurement is important in determining that the above procedures are being adhered to and to ensure that consistent, reliable data on meat tenderness are being collected. Certification requires that individuals performing Warner-Bratzler shear force tests at each institution maintain a shear force repeatability of 0.65 or higher on duplicate steaks from the same animal.

In the absence of a standard material, cooked meat from the same animal must serve as the standard. All shear force values will be adjusted to a MARC-shear-force equivalent. Institutions interested in certification should obtain four steaks from each of 15 animals, arrange to send one pair of steaks to MARC personnel for shear force determination, and analyse the second pair of steaks themselves. The coefficient of variation of shear force for the certification steaks must range between 20% and 35%, because the amount of variation affects repeatability. MARC personnel will calculate a repeatability value and an adjustment factor, if needed, to equate each institution’s mean shear force to a MARC basis.

3.11.5.6 Data to be recorded

For the purpose of genetic evaluations on meat quality traits from data collected at abattoirs, it is necessary to collect all relevant data that could influence the particular recorded meat quality data. These additional data may relate to pre-slaughter management and feeding (e.g. growth promoting implants), slaughter (e.g. electric stimulation), chilling (e.g. period), aging process (e.g. period) and cooking process (e.g. cooking method).

a. Feedlot recordings
   - Regular data as specified in the section relating to tests in “Finishing Herds”, and additionally:
   - Implantations (where administered)
     - Date
     - Type
     - Dose/amount
     - Single or re-implant
   - Beta-agonist (in case of application)
     - Start date
     - End date
   - Pre-slaughter conditions:
     - Distance transported

  - Weather conditions
  - Time from loading to off-loading
  - Time from arrival at abattoir to slaughter

b. Slaughter and warm carcass recordings

- Regular data as specified in the section relating to “Commercial Slaughter Data”, and additionally:
- Fat colour assessment
- Meat colour assessment
- Marbling assessment
- Kidneys and channel fat weight
- Eye muscle area
- Electric stimulation:
  - (Yes/No)
  - Type of stimulator
  - Voltage
  - Duration/period
- Ph 1.5h after slaughter

c. Cold carcass recordings

- Fat thickness (e.g. back fat and P8)
- Chilling
  - Temperature
  - Period
- pH 24h after slaughter

d. Palatability recordings

- Aging
- Temperature
  - Duration/period
- Frozen weight
- Thawed weight
- Thawed temperature
- Time-on
- Time-off
- Cooking method
- Final (meat core) temperature
- Cooked weight

- Shear force
  - Type of measurement
  - Sample core diameter
  - Shear force value

    Frozen weight, thawed weight, thawed temperature, time-on, time-off, final temperature and cooked weight will be collected on each steak, in addition to the Warner-Bratzler shear values. Warner-Bratzler shear force should be reported as the mean of all core values.
- Sensory scores
  - Maximum
  - Minimum
- Sensory attributes
  - Juiciness score
  - Flavour score
  - Tenderness score
  - Aroma score
  - Off-flavour score
- Chemical measurement of marbling

4 Organisation and execution of testing schemes

4.1 Field test

4.1.1 Field of application

This recommendation applies to on-farm beef performance recording undertaken in herds of cows, which suckle their calves until an age of at least four months.

Data is collected in order to provide farmers with information useful for herd management and to provide raw data for genetic evaluations.

It allows for genetic evaluation both for growth ability and milking ability.

4.1.2 Symbol

The symbol of the recommendation is 'SH'.

4.1.3 Method of recording

ICAR recording methods "A", "B" and "C" can be used.

4.1.4 Reference performance

The reference performance is the weaning weight adjusted to an age of 205 days. Additional references can be set such as adjusted 100 days weight.

4.1.5 Minimum requirements

4.1.5.1 Animals to be recorded

Records have to be obtained for all animals from the same group of dams/calves kept at the same location for the same purpose.

4.1.5.2 Mandatory data to be recorded

For each of the animals the following data should be recorded:

a. Animal ID.

b. Weighing date.

c. One weight taken at an age between 90 and 250 days.

d. Farm ID.

e. Abnormal records in relation to any preferential treatment relative to the rest of the contemporaries.

f. ID of the management group within herd when they exist.

g. Fostering (if applied).

h. Particular details in relation to illness or other performance related factors.

4.1.6 Optional data to be recorded

4.1.6.1 Weights

Additional weight records that may be recorded in suckler herds include:

a. Regular calf (and dam) weights (e.g. every 30 days or every 90 days);

b. Dam weight at mating.

c. Dam weight at calving.

d. Dam weight at weaning of calf.

Additional weight recordings should comply with the same standard, in that the ID of the animal, the date of weighing, the management group, etc. is recorded with the weight.

4.1.6.2 Assessments

Additional assessment records that may be recorded in suckler herds include:

a. Body condition.

b. Wither height.

c. Muscular development.

d. Temperament.

4.1.7 Age restrictions and test length

The recommended age for weaning weight is 205 ± 45 (161 to 250) days. The maximum variation in birth dates of all calves in a test should thus not exceed 90 days. This implies that the minimum and maximum age difference (with one weigh date for all calves) per test should also not exceed 90 days. Table 10 indicates the proposed age limits for Birth, Pre-wean and Wean Tests.

Table 3.10. Age restrictions for recordings in suckler herd tests.

Test	Age restriction
Birth	0-3 days
Pre-wean	51-150 days
Wean	161-250 days

4.1.8 Definition of contemporaries

Apart from the definition given in section 2, the following applies. The responsibility for proper contemporary grouping lies primarily with the individual farmer. In most cases calves born within the same season (preferably not longer than a 90-day period) on the same farm can be grouped together. However, consideration should always be given to the way the calves are managed and also to the nutritional regime they were subjected to. Differences can exist on the same farm within a season, which require the establishment of two or more contemporary groups.

Creep fed calves should be separated from non-creep fed calves. Likewise, orphaned or extremely sick calves should not be compared to their normal herd mates. Crossbred calves should not be compared to straight-bred calves, except where an appropriate correction or model is applied resulting in a fair comparison.

In very large ranches or cattle operations, environmental, pasture and even management differences may exist between cattle stations or paddocks on the same property. In such cases, it is recommended that such cattle stations or paddocks be regarded as different herds and calves from different cattle stations or paddocks be handled as separate contemporary groups.

It is recommended that the information used to determine contemporary groups be maintained in the data bank to facilitate any future changes in contemporary grouping. Contemporary groups of two animals per group are useful in cattle evaluations but may show a lack of useful variation.

Birth and weaning contemporary groupings should be independent. This facilitates the inclusion of birth weights from calves that died before weaning.

4.2 Finishing herds

4.2.1 Field of application

This recommendation applies to on-farm beef recording undertaken in finishing herds from start to slaughter.

Data may be collected in order to provide farmers with information useful for herd management and to provide raw data for genetic evaluation. It facilitates the genetic evaluation of performance traits including growth.

The test is often used for dual-purpose breeds where young calves are weaned at an early stage.

As it is normally possible to assemble the contemporary groups it is important that the test design should be optimised as far as is possible. This property distinguishes the testing scheme from other field tests such as beef recording in abattoirs where no influence on the test design is possible. Therefore the inclusion of slaughter data does not affect the application of this testing system.

4.2.2 Symbol

The recommended ICAR symbol or abbreviation for this beef recording system is 'FH'.

4.2.3 Method of recording

ICAR recording methods "A", "B" and "C" may be used.

4.2.4 Description of Test

4.2.4.1 Organisation of the test

Weaned progeny of test and reference sires are grouped into finishing units and subjected to the same management conditions. The group should comprise at least 6 animals. In order to allow for an informative test design care must be taken to insure that the group is composed of progeny from several sires.

Accurate weighing should be undertaken on each animal on entering the finishing unit and on exit for slaughter. If an animal obviously is affected by illness or disease, this should be noted with the weighing details should always be retained with the weight and weighing date when the data is loaded to the database.

It is recommended that the length of the test be at least 1 year. At the end of the test further traits like body condition, muscular development, skeletal development may be recorded. Slaughter details of the animals such as shrunk live weight, carcass weight, national grading scores, carcass trim details and meat yield may also be recorded.

4.2.4.2 Minimum requirements

4.2.4.2.1 Animals to be recorded

Records should be recorded on all animals from the same group of finishing animals kept at the same location for the same purpose.

4.2.4.2.2 Mandatory data to be recorded

For each of the animals the following data should be recorded:

a. Farm identification.
b. Identification of the management group within herd when they exist.
c. Animal ID number.
d. Two weights taken at the start and end of the finishing period.
e. Weighing dates.
f. Abnormal records in relation to any preferential treatment relative to the rest of the contemporaries.
g. Details of animals negatively affected by illness or other factors.

4.2.4.3 Optional data to be recorded

4.2.4.3.1 Slaughter records

Additional records that may be recorded in finishing herds include:

a. Slaughter date.
b. Shrunk weight.
c. Hot carcass weight.
d. Carcass grade according to the national grading system.
e. Carcass cut details that provide information for meat yield.

4.2.4.3.2 Linear assessments

Additional assessment records that may be recorded in finishing herds include live animal data:

a. Scoring date
b. Body condition;
c. Muscular development
d. Skeletal development
e. Other linear traits

4.2.4.4 Data verification

Prior to evaluation, records should be check and combined with other data on the animal stored in the database (e.g. place of birth, birth date, breed, parents etc.). Inaccurate or implausible data should be removed from the data file. Apart from these deletions and rejection of records due to illness or disease, no other data should be excluded.

4.2.5 Definition of contemporaries

The contemporary group may comprise all animals from the same breed, sex, finishing period and management group. Due to the uniform environment within contemporary groups medium to high heritabilties can be expected.

4.3 Test Stations

4.3.1 introduction

The main objective is to estimate the breeding value of potential sires by minimising all possible sources of non-genetic variation. Station testing can normally facilitate feed efficiency tests.

The more the conditions in the test station replicate those under which the animals are reared commercially, the more the appropriate the test is as a measure of economic value. The test procedures should be designed to meet the requirements of specific production systems.

Test specifications such as the length of test, the age of the animals at the end of the test, the diet in terms of energy level may be chosen taking into account commercial and production realities. Consequently, a range of different procedures for such tests may satisfy the present recommendations.

4.3.2 Field of application

Test stations can be used for both individual performance test and for progeny test on males and/or females of test sires.

4.3.2.1 Individual performance test

The objectives is to assess genetic differences based on individual performances of assembled bulls from several herds in a single location and raised under uniform and standardized conditions. Tested bulls may subsequently go for use in AI or natural service.

The animal model using the relationships between the recorded bulls allows for comparisons when there are enough genetic connections between animals from different management groups and/or different stations.

4.3.2.2 Progeny test

The objectives is to assess genetic differences from the performance records of a sires progeny from several herds assembled in a single location and raised under uniform and standardized conditions. Progeny testing is most useful where carcass traits or maternal traits such as (reproduction, calving aptitude, milking performance) are important. Tested sires are mainly designed for AI use.

Generally the tested sires have been previously selected on the basis of an individual performance test. The size of the progeny groups will be determined by the accuracy required for the estimation of breeding value.

4.3.3 Test procedure description

The test procedure should be precisely documented and published.

4.3.4 Method of recording

Only the “A” method should be used, an official recording organization must carry out recording.

4.3.5 Recorded animals

Tested bulls may be from dairy, dual purpose or specialized beef breeds and the test animals should be selected from several herds.

The herds of origin should ideally be participants in an ICAR compliant performance recording scheme to ensure that the records related to the pre-test influences are available in the database.

4.3.6 Organisation

4.3.6.1 Age at entry at station

Entry in the station should occur at the earliest opportunity after birth in order to minimize the environmental influences of the herd of origin. Age at entry varies according to the type of production (dairy or suckler herds), to the breed and to sanitary/veterinary requirements.

Animals from dairy or dual-purpose breeds should be assembled before weaning, ideally within days after birth, and be artificially reared in a nursery up to the weaning stage. When selecting animals from suckler herds, animals should be selected as early as possible after weaning.

4.3.6.2 Adaptation period

Once weaned in the nursery or in the herd of origin, the test animals are assembled in the feedlot or finishing farm. During the post-weaning period, the animals should undergo a pre-test adaptation period which is necessary to overcome as far as is possible any pre-test environmental influences, and to limit the effects of compensatory growth during the test period. This is particularly important for the suckler calves, which are generally older when they enter the test station. The housing and feeding environment during the adaptation period should allow an easy transition to the test conditions.

The length of the pre test adaptation period should ideally be at least of four weeks.

4.3.6.3 Test period/termination point

The duration of the test period is determined by the age at the start, the plane of nutrition and the desired slaughter age. The test period should be sufficiently long for pre-test influences to be overcome. The test can be terminated at constant age or weight, at constant degree of finish or after a test period of fixed duration.

The recommended length of the test period should be at least of four months (120 days) in the case of performance testing.

4.3.6.4 Feeding and nutrition

Breed, nutritional factors and breed-nutrition interaction influence the rate of gain, the gain composition and feed efficiency.

Concentrate and roughage should be fed in a physical form, which prevents the selection of individual ingredients, in order to allow valid comparisons of gain and valid estimations of feed efficiency.

If complete high-energy diets are fed ad libitum (concentrates ad lib. / roughage restricted) daily gain will then be limited only by the growth potential of the bull. Conversely, if low energy diets are offered ad libitum (concentrates restricted / roughage ad lib.), daily gain will in addition also limited by the feed intake capacity of the bull.

Feeding restriction may be applied according to live weight to allow for a given average daily gain of the test group.

Feeding level and method should be documented.

a. Feeding level: energy and protein concentrations
b. Roughage / concentrate – restricted / ad libitum.
c. Feeding method: restriction on age or weight or ad libitum

4.3.6.5 Slaughter

Progeny test animals are normally slaughtered to record slaughter traits.

Ideally the animals should be slaughtered at the optimal carcass weight for market requirements. Animals are either slaughtered at constant live weight, at constant age or at constant degree of finish.

The animals should be slaughtered in the same place and the handling of the animals before slaughter, the slaughtering procedures and the post-slaughter aging should be standardized. Should it not be possible to slaughter all the animals at once, it will be necessary to ensure that satisfactory linkage is maintained in the slaughter groups.

4.3.6.6 Reference performance

During the test period, the reference performance is the average daily gain

In case of slaughter (progeny test), the reference performance is the net carcass weight gain per day of age

4.3.7 Mandatory data to be recorded

For each of the recorded animals, the following data should be recorded

4.3.7.1 Test period

a. Animal identification
b. Station identification
c. Identification of the management group, if existing
d. Date of weighing at the start of the test period
e. Live weight at the start of the test period
f. Date of weighing at the end of the test period
g. Live weight at the end of the test period

Live weight should be the average of at least two weights taken on successive days.

If shrunk weights are measured, a single weight after a shrink pereiod of 12 hours is adequate. Actual weights can also be adjusted using an appropriate regression to account for temporary environmental effects on individual animals. All raw data should be recorded and stored.

4.3.7.2 Slaughter

a. Slaughter animal identification must be linked to the animal identification where different.
b. Abattoir identification.
c. Slaughter date.
d. Live weight at slaughter (full or shrunk).
e. Commercial official slaughter weight of carcass (hot or cold).

4.3.8 Optional data to be recorded

a. Date and weight at entry in nursery if relevant.
b. Date and weight at feedlot entry.
c. Linear scoring both for muscular and skeletal development as well as for functional capacity.
d. Individual feed intake over the test period (kg).
e. Official carcass conformation and carcass fat score, for animals slaughtered where available.

4.3.9 Calculated traits

a. Average daily gain during test period (kg).
b. Efficiency of feed conversion should be expressed as weight of feed (as fed) relative to gain (this ratio can be adjusted to a common body weight to allow for weight and

growth rate differences as they affect feed requirements for maintenance). The way the feed intake is controlled should be described.

c. Dressing-out percentage (%).

4.3.10 Definition of contemporaries

A contemporary group is a set of animals of the same breed and sex, that are similar in age, that have been tested in the same season, on the same diet, in the same housing system and have received similar prophylactic treatments.

The animals within a contemporary group should be born within the shortest possible period, but not greater than 90 days.

Where acceptance of animals into a test station is continuous (animals to be evaluated enter the station throughout the year) season should also be taken into account.

Such a grouping into management groups should allow for sufficient genetic connections between contemporary groups, the size of which should be at least 15.

4.4 Commercial Slaughter Data

4.4.1 Field of application

This recommendation applies where beef recording is undertaken routinely at commercial abattoirs.

Since only the finishing unit is likely to be identified and since changes in the ownership chain of the animal are usually unavailable, it is recommended that use is made only of animals who have been at least one year on the finishing farm. This test is particularly appropriate for dual purpose breeds using AI based breeding programs and where the calves enter the finishing unit at an age of 2 3 months and are kept there until slaughtered.

The link between slaughter records and basic animal data is provided by the animal's ID number. It is important therefore that a link can be made between the national identification number and the carcass number if different. The ICAR symbol of this beef recording system is 'SH'.

4.4.2 Description

4.4.2.1 Organisation of the test

Ideally at birth the basic non-variant data on the animal such as farm ID, animal ID, birth date, birth location, sex, calving ease score will have been stored in the central database. When the animal is slaughtered, the hot carcass weight and the carcass grade are determined and stored in the database of the abattoir. The slaughter data should be sent to the animal recording organisation at regular intervals. The link between slaughter records and the standing or non-variant data of the animal is provided by the animal's ID number.

4.4.2.2 Reference performance

The reference performance is net gain being defined as hot carcass weight divided by the age at slaughter.

4.4.2.3 Minimum requirements

4.4.2.3.1 Mandatory data to be recorded

For each of the animals at least the following data should be recorded:

a. ID of the finishing farm.

b. Animal ID number.

c. Hot carcass weight.

d. Slaughter date.

e. Carcass grade according to the national grading system.

4.4.2.4 Optional data to be recorded

Additional records that may be recorded include:

a. Shrunk weight.

b. Carcass cut details and trim specifications which allow the determination of meat yield.

c. Video imaging results which can allow for the determination of meat yield, lean meat percentage, conformation score and fat score.

4.4.2.5 Data editing, data verification

Prior to any data evaluation, records should be check and combined with the other data on the animal. Inconsistent or non-plausible data should be removed from the data file. Apart from these deletions no other data should be excluded.

4.4.3 Definition of contemporaries

The contemporary group comprises all animals from the same breed type, sex, slaughter date and finishing farm. Due to the unknown specific environments of contemporary groups low to moderate heritabilties can be expected, thus requiring large progeny groups for accurate breeding values estimation.

5 Data transfer

5.1 General

Automated data exchange between computers is a fast growing business. This trend is strongly favoured by an increasing use of the Internet. Most areas of animal production are also involved in this process, such as routine data exchange between process computers, farm computers and mainframe computers at all levels of production, and in any direction within and across farms, breeding and recording organizations, commercial firms and administration authorities.

If animal production is subjected to quality assurance and/or takes place in complex production systems, i.e. in production chains with different owners and locations, there is the compelling necessity that the animal is accompanied by its individual data background during the whole production process beyond the animal’s own life span.

5.2 Use of the ADIS-ADED standard

Data exchange is still frequently carried out by individual agreements between sender and receiver about data contents and data structure. An alternative approach is the definition of fixed data formats by umbrella organisations applying for each member organisation and their personal members. However, such system quickly become inefficient with complex or fast growing information systems distributed to various participants.

The solution to this problem, is a fully automated data interchange based on flexible international standards. Automated data exchange using an international electronic data interchange protocol (EDI) avoids endless problem with bilateral data interfaces. Any individual agreements for data description are superseded and no adjustments to computer programs or manually operations are required any more. In the agricultural sector the use of the international ISO standard ADIS-ADED has become a routine application in many processor, personal and mainframe computers.

Compared to the prohibitive EDIFACT system, which is frequently used in the trade, the ADIS-ADED can be implemented stepwise thus saving resources. An ADIS-ADED interface is a simple ASCII file subject to the rules of ADIS-ADED. Because of this property it is able to ensure the data flow even through very heterogeneous system platforms. However, there is the restriction that ADIS-ADED only contains ordinary lists. Hierarchical or tree structures will not be reproduced.

ADIS-ADED provides a very transparent and clear interpretation of data fields. The clear definition of data items and entity tables with a unique distinction of different entry modes like key fields, mandatory and optional fields requires that the user accepts and anticipates the transparency of data definitions. The similarity of data structures and handling syntax with relational data banks makes the ADIS-ADED most suitable for data exchange across data banks without causing as much overhead as the standard internet data interchange protocol XML or EDIFACT. By using an appropriate SQL converter program, transmitted data can easily feed into the internal data bank.

5.3 Structure of the ADIS-ADED

Modern EDI systems are composed of modular structures to allow for an easy extension and for a stepwise integration of software components or modules from different manufacturers of diverse network systems. The most important components of ADIS-ADED is the Data Dictionary ADED (= Agriculture Data Element Dictionary) and the data transfer protocol ADIS (=Agriculture Data Interchange Syntax). The following parts of this chapter aim to give a brief summary of the most important elements of ADIS-ADED. More details can be found at ISO http://www.iso.ch. The ADIS ADED has been developed by ISO since 1995.

5.3.1 The Data Dictionary ADED

5.3.1.1 General

In the case of data exchange across computers the structure of transmitted data must be known and the data elements must be defined to enable the receiving program to pass the data according to its meaning into the internal data model. For this purpose, the data dictionary contains data objects (entities), that are composed of a set of data elements (items and code sets).

Data elements as defined by the Data Dictionary ADED originally referred mainly to the data exchange across process control computers and management computers. However, there is no implication that data elements may not be used for other levels of data exchange such as across the management computer and external computers as well as between/across software applications within the same management computer. The use of the same version of the ADED Data Dictionary by the sender as well as by the receiver is an essential prerequisite for any data exchange.

The general structure of ADED is defined by ISO11788-1. There are 3 different standard levels of the data elements:

Level 1:

a. International data elements as defined by ISO 11788-2 are centrally stored and apply world wide.
b. International data element numbers are indicated by the leading digit "9".

Level 2:

a. National data elements are centrally stored and apply at national level.
b. National data element numbers are indicated by a leading digit between "1" and "8".

Level 3:

a. Private data elements are specific to the software developer.
b. Private data element numbers are indicated by the leading digit "0".

In most cases data exchange will contain a mixture of international and national data elements. The international data dictionary for cattle is described in detail by ISO 11788-2. In this respect it is notable that the international Data Dictionary only contains a very limited number of items used for dairy farming and at present most Data Dictionary elements are developed on a national level.. Therefore, a broad extension of the international data dictionary to include more elements for dairy and beef farming seems to be essential.

5.3.1.2 Data elements (items, code sets)

Data elements (DDI = items) provide a unique and clear definition of each item appearing in the Data Dictionary. They are uniquely defined by:

a. Unique identification number.
b. Name with a length of up to 65 characters.
c. Data type that may my be either numerical or alphanumerical.
d. Use of ISO units.
e. Use of the extended 8-bytes ASCII characters (ISO 8-bit code).
f. Being a component of at least 1 data object.

5.3.1.3 Data objects (Entities)

Data exchange requires the definition of entities. The entity describes the contents and the structure of records that are transmitted according to ADIS rules. An entity might be composed of international, national und producer specific data elements. It is defined as a logical unit and structured by attribute lists describing an event or a simple object. Entities show some analogy to tables in data banks. According to convention key fields should be placed first in each record line. Optional fields may be omitted if appropriate.

5.4 Recommendation

The ADIS-ADED standard is able to provide an unambiguous, flexible, fully automated and cheap data exchange standard across different system platforms and computer communication in a peer-to-peer system. Because of these properties it is recommended to use ADIS-ADED for any kind of data transfer in beef production and beef recording.

5.4.1 Scope

The international Data Dictionary ADED for cattle aims to unify and to standardise beef data interchange across computer systems on an international and also in certain circumstances at a national and private level. Furthermore it aims to map a comprehensive data model associated with cattle production relieving national and private bodies from the need to establish their own country specific standards as far as possible.

The definitions and descriptions of ADIS-ADED apply for data exchange of ASCII-files within and across process computers, personal computers and mainframe computers in any direction across those systems. The data applies for data exchange within and across farm level, management- und evaluation computer programs on farm level and computer programs of service providers (e.g. recording organisations, breeding organisations and veterinarian and public services).

5.4.2 Responsibilities

5.4.2.1 The ISO ADIS-ADED Working Group

The international standards for data exchange by ADIS-ADED are developed by the ISO working group ISO/TC 23/SC 19/WG 2. However with regard to the maintenance, update and new developments of the cattle data dictionary, close cooperation with competent international professional bodies like ICAR is strongly recommended.

5.4.2.2 Role of ICAR

Within ICAR the Animal Recording Working Group is responsible for the development of the international Data Dictionary for ruminants. Therefore proposals to ISO/TC 23/SC 19/WG 2 for updates and extensions to the international dictionary for cattle are forwarded exclusively by this Group. The Animal Recording Working Group acts in close collaboration with the responsible ISO group and collects suggestions and proposals from other ICAR working groups and national developer groups involved in the development of an international ADED.

The other ICAR working groups contribute to the ICAR Animal Recording Group according to their specific expertise. Their contribution includes first drafts and proposals for new Data Dictionary elements being forwarded to the Animal Recording Group.

Beef recording implies an intensive data exchange between many participant involved in the recording and breeding process. Therefore the ICAR Beef Recording Group is developing a comprehensive data model referring to each of the recording schemes as mentioned in the previous chapters. This data model forms the base for the beef data elements which can be seen as a sub set of the Data Dictionary for cattle. Differences between national laws and regulations, breeds and production schemes will be taken into account.

Proposals for beef recording and beef breeding elements in the international cattle data dictionary may be made by individuals and organisations. However, prior to any handling within the ICAR Animal Recording Group they will be reviewed with regard to their relevance, completeness and systematic correctness by the ICAR Beef Group. If the Beef Group agrees, the proposals will be forwarded to the Animal Recording Group.

6 Glossary of terms

ABRI	Agricultural Business Research Institute at University of New England (UNE) Armidale. Is responsible for data processing and commercial operation of BREEDPLAN.
AGBU	Animal Genetics and Breeding Unit at joint institute of NSW Agriculture and UNE. Is responsible for research, development and management of BREEDPLAN
Age at first calving	Age of the dam in days at first calving
Age at puberty	Time at which the animal acquires the ability to reproduce offspring (first spontaneous ovulation or ability to produce an ejaculate of 50 million spermatozoa/ml)
Age of heifer first oestrus	Age of the heifer in days
Birth Weight	Weight of calf within 48 hours after birth
Body Condition Score	Numerical score to describe the nutritional body state of the animal
Bone %	Percent ratio of bone weight and carcass weight
Breeding	Natural mating or artificial insemination service (AI)
BREEDPLAN	The Australian genetic evaluation system for Beef Cattle.
Calf Mortality	Mortality of the new born calf during or within 48 h after birth
Carcass length	Carcass length between fixed points
Cause of death	Choice from a coded list of causes of death
Code of Practice	The minimum requirements that have to be met in each case to achieve accreditation
Conception	Formation of a diploid zygote
Conception rate of bull	Number of services or matings per (a) conception, (b) gestation or (c) calving when the same (only one) bull is used to breed cows and to obtain a gestation
Conception rate of herd	Proportion of cows mated to a bull or inseminated with a bulls semen which conceived or become pregnant at a defined stage of gestation
Conformation score	Subjective assessment of conformation in live animals or carcasses
CRC	Co-operative Research Centre for the Cattle and Beef Industry (Meat Quality) with head office based at UNE and the Tropical Beef Centre at Rockhampton Queensland
Disposal reason	Coded list to describe the exit of an animal from the herd;

	1. Death on farm
	2. Sale for breeding
	3. Sale for finishing
	4. Slaughter
EBV	Estimated Breeding Value. A measure of an animals genetic merit for a given trait
Embryo	The conceptus arising from the zygote through mitotic divisions
Estimated weight	Linear function of chest girth and age by breed
Fat score	Subjective assessment of fat cover of carcass
Fecundity	Reproductive potential of an animal as measured by the quantity and quality of gametes produced or by the quantity of developing eggs or of fertile breeding
Fertility	Reproductive potential of an animal as measured by the quantity and quality of gametes produced or by the quantity of developing eggs or of fertile breeding
Fertilization	Formation of a diploid zygote
First successful	
semen collection	Date of first successful collection
Foetus	The young organism after completion of organogenesis, when implantation of the conceptus is completed
Herd female Non-return rate	Proportion of cows inseminated for the first time during a given period of time, (such as a month), that have not been recorded as having returned for another service within a specified number of days, and so are presumed pregnant
Hot carcass weight	Weight of carcass after bleeding and removal of head, legs, skin, visceral organs
Implantation	Process of attachment of the conceptus in the uterus, begins at day 19-20 and is completed between days 35 and 42
Infertility	Any complete or partial (semi sterility) failure of an individual to produce functional gametes or viable zygotes
Kidney fat %	Percent ratio of kidney fat weight and carcass weight
Linear score	A numeric score recorded on one or more anatomical sites on the animal using a numeric scale designed to describe the biological variation
Live empty/shrunk weight	Live weight following 12 hours of food and water withdrawal
Live full weight	Average of two consecutive live weights where animal has access to food and water recorded 24 hours apart
Mating date	Date of actual mating

NFE	Net Feed Efficiency. Refers to the difference in animals feed intake independent of requirements for growth rate and body weight
NFI	Net Feed Intake. The trait calculated by phenotypic adjustment of feed intake for body weight and growth as a measure of NFE
Oocytes produced	No. of oocytes per flush
Pastural natural mating dates	Start and end dates of exposure to sire(s)
PBBA	Performance Beef Breeders Association. A technical committee representing each of the Breed Societies that conduct annual GROUP BREEDPLAN analyses
Pelvic Diameter	Vertical and or horizontal pelvic diameter
Prolificacy of female	Number of calves per gestation
Reproductive lifetime	A function of age at puberty and stayability
Scrotal Circumference	The largest circumference of the scrotum recorded with both testicles positioned beside each other
Serving capacity	Number of services achieved by a bull under stipulated/defined conditions
Sterility	Any complete or partial (semi sterility) failure of an individual to produce functional gametes or viable zygotes
Weaning Weight	Weight of calf at weaning

7 Literature

1. Amin, V., D.E. Wilson, and G.H. Rouse. 1997. USOFT: An ultrasound image analysis software for beef quality research. Beef Research Report, A.S. Leaflet R1437, Iowa State Univ., Ames.: 41-47.
2. Andersen B B *et al.* 1981. Performance testing of bulls in AI: Report of a working group of the commission on cattle production. Livest. Prod. Sci. 8: 101-109.
3. Beef Improvement Federation Guidelines Brethour, J.R., 1994 Estimating marbling score in live cattle from ultrasound images using pattern recognition and neural network procedures. J. Anim. Sci. 72:1425-1432
4. Beef Improvement Federation. Guidelines for uniform beef improvement programs. 8th edition.
5. Blockey M A de B. 1976. Serving capacity – a measure of the serving efficiency of bulls during pasture mating. Theriogenology; 13: 353-356.
6. Blockey M A de B. 1981. Development of a serving capacity test for beef bulls, Appl. Anim. Ethol., 7: 307-319.
7. Chenoweth P. J. 1981. Libido and mating behaviour in bulls, boars and rams. A review. Theriogenology, 16: 155-177.
8. Chenoweth P. J. 1992. A new bull breeding soundness evaluation form. Proc. Ann. Meeting Soc. Theriogenology, 63.

9. Courot M. (Ed.) 1984. The male in farm animal reproduction. Martinus Nijhoff Publishers, Dordrecht, for the Commission of the European Communities.
10. Hanzen C., Laurent Y., Lambert E., Delsaux B. Ectors F; 1990. Etude épidémiologique de l'infécondité bovine. 2. L'évaluation des performances de reproduction. Ann. Méd. Vét., 134: 105 114.
11. Hassen, A., D.E. Wilson, V.R. Admin, and G.H. Rouse. 1999. Repeatability of Ultrasound-predicted percentage of intramuscular fat in feedlot cattle. J. Anim. Sci. 77:1335-1340.
12. Hassen, A., D.E. Wilson, V.R. Admin, G.H. Rouse, C.L. Hays 2001. Predicting percentage of intramuscular fat using two types of real-time ultrasound equipment. J.Anim. Sci. 79:11 18.
13. Herring, W.O., L.A. Kriese, J.K. Bertrand, and J. Crouch. 1998. Comparison of four real-time ultrasound systems that predict intramuscular fat in beef cattle. J. Anim. Sci. 76: 364-370.
14. ICAR – International Agreement of Recording Practice. 2003. Approved by the General Assembly held in Interlaken, Switzerland, on May 30 2002.
15. ISU, 1994. Real-time ultrasonic evaluation of beef cattle. Study Guide. Iowa State University. Department of Animal Science, Ames, IA.
16. Jansen P. 1985. Genetic aspects of fertility in dairy cattle based on analysis of AI data – A review with emphasis on areas for further research. Liv. Prod. Sc., 12: 1-12.
17. Kastelic B.J., Curran S., Pierson R.A., Ginther O.J. 1988. Ultrasonic evaluation of the bovine conceptus. Theriogenology, 29: 39-54.
18. Kräusslich H *et al*. 1974. General recommendations on procedures for performance and progeny testing for beef characteristics. Livest. Prod. Sci. 1: 33-45.
19. Lewis W H E and Allen D M. 1974. Performance testing for beef characteristics. Proc. 1st World Congress on Genetics Applied to Livestock Production. Madrid, Spain: 671-679.
20. Meredith M. J. (Ed.). 1995. Animal breeding and infertility. Blackwell Science, Oxford.
21. Nicholoson, M J and Butterworth, M H, 1985. A guide to condition scoring of zebu cattle. International Livestock Centre for Africa. Addis Ababa. Ethiopia.
22. Pearson, R A and Ouassat, M, 2000. A guide to live weight estimation and body condition scoring of donkeys. Centre for Tropical Medicine. University of Edinburgh. UK.
23. Philipsson J. 1981. Genetic aspects of female fertility in dairy cattle. Liv. Prod. Sc., 8: 307-319.
24. Proc. Internat. Workshop on Genetic Improvement of Functional Traits in Cattle; Fertility and reproduction, Grub, Germany. November, 1997. Interbull Bulletin No. 18, 1998.
25. Van Niekerk, A and Louw, B P, 1990. Condition scoring of beef cattle. Natal Region. Department of Agricultural Development. Pietermaritzburg. South Africa.
26. Wilson, D.E., H.-U. Graser, G.H. Rouse and V. Amin. 1998. Prediction of carcass traits using live animal ultrasound. Proc. 6th WCGALP Vol 23: 61.