Using Pregnancy Analytics App to Diagnose Reproductive Inefficiency

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Abstract: Good reproductive efficiency is critical for economic sustainability of beef cow-calf herds. Two standard measurements of reproductive success for beef cowherds are the percentage of cows exposed to bulls that are identified as pregnant at a mid-gestation evaluation, and the percentage of pregnant cows that give birth to a live calf. In addition to these standard performance assessments, converting fetal age data to a reproductive distribution (or pregnancy distribution) that displays pregnancy percentages by 21-day periods can provide enhanced information to assist in the diagnostic work-up for sub-optimal reproductive efficiency and to guide the design of intervention strategies. The value of fetal age data can be amplified by further segregating reproductive distributions by animal age and/or other management groups when evaluating a herd with reproductive or production shortfalls.

Keywords: pregnancy diagnosis, fertility, pregnancy distribution

Introduction

Beef cow reproduction is limited by two key factors, the first being a relatively long period of infertility following calving and the second being that only 60% to 70% of successful matings between a fertile bull and fertile cow will result in a viable pregnancy at the time pregnancy status is determined. We know that approximately 30% to 40% of fertile matings result in either failure of fertilization or death of the early embryo, but in most situations, the mated, but non-pregnant cow will express heat and ovulate a fertile egg about 21 days after her last heat and will have another 60% to 70% probability of conceiving and maintaining a pregnancy. Fertile cows that have three opportunities to be bred by a fertile bull (each with a 65% probability of a successful pregnancy) will have a 96% probability of being pregnant at the time of a preg-check.

If nearly all the cows in a herd calved early enough so that they have resumed fertile cycles by the 21st day of the next breeding season, and the bulls are fertile and able to successfully mate, then the ideal pregnancy pattern would have about 60% to 65% pregnant in the first 21 days of the breeding season, 85% to 90% pregnant by the 42nd day of breeding, and about 95% pregnant after 63 days of breeding (Figure 1).

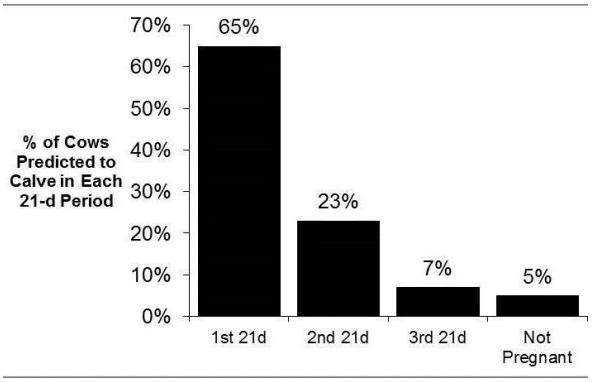

Figure 1: Pregnancy distribution goal for a 63-day breeding season

BCI Pregnancy Analytics App: Gathering Pregnancy Data Chute-Side

The BCI Pregnancy Analytics App is being used by veterinarians to enhance monitoring and evaluating cowherd breeding season success. Veterinarians know that being able to visualize the percentage of a cowherd that becomes pregnant each 21-days of the breeding season can provide important information to identify the contributing causes for situations when a lower than desired percentage of the herd becomes pregnant, or to identify areas for improved reproductive efficiency. Until now, collecting and evaluating that information while at the chute during preg-checking has been difficult. Data entry for the BCI Pregnancy Analytics App is even easier than using a paper-and-pen method and has the benefit of data analysis that is automatically available immediately after the last cow is palpated.

The only data required by the Pregnancy Analytics App are the dates for the start and end of the breeding season and an estimate of the fetal age for each cow's pregnancy. Additional information such as cow id, cow age, body condition score, and breed (or other descriptor) can be added to enhance the value of the preg-check information. After preg-check data is entered, projected calving dates are generated and graphs are created to display the distribution of the upcoming calving season. These pregnancy patterns can help identify the most likely contributing factors when investigating herds with lower than desired percent pregnant.[1,2]

Veterinarians can be fairly precise estimating fetal age early in gestation but the ability to estimate fetal age accurately decreases as gestation progresses.[3] Therefore, to confidently place cows/heifers within fetal age groups, pregnancy diagnosis should occur no more than 120 days after the start of the breeding season. This opportunity to place females within fairly tight "stages" or 21-day periods is a great advantage for producers and their veterinarians when evaluating the nutritional and reproductive status of the herd's recent past and in planning to optimize the upcoming nutritional and marketing options for the herd.

For a 63-day breeding season, the ideal distribution should resemble Figure 1. Producers should strive for nutritional and management systems that allow at least 60% of the exposed females to become pregnant in the first 21 days of the breeding season.[4] The majority of the remaining females should become pregnant in the second 21-day period. Moreover, 5% or less of the herd should be non-pregnant at the end of the breeding period.

Another way to evaluate pregnancy distribution data is to determine the percent of the available (non-pregnant) cattle that become pregnant each 21-day period of the breeding season. Recognize that as the breeding season advances and cattle that become pregnant are no longer available to get pregnant again, the percent of the herd that becomes pregnant each 21 days is not the same as the percent of available (non-pregnant) cattle that become pregnant each 21 days. To display this important measure of reproductive success using the Pregnancy Analytics App, click on "***% Pregnancy Success***". A table will then be displayed that reports the percent of the non-pregnant cows at the start of each 21 days that became pregnant within that 21 days.

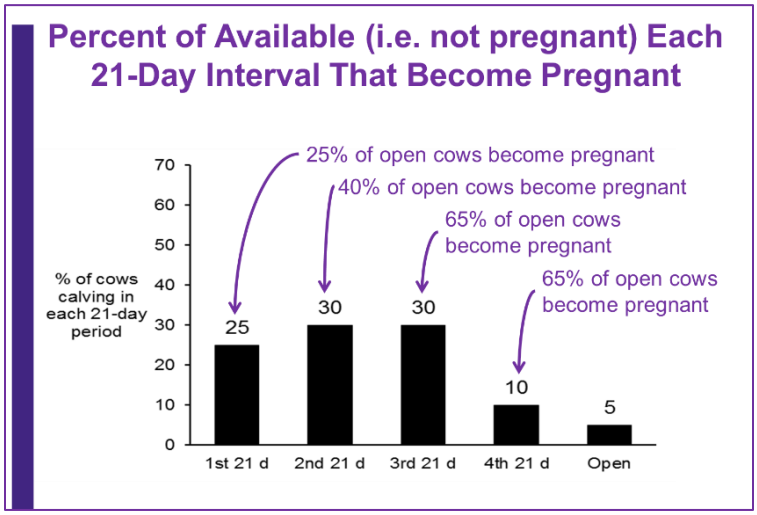

Figure 2. Reporting % Pregnancy Success as a percent of the available (non-pregnant) cows at the start of each 21 days that became pregnant within each 21-day period of the breeding season

Looking at the percent of the herd that became pregnant each 21 days does not immediately inform the veterinarian about how fertility is changing over the breeding season. Examining the pregnancy distribution displayed in Figure 2 provides evidence that 25% of the non-pregnant cows became pregnant in the first 21 days. But it is not as clear that in the second 21 days, of the cows that weren't pregnant already, 40% became pregnant; (which is 30% of the herd), and in the third 21 days, of the cows that weren't pregnant, 65% became pregnant (which is 30% of the herd), and finally, that in the 4th 21 days, 65% of the available (non-pregnant) cows became pregnant.

Based on expected pregnancy success when both cow and bull fertility is optimum, the "% Pregnancy Success" goal should be between 60%-70% for every 21-day period of the breeding season. Using the herd represented in Figure 2, by the third 21 days there is no problem with fertility in the cows or bulls. The % Pregnancy Success values clearly indicate that the reproductive problems in this herd occurred during the first two cycles and in the last two cycles of the breeding season, fertility was optimal.

BCI Pregnancy Analytics App: Interpreting the Charts and Tables

At the time of pregnancy diagnosis, veterinarians can estimate fetal age and evaluate the palpable or ultrasonographic characteristics of non-pregnant reproductive tracts (Figure 3). If low pregnancy percentage is due to failure to conceive due to cows not resuming fertile cycles post-calving or bulls failing to deliver fertile semen to the cow reproductive tract, reproductive tract examination should reveal the characteristics of a non-pregnant uterus with no indication of previous pregnancy or uterine pathology. Timing of pregnancy diagnosis relative to reasons for low pregnancy percentage due to non-infectious (e.g. stress) or infectious (e.g. Trichomoniasis) causes of early gestation pregnancy loss reveals that the loss occurs a few weeks to a few months prior to examination and may or may-not be associated with still-detectable uterine involution or pathology. Because infectious agent or toxin causes of fetal loss often occur in late gestation just prior to or following examination for pregnancy status, examination of non-pregnant reproductive tracts should reveal characteristics of involution or uterine pathology.

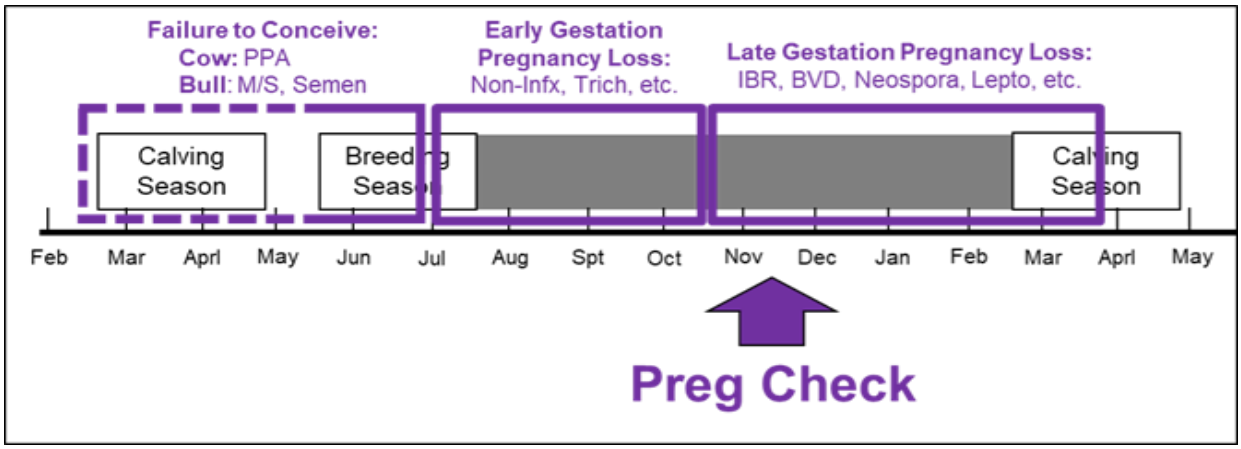

Figure 3. Timing of pregnancy diagnosis relative to reasons for low pregnancy percentage indicates that failure to conceive due to cows not resuming fertile cycles post-calving or bulls failing to deliver fertile semen to the cow reproductive tract occurred many weeks prior to examination, early gestational loss due to non-infectious (e.g. stress) or infectious causes (e.g. Trichomoniasis) occurred a few weeks to a few months prior to examination, and late gestational loss due to infectious agents or toxins occurred just prior to or following examination.

Once all the data collected at the time of pregnancy diagnosis is organized for analysis, an in-depth and efficient evaluation of the herd reproductive success can be conducted. The reasons for low pregnancy percentage during any 21-day period of the breeding season can be placed into one of three categories: 1) an inadequate percentage of females were having fertile estrous cycles, 2) the bulls were not able to deliver adequate amounts of fertile semen to the female's reproductive tract, or 3) infectious or non-infectious agents prevented or ended pregnancy. The charts and graphs produced by the Pregnancy Analytics App along with the physical examination findings of the reproductive tract and cow body condition at the time of pregnancy diagnosis can guide history questions, further physical examination, herd record evaluation, and diagnostic laboratory testing to assist the veterinarian's evaluation of the possible rule-outs as likely or unlikely causes of the undesired pregnancy distribution.

1) Inadequate percentage of females were cycling by the 21st day of breeding

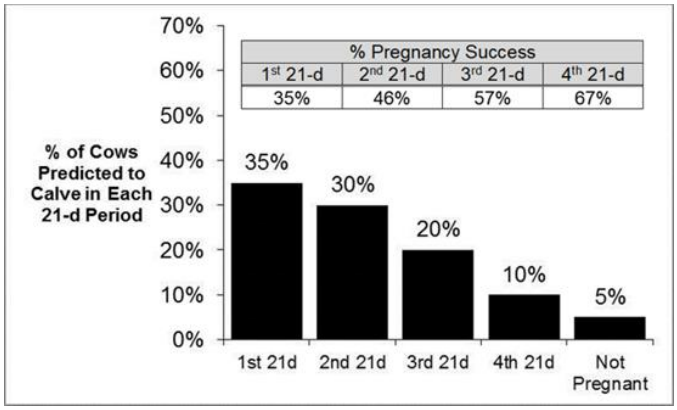

Figure 4. Typical reproductive distribution for herd with 50% of cows cycling by the end of the first 21 days of the breeding season.

Although Figure 1 depicts an ideal herd, many times the evaluation of herd preg-check data reveals a much different pregnancy distribution. Figure 4 illustrates a very common distribution. In this situation, the percentage of cows open at the end the breeding season would not necessarily alert the veterinarian to a problem if the breeding season lasts long enough, and an evaluation of the distribution is needed to begin a diagnostic work-up.

One common reason a herd has a pregnancy distribution like that depicted in Figure 4 is that a similar pregnancy distribution the previous year resulted in many cows calving in the 3rd or later 21-day period of the calving season. Because the average bovine pregnancy lasts 283 days, one can calculate that a cow must rebreed within 82 days after calving in order to maintain a 365-day calving interval. The typical amount of time from calving to the resumption of fertile cycles (postpartum period) for 90% of a herd's mature cows is 60 to 80 days.[5] For first-calf heifers, the number of days post-calving for 90% to resume fertile cycles is closer to 100 to 120 days.[6] If the breeding season begins on the same date as the previous year (and the breeding season lasts 63 days) the breeding season will commence 63 to 82 days postpartum and end 123 to 142 days postpartum for cows calving in the first 21-day period of the previous calving season.

Therefore, all early-calving cows (including first-calf heifers) are expected to have the opportunity to cycle and be bred several times during the breeding season. Cows calving in the second 21-day period will be to 43 to 62 days postpartum at the start of the breeding season and 103 to 122 days past calving at the end of the breeding season. Once again, this timing should allow the mature cows to resume cycles and have the opportunity to be bred several times during the breeding season. First-calf heifers should also resume cycling early enough in the breeding season to have one or two opportunities to be bred. In contrast, for those cows that calve in the fourth 21-day period, calving has just finished as the breeding season begins and for those in the fifth 21-day period, the breeding season has begun prior to the time they calve. Limited (or non-existent) time from calving until the start of the breeding season essentially eliminates the potential for nursing cows, and even more so first-calf heifers, to rebreed early in the breeding season if at all.

Without implementing culling, nutrition, and heifer development changes in herds with flat pregnancy distributions similar to the herd in Figure 4, it is very difficult to influence the percentage of the herd pregnant in the first 21-days of the breeding season. Reasons that a herd with a previously ideal calving distribution can deteriorate to a less-than-ideal situation includes females too thin at calving, poor postpartum cowherd nutrition, subfertile bulls, or infectious or non-infectious pregnancy loss.[5,7,8,9]

2) Bulls did not deliver adequate amounts of fertile semen to the female reproductive tract

If reproductive performance is initially adequate - indicating that conception occurred and pregnancy was maintained early in the breeding season, the veterinarian can assume that fertile bulls were turned out with fertile, cycling cows, the herd was free of pregnancy wasting disease, and the postpartum period and energy reserves (as indicated by BCS) were adequate. A sharp decline in *Percent Pregnancy Success* during the breeding season should cause the veterinarian to investigate whether bulls developed testicular or musculoskeletal problems that prevented the production or delivery of fertile semen and whether herd replacements brought in after the start of the breeding season could have introduced a venereal disease.

Figure 5 illustrates a problem that is seen fairly frequently in herds with one bull for each breeding pasture. Although multiple-bull breeding pastures are more resilient to breeding failure due to bulls being unable to successfully mate cows compared to single-bull pastures, because of

potential problems arising from injuries due to bull-on-bull fighting, social dominance by subfertile bulls, and isolation of groups of cows in an extensive breeding pasture without one or more bulls present, multiple-bull pastures can also have poor reproductive efficiency due to bull problems and can have reproductive distributions similar to Figure 5.

The breeding season in this example (Figure 5) starts out with a high percentage of cows cycling, good cowherd fertility and good bull fertility. Because 55% of the herd becomes pregnant in the first 21-day period, the veterinarian can be confident that the pre-breeding feeding/supplementation program offered adequate nutrients for a fairly high level of reproductive performance. It is also evident that the bull(s) was able to cover the breeding pasture, find the cows displaying estrus, and successfully breed the cycling cows.

The dramatic decrease in pregnancy percentage during the second 21-day period of the breeding season is strong evidence for bull infertility. The cause can be testicular or musculoskeletal insult.[10] The incremental increase in the percentage of available (open) cows bred in each of the following 21-day periods in Figure 4 indicates that bull fertility is gradually returning.

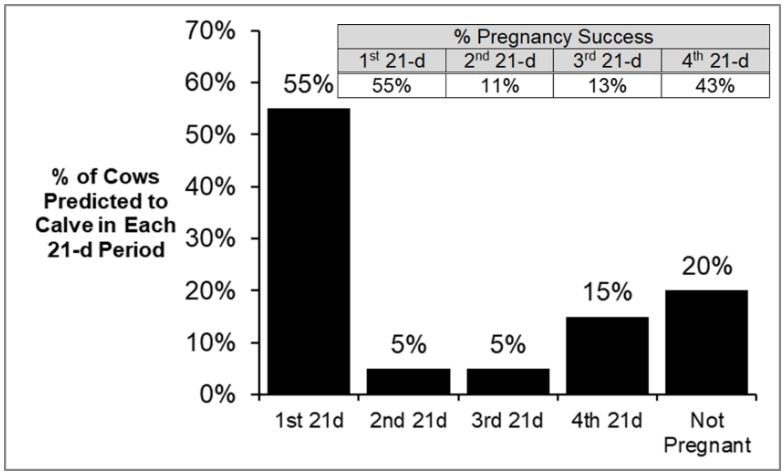

Figure 5. Pregnancy distribution in a herd where a high percentage of cows are cycling at the start of the breeding season, the bull is successfully mating cows, but an acute onset of bull infertility occurring late in the 1st 21 days or early in the 2nd 21 days of the breeding season (such as injury, disease, etc.) followed by a period of partial recovery.

In a situation where the veterinarian evaluated overall pregnancy percentage but not the pregnancy distribution for the herd depicted by Figure 5, the percentage of open cows would indicate herd fertility problems, but the cause of the high open percentage would not be evident. With limited information, one could guess that nutrition or cow fertility were to blame. And, as with this example, a bull may pass a breeding soundness examination both before and after being placed in the breeding pasture without revealing that a fertility problem existed during the breeding season. By categorizing and displaying the information gained at pregnancy diagnosis the cause of the problem becomes more obvious.

A breeding soundness examination (including a through physical examination) at the time the breeding season problem is discovered may supply information about penile, testicular, foot and leg or other musculoskeletal problems during the breeding season. However, lack of identifiable pathology following the breeding season does not rule-out a physical (locomotion, mounting, intromission) or semen quality problem several weeks to months earlier.

3) Infectious or non-infectious agents prevented or ended pregnancy

In situations when early pregnancy loss leads to negative effects on the reproductive distribution, the problem occurred after the breeding season started and before the time of pregnancy diagnosis. In addition to the effect of pregnancy loss on the reproductive distribution, in some situations, non-pregnant cows may exhibit palpable evidence of an involuting uterus at the time of mid-gestation pregnancy diagnosis.

Non-infectious pregnancy loss very early in gestation due to environmental or nutritional stress placed on the cow or fetus should not result in uterine pathology and would not be expected to have negative carry-over effects in the next 21-day period of the breeding season. In contrast, non-infectious pregnancy loss after maternal recognition of pregnancy (around day-13 after estrus) will result in a delayed return to normal fertility until after the embryo is resorbed or expelled and the hypothalamic-pituitary axis has resumed normal estrous cycle activity – which may be later than the 21-day period following the initial conception. Early, non-infectious pregnancy loss that occurs before pregnancy is detectable by palpation or ultrasonography is unlikely to be differentiated from failure to conceive.

Infectious pregnancy loss may result from fertilization failure or very early embryonic death so that palpation or ultrasonographic examination is indistinguishable from failure to conceive or early non-infectious pregnancy loss. However, because many common causes of infectious pregnancy loss in North America have peak incidence after the pregnancy could have been diagnosed, it is expected that evidence of previous pregnancy will remain for several weeks after fetal loss in some of the affected cows. The length of time that pregnancy loss would be evident is influenced by the stage of gestation at the time of pregnancy loss and whether or not uterine pathology accompanied the pregnancy loss.

Infection with the protozoa *Trichomonas foetus* (Trich), which is transmitted during mating, is an important cause of pregnancy loss in North America because it is diagnosed in many cattle-dense areas and because it can cause a high percentage of exposed cows to abort. The pregnancy distribution of a herd infected with Trich will vary depending on what the distribution would have been without infection and the timing of Trich introduction into the herd.

If Trich entered the herd prior to the start of the breeding season so that a high percentage bulls are already infected, the cows will become pregnant at a time similar to last year's breeding season, but infected cows are likely to lose their pregnancies approximately 15 to 80 days into gestation. A period of female infertility is expected to last for another two to six months as a result of infection. The magnitude of loss is expected to approach 30% to 50% of exposed cows. If Trich entered the herd during the breeding season or few bulls were infected at the start of the breeding season but the number of infected bulls increased as the breeding season progressed, then the reproductive distribution is greatly influenced by what the distribution would have been without Trich exposure, and the speed at which additional bulls become infected.

Other causes of early gestational loss (e.g. *Campylobacter fetus* ss *venerialis*, Bluetongue virus, *Leptospira borgpetersenii* serovar *hardjo* type *hardjobovis*, bovine viral diarrhea virus) will have a similar effect on the reproductive distribution but the magnitude of pregnancy loss is not expected to be as high as with Trich.[11,12] Infectious and toxic causes of pregnancy loss

commonly expressed in mid- to late-gestation include: Bovine Herpes virus 1 (Infectious Bovine Rhinotracheitis – IBR), bovine viral diarrhea virus (BVDv), *Neospora caninum*, *Leptospira* sp., pine-needle toxicosis, and others.[13,14] Pregnancy losses in mid- to late-gestation are likely to occur after the time of pregnancy diagnosis and the effect is not limited to one period of the reproductive distribution. If pregnancy losses have occurred by the time that pregnancy status is determined, evidence of that loss is likely to be found upon palpation of the non-pregnant uterus of some of the affected cows.

Second-level analysis of gestational age data

To capture more information from fetal aging, the distribution of breeding dates can be analyzed not only by 21-day intervals, but also by category within those 21-day intervals. The herd depicted by Figure 7 has a pregnancy percentage of 94.5%, which meets the overall herd goal for a 63-day breeding season. In addition, 61.8% of the herd became pregnant during the first 21 days of the breeding season – which exceeds the 60% cut-off associated with good cow and bull fertility at the start of the breeding season. From these observations, one could conclude that the herd has normal fertility and that there are no nutritional and reproductive management problems.

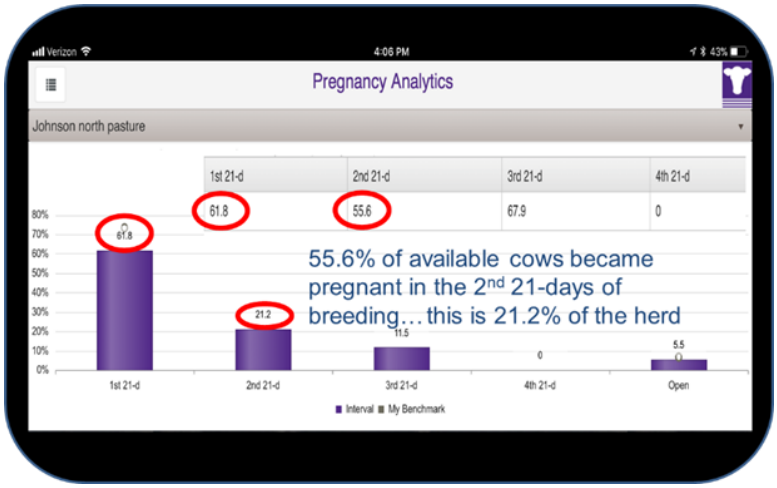

Figure 7. Herd with a good pregnancy distribution that has a hidden problem

Looking at *Percent Pregnancy Success*, during the first 21 days of the breeding season 62% of the available cows become pregnant. In the second 21 days, 55.6% of the non-pregnant cows become pregnant; which is 21% of the herd. In the third 21 days, 68% of the available cows become pregnant; which is 11.5% of the herd. These measures of reproductive success also indicate that overall herd fertility is good, but there is an indication that fertility may be sub-optimal during the second 21-days and closer examination of the information is warranted.

If the data collected at pregnancy diagnosis for the herd depicted in Figure 7 is further analyzed by breaking it into age categories for each 21-day period (Figure 8), the pregnancy distribution for the first-calf heifers indicates that management for this herd is not satisfactory. The important diagnostic information is that while the mature cows performed very well throughout the breeding season, the *Percent Pregnancy Success* of the first-calf heifers is good during the first 21-days of the breeding season but dramatically decreases during the second 21-day period before returning to 70% for the final 21 days of breeding.

	1st 21-d	2nd 21-d	3rd 21-d	4th 21-d
Heifer	0	0	0	0
1st Calf Heifer	61.1	28.6	70	0
Cow	62	63.3	66.7	0

Figure 8. Second-level analysis of gestational age data from a herd with sub-optimal fertility not recognizable when evaluating the whole-herd pregnancy distribution.

The fact that the first-calf heifers performed well the first 21 days of the breeding season is important to recognize because my bias when first-calf heifers perform worse than mature cows is that the deficit is because it took them longer to begin fertile cycles after calving and therefore, they performed poorly early in the breeding season. But the information provided by the Pregnancy Analytics App for this herd indicates that the first-calf heifers did not experience a delayed return to estrus. The problem was the second 21 days. Without the second-level analysis, I would probably assume that the heifers were too thin when they calved or that the producer should move the heifers' breeding season so that they could calve earlier than the mature cows. Because of the information provided by second-level analysis of data collected at preg-check, I am able to identify **"which"** cattle were not pregnant, and **"when"** during the breeding season fertility was reduced; and for this example, I am most interested in investigating bull issues confined to the second 21-day of the breeding season.

Having this type of analytics available immediately after pulling the palpation sleeve off isn't diagnostic by itself; but as I am talking to the producer, I can confine my history questions to the first-calf heifers during the second 21 days of the breeding season (which for this herd would have been the last two weeks of June through the first week of July). If I use any diagnostic testing, I will focus my testing on the bulls in the first-calf heifer breeding pasture.

Summary

Information gathered at the time of pregnancy diagnosis is very valuable to both veterinarians and beef producers, particularly if fetal age is estimated within 21-day periods. Despite the importance of reproductive performance to cowherd profitability and sustainability, without an efficient and convenient method to collect and analyze preg-check data, the value is difficult to capture. Nutrition, genetics, animal husbandry, male and female reproductive soundness, and health all influence the distribution of pregnancy within a herd. By combining uterine palpation or ultrasonographic imaging to determine pregnancy status with analysis and graphing of the information, veterinarians can identify **when** during the breeding season **which categories** of cows did not become pregnant. The Pregnancy Analytics App allows the knowledge and skill of the veterinarian to be augmented by efficient digital data entry and immediate creation of commonly used herd reproductive assessments in order to enhance communication between the veterinarian and producer.

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I have the following disclosures related to my presentation:

Employee:

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National Cattlemen's Beef Association
USDA
Zoetis Animal Health
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CEVA Biomune
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