

# Calculating Reproductive Indices

(Recommendations of the American Association of Bovine Practitioners)

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## Abstract

This paper presents the report of a committee of the American Association of Bovine Practitioners recommending methods for calculating several basic indices of reproductive performance on dairy farms. Indices for several major analytic areas are presented: overall reproductive performance, estrus detection intensity, conception efficiency, pregnancy losses, reproductive culling, and also reproductive efficiency in herds using a bull.

## Introduction

Satisfactory reproductive performance is necessary for a dairy to achieve its goals for production and profitability. Reproduction directly affects milk production per cow per day, as well as other economically important aspects of the dairy such as genetic progress and culling policy (1,3,4). Adequate records and their reliable analysis and interpretation are fundamental to effective reproductive management. Computer systems are being used widely to

provide analytic summaries of the reproductive status of dairy herds. The major source of such summaries are the Dairy Herd Improvement Association (DHIA) records processing centers, although an increasing number of dairies are using other computer record systems, particularly on-farm microcomputer systems.

There is a wide variation between different DHIA records processing centers and among microcomputer systems in the methods for calculating reproductive indices (2). These variations make comparisons between different systems difficult, and interpretation of reproductive performance goals confusing. Because of this variation between systems, the American Association of Bovine Practitioners (AABP) formed an ad hoc committee to develop a set of proposed standards for the calculation of several of the major indices used to evaluate dairy reproduction. Table 1 lists the parameters considered by the committee. Developing these recommendations has involved extensive consultation with members of the AABP, with dairy records processing center personnel, and with experts in the field of dairy cattle reproduction. This paper is a report of those recommendations.

## Basic Definitions and Abbreviations

**Period:** Typically a month, but for DHIA Record Processing Centers (DRPC)— this will usually correspond to the time between two herd test days. The designation “Past Year” would include 12 such periods. The terms period and month will be used interchangeably in this report.

**Test Date:** For DRPCs, this is the date of herd test. For other computer programs, this would generally be either the day reports are generated by the computer, the date the data was collected, or else the end of each month.

**Voluntary Wait Period (VWP):** the time (in days) before which the dairyman will not breed a cow, even if she is detected in estrus.

Recommended default: 50 days

**Service or Breeding:** Artificial inseminations reported by dairyman. Two or more inseminations within the same 3-day period should be handled as one service or breeding for the purpose of calculations.

**To-Be-Culled Cows (TBC):** Cows still in the herd that have been reported as “to be culled,” independent of reason, with date of report (test date) as TBC date unless dairyman specifies a different date.

**Turned-with-Bull Cows (TWB):** Cows turned in with a bull. Test date should be used as TWB date, unless a specific date is provided.

## Additional Data Not Routinely Collected by Most Programs That Would Be Required to Implement These Recommendations Fully

In addition to the routinely collected data regarding calvings, breedings, and pregnancy confirmation, the following items would need to be recorded by the dairyman for these recommendations to be fully implemented.

1. Confirmed abortion
2. Date turned with bull
3. Confirmed pregnant to bull
4. Date of conception to bull
5. Number of bulls used for herd breeding
6. Date cow was given prostaglandin to induce a breedable estrus

## General Reporting Considerations

Computer records will play an increasingly important role in the dairy industry. Record systems should allow the user access to individual observations, as well as summary information. DHIA centers should provide for downloading of data to remote users. Microcomputer systems should be designed to upload data to DHIA centers. We recommend that all dairy record systems move toward maintaining detailed data for individual cows for all lactations. This should include the data for cows culled

from the herd during the recent past. Culled-cow records should be retained for a minimum of for 14 periods before being deleted from a herd’s active file.

Most reproductive indices should be reported on the basis of the current month’s performance, as well as for the past year as a whole. Programs should avoid using averages or sums of the last 12 months’ statistics to arrive at a yearly value. While convenient, such an approach may distort the true herd status by combining numbers derived from different denominator populations and by ignoring corrections made to the data after a monthly index was calculated. Ideally, the data base should include all events on each cow for at least the past 12 months. This will allow indices to be calculated newly each month for both the current month’s and the past year’s performance. This allows for correction of data in previous test periods, and avoid the problem of attempting to produce weighted averages of different months’ data where the weighting factors may be difficult to determine.

In addition to reporting rates of reproductive performance, it is valuable in many cases to report the number of cows that produce a given calculated rate. Monthly indices in small herds may vary widely, due to small denominators used in the calculations. Providing the denominator number of cows may prove impractical in many cases, due to limits on the available space on forms for monthly summary information. If the computational problems can be resolved, it might prove useful to allow the dairyman to define a longer “window” of time (from 2 to 6 months) over which the “current month” indices are calculated. This would provide a more consistent denominator population for rates in small herds.

The calculations recommended in this report will be most accurate if the herd uses a veterinarian to confirm pregnancy. For herds that use nonreturn to estrus to establish pregnancy, a 65-day nonreturn period should be used, rather than the traditional 60-day nonreturn period. The 65-day cutoff would increase the possibility of detecting the third estrus following a breeding before the cow is considered pregnant.

## Measuring Overall Reproductive Performance

### *Projected Minimum Average Days Open*

Days open on a projected basis should be a prospective “best estimate” of the minimum days open that will be experienced in the herd’s future.

The average days open should be calculated across three groups of cows.

1. Pregnant cows in the herd:  
days open is the day from calving to conception.
2. Cows with a breeding date, but not yet confirmed pregnant:

assume cows are pregnant at the last breeding and calculate as in #1 above.

3. Cows past voluntary wait period, but not yet bred, and cows previously bred, but known to be open: assume those cows will be seen in estrus, bred, and conceive 10 days after test day.

This calculation would be done only for cows currently in the herd on the day of test that are past the voluntary wait period. It would exclude TBC cows.

#### *Past Year Days Open*

The days open on a past-year basis should be a retrospective measurement of the reproductive performance of the herd for all calvings in the past 12 periods. It should be calculated for all cows calving in their second or greater lactation, by subtracting the previous calving date (PC) from the most recent calving date (RC) and subtracting 280 from that difference.

$$\text{Past Year Days Open} = (\text{RC} - \text{PC}) - 280$$

Past Year Days Open should include all eligible calvings in the past 12 periods, even if the cow has subsequently been culled. For both Projected Minimum Average Days Open and Past Year Days Open results should be reported as both average and standard deviation.

#### *Projected Calving Interval*

Projected Calving Interval should be based on the calculated Projected Minimum Average Days Open for cows, plus a standard 280-day gestation divided by 30.4 days per average month. The result would be calving interval in months.

$$\text{Projected Calving Interval} = (\text{Projected Minimum Average Days Open} + 280) / 30.4$$

#### *Past Calving Interval*

Past calving interval converts the Past Year Days Open to a historic calving interval.

$$\text{Past Calving Interval} = \text{Past Year Days Open} + 280 / 30.4$$

For both Projected Calving Interval and Past Calving Interval, report results as both average and standard deviation.

### **Measuring Estrus Detection Intensity**

#### *Percent of Possible Heats Detected*

Percent of Possible Heats Detected provides an estimate of the intensity of estrus detection. It does not measure the accuracy of detection.

#### Current Month:

Numerator (N): all breedings and reported heats in eligible cows in the period. Denominator: (D) estrus days in the period in eligible cows.

$$\text{Percent of Possible Heats Detected} = (N / [D / 21]) \times 100$$

Eligible cows: all cows past VWP contributing estrus cycle days in the period includes:

1. Unbred and known open cows: days past VWP in the period.
2. Bred cows not known to be pregnant: days in the period up to the last breeding + (days in period after last breeding \* [1 - CR]), where Conception Rate (CR) would be: 1/services per pregnancy, all cows; using the value for the current month.
3. Pregnant cows: days in the period up to the last breeding date (this would rarely occur).
4. To-be-culled cows: days past VWP in period up to date reported as to TBC, unless cow has been reported pregnant, in which case she is handled as a pregnant cow.
5. Cows turned with bull: days past VWP in period up to TWB date, unless cow has been reported pregnant to a breeding prior to TWB, in which case she is handled as a pregnant cow.
6. Use of prostaglandin (PGF): each use of PGF in an eligible cow would add 7 days to estrus days in the period.

#### Past Year

The herd's performance over the past 12 periods should also be calculated for this parameter. This can be done by calculating the numerator and denominator for each period and then summing those numerators and denominators and using the same formula as for the current month. The estrus days in each period would be calculated in the same way as for the current month, except that bred cows should be handled based on known final outcome of any breeding, even if that outcome would have been unknown during the period. Thus, if a cow were bred during Period 1 and a pregnancy to that breeding were confirmed in Period 3 (two months later), then the cow should be treated as a pregnant cow in Period 1. Similarly, if the breeding in Period 1 had later been shown to have been unsuccessful, then the cow should be treated as an open, unbred cow in Period 1.

The past-year parameter cannot be calculated by simply accumulating the raw numerator and denominator each period while calculating the current month values, since it would tend to underestimate the estrus days contributed by cows bred, but not confirmed pregnant and would not adjust for corrections made in the data during the year. The calculation should be newly made, using raw data for each test period to create the summary of the year.

If possible, data from culled cows and TBC cows should be included in the calculations, provided they were part of the eligible cows in the herd at any time during the 12 periods.

## Measuring Conception Efficiency

### *Services Per Pregnancy, All Cows*

Services per Pregnancy, all Cows is a measure of the conception rate for breeding in the herd as a whole.

#### Current Month:

Determine the outcome for all artificial insemination (AI) breedings (B1) in the test period 2 periods ago (numerator). Those breedings that resulted in a confirmed pregnancy make up the denominator (P1). Pregnancy can be designated either by veterinary examination or by 65-day nonreturn, depending on the herd's policy. Confirmation of pregnancy by examination is preferred.

$$\text{Services Per Pregnancy, All Cows} = B1/P1$$

All cows in the herd are eligible for inclusion in this calculation, even TBC cows.

#### Past Year:

Determine the outcome for all AI breedings (B2) in the test periods from 2 periods ago back to the test period 14 periods ago (for a total of 12 periods). Those breedings that resulted in a confirmed pregnancy make up the denominator (P2).

$$\text{Services Per Pregnancy, All Cows} = B2/P2$$

Ideally, the cows considered should include all cows in the herd that were bred during the 2 to 14 retrospective test period intervals, including cows that were subsequently culled. If this is not possible, then at least all cows currently in the herd should be included, even TBC cows.

### *Services Per Pregnancy, Pregnant Cows*

Services per Pregnancy, Pregnant Cows is a measure of the overall conception rate when fertile cows are bred.

#### Current Month:

For all cows designated pregnant this period (P3), sum the AI breedings used on those cows (B3). A designation of pregnancy can be by veterinary examination or 65-day nonreturn, depending on the herd's policy.

$$\text{Services Per Pregnancy, Pregnant Cows} = B3/P3$$

#### Past Year:

For all cows designated pregnant in the past 12 test periods (P4), sum the breedings used on those cows prior to pregnancy designation (B4).

$$\text{Services Per Pregnancy, Pregnant Cows} = B4/P4$$

Cows confirmed pregnant to a breeding date after being turned with the bull (TWB) would not contribute to these calculations.

Ideally, the cows considered should include all cows in

the herd that were pregnant to an AI breeding in the last 12 periods, including cows that were subsequently culled. If this is not possible, then at least all cows currently in the herd should be included, even TBC cows.

### *Service-Specific Conception Rates (%)*

Service Specific Conception Rates provide a measure of conception efficiency broken down by the number of services a cow has received.

Current Month: (using first service conception rate as an example)

Determine the outcome of all first services (B5) in the test period 2 periods ago for cows still present in the herd. Those breedings that resulted in a pregnancy make up the numerator (P5). Pregnancy can be designated either by veterinary examination or by 65-day nonreturn, depending on the herd's policy.

$$\text{First Service Conception Rate (\%)} = P5/B6 \times 100$$

#### Past Year:

Determine the outcome of all first services (B6) in the test period from 2 periods ago back to the test period 14 periods ago (for a total of 12 periods). Those breedings that resulted in a pregnancy make up the numerator (P6).

$$\text{First Service Conception Rate (\%)} = P6/B6 \times 100$$

Ideally, the cows considered should include all cows in the herd that were bred during the 2 to 14 retrospective test period intervals, including cows that were subsequently culled. If this is not possible, then at least all cows currently in the herd should be included, even TBC cows.

In addition to first service conception rate, similar calculations should be made for conceptions on second, third, and greater than third services.

## Loss of Confirmed Pregnancies

### *Abortions Per Known Pregnancy (5)*

Abortions per Known Pregnancy estimates fetal loss after pregnancy has been confirmed by veterinary examination. In effect, it is an answer to the dairyman's question: Once a cow is confirmed pregnant, what is the chance she will abort?

Abortions per Known Pregnancy can only be calculated in herds that confirm pregnancy by veterinary palpation. There are two events that should be recognized as abortions:

1. Visible abortions (seen by dairyman)
2. Cows confirmed open on examination after previously being confirmed pregnant on examination. This criterion cannot be used in herds that establish pregnancy by 65-day nonreturn to estrus.

Current Month:

Cows eligible for this calculation would include all adult pregnant cows. Nulliparous pregnant heifers would be excluded.

Numerator: number of abortions by above definitions (A)

Denominator: (number of pregnant cows at the end of the last period [PL] + number of pregnant cows at the end of this period [PT])/2

Percent abortions per Known Pregnancy for the current month should be reported both as the absolute number of abortions (A), and as:

$$\text{Abortions Per Known Pregnancy (\%)} = \left( \frac{A}{(PL + PT)/2} \times 7.5 \right) \times 100$$

The ratio of  $A/[(PL + PT)/2]$  is the loss of known pregnancies per pregnant cow per month. Assuming that the average cow is confirmed pregnant at 50 days of gestation, then the average pregnancy is "known" for approximately 7.5 months. The risk that a cow will abort during the time she is confirmed pregnant is thus approximately the loss per month multiplied times 7.5 months. Abortions per Known Pregnancy is a measure of the risk of fetal loss once a pregnancy has been confirmed. If a herd confirms pregnancies at a time substantially different than 50 days, then the 7.5 could be adjusted to reflect this difference.

Past Year:

Numerator: sum of abortions in the last 12 periods (SA) divided by 12

Denominator: average of the number of pregnant cows (AP) on each test day for the last 12 periods.

$$\text{Abortions Per Known Pregnancy (\%)} = \left( \frac{(SA/12)/AP}{7.5} \right) \times 100$$

If an abortion occurs prior to day 150 of pregnancy, it should be considered as a return to open status. No new lactation would be begun. The breedings and the pregnancy that resulted in the abortion should be retained for the calculation of other reproductive indices.

### **Cows Leaving the Herd Due to Reproductive Failure**

Reproductive Culling Rate is a measure of the cows exiting from the herd due to unacceptable reproductive performance.

#### *Reproductive Culling Rate (%)*

For each cow that leaves the herd, the dairyman should report the reason for the cow's exit. Both the number of cows culled over the past 12 periods for reproduction (NR) and the percent of the herd should be reported. The percent

of the herd should be calculated using the number culled (NR) as the numerator and the average herd inventory (i) as the denominator. The average inventory is calculated by averaging the total number of cows, both milking and dry, on each test day for the past 12 periods. Both the number of cows culled for reproduction (NR) and the percent of the herd culled should be reported. Because the month of culling does not usually correspond to the month of the reproductive event that caused the culling, this parameter should be calculated only on a past year basis, not for the current month's culls.

$$\text{Reproductive Culling Rate (\%)} = (NR/I) \times 100$$

### **Measuring the Efficiency of Bull Breeding Programs**

Measures of reproductive performance are also needed for herds where natural service by bulls plays an important role in the overall reproductive program.

#### *Percent Pregnant by the Bull*

Current Month:

Numerator: pregnancies confirmed in the period that were the result of a bull breeding (BP). This requires that the herd report estimates of the date of pregnancy in cows that have been bred by a bull, so that pregnancies from the bull can be distinguished from pregnancies from previous AI breedings.

Denominator: all pregnancies reported in the period (TP).

$$\text{Percent Pregnant by the Bull} = BP/TP \times 100$$

Past Year:

Same as CURRENT MONTH calculation, except that pregnancies reported in the past 12 test periods would make up the calculation group.

#### *Average Days Open with the Bull*

Current Month:

For each cow confirmed pregnant to a bull breeding in the period, calculate the number of days between the turned with bull date (TWB) and the estimated date of conception to bull breeding. This requires that the herd report estimates of the date of conception in cows with bull breedings. Calculate the average of these days from TWB date to conception for all cows confirmed pregnant during the period to a bull breeding.

Past Year:

Same calculation for the past 12 periods, with all cows confirmed pregnant to a bull in each period making up the group for calculation.

### *Average Days in Milk When Turned with the Bull*

For all TWB cows not confirmed pregnant to an AI breeding, calculate average days in milk at TWB date. This can be calculated on both a Current Month and a Past Year basis.

### *Conception Rate for Cows Turned with the Bull*

For pregnant TWB cows confirmed pregnant to a bull breeding, calculate: Bull Services Per Pregnancy = average of: (conception date - [TWB date + 10]) / 21 Bull Conception Rate = 1 / bull services per pregnancy

This can be calculated on both a Current Month and a Past Year basis.

### *Bull Usage Rate*

Current Month:

TWB cows that are not confirmed pregnant divided by number of bulls with access to such cows.

Past Year:

Same as this month, calculated for the past 12 periods.

### **Summary**

The indices that are defined above can serve as a basis for analyzing a dairy's reproductive performance. They are clearly not the only possible summary statistics that can be used. Those of us that developed these recommendations did so with the intention of providing useful, practical, and accurate approaches to the calculations. We have tried to strike an appropriate balance between the practical difficulties of collecting on-farm data, the task of programming systems to analyse and store that data, and the need for unbiased, accurate estimates of the actual reproductive status of a dairy. We hope that these recommendations might be adopted by all people developing record keeping software for the dairy industry, so that the industry as a whole might move toward one standard method of reporting reproductive performance.

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Table 1. Indices of Dairy Herd Reproductive Performance.

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Overall reproductive performance:
Projected minimum average days open
Past year days open
Projected calving intervals
Past calving interval
Estrus detection intensity
Percent of possible breedings that were serviced
Conception efficiency:
Services per pregnancy, all cows
Services per pregnancy, pregnant cows
Service specific conception rates
Pregnancy losses:
Abortions per known pregnancy (%)
Cows leaving the herd due to reproductive failure
Reproductive culling rate (%)
Reproductive efficiency in herds using a bull:
Percent pregnant by the bull
Average days open with the bull
Average days in milk when turned with the bull
Bull services per pregnancy
Bull conception rate
Bull usage rate