SECTION 7.2 - GUIDELINES FOR RECORDING, EVALUATION AND GENETIC IMPROVEMENT OF FEMALE FERTILITY IN DAIRY CATTLE

7.2.1 Technical abstract

These guidelines are intended to provide people involved in keeping and breeding of dairy cattle with recommendations for recording, management and evaluation of female fertility. Aspects of bull fertility are covered by another set of ICAR guidelines, compiled by the ICAR working group for Artificial Insemination (see: Guidelines for the expression of non-return rates (NRR) for the purpose of AI organisations). The guidelines described in this chapter support establishing good practices for recording, data validation, genetic evaluation and management aspects of female fertility.

To establish a recording scheme for female fertility the following data are desirable:

1. Calving dates.
2. All artificial insemination dates including natural mating dates where possible.
3. Information on fertility disorders.
4. Pregnancy test results.
5. Culling data.
6. Body condition score.
7. Hormone assays.

Other novel predictors of fertility, such as activity based information (pedometer), are also growing in popularity.

This document includes a list of parameters for female fertility and information on recording and validating these data.

7.2.2 Introduction

In broad terms, "fertility" is defined as the ability to produce offspring. In the dairy industry, female fertility refers to the ability of a cow to conceive and maintain pregnancy within a specific time period; where the preferred time period is determined by the particular production system in use. The relevance of certain fertility parameters may therefore differ between production systems, and evaluations of female fertility data have to account for these differences.

There are currently significant challenges to achieving pregnancy in high yielding dairy cows. Accordingly, female fertility has received substantial attention from scientists, veterinarians, farm advisors and farmers. Culling rates due to infertility are much higher than two or three decades ago, and conception rates and calving intervals have also deteriorated. There is no doubt that selection for high yields, while placing insufficient or no emphasis on fertility, has played a role in declining rates of female fertility worldwide, because genetic correlations between production and fertility are unfavourable (e.g. Pryce and Veerkamp 1999; Sun *et al.*, 2010). Most breeding programs have attempted to reverse this situation by estimating breeding values for fertility and including them with appropriate weightings in a multi-trait selection index for the overall breeding objective of dairy cattle.

One of the most important ways that fertility can be improved, through both management strategies and getting better breeding values is by collecting high quality fertility phenotypes. Female fertility is a complex trait with a low heritability, because it is a combination of several traits which may be heterogeneous in their genetic background. For example, it is desirable to have a cow that returns to cyclicity soon after calving, shows strong signs of oestrus, has a high probability of becoming pregnant when inseminated, has no fertility disorders and the ability to keep the embryo/foetus for the entire gestation period. For heifers, the same characteristics except the first one apply. Multiple physiological functions are involved including hormone systems, defense mechanisms and metabolism, so a larger number of parameters may reflect fertility function or dysfunction. However, in initiating a data recording scheme for female fertility it is often not practical (although desirable) to encompass all aspects of good fertility.

The obstacles that exist in adequate recording of fertility measures include: data capture i.e. handwritten notebooks versus computerized data recording and how these data link to a central database used to store data from multiple herds. Although many countries already have adequate fertility recording systems in place, the quality of data captured may still vary by herd. Many farmers are already motivated to improve fertility (as there is global awareness of the decline in dairy cow fertility over recent years). However, what is not always clearly understood is the importance of different sources of fertility data in providing tools that can be used to improve fertility performance.

The principles and type of data that should be recorded are the same regardless of the production system. However, the way in which the data are used i.e. the measures of fertility may vary according to the type of production system. For this reason, we have made a distinction between seasonal and non-seasonal herds:

In seasonal systems cows calve (typically) in the spring, so that peak milk production matches peak grass growth. An alternative is autumn calving herds that use feed conserved from pasture grown in the summer months. True seasonal systems have all cows calving as a tight time frame, i.e. within 8 weeks of the planned start of calvings.

In year-round-systems heifers calve for the first time (predominantly) at a certain age e.g. close to two years of age regardless of the month of year and calvings occur all through the year, so that the calving pattern appears to be reasonably flat.

7.2.3. Types and sources of data

7.2.3.1. Types of data

7.2.3.1.1. Calving dates

Calving dates can be used to calculate the interval between consecutive calvings and to confirm previously predicted pregnancies / conceptions.

To consider: In order to handle bias from culling it is useful to also record culling of cows and the culling reasons.

7.2.3.1.2. Insemination data

Data on inseminations can be used either alone or in combination with other data e.g. calving dates to define interval traits. Where the measure is initiated by a calving date, it can only be calculated for cows.

Insemination (and calving) dates can be used to calculate the following traits, those that can be measured for cows and/or heifers are indicated in brackets:

- Interval from calving to first insemination (cows).
- Interval from planned start of mating to first insemination (cows and heifers).
- Non-return rate (to first insemination or within a defined time period) (cows and heifers).
- Conception rate (to any insemination).
- Calving rate within a time period (an individual's phenotype is 0/1) (cows and heifers).
- Number of inseminations per lactation or insemination period (cows and heifers).
- Number of inseminations per calving or pregnancy.
- Interval from first to last insemination (cows and heifers).
- Interval between inseminations (cows and heifers).
- Interval from calving to last insemination (cows).

There is no best set of traits for evaluation of female fertility, but it is recommended to consider traits which reflect more than one aspect of fertility, e.g. interval from calving to first insemination or interval from calving to first oestrus (return to cyclicity) and non-return rate (probability of conception). For seasonal calving systems, submission rate and calving rate could be alternatives, see table 1. However, calving interval (the interval between two calvings) requires the least data, only calving dates, and is often used as a first step to genetic evaluations for fertility in the absence of insemination or other fertility data. It has to be used with care as highlighted above.

7.2.3.1.3. Fertility disorders

These data are either diagnoses related to treatments by veterinarians or observations from farmers. Details can be found in the ICAR Health Guidelines (ICAR guidelines for recording, evaluation and genetic improvement of health traits).

7.2.3.1.4. Milk production and composition data

Milk yield is correlated to fertility, and could be used as a predictor (for example in a multi-trait analysis of fertility). However, care should be taken, as the heritability of milk yield is high compared to fertility, the contribution of milk yield to the fertility breeding value could be considerable, making it difficult to identify bulls that are superior for both fertility and milk production. Results from selection based on Total Merit Indices show that it is possible to stabilize fertility if a certain weight is put on fertility.

Recent research confirmed genetic links between fertility and milk composition. In particular, changes of milk fatty acid profiles were identified (Bastin *et al.*, 2011) as useful predictors.

7.2.3.1.5. Results of pregnancy tests and further hormone assays

Pregnancy status can be determined by veterinary diagnosis, such as uterine palpation or ultrasound or by using information from hormones or circulating peptides associated with pregnancy. The timing of this data is important and should generally be done in consultation with veterinary practitioners. Other hormones, such as progesterone can be used to to determine the post-partum onset of cyclic activity and calculate e.g. interval from calving to first luteal activity (CLA) or other similar traits. The advantage of this trait, is that compared with the interval from calving to first insemination, it is not influenced by the farmer's decision of when to start inseminations. However, it may be costly.

7.2.3.1.3.6. Heat strength

Physical activity increases during oestrus, in addition there are other behavioural changes, such as standing heat and mounting behavior. These signs are used to detect oestrus and can be used to calculate traits such as interval between calving and resumption of oestrus. Tail paint (on the tail head) or colour ampoules attached to the tail head are used in some countries to aid oestrus detection. For larger herds, tail painting is used as a tool to aid insemination rather than resumption of cyclicity, however, on many farms, the decision to inseminate is often made after a defined period between calving and first insemination. In many practical situations it may be unrealistic to expect oestrus (without insemination) data to be collected, however recently there has been innovation in automating heat detection. For example, pedometers and more sophisticated activity monitors are now being used routinely on many farms as part of a management package. As cows become more active when in oestrus, the pedometer information needs to be compared to a baseline for the same cow and algorithms have been developed to interpret the data collected. The efficiency of oestrus detection rate has been reported to range between 50 and 100% depending on the criteria of success (At-Taras and Spahr, 2001). The gold-standard of oestrus detection are still progesterone measurements and imperfect concordance between pedometer and progesterone determined oestrus has been determined because activity monitors will not detect silent behavioural oestrus (Lovendahl and Chagunda, 2010). However, clearly there is an advantage in both progesterone and activity determined oestrus as they do not require farm observations.

7.2.3.1.3.7. Culling data

Culling data and culling reasons are important information especially if traits referring to longer time intervals (i.e. particularly those referring to calving dates) are used. Information on cows or heifers culled because of fertility disorders are of use, especially to remove bias arising from cows disappearing from the recording system i.e. a bull can have a biased proof if a lot of his daughters are culled for infertility and this is not recorded.

In the absence of accurate culling data, a useful proxy for monitoring fertility at the herd level is the proportion of animals failing to conceive by 300 days post calving. Cows not served by 300 days most likely reflect non-fertility culls, whereas cows that have been served and fail to conceive are more likely to reflect culls as a result of failure to conceive given that the majority of involuntary culls and decisions on planned culling occur in early lactation prior to the start of the breeding season.

7.2.3.1.3.8. Metabolic stress and body condition

Metabolic stress is defined as the degree of metabolic load that distorts normal physiological function. A distortion of normal physiological function may be temporary infertility, where the metabolic load is too great for the cow to invest in reproduction (future pregnancy) when the current lactation is not sustainable. Metabolic load is reflected by the stability of energy balance, which Veerkamp *et al.* (2001) suggested was related to traits such as milk yield, body condition score (BCS) and live weight (LWT).

By itself live weight is not a particularly good measure of energy balance, as tall thin cows may have weights similar to smaller cows in better condition. Therefore, BCS has been favoured as an indicator for energy balance. Cows with low BCS may have health problems, such as metritis, which may be the underlying problem for poor fertility. However, most studies worldwide have shown that BCS is a good indicator of female fertility, as cows that are mobilize body tissue may be more likely to use this energy to sustain lactation instead of invest in a pregnancy. Therefore, BCS has been found to be suitable to be incorporated into selection indexes for fertility, such as in New Zealand (Harris *et al.*, 2007). BCS is sometimes measured as part of the linear type assessment in pedigree and progeny testing herds it can also be measured by the farmer. However, in some situations, use of BCS as a predictor trait for fertility has been found to be limited (Gredler *et al.*, 2008).

7.2.3.2. Sources of data

Female fertility data originates from different data sources which differ considerably with respect to information content and specificity; for example from veterinary practices, laboratories, milk recording organizations, breed associations and farms etc. Therefore, ideally, the data source should be clearly indicated whenever information on fertility status is collected and analyzed. When data from different sources are combined, the origin of data must be taken into account. Regardless of the data source, it is desirable to have as few steps as possible from initial data recording.

7.2.3.2.1. Milk-recording

Initiation of lactation requires a calving date to be recorded for a cow. Calving dates are generally collected by organizations that are responsible for recording milk production, based on dates reported by the farmer, or more commonly gathered during the registration of births in countries operating mandatory birth registration systems. Calving dates are the most basic source of data available for evaluation of female fertility and can be used to determine calving intervals (defined as the number of days between two consecutive calvings).

Content:

- Calving dates.
- Culling reasons.

Advantages:

- Covers both cyclicity and conception.
- No additional effort for recording and therefore can be used as an easy first-step into evaluating fertility.
- Possible use of already-established data flow (reporting of calving).

Disadvantages:

- Missing dates for cows with problems around calving that do not enter the herd for milk recording.
- Only available for cows, not for heifers.
- Calving interval data may be censored, as cows that are infertile are often culled before calving again. If specific culling reasons are available, then information on animals that are culled for infertility can be a very useful addition to calving interval data, as the least fertile cows (i.e. cows culled for infertility) can be distinguished from cows culled for other reasons.

7.2.3.2.2. AI organisations or producers

AI organisations and other AI operators record insemination dates and the AI sire used for the insemination. Inseminations can either be recorded in a log book and later transferred to a computer or directly into a computer (sometimes handheld device).

Content:

- Information on inseminations (date of insemination, sire/origin of semen, semen batch, inseminator e.g. technician or member of farm staff).
- Sexed semen, embryo transfer, straw splitting etc. should be noted.
- Interventions such as synchrony should also be recorded, as it is possible that this may affect analysis results.

Advantages:

- If logistics for collection of insemination data are established, data can be collected from many farms.
- A broad range of measures of fertility can be calculated from insemination dates (often with calving dates) see Table 1. These measures can cover conception and cyclicity.

Disadvantages:

- If logistics for collection of insemination data are not established, considerable efforts may be needed to set-up recording.
- Completeness of recording may vary, especially if there are no legal documentation requirements.
- In situations where farmers often use AI for a set period of time followed by natural mating to farm bulls, some mating dates will be missing.

7.2.3.2.3. Veterinarians

Veterinarians are often involved in monitoring herd fertility. Pregnancy diagnosis or pregnancy testing is practiced and recorded by many veterinary practices to confirm a pregnancy. Uterine palpation per rectum or ultrasonography at around day 60 of conception is a valuable source of data because it is more accurate than non-return rates. Treatment for fertility disorders should also be recorded. From the economic point of view, a cow with good fertility without any treatments needed may be clearly preferred over a cow that was treated several times before it got pregnant.

Content:

- Pregnancy status.
- Diagnoses of fertility disorders.

Advantages:

- Direct information on fertility, which is not covered by calving and insemination data.

Disadvantages:

- Veterinary support and training needed to ensure data quality and consistency in diagnosis and definitions.
- Completeness of recording may vary depending on work peaks on the farm.
- Accurate animal identification may be an issue, as the data may be used (by the veterinary practice) to assess herd-level fertility rather than individual cow fertility.
- Data on pregnancy diagnosis may only be available for a subset of the herd.

7.2.3.2.4. On-farm computer software

Multiple herd management software packages are available for dairy farmers to record their own data. Some of this software interacts with the milk-recording organizations via standard interfaces, i.e. there are automatic exchanges of data between the central database and the computer on the farm. Farmers can enter calving, insemination, culling and pregnancy test information themselves. For genetic evaluation purposes, it is important that all the data is entered. Information on natural matings (if applicable) should also be recorded where possible and practical, which may not be the case for very large herds.

Content:

- Insemination data.
- Calving data.
- Pregnancy test results.

Advantages:

- No additional effort for recording.
- Continuous recording.

Disadvantages:

- Very often only software solutions within farm, difficulties of standardized export of data, although many software packages ensure data exchange with the genetic evaluation unit is possible.
- Trait definitions may differ between systems, requiring source-specific data handling.
- Incompleteness of insemination data, for example in some cases only the last successful insemination may be recorded for management purposes

7.2.4. Data security

Data security is a universally important issue when collecting and using field data.

The legal framework for use of fertility data has to be considered according to national requirements and data privacy standards. The owner of the farm on which the data are recorded is the owner of the data, and must enter into formal agreements before data are collected, transferred, or analyzed.

7.2.5. Documentation

Documentation is the precondition of use of fertility data for management and breeding purposes.

Pre-requisite information:

- Unique animal identification of both the cow and service sire.
- Unique herd identification.
- Ancestry or pedigree information (at the very least the cow's sire should be recorded).
- Birth registration.
- A central database (Often data is recorded on the farm's computer(s) and then uploaded to the milk recording agency who then transfer the data to a central database. Alternatively, data can exchange directly between the farm computer and the central database).

Useful additional documentation:

- Individual identification of the recording person.
- Details on respective fertility event.
- Artificial insemination or natural service.
- Type of semen used (e.g. sexed semen, fresh semen).
- Type of recording and method of data transfer (software used for on-farm recording, online-transmission).

The systematic use and appropriate interpretation of fertility data requires that different types of information can be combined such as date of birth, sex, breed, sire and dam, farm/herd; calving dates, and performance records. Therefore, unique identification of the individual animals used for the fertility database must be consistent with the animal ID used in existing databases (for more details see the "ICAR rules, standards and guidelines on methods of identification").

Data that can be used to calculate female fertility measures can originate from a number of sources including farm software, milk-recording organisations, veterinarians, breed societies and laboratories. Ideally, as much data as possible should be recorded electronically, as this reduces transcription errors. As long as data is as error free as possible, the origin of data is less important. However, it is preferable for data to be transferred to a central database in as few steps as possible and as quickly as possible. Genetic evaluation of young bulls relies on early information on fertility being available.

7.2.6. Recording of female fertility

Stepwise decision support for recording fertility

In setting up a recording scheme or using data for genetic evaluation of fertility, the data that is currently captured needs to be considered in addition to implementing strategies for including other data. For example, calving dates and consequently calving interval, is the most basic measure of fertility. Then, insemination dates can be added, to calculate interval traits and non-return rates.

Ideally, pregnancy test results should also be recorded as these can be used as early indicators of conception. Finally, or in some cases alternatively, other predictors, such as fertility disorders, type traits, culling reasons and measures derived from hormones assays can also be added.

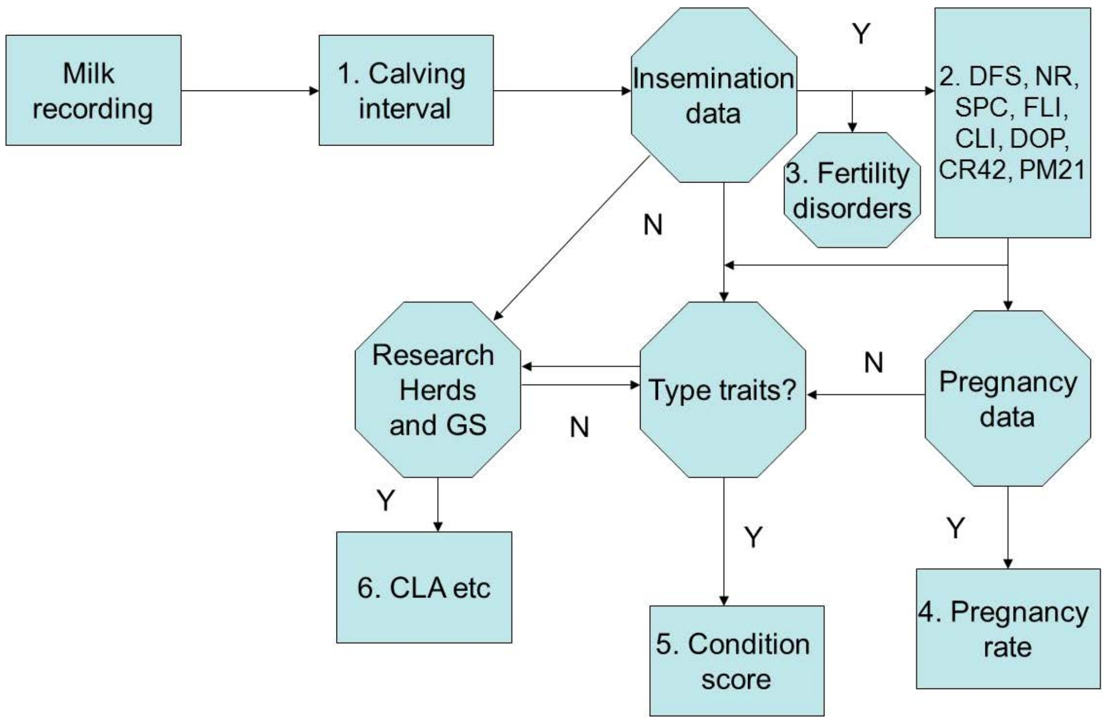

Figure 1. A flow chart describing the possible steps in developing a recording program for female fertility.

1. If only data from a milk recording organization is available then calving interval can be measured as the interval between 2 successive calvings.
2. If insemination data is available then days to first service (DFS), non-return (NR), number of services per conception (SPC), first to last service interval (FLI), calving to last insemination (CLI), days open (DOP) can be measured. Conception within 42 days of the planned start of mating and presented for mating within 21 days of the planned start of mating are measures suitable for seasonal systems and require a day when inseminations were started in the breeding season to be identified. Similarly first service submission can be used if a voluntary wait period is defined.
3. If information about fertility disorders (diagnoses) are available, the information about cows with e.g. cystic ovaries, silent heat, metritis, retained placenta or puerperal diagnoses can be included in an fertility index.
4. If pregnancy test/diagnosis data is available, then conception or pregnancy to the first (or second) insemination can be calculated, or in seasonal systems, conception within 42 days of the planned start of mating.
5. If type data is recorded regularly across parities, body condition score (a measure of fatness and metabolic status) can be evaluated. The limitation with condition score as part of a type classification scheme is that it is generally only recorded once, often on only selected cows, and therefore its usefulness may be limited.

6. If there are research herds or dedicated nucleus herds available, then commencement of luteal activity can be measured on a subset of animals (reference population). If these animals are also genotyped, then a genomic prediction equation can be calculated that can be applied to animals with genotypes but not phenotypes.

7.2.7. Data quality

7.2.7.1. General aspects

Recorded data should always be accompanied by a full description of the recording program.

- If herds were selected how was this done?
- How were the people involved in recording (e.g., veterinarians, and farmers) selected and instructed? Any standardized recording protocol used?
- What types of recording forms or (computer) programs were used? - What type of equipment was used?

Is there any selection of animals within herds? Consistency, completeness and timeliness of the recording and representativeness of the data compared to the national population is of utmost importance. The amount of information and the data structure determine the accuracy of the data; measures of this accuracy should always be provided.

7.2.7.2. General quality checks

National evaluation centers are encouraged to devise simple methods to check for logical inconsistencies in the data. Examples of data checks include:

- The recording farm must be registered or have a valid herd-testing identification.
- The animal must be registered to the respective farm at the time of the fertility event.
- The date of the fertility event must refer to a living animal (must occur between the birth and culling dates), and may not be in the future.
- A particular insemination must be plausible. For example are the insemination dates impossible? (e.g. before the calving or birth date)

7.2.8. Continuity of data flow. Keys to long-term success

Regardless of the sources of fertility data included, long-term acceptance of the recording system and success of the fertility improvement program will rely on the sustained motivation of all parties involved. Quantifying the benefits of data recording of these data is important. For example, data can be useful information for herd management, but also genetic evaluation and integration of these traits into selection programs.

7.2.9. Trait definition

7.2.9.1. Calving interval

Calving interval is the number of days between two consecutive calvings. Calving interval covers both return to cyclicity and conception, however its main disadvantage is that it is sometimes biased because cows with the worst fertility are often culled early and hence do not re-calve. Calving interval is also available later than many other measures of fertility, so is not as useful for selection decisions.

7.2.9.2. Days Open

Days open is the interval between calving and the last insemination date. It is similar to calving interval provided the cow conceives to the last insemination, in which case days open is calving interval minus the gestation length. The USA currently calculates daughter pregnancy rate as 21/(Days Open - voluntary waiting period + 11). The voluntary waiting period is the period after calving that a farmer deliberately does not inseminate the cow.

7.2.9.3. Non-return rate

Non-return rate is a binary measure of whether a new mating or insemination event occurs after the first insemination within a time period. Frequently studied intervals are 28 days (NR28), 56 days (NR56) or 90 days (NR90). The reference period recommended by Interbull is 56 days. This trait can be evaluated for both heifers and cows.

7.2.9.4. Interval from calving to first insemination

The number of days between calving and first insemination is sometimes influenced by management aspects and this needs to be considered in fertility evaluations. However, it does provide a measure of return to cyclicity post-calving. However, it does not provide information on conception (Table 1).

7.2.9.5. Interval between 1st insemination and conception

The number of days between first insemination and positive pregnancy diagnosis.

7.2.9.6. Conception rate

Success or failure to conceive after each AI (this can be evaluated for heifers and cows)

7.2.9.7. Calving rate, e.g. 42 or 56 days, from planned start of calving (seasonal systems)

The binary measure of whether a cow returns 42 or 56 days from the herd's planned start of mating. It is generally confirmed by the presence of a subsequent calving date. A herd's planned start of mating is when artificial inseminations for the herd commence.

7.2.9.8. Number of inseminations per series

The number of inseminations in a lactation or within a certain time period (this can be evaluated for heifers and cows).

7.2.9.9. Heat strength

A subjective scale is often used for recording of heat strength. This scale could be divided in different ways and could have various numbers of classes, but the classes should be ordered in intensity. As an example, the Swedish system has a five-point scale (very weak, weak, clear signs, strong, very strong heat signs) where each point is described in more detail regarding physical signs of the vulva and mounting/being mounted.

7.2.9.10. Submission rate

The percentage of cows mated in a fixed number of days after the herd's start of mating. On an individual cow basis, recording is a binary score i.e. AI'd within a period of days from the herd's start of mating.

7.2.9.11. Fertility disorders - treatments for fertility disorders

Information on specific fertility disorders can provide valuable information for evaluation of female fertility. Recording details can be found in the ICAR Health guidelines.

7.2.9.12. Body condition score

The Body Condition Score (BCS) measures the fatness of the cow, especially in the region of the loin, hip, pinbone, and tailhead areas. Change in BCS in early lactation may be a better indicator of fertility compared with single observations of BCS per parity. To consider change in BCS it has to be recorded at least twice in early lactation and requires the dates of measurement.

7.2.9.13. Overview over traits

For monitoring the health status of dairy cows, an assessment of fertility is also useful to ensure that a complete picture of the health of the herd is available. For more information see the ICAR Health Guidelines.

7.2.10. Use of data

7.2.10.1. Improvement of management (individual farm level)

Although these guidelines focus mainly on evaluation of female fertility for genetic improvement, information is also very useful for on-farm decision-support. Routinely recording of fertility data allows the presentation of key figures for veterinary herd management.

7.2.10.1.1. Farmers

Optimized herd management is important for financially successful farming

Results of recording can be presented per individual animal or about cohorts and distinguish between retrospective "outputs" such as calving index and "inputs" such as number of services, results of pregnancy diagnosis in order to analyze overall performance (Breen *et al.*, 2009).

However, for short term decisions (e.g. whether to continue to inseminate or not) on-farm recording of fertility is probably the only practical solution. More sophisticated decision support may include correction of the observed level for systematic environmental effects (such as parity or stage in lactation) and time analysis. Fertility reports summarizing the fertility performance of age-groups within the dairy herd also allows farmers to benchmark their farm to others.

Timely availability of fertility information is valuable and supplements routine performance recording for optimized fertility management of the herd. Therefore, fertility data statistics should be added to existing farm reports provided by milk recording organizations. Examples from Austria are found in the Austrian Ministry of Health (2010).

Immediate reactions

It is important that farmers and veterinarians have quick and easy access to herd fertility data. Only then can acute fertility problems, which may be related to management, be detected and addressed promptly. An Internet-based tool may be very helpful for timely recording and access to data. Lists of actions with animals ready to be inseminated or pregnancy tested are helpful.

Long term adjustments

Less-detailed reports summarizing data over longer time periods (e.g., one year) may be compiled to provide an overview of the general fertility status of the herd. Such summary reports will facilitate monitoring of developments within farm over time, as well as comparisons among farms on district and/or province level (Breen *et al.*, 2009; Austrian Ministry of Health, 2010). Publication of key figures on female fertility at herd level will provide decision support at the tactical level. A general recommendation is to present recent averages (last year), but also to present trend over several years. If available, it is advised to include a comparison of the averages with a mean of a larger group of (similar) farms. For example, the average days open might be compared with the average days open for all farms in the same region or with the same milk production level.

Farm averages might also be specified for different groups of animals at the farm. For example, days open might be presented as an average for first lactation cows versus later parity animals. This denotes which groups require specific attention in the preventive management.

Definitions of benchmarks are valuable, and for improvement of the general fertility status it is important to place target oriented measures.

7.2.10.2. Monitoring of the health status (population level)

Government bodies and other organizations involved in animal health issues are very interested in monitoring the health status of the cattle population. Consumers also are increasingly concerned about aspects of food safety and animal welfare. Regardless of which sources of health information

Table 1. Various traits used or possible to use and their potential relation to various aspects of cow fertility.

	Aspect				System	
Trait	**Return to cyclicity**	**Oestrus signs**	**Prob. of conception**	**Ability to keep embryo**	**Seasonal**	**Yearly**
Interval between two consecutive calvings (calving interval)	+	+	+	+	✓	✓
Interval from calving to first insemination	++	+				✓
Submission rate: e.g., interval from planned start of mating to first insemination	++	+			✓	
Interval from calving to first luteal activity♣	++				✓	✓
Body condition score, live weight change during early lact., energy balance	+	+	+	+	✓	✓
Non-return rate (56, 128, .. days)			++	+		✓
Conception to 1st insemination (determined with pregnancy diagnosis)			++	+		✓
Calving rate (e.g. 42 or 56 days) from planned start of calving			++	++	✓	
Number of ins. per series		+	++	+		✓
Interval from first ins. to conception (or last insemination)		+	++	+		✓
Interval between inseminations		+		(+)		✓
Heat strength		+			✓	✓
Treatments for fertility problems	+	+	+		✓	✓
Days open, interval from calving to conception (or last insemination)	+	+	+	+		✓

The number of + indicates how well the measure relates to the aspect of fertility
✓ indicates the suitability of the measure to the production system

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are used, national monitoring programs may be developed to meet the demands of authorities, consumers and producers. The latter may particularly benefit from increased consumer confidence in safe and responsible food production.

7.2.10.3. Interbull

Fertility data is also important for providing genetic evaluations, both within country and between countries. The following section is from the Interbull website (*www-interbull.slu.se/Female_fert/framesida-fert.htm*) and are the traits that the Interbull Steering committee chose in August 2007 to become part of MACE evaluations of fertility. Interbull considers female fertility traits classified as follows:

- T1 (HC): Maiden (H)eifer's ability to (C)onceive. A measure of confirmed conception, such as conception rate (CR), will be considered for this trait group. In the absence of confirmed conception an alternative measure, such as interval first-last insemination (FL), interval first insemination-conception (FC), number of inseminations (NI), or non-return rate (NR,preferably NR56) can be submitted.
- T2 (CR): Lactating (C)ow's ability to (R)ecycle after calving. The interval calving-first insemination (CF) is an example for this ability. In the absence of such a trait, a measure of the interval calving-conception, such as says oprn (DO) or calving interval (CI) can be submitted.
- T3 (C1): Lactating (C)ow's ability to conceive (1), expressed as a rate trait. Traits like conception rate (CR) and non-return rate (NR, preferably NR56) will be considered for this trait group.
- T4 (C2): Lactating (C)ow's ability to conceive (2), expressed as an interval trait. The interval first insemination-conception (FC) or interval first-last insemination (FL) will be considered for this trait group. As an alternative, number of inseminations (NI) can be submitted. In the absence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.
- T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

Based on the above trait definitions the following traits have been submitted for international genetic evaluation of female fertility traits.

7.2.11. Literature

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7.2.12. Acknowledgments

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The working group acknowledges the valuable contributions and support in improving this document of Brian Wickham (ICAR) and Pavel Bucek (Czech-Moravian Breeders' Corporation), Stephanie Minery (Idele, France), Pascal Salvetti (UNCEIA), Oscar Gonzalez-Recio and Mekonnen Haile-Mariam (DEPI, Melbourne, Australia) and John Morton (Jemora, Geelong, Australia).