Pregnancy analytics app adds value to pregnancy diagnosis in beef herds

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Abstract

Determining pregnancy status of beef cattle is an important service both as a major source of income for veterinary practices and a valuable information resource for cow-calf producers. However, value of pregnancy status information should be enhanced to give veterinarians a competitive advantage against alternate methods for identifying nonpregnant cows. Obtaining fetal age estimates is vital to create charts to evaluate and display pregnancy percentages by 21 day periods. Evaluating breeding seasons by 21 day periods and by animal age and/or other management groups is useful to practitioners investigating herds with reproduction shortfalls by identifying specific periods within breeding seasons when cows did not becoming pregnant. In addition, easy-to-read charts can enhance communication between veterinarian and beef producer by illustrating results of fetal aging. Once fetal age data are collected and organized for analyses, conclusions or further questions will present themselves. Nutrition, genetics, animal husbandry, male and female reproductive soundness and health all affect distribution of pregnancy within a herd. By combining transrectal uterine examination to determine pregnancy status with chute-side analysis and graphing of information, veterinarians can readily identify strengths and weaknesses within herd management.

Keywords: Beef cattle, pregnancy diagnosis, histogram

Introduction

Determining pregnancy status of beef cattle is an important veterinary service. For veterinary practices, it is a major source of income. For cow/calf clients it is a cost-effective source of valuable information. However, to increase value of this service and for veterinarians to have competitive advantage compared to other persons and alternate methods, veterinarians should gain additional information from pregnancy status determination and use key metrics to optimize ranch productivity.

Beef cow reproduction is limited by 2 key factors: first, a relatively long infertile interval after calving and second, only 60 - 70% of successful matings of fertile cattle results in a viable pregnancy. Approximately 30 - 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 estrus and ovulate a fertile oocyte about 21 days after her last ovulation and will have another 60 - 70% probability of conceiving and maintaining a pregnancy. Cows with 3 opportunities to be bred (each with a 60 - 70% probability of a successful pregnancy) have ~ 95% probability of being pregnant at mid-pregnancy examination. If nearly all cows in a herd calved early enough so that they resume fertile cycles by the 21st day of the next breeding season and bulls are fertile and able to successfully breed, the ideal pregnancy pattern will be ~ 60 - 65% pregnant in first 21 days of breeding season, 85 - 90% pregnant by 42nd day of breeding and ~ 95% pregnant after 63 days of breeding (Figure 1).

BCI pregnancy analytics app: gathering pregnancy data chute-side

Beef Cattle Institute developed a pregnancy analytics app to assist veterinarians collect data, process it rapidly and create valuable graphs and charts to allow diagnostic analytics of the pregnancy distribution. This app is used by veterinarians to enhance monitoring and evaluating cowherd breeding season success. Ability to visualize the percentage of cows becoming pregnant each 21 days of the breeding season can provide important information to identify contributing causes for situations when a lower than desired percentage of herd becomes pregnant, or to identify areas for improved reproductive efficiency. Until now, collecting and evaluating information chute-side was difficult.

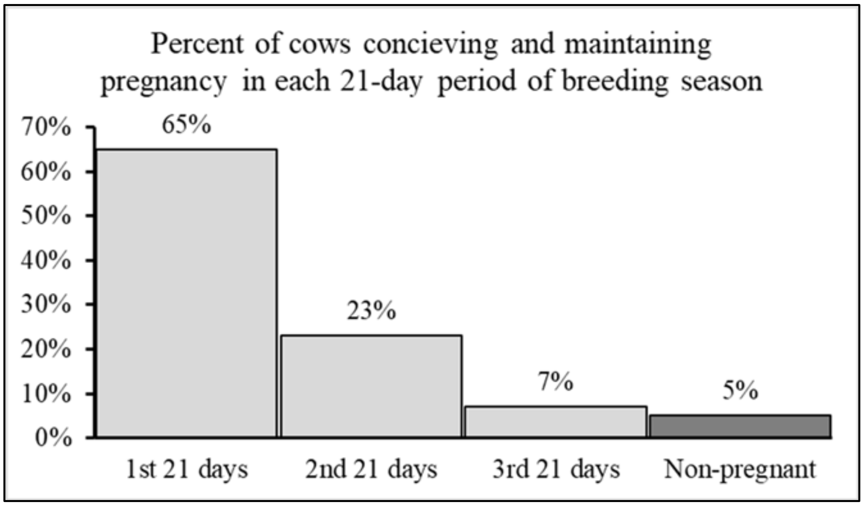

Figure 1. Histogram of the percentage of cows that conceive and maintain a viable pregnancy if nearly all cows ovulate a fertile oocyte during the first 21st days of the breeding season and are bred by fertile bulls and 60 - 70% of available (nonpregnant) cows conceive and maintain a viable pregnancy in each subsequent 21 day breeding period.

Data required by this app are starting and ending dates for the breeding season and an estimate of fetal age for each pregnancy. Additional information such as cow id, cow age, body condition score, and breed (or other descriptor) can be added to enhance value of pregnancy status information. After data are entered, estimated conception dates are generated and histograms created. These pregnancy patterns can help identify most likely contributing factors when investigating herds with a lower than desired percent pregnant.[1,2]

Veterinarians can be fairly precise estimating fetal age early in pregnancy; however, ability to estimate fetal age accurately decreases as pregnancy progresses.[3] Therefore, to confidently place cows within fetal age groups, pregnancy diagnosis should occur $\leq$ 120 days after breeding season initiation. Ability to place animals within fairly tight 21 day periods is a great advantage for veterinarians when evaluating the herds' recent past and optimizing future herd management.

The ideal distribution for a 63 day breeding season should resemble Figure 1. Producers should strive for nutritional and management systems that allow $\geq$ 60% of exposed animals to become pregnant in the first 21 breeding season days,[4] with the majority of remaining animals becoming pregnant in the second 21 day period and no more than 5% of the herd being classified as nonpregnant.

Another way to evaluate pregnancy distribution data is to determine percent of the available (nonpregnant) cattle that become pregnant each 21 day period. As the breeding season advances and pregnant cattle are no longer available to be bred, the herd percentage that becomes pregnant each 21 days is not same as the percentage of available (nonpregnant) cattle that becomes pregnant each 21 days. This important measure is displayed as a table by clicking "***% Pregnancy Success***".

Evaluating the percent of the herd that became pregnant each 21 days does not directly provide accurate visualization of how fertility is changing over the breeding season. The pregnancy distribution displayed in Figure 2 provides evidence that 25% of nonpregnant cows became pregnant in the first 21 day period. However, it is not as clear that in the second 21 day period, 40% of nonpregnant cows became pregnant (30% of herd), and in the third period, 65% of nonpregnant cows became pregnant (30% of herd), and finally, that in the fourth period, 65% of nonpregnant cows became pregnant.

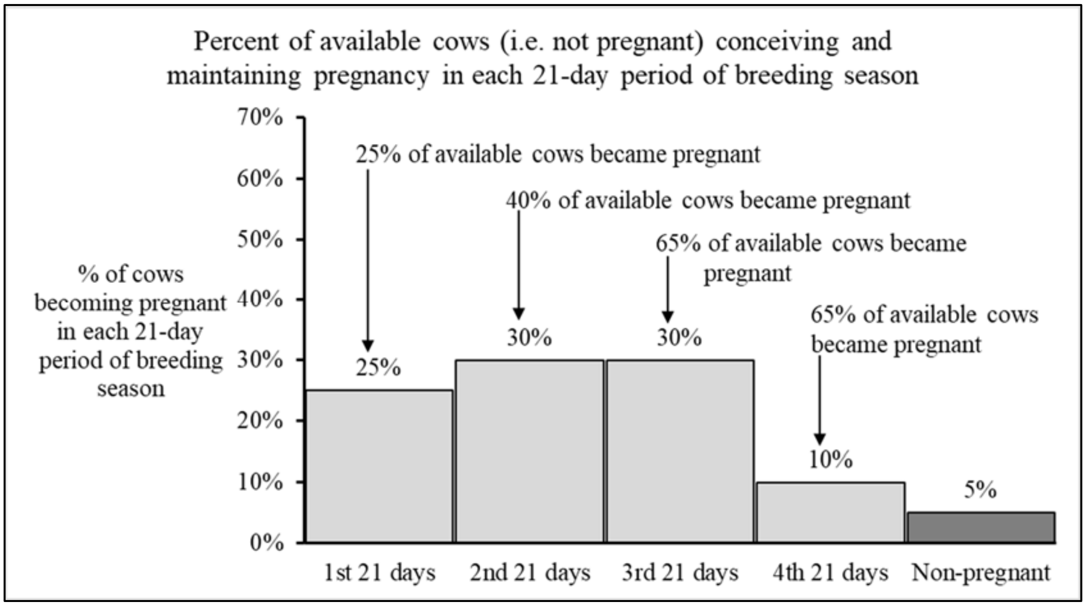

Figure 2. Reporting % Pregnancy Success as a percent of available (nonpregnant) cows at the start of each 21 day period that became pregnant within each 21 day period provides a more direct indication of changing fertility over the breeding season.

Based on expected pregnancy success when cow and bull fertility is optimal, the "% Pregnancy Success" goal should be between 60 and 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 cows or bulls. The % Pregnancy Success values clearly indicate that reproductive problems in this herd occurred during the first 2 cycles, whereas fertility was optimal in the last 2 breeding season cycles.

BCI pregnancy analytics app: interpreting charts and tables

At pregnancy diagnosis, veterinarians can estimate fetal age and evaluate palpable or ultrasonographic characteristics of nonpregnant reproductive tracts (Figure 3). If low pregnancy percentage is due to failure to conceive due to cows not resuming fertile cycles postpartum or bulls failing to deliver fertile semen, reproductive tract examination should reveal characteristics of a nonpregnant uterus with no indication of previous pregnancy or uterine pathology. Typical timing of pregnancy diagnosis relative to reasons for early gestation loss due to noninfectious (e.g. heat or transportation stress) or infectious (e.g. Trichomoniasis) causes may or may not be associated with still-detectable uterine involution or pathology. Because infectious agents or toxins causing pregnancy losses often occur in late pregnancy just prior to or following examination for pregnancy status, examination of nonpregnant reproductive tracts due to recent abortion should reveal some reproductive tracts with characteristics of involution or uterine pathology.

Once all data collected at pregnancy diagnosis are organized, in-depth and efficient evaluation of herd reproductive success can be conducted. Reasons for low pregnancy percentage during any 21 day period can be placed into one of 3 categories: 1) inadequate percentage of females having fertile estrous cycles; 2) bulls not able to deliver adequate amounts of fertile semen; or 3) infectious or noninfectious agents prevented or ended pregnancy. Pregnancy analytics app charts and graphs, along with reproductive tract and cow body condition physical examination findings at pregnancy diagnosis, can guide history questions, further physical examination, herd record evaluation, and diagnostic laboratory testing to assist evaluation of possible rule-outs as likely or unlikely causes of undesired pregnancy distributions.

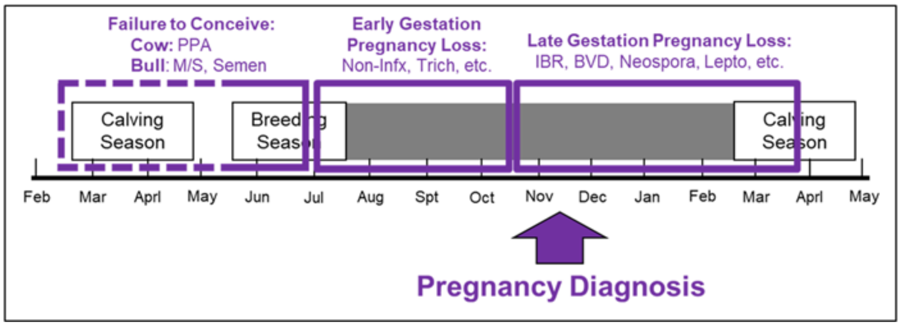

Figure 3. Timing of pregnancy diagnosis relative to reasons for low pregnancy percentage indicates that failure to conceive due to cows not resuming fertile cycles postpartum or bulls failing to deliver fertile semen to cow's reproductive tract occurred many weeks prior to examination, early gestational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

Inadequate percentage of animals were cycling by the 21st day of breeding

Although Figure 1 depicts an ideal herd, many times evaluation of herd pregnancy status data reveals a distinctly different pregnancy distribution. Figure 4 illustrates a very common distribution. In this situation, the percentage of nonpregnant cows would not necessarily indicate a problem if the breeding season lasts long enough; therefore, further evaluation is needed to begin a diagnostic workup.

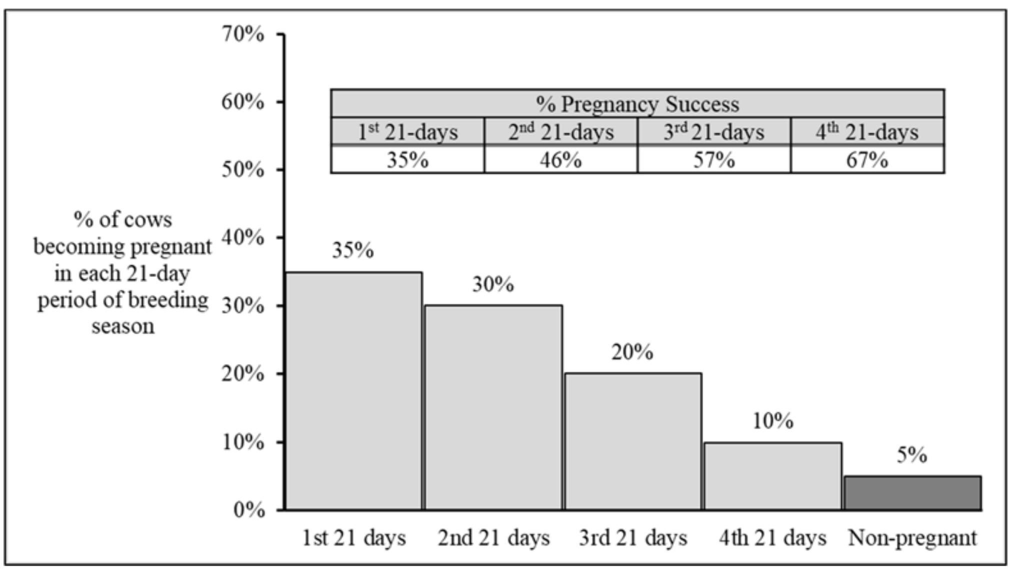

Figure 4. Typical pregnancy distribution for herd with 50% of cows cycling by end of first 21 days of breeding season.

A common reason for a pregnancy distribution similar to Figure 4 is that a similar pregnancy distribution the previous year resulted in many cows calving in third or later 21 day period of the calving season. The typical amount of time from calving to resumption of fertile cycles (postpartum anestrus period) for 90% of a herd's mature cows is 60 - 80 days[5] and for primiparous cows, it is closer to 100 - 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 62 - 82 days postpartum and end 125 - 145 days postpartum for cows calving in first 21 day period of previous calving season.

Therefore, all early-calving cows (including primiparous cows) are expected to express estrus and be bred several times during the breeding season. Cows calving in the second 21 day period will be

41 - 61 days postpartum at the start of breeding season and 104 - 124 days past calving 63 days later. Once again, this timing should allow mature cows to resume cycles and have multiple opportunities to be bred during the breeding season. Primiparous cows calving in the second 21 day period should also resume cycling early enough in breeding season to have 1 or 2 opportunities to be bred. In contrast, for cows that calve in the fourth 21 day period, calving has just finished as breeding begins and for those in the fifth 21 day period, the breeding season begins prior to the time they calve. Limited interval from calving to breeding season initiation essentially eliminates the potential for nursing cows, and in particular, primiparous cows, to rebreed early in the breeding season.

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

Bulls failed to deliver adequate amounts of fertile semen

If reproductive performance is initially adequate - indicating that conception occurred and pregnancy was maintained early in the breeding season, veterinarians can assume that fertile bulls were mating fertile, cycling cows, the herd was free of pregnancy wasting disease, and the postpartum anestrus period and energy reserves (as indicated by body condition score) were not problematic. A sharp decline in *Percent Pregnancy Success* during the breeding season should initiate an investigation to identify potential testicular, reproductive tract, or musculoskeletal problems that prevented production or delivery of fertile semen or whether herd replacements brought in after start of breeding season could have introduced venereal disease.

Figure 5 illustrates a problem that is quite common in herds with 1 bull for each breeding pasture. Although multiple-bull breeding pastures are more resilient to breeding failure due to bulls being unable to successfully breed 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 extensive breeding pasture without 1 or more bulls present, multiple-bull pastures can also have poor reproductive efficiency due to bull problems and can have a pregnancy distributions similar to Figure 5.

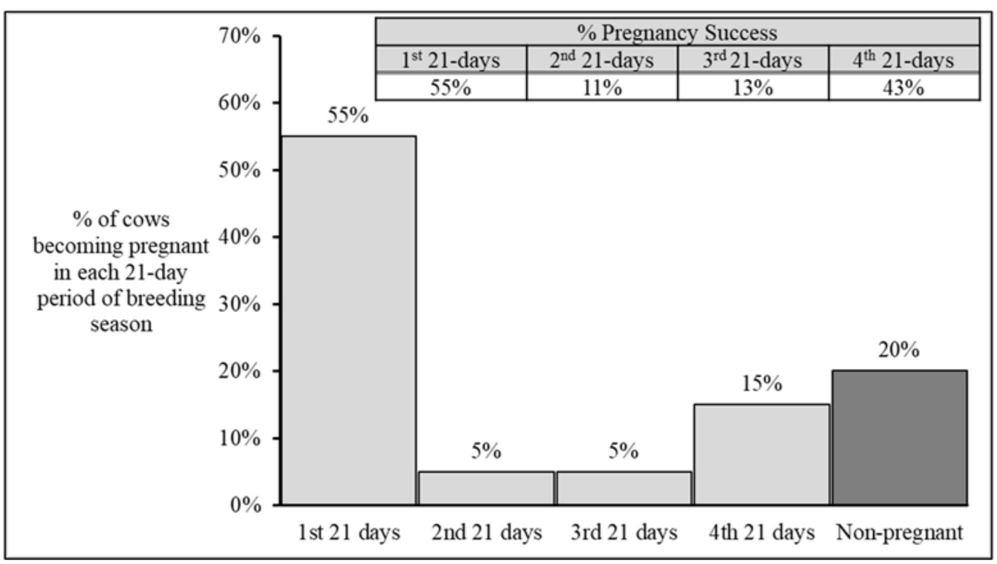

Figure 5. Pregnancy distribution in a herd where a high percentage of cows are cycling at breeding season initiation and bulls are successfully breeding cows, but acute onset of bull infertility occurring late in the first 21 day period or early in the second 21 day period of the breeding season (e.g. injury, disease, etc.) resulted in reduced herd fertility followed by partial recovery.

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

The dramatic decrease in pregnancy percentage during the second 21 day period is strong evidence for bull infertility due to testicular or musculoskeletal insult.[10] Incremental increase in the percentage of available (nonpregnant) cows bred in each subsequent 21 day period in Figure 5 indicates bull fertility is gradually returning.

In a situation where veterinarians evaluated overall pregnancy percent but not pregnancy distribution for the herd depicted by Figure 5, the percentage of nonpregnant cows would indicate herd fertility problems, although the cause of high nonpregnancy would not be evident. With limited information, nutrition or cow fertility could be suspected. 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 breeding season. By categorizing and displaying information gained at pregnancy diagnosis, the problem cause becomes more obvious.

A bull 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 that commenced 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.

Infectious or noninfectious agents prevented or ended pregnancy

In situations when early pregnancy loss leads to negative pregnancy distribution effects, the problem occurred after breeding season initiation and before pregnancy diagnosis. In addition to the pregnancy distribution effect of pregnancy loss, in some situations, nonpregnant cows may exhibit palpable evidence of an involuting uterus at pregnancy diagnosis.

Noninfectious pregnancy loss very early in pregnancy due to environmental stress should not result in uterine pathology and would not be expected to have negative carry-over effects in the next 21 day breeding season period. In contrast, noninfectious pregnancy loss after maternal recognition of pregnancy (~ 13 days after estrus) will delay returns to normal fertility until after the embryo is resorbed or expelled and hypothalamic-pituitary axis has resumed normal estrous cycle activity – which may be later than the 21 day period following initial conception. Early, noninfectious pregnancy loss that occurs before pregnancy is detectable by transrectal 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; therefore, transrectal palpation or ultrasonographic examination is indistinguishable from failure to conceive or early noninfectious pregnancy loss. However, because many common causes of infectious pregnancy loss in North America have peak incidence after mid-gestation when pregnancy is typically diagnosed, it is expected that palpable evidence of previous pregnancy will be detected. The length of time that palpable evidence would be evident is influenced by the stage of pregnancy at the time of pregnancy loss and whether or not the loss was accompanied by uterine pathology.

Infection with *Trichomonas foetus* (Trich), a protozoa transmitted during breeding, is an important cause of pregnancy loss in North America because it is diagnosed in many cattle-dense areas and can cause a high percentage of exposed cows to resorb or abort their pregnancy. 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.

If Trich entered herd prior to breeding season initiation so that a high percentage of bulls are already infected, cows will become pregnant at a time similar to last year's breeding season, but infected cows are likely to lose their pregnancies ~ 15 - 80 days into pregnancy. A period of female infertility is expected to last for another 2 - 6 months as a result of infection. The magnitude of loss is expected to approach 30 - 50% of exposed cows. However, if Trich entered the herd during breeding season or fewer bulls were infected at the start of breeding season but the number of infected bulls increased as the breeding season progressed, then the pregnancy distribution is greatly influenced by what the distribution would have been without Trich exposure, and the speed at which additional bulls became infected.

Other causes of early pregnancy 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 pregnancy distribution, although 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 pregnancy include: Bovine Herpes virus 1 (Infectious Bovine Rhinotracheitis), bovine viral diarrhea virus, *Neospora caninum*, *Leptospira* sp., pine-needle toxicosis, and others.[13,14] Pregnancy losses in mid to late pregnancy are likely to occur after pregnancy diagnosis time and the effect is not limited to a single period of the pregnancy distribution. If pregnancy losses occurred prior to pregnancy diagnosis, evidence of that loss is likely to be apparent during transrectal examination of the nonpregnant uterus of some of the affected cows.

Second-level analysis of pregnancy 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 21 day intervals. For example, the herd depicted in Figure 6 has a pregnancy percentage of 94.5%, which meets the 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% cutoff associated with good cow and bull fertility at breeding season initiation. From these observations, one could classify this herd as having normal fertility, with no nutritional or reproductive management problems.

Looking at *Percent Pregnancy Success*, during the first 21 days of the breeding season, 62% of available cows became pregnant. In the second 21 days, 55.6% of nonpregnant cows became pregnant; which is 21% of the herd. In the third 21 days, 68% of available cows became pregnant; which is 11.5% of the herd. These measures of reproductive success are not alarming, but there is an indication that fertility may be suboptimal during the second 21 days and closer examination of data is warranted.

If data collected at pregnancy diagnosis for the herd depicted in Figure 6 are further analyzed by age categories for each 21-day period (Figure 7), the pregnancy distribution for primiparous cows indicates a clear problem. Diagnostic information provided by *Percent Pregnancy Success* indicates that whereas mature cows perform very well throughout the breeding season and primiparous cows performed well during in first 21 days, pregnancy success dramatically decreases during the second 21-day period for primiparous cows before returning to 70% for the final 21 days of breeding.

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

Having this type of analytics available immediately after pulling the palpation sleeve off is not diagnostic *per se*. However, as I am talking to a producer, I can confine my history questions to primiparous cows during the second 21 days of the breeding season (which for this herd would have been the last 2 weeks of June through the first week of July). If I pursue diagnostic testing, I will focus my testing on bulls in the primiparous cow breeding pasture.

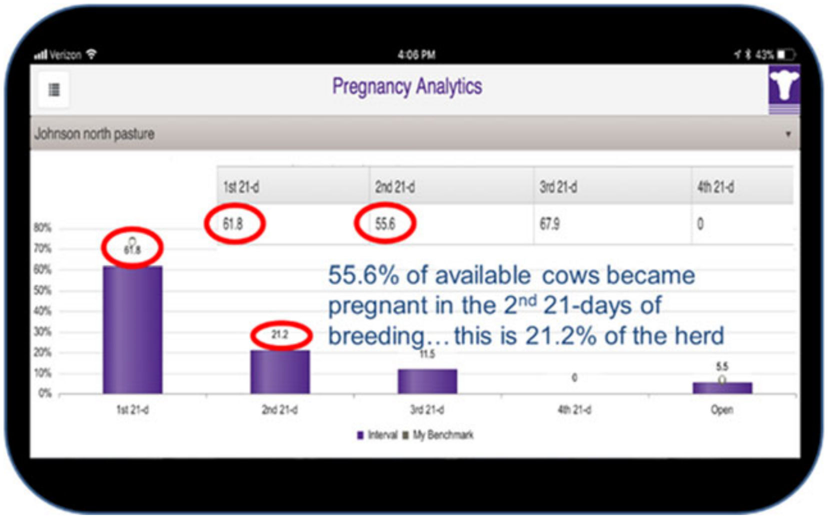

Figure 6. Herd with a good pregnancy distribution that has a hidden problem

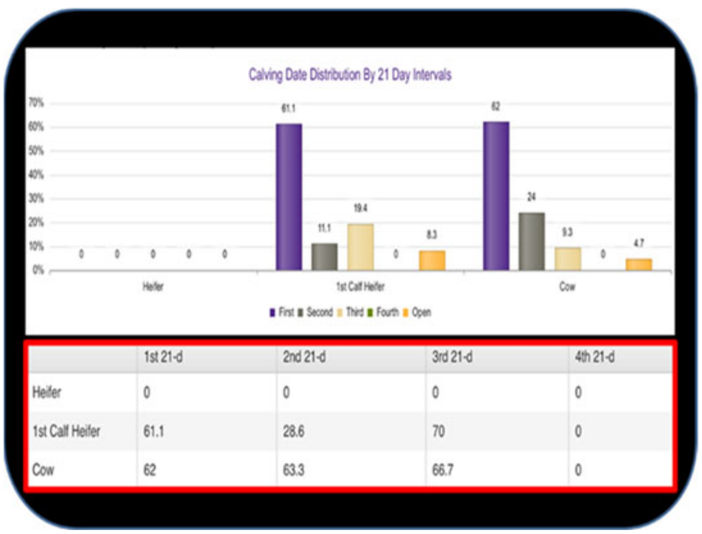

Figure7. Second-level analysis of pregnancy data from a herd with suboptimal fertility not apparent when evaluating overall herd pregnancy distribution.

Conclusion

Information gathered at 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 pregnancy status data, that value is difficult to capture. Nutrition, genetics, animal husbandry, reproductive soundness and health influence distribution of pregnancy within a herd. By combining transrectal palpation or ultrasonographic imaging of the reproductive tract to determine pregnancy status with analysis and graphing of information, veterinarians can identify **when** during the breeding season **which specific categories** of cows did not become pregnant. The Pregnancy Analytics App allows a veterinarian's knowledge and skill to be augmented by efficient digital data entry and rapid generation of commonly used herd reproductive assessments to enhance communication between veterinarian and producer. More information about the BCI Pregnancy Analytics App is available at https://ksubci.org/pregnancy-analytics-mobile-app/

Conflict of interest

There are no conflicts of interest to declare.

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