Heat Detection Accuracy and AI Technician Evaluation

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Take Home Messages

The following points are important to remember in the quest to achieve a successful dairy reproductive program:

- Pregnancy rate is a sensitive and valuable indicator of reproductive performance.
- Insemination risk and conception risk are components of pregnancy rate.
- Low heat detection accuracy can reduce conception risk and ultimately decrease pregnancy rate.
- In an on-going heat detection accuracy study, the percentage of cows not in heat when inseminated varied between herds, from 0 to 13%, signifying a specific individual herd problem. Overall the average heat detection accuracy across all 10 dairies was 95.3%.
- Evaluate AI technicians by
    - considering the numbers necessary to draw meaningful conclusions,
    - going behind the numbers and stratifying by insemination code or lactation number,
    - asking the question: Are the AI technicians breeding the same types of cows?
    - comparing like groups, or "apples to apples" and not "apples to oranges."
- Proper semen handling and deposition of semen is critical to the success of an AI program.
- Continuing education is important to the success of an AI technician's career and to the profitability of a dairy.

Introduction

Reproductive performance has declined over the last few decades in U.S. dairy herds (Lucy, 2001; Washburn et al., 2002; de Vries and Risco, 2005). The downward trend in reproductive performance is disturbing and has eroded the profitability of dairies. The loss of potential income for each day a cow remains non-pregnant over 100 days in milk has been estimated at \$0.42 to \$4.95 per day, depending on stage of lactation (French and Nebel, 2003). In 2008, the average days open for southwestern, northwestern and eastern dairy herds that processed records at DHI-Provo was 149, 154, and 165 days, respectively (DHI-Provo, 2008).

Pregnancy rate is defined as the percentage of eligible cows that become pregnant within a given time frame. **Pregnancy rate (PR) is a timely measurement, and as such, is a more sensitive and valuable indicator of reproductive performance than average days open.** Nationally, average 21-day pregnancy rates have been reported to range between 12 to 16% (Buelow et al., 1999; Niles et al., 2001). According to Overton (2008) the optimal 21-day pregnancy rate approaches 30%.

What's the value of an increase (or decrease) in pregnancy rate? Depending upon milk price and milk yield, each 1% increase (or decrease) in pregnancy rate results in the gain (or loss) of approximately $12 to $25 per cow per year (Overton, 2001, 2005, 2008). Why? Because as pregnancy rate increases, over time the average days in milk for the milking herd will decrease, leading to higher average milk production per day of lactation, more time per lifetime spent in the most profitable portion of lactation, and less veterinary and breeding costs. As pregnancy rate decreases, average days in milk increases, leading to increased management, feed, and veterinary costs for cows in the least profitable portion of lactation.

Insemination risk (**IR**) and conception risk (**CR**) are components of PR. Insemination risk (formerly known as heat detection rate) is the percentage of eligible cows that are inseminated within a given time frame (including animals inseminated following a detected heat or a timed AI), while conception risk (formerly known as conception rate) is the total number of pregnant cows divided by the total number of inseminated cows with known outcomes (Overton et al., 2007). Thus, an increase (or decrease) in PR may be traced to an increase (or decrease) in IR, CR, or both components. In order to troubleshoot low PR in a herd, factors that impact IR and CR must be identified, and a plan must be made to alleviate problems associated with the factors identified.

Factors affecting conception risk

Heat detection accuracy is defined as the proportion of detected periods of heat in which cows were truly in heat, as evidenced by low progesterone concentration in milk or blood. **Simply stated, if a cow is inseminated when not in heat, there's little to no chance of a pregnancy resulting from that particular insemination. Consequently, low heat detection accuracy can reduce CR and ultimately decrease PR.**

Other than heat detection accuracy, what else impacts CR and ultimately PR? Other factors may include fertility and general health of the cow, timing of insemination relative to heat or ovulation, semen handling, AI technique, semen quality, increased environmental temperature, and compliance with estrous or ovulation synchronization protocols. Although heat detection accuracy, semen handling, and AI technique are all under the control of the AI technician, evaluation of AI technicians based on conception risk should be done with caution. Prior to the discussion on AI technician evaluation, however, we'll discuss 1) previous heat detection accuracy research, and 2) current data from an on-going heat detection accuracy study. Finally, at the end of this paper we'll briefly review semen handling and site of semen deposition.

Previous heat detection accuracy research

The failure to accurately detect heat is a common and costly problem of AI programs and a major limiting factor of reproductive performance on many dairies (Nebel and Jobst, 1998). Published literature provides evidence that heat detection accuracy varies widely. As previously mentioned, heat detection accuracy is defined as the proportion of detected periods of heat in which cows were truly in heat, as evidenced by low progesterone concentration in milk or blood. Progesterone concentration in blood and milk is associated with events of the estrous cycle as concentration is low (~1.0 ng/mL or less) for 2 d prior to heat and remains low for approximately 2 to 3 d after heat (Figure 1; Senger, 1999; Hopkins, 1989; Nebel et al., 1987). Low milk or blood progesterone ***alone*** is not an indicator of heat; however, high milk or blood progesterone is considered a ***confirmation that a cow is not in heat.***

Using milk progesterone analyses, Reimers et al. (1985) reported the proportion of cows not in or near heat when inseminated varied from 0 to 60% among dairy herds, signifying a specific individual herd problem. Nebel et al. (1987) also reported highly variable heat detection accuracy among AI personnel and argued that errors in heat detection should be considered "a significant cause of low conception rates." Nevertheless, one limitation of previous studies is the use of small herds (~42 to 300 cows; Reimers et al., 1985; Nebel et al., 1987) and the inclusion of up to 10 producer-identified signs of heat, ranging from "standing" (presumably as determined by visual observation) to "blood on the vulva."

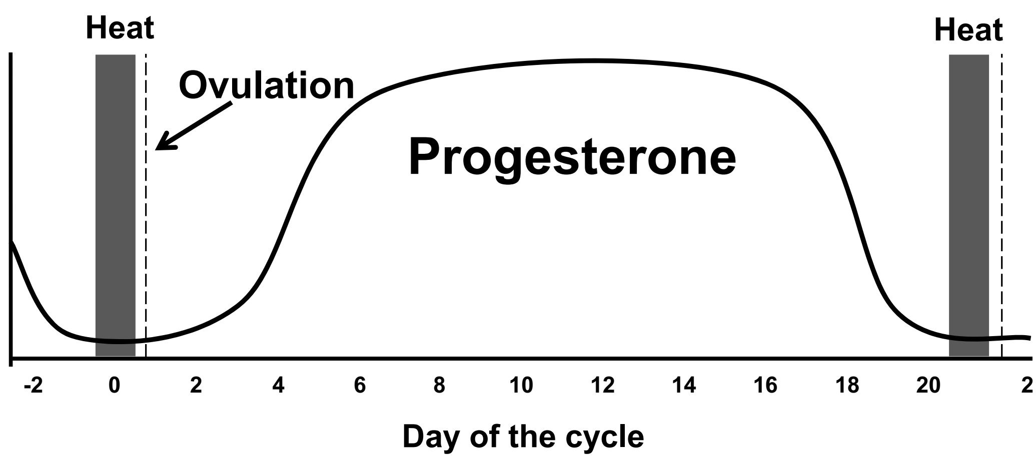

Figure 1. Progesterone concentration in blood during the estrous cycle of the cow (Courtesy of H. Lopez, 2008).

Visual observation (defined as specifically watching a group of cows for a period of time without performing another duty) almost never occurs on large dairies. Consequently, labor efficient management strategies such as once-daily heat detection, via daily tail chalk or paint application and subsequent identification of ruffled hair on the tailhead or lost chalk or paint, and once-daily AI are more common. Therefore, current management strategies on large dairies require that cows are restrained in headlocks daily, during which time tail chalk or paint is applied and read in a matter of seconds as AI personnel walk behind the cows.

Another limitation of previous work includes the use of professional AI technicians who inseminated cows detected in heat by the dairy herd owner or farm personnel (Reimers et al., 1985). Heat detection by the herd owner coupled with AI by a professional AI technician is a practice still in use on some small dairies, in certain geographic regions of the U.S. In contrast, professional AI technicians or herdsman-inseminators perform *both* heat detection and AI on large dairies.

Lastly, in a case study conducted in a 3,000 cow California dairy (Moore et al., 2005), 91.8% (350/381) of cows sampled had low blood progesterone concentration on the day of insemination. Unfortunately, the data does not truly describe heat detection accuracy, as greater than 50% of cows were inseminated "at the completion of a timed AI program," and by definition, were not detected in heat and then inseminated. Therefore, the question remains, what is the heat detection accuracy of AI technicians on large, modern dairies?

Current heat detection accuracy study

A study is underway to determine the heat detection accuracy, as measured by plasma progesterone concentration, of AI technicians working with lactating dairy cows housed in open lots or free-stalls in large dairies. This research focuses on dairies that use once-daily tail chalk for heat detection. Data from herds using professional AI technicians or herdsman-inseminators to detect heat and perform AI are (and in the future, will be) included.

On the day of AI (or the day after AI), one blood sample was obtained from a minimum of thirty lactating cows detected in natural heat or a prostaglandin-induced heat. No blood samples have been obtained from cows receiving timed AI. Samples were analyzed for progesterone concentration. High blood progesterone (> 1 ng/mL) is considered a confirmation that cows were not in heat when they received AI.

Figure 2 depicts the results from 10 Idaho dairies ranging in size from 1,200 to 5,200 lactating cows. Similar to the results of Reimers et al. (1985) and Nebel et al. (1987), the percentage of cows not in heat when inseminated varied between herds, from 0 to 13%, signifying a specific individual herd problem. Overall the average heat detection accuracy across all 10 dairies was 95.3%.

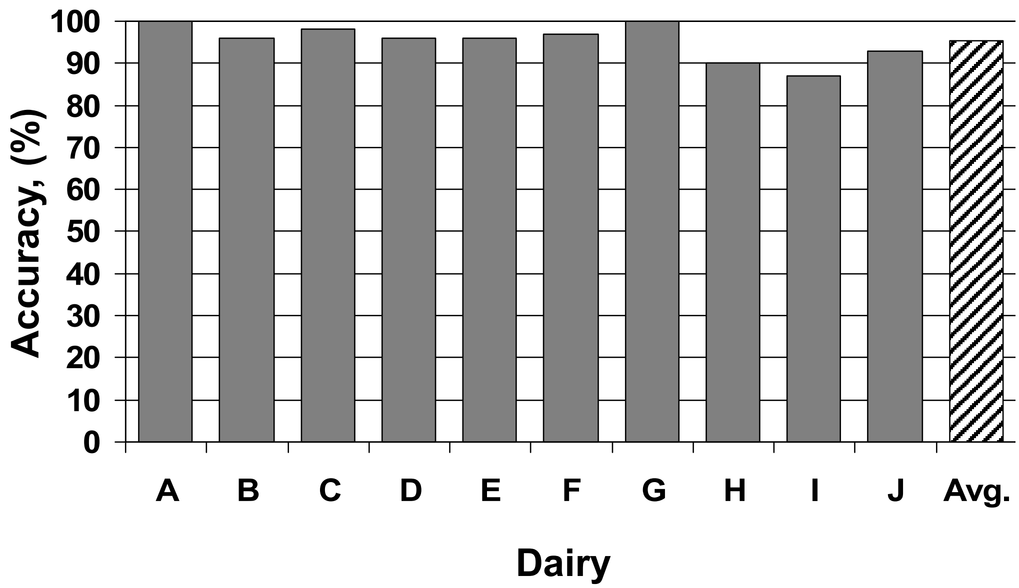

Figure 2. Heat detection accuracy results for 10 Idaho dairies.

The average insemination risk for the 10 herds was 62% (range 49 – 70%). The average conception risk was 29% (range 18 – 36%). Finally, the average 21-day pregnancy rate (for the period that included the blood sampling date) was 18% (range 10 – 24%).

So, have we answered the question regarding the heat detection accuracy of AI technicians on large, modern dairies? Preliminary data provides evidence that AI technicians can use tail chalk and detect heat with high accuracy, although specific individual herd problems appear to exist. Consequently, to adequately characterize heat detection accuracy on large dairies, data collection will continue until at least 20 dairies comprise the data set.

AI technician evaluation

In the preceding section of this paper we've seen evidence that there are AI technicians that can detect heat with high accuracy. Further technician evaluation can provide valuable insight into the success or inadequacies of a reproductive program. Nevertheless, how do we evaluate technicians fairly? Start by considering the number of inseminations necessary to draw meaningful conclusions. Realistically, a ***minimum*** of 250 observations per insemination code or technician is recommended. When possible, go behind the numbers and stratify by insemination code or lactation number. Ask the question: Are the AI technicians breeding the same types of cows? Are all technicians breeding throughout the year or only during a specific season? Compare like groups, or "apples to apples" and not "apples to oranges" and try to determine if perceived differences in CR are real. Lastly, keep in mind that CR is a component of PR, and that PR is really the important monitor of success.

The purpose of this section is to provide a starting point for the evaluation of AI technicians. The suggestions provided here are not intended to be used as a step-by-step method, but rather to show a logical progression into the evaluation of AI technicians based on CR. The reader is cautioned that there are many ways to evaluate records; however, the evaluator should always search for meaningful data from which reasonable decisions may be made. Lastly, the authors do not support one product over another and any mention of a particular product is meant solely as an example, and not as an endorsement.

Scenario 1- The basics

If a technician named "Junior" has a CR of 37%, and a technician named "Bob" has a CR of 32%, are these two numbers different? (Table 1; circle). At first glance, it appears that there is a 5 percentage point difference in conception risk. However, is the apparent 5 percentage point difference **real**?

To answer this question, we must first briefly discuss the confidence interval (**CI**). A confidence interval is a range around a mean (or average) that has a certain probability of containing the true mean (or average). Relative to the term "95% confidence interval (or 95% CI)," it is important to remember that in repeated sampling of data, we are 95% confident that the mean (or average) will reside within the intervals calculated.

Table 1. Dairy Comp 305 report (bredsum\x) showing the 95% CI, percent CR, and count (number) of inseminations.

95% CI		Total
	Bob	29-35
	Junior	32-43
Percent		
	Bob	32
	Junior	37
Count		
	Bob	882
	Junior	270

Note that the 95% CI for Bob is 29-35, while it is 32-43 for Junior (Table 1; square). **Do the confidence intervals for Bob and Junior overlap? Yes, they do. Therefore, the mean percentage CR (Bob 32% vs. Junior 37%) is NOT statistically different.** What does this mean? It means that there is not enough evidence to say that Bob and Junior actually have a different CR. One facet you should have noticed is the difference in the width (range) of the confidence intervals for the two technicians. As observations (number of inseminations) go up (Table 1; Bob = 882; triangle), the width of the confidence interval narrows (29-35, or a 6 percentage point range). Conversely, when there are fewer observations (Table 1; Junior = 270; triangle) the width of the confidence interval increases (32-43, for an 11 percentage point range).

Scenario 2-What's behind the numbers?

Mark and Neil are AI technicians at a 9,000 cow dairy. Mark has an overall CR of 31%, while Neil has an overall CR of 26% (Table 2; circle). The data shown in Table 2 is from Dairy Comp 305 (bredsum\t).

Table 2. Conception risk (CR) for two AI technicians.

Technician	% CR	# Preg	# Open	Total
Mark	31	926	2,060	2,986
Neil	26	407	1,158	1,565

To begin the process of trying to determine if in fact the CR of these two AI technicians is really different, examine the breeding codes (bredsum\o) (Table 3). Although all inseminators are included in this report, this will give you a feel for the distribution of inseminations, that is, what percentage occur after 1) heat is detected, 2) Ovsynch, 3) Resynch, or 4) other programs.

Table 3. Conception risk (CR) by breeding code.

Code	% CR	# Preg	# Open	Total	% Total
Ovsynch1	28	461	1,188	1,649	6
Ovsynch2	27	297	788	1,085	4
Heat	32	6,194	13,083	19,277	66
Resynch	22	1,526	5,488	7,014	24

A quick glance at the data in Table 3 shows that 66% of all inseminations occur after heat detection (rectangle) . In contrast, only 24% of inseminations are the result of Resynch. Next, compare and contrast the results of Mark and Neil, by breeding code, for first lactation cows only (bredsum\x, click "options," then click "lact 1.") The data is shown in Table 4.

If we look at the "Count" (number of inseminations; see circle) for Mark and Neil in Table 4, it quickly becomes clear that we are NOT comparing "apples to apples." For first lactation animals, Mark has 1,584 inseminations whereas Neil has only has 80 inseminations. Also notice the wide CI (15-33) for Neil and how it overlaps with Mark's CI. Consequently, ferreting out potential differences between these AI technicians in first lactation cows would be meaningless. So where may the potential differences be? Let's look at second and greater lactation cows, while excluding first lactation cows (bredsum\x, click "options," then click "lact = 2" and "lact 2+"). The data is shown in Table 5.

Table 4. Confidence intervals (CI), conception risk (CR), and count (number) of inseminations by breeding code[1].

95% CI		Total	Resynch	Heat	Ovsynch1	Ovsynch2
	Mark	28-33	17-26	30-35		22-43
	Neil	15-33		18-38		
Percent						
	Mark	30	21	33		32
	Neil	23		26		
Count						
	Mark	1,584	321	1,146	44	73
	Neil	80	8	72		

[1]First lactation animals only.

Table 5. Confidence intervals (CI), conception risk (CR), and (count) number of inseminations by breeding code[1].

95% CI		Total	Resynch	Heat	Ovsynch1	Ovsynch2
	Mark	29-34	20-29	31-38	27-49	19-39
	Neil	24-28	17-23	31-39	18-29	14-29
Percent						
	Mark	32	24	34	38	28
	Neil	26	20	35	23	21
Count						
	Mark	1,402	336	916	72	78
	Neil	1,485	621	521	231	112

[1]Second and greater lactation animals.

At first glance at Table 5 (see the vertical box) the CR difference between Mark and Neil appears to be real because the confidence intervals (Total column) do not overlap. **However, it is important to note that the individual 95% confidence intervals for each breeding code do in fact overlap (see horizontal box).** Furthermore, although we can see that Mark and Neil each have greater than 1400 inseminations of second and greater lactation cows, we have not yet fully answered the question: **Are the technicians breeding the same type of cows?** Continued analysis of the data in this table is warranted to attempt to understand whether the distribution of inseminations among breeding codes is different for Mark as compared with Neil.

The data in Table 6 was taken directly from Table 5. Over 65% of inseminations performed by Mark are in cows identified in heat (Table 6; box) which, as shown previously (Table 3) has the highest CR of all breeding codes (across all technicians; 32%). Neil, however, has nearly twice as many inseminations following Resynch (Table 6; box) as compared to Mark, which, as shown previously (Table 3) has a CR (across all technicians; 22%) much lower than that following heat (32%). Neil is also at a further disadvantage because he has performed only half as many inseminations to cows identified as in heat.

Table 6. Distribution of inseminations, by breeding code, for each technician[1].

	Type of insemination, %, (n/total)			
Technician	Resynch	Heat	Ovsynch1	Ovsynch2
Mark	24 (336/1402)	65 (916/1402)	5 (72/1402)	6 (78/1402)
Neil	42 (621/1485)	35 (521/1485)	15 (231/1485)	8 (112/1485)

[1]Second and greater lactation animals.

At this point, there is not enough data to support the belief that there is a difference in the success, (as measured by CR), of Mark and Neil. Instead, there is ample evidence that Mark and Neil are not breeding the same types of cows, and that the perceived difference in CR is most likely a result of the proportions of types of cows being inseminated by each technician. It is very important that managers and dairy producers employ a logical approach and exercise caution when evaluating AI technicians. A rash decision, based on insufficient data, could cost the technician his job, and the dairy a technician who, in reality, was doing a reasonable job.

Additional caution is warranted when evaluating a new technician. As described by Overton (2007), CR is determined using inseminations with known outcomes. Consequently, a new technician's early CR will tend to be biased downward because negative outcomes (conception failure) will be gained earlier when cows return to heat, as opposed to positive outcomes (pregnancies), which will lag due to the difference in time for outcome determination (Overton, 2007).

Technician management: Semen handling and site of semen depostion

When numerous cows must be inseminated on a given day, AI technicians routinely thaw multiple straws of semen simultaneously to facilitate AI in a timely manner. In 2004, Dalton and coworkers conducted a field trial to answer the following questions:

- What is the effect of simultaneous thawing of multiple straws of semen and sequence of insemination (1^{st}, 2^{nd}, 3^{rd} or 4^{th}) on CR?
- Are conception risks achieved following AI by professional AI technicians (**PAI**) and herdsman-inseminators (**HI**) different?

- What is the effect of elapsed time from initiation of thawing straws of semen to seminal deposition on CR?

Although the average CR differed between PAI and HI (45% vs. 27%, respectively), simultaneous thawing and sequence of insemination (1st, 2nd, 3rd or 4th), and elapsed time from initial thaw to completion of fourth AI had no effect on CR within inseminator group (Dalton et al., 2004). Nevertheless, a general recommendation as to the number of straws that may be thawed simultaneously detracts from the overall importance of proper semen handling for successful AI. Conception risk is most likely to be maximized when personnel:

- accurately identify and administer the appropriate treatments to all cows to synchronize heat or ovulation,
- accurately identify cows in heat,
- follow the AI stud's recommendations for thawing semen,
- prevent direct straw-to-straw contact during thawing to avoid decreased post-thaw sperm viability as a result of straws freezing together,
- use appropriate hygienic procedures,
- maintain thermal protection of straws during AI gun assembly and transport to the cow,
- deposit semen in the uterus of the cow within approximately 10-15 minutes after thawing.

Many studies have compared semen deposition near the greater curvature of the uterine horns with conventional deposition into the uterine body. Although Senger et al. (1988), López-Gatius (1996), and Pursley (2004) reported increased fertility when semen was deposited in the uterine horns rather than the uterine body, Hawk and Tanabe (1986), Williams et al. (1988), and McKenna et al. (1990) found no difference in fertility when comparing uterine body and uterine horn inseminations. Furthermore, Diskin et al. (2004) reported an inseminator and site of semen deposition effect (interaction), with evidence of either an increase, decrease, or no effect of uterine horn deposition on conception risk for individual inseminators.

Unfortunately, it is not clear why a few studies have shown a fertility advantage following uterine horn insemination while others have not. A possible explanation for the positive effect of uterine horn inseminations may be related to the minimization or elimination of cervical semen deposition. Cervical insemination errors account for approximately 20% of attempted uterine body depositions (Peters et al., 1984). Macpherson (1968) reported that cervical insemination resulted in a 10% decrease in fertility when compared with deposition of semen in the uterine body. To maximize conception risk, all AI technicians must develop sufficient skill to recognize where the tip of the AI gun is at all times.

Attention to detail is an important trait of successful AI technicians, whether it is in the areas of heat detection, semen handling, or site of semen deposition. In addition to evaluation of AI technicians, it is imperative that dairy producers and AI studs provide continuing education to their technicians to offer them the greatest opportunity to succeed, which, in turn, will offer the dairy a greater opportunity to accumulate pregnant cows quickly and increase profitability.

Acknowledgements

The heat detection accuracy research has been supported by a grant from ABS Global, Inc., DeForest, WI. The authors also thank R. Chebel, K.S. Jensen, S. Etter, and C. Johnson for technical support.

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