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Beef Production Systems in the Nebraska Sandhills

McKay Erickson

University of Nebraska - Lincoln, mckay.erickson10@gmail.com

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BEEF PRODUCTION SYSTEMS IN THE NEBRASKA SANDHILLS

by

McKay R. Erickson

A THESIS

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Rick N. Funston

James C. MacDonald

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BEEF PRODUCTION SYSTEMS IN THE NEBRASKA SANDHILLS

McKay Reed Erickson, M.S.

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Advisors: Richard N. Funston and James C. MacDonald

Four studies were conducted to determine the effectiveness of improving production systems of beef cattle in the Sandhills region of Nebraska. These studies were to determine impacts of modified estrus synchronization protocols, genomic testing heifer calves for longevity, and evaluation of 2 differing calving systems (March or May) for improving biological outcome and improved production. Experiment 1 utilized 180 yearling heifers to determine the effectiveness of a second dose of prostaglandin $F_{2\alpha}$ (PGF) with those females not expressing estrus after an initial 14 d MGA-PG estrus synchronization protocol. The treatment of PGF did increase estrus expression, but did not increase the pregnancy success of these females.

Experiment 2 utilized 1,518 yearling heifers in a 14 d MGA-PG estrus synchronization protocol. Treatment of 5 μ g GnRH was administered 72 h prior to a fixed-time AI (TAI) simultaneous with the typical PGF administration (25mg). The dose of 5 μ g GnRH did not increase pregnancy success for initial TAI when compared to the control females.

Study 3 genotyped 414 March or May born heifers from the Gudmundsen Sandhills Laboratory from the years 2009-2012. Phenotypic data for each individual was compared to the genomic results from the Igenity Gold panel reported on a 1-10 scale. Regression analysis revealed the birth BW genomic score is a predictor for actual birth BW. The genomic score for calving-ease direct is also a predictor for weaning BW. The

genomic predictor scores for heifer pregnancy as well as stayability show no significance as predictors for actual heifer pregnancy and female stayability.

The final study compared the biological differences when calving in a March versus a May calving season. Data from 3 consecutive years were utilized with 503 cows from the March and 301 from the May systems. Calf birth BW and calf BW at dam's breeding was greater for May-born calves than March-born. Adjusted weaning BW was greater for March-born. Pregnancy rates, weaning rates, calving interval, calving difficulty, and calf vigor were similar between the systems.

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CHAPTER I: LITERATURE REVIEW

INTRODUCTION

Beef production in the Nebraska Sandhills is a major contributor to the culture, community, and economy. The importance of production systems for these producers is vital for the success of the future of the beef industry as well as the sustainability and overall health of the environment and ecosystem that makes up this unique landscape. Taking a systems approach to beef production allows a producer to look at the whole cycle of the animal from birth to harvest and everything in between. By managing each step and understanding how each is intertwined with another will increase the success of production as well as the cattle breed as a whole. Taking advantage of technologies such as estrus synchronization and genomic testing or improved protein supplementation strategies can lead to increased profit per animal with increased management. This holistic picture will lift the industry, prepare for the future of a growing planet, and increase cattle producer success.

PROTEIN SUPPLEMENTATION

Cattle grazing dormant, low-quality forage are not generally meeting protein requirements without some form of protein supplementation. These mature, fibrous roughages are often lacking in requisite protein. Low-quality forage is usually defined as $\leq 6\%$ CP and $\leq 45\%$ TDN (Adams et al., 1996). The rumen of the cow requires protein itself, as the microbes need ammonia to break down feeds and synthesize amino acids that pass further into the GI tract of the cow. The appropriate protein supplementation can effectively remedy this deficiency and better utilize these forages. In North America, protein supplementation is a common practice, but strategies involving timing, types of

feedstuffs utilized, and delivery of supplement all differ significantly. Forage resources also vary as they can be sourced as meadow, upland range, cornstalks, etc. All protein sources are not created equal as some have higher ratios of undegradable to degradable (RUP:RDP) rumen protein and vice versa. These sources supply more protein to either the animal or the rumen and can offer different benefits depending on animal requirements and forage value of the range being grazed. Certain circumstances in the beef production cycle heighten protein requirements like stage of gestation, amount of milk produced for mature females, or growth and attainment of puberty for steers and heifers, respectively. Understanding these requirements is crucial to proper supplementation strategies and optimal animal performance. The aim of this article is to review protein supplementation and key aspects associated with it in order to build a better base to understand where the industry can better utilize valuable protein sources strategically and eliminate waste.

RUMEN DEGRADABLE PROTEIN

Non-Protein Nitrogen

Ammonia is utilized as an alternative protein source to natural protein supplements. Urea, which is the most commonly used source of nitrogen fertilizer for crop and forage production, is also the most common source of non-protein nitrogen (NPN) fed to ruminants. Non-Protein Nitrogen is typically only fed to ruminant animals because of the ammonia utilization by the rumen microbial population. It can be toxic if fed to non-ruminant animals at high levels. Urea typically does not produce satisfactory results as a supplement when it is used as the only protein source in diets low in TDN or starch. Best success is usually achieved when it is combined with other natural protein

sources (Lardy and Endecott, 2010). Another source of NPN used for animal protein supplements is biuret, which is formed by the heating of urea near or above its melting point. Two urea molecules combine to form biuret.

Satter and Slyter (1974) saw the ammonia concentration in simulated rumen conditions increase when urea was added. The output of protein from this also increased as urea was added until the concentration in the rumen fluid was 50 mg NH₃-N per liter. Urea could continually be added and the ammonia concentration would increase, but the output of protein from microbes would not increase, showing a natural governor to the amount of protein produced from the rumen.

Urea affects palatability and can inhibit some animals from consuming supplement, but this is usually at levels much higher than can be utilized by the animal (Clanton, 1978; Kunkle et al., 1996). When urea supplement was added to a low-quality hay diet fed to heifers compared with heifers fed a natural protein supplement, those consuming the NPN diet lost more weight and body condition while growing in a drylot setting compared with those fed the natural protein (Rush et al., 1976). This palatability issue can be resolved somewhat by feeding biuret over urea. Clanton (1978) reported steers being fed differing sources of NPN and in different amounts performed better with biuret rather than urea as the supplement. Biuret could be increased in the diet without depressing the intake of the animal, but as inclusion of biuret increased, animal gains began to suffer. Equal inclusions of biuret and urea (3% of DM) showed similar results, but biuret was better utilized as the amount increased to 6%. Supplementation of urea + DL-methionine on poor-quality grazed forage showed increased disappearance of NDF than DL-methionine fed alone. DM disappearance of the urea with DL-methionine was

similar to soybean meal supplement and cow body weight and body condition was similar for both supplements. Ammonia concentration for urea + DL-methionine (52 mg/L) was greater than soybean meal (38 mg/L) or DL-methionine (18 mg/L) alone. Adding urea made the DL-methionine more effective as a supplement as it was more similar to soybean meal than just DL-methionine fed alone to cattle grazing low-quality forage (Wiley et al., 1991). This agrees with Satter and Slyter (1974) that the effective peak production for ammonia in the rumen is near 50 mg/L. The poor results exhibited from the feeding NPN sources to cattle grazing low-quality forages may be due to limiting amino acids, which if supplemented with the NPN show similar results to a natural protein source. The source of carbon chains available to capture ammonia may also be a limiting factor. When grazing forages, rumen-synthesized microbial protein is essentially the sole source of protein provided to growing steers, it has been shown methionine, lysine, and threonine are the first 3 limiting amino acids, in that order (Richardson and Hatfield, 1978).

Natural RDP

Pregnant cows grazing dormant forage show increased NDF fermentation rate when supplemented with soybean meal. When more undegradable protein sources like corn gluten meal or blood meal are added along with soybean meal fermentation rate increases, ruminal dilution rate decreases, and ruminal volume increases (Miner and Petersen, 1989). The increased ability to ferment and digest these low-quality feeds through protein supplementation with a combination of degradable and undegradable sources aide the cow through the winter to maintain body weight and condition better than without any supplement. Intake and digestibility are increased in cattle grazing

shrub-grass pastures in the Northern Great Plains when supplemented with protein. Evidence of this was strongest during times of severe winter conditions and limited forage availability (Kartchner, 1980). The increase in intake and digestibility means an energy increase for the cow. Hollingsworth-Jenkins et al. (1996) noted through winter grazing trials on native range, the RDP requirement for a gestating beef cow at this time is somewhere between 340 to 430 g/d, which is about 4% of OM intake. These females required between 61.7 and 140 g/d supplemental RDP, which was supplied via corn steep liquor (approximately 100% RDP) and soyhulls as carrier. The variability in this range is due to variance in forage quality, intake, and cow size. The overall conclusion drawn was the RDP requirement being 7.1% of digestible OM for a gestating cow grazing low-quality native range.

Protein sources that have a high RDP:RUP ratio include alfalfa, corn steep liquor, sunflower meal, urea, and biuret (Paterson et al., 1996). Nichols and Clanton (1987) stated a high-quality forage can be just as effective as a protein supplement when provided to cows grazing dormant, native winter range. Regrowth grass hay from a subirrigated meadow is as effective as a soybean meal-based supplement in gestating cows grazing dormant, winter range in the Nebraska Sandhills for maintaining body condition and body weight (Villalobos et al., 1997). Similar results were seen in Montana where cows supplemented with alfalfa cubes maintained body condition as well as cows fed a cottonseed meal-based supplement (Cochran et al., 1986). High-quality meadow hays and alfalfa hays that are harvested and stored correctly can meet all animal requirements when on dormant, native rangeland.

RUMEN UNDEGRADABLE PROTEIN

Pregnant ewes consuming chopped barley straw were supplemented with urea, soybean meal, or blood meal+soybean meal (Hoaglund et al., 1992). The ewes fed the blood meal + soybean meal ration gained more weight, had longer wool fiber length, had higher blood urea nitrogen and albumin concentrations, and lost less body condition compared with ewes supplemented with just urea alone. Ewes within these groups were also allocated to either 80% or 100% metabolizable energy, in which there was no performance or blood differences between the two. This indicates protein plays a bigger role than metabolizable energy for a pregnant ewe that is maintaining body weight and condition. The addition of blood meal to soybean meal showed great benefit to the animal over just feeding soybean meal alone. Rumen undegradable protein must be limiting with soybean meal for the pregnant ewes so the blood meal allows protein to bypass the rumen and enter the small intestine and increase benefit potential for maintenance to the ewe.

Heifers developed on native range and grazing dormant forage can benefit from a high RUP supplement. This helps young females to grow steadily, but slowly, to a managed low BW and achieve reproductive success similar to heifers grown at a higher rate of gain to heavier BW. This practice, as opposed to drylot management, retains females in the herd longer due to increased reproductive success (Mulliniks et al., 2013).

Rations or diets with low rumen digestibility tend to increase the time taken to physically degrade undigested particles and transport them from the rumen, limiting the daily forage intake of the animal (Hunter, 1991). Protein sources that have a high RUP:RDP ratio include blood meal, corn gluten meal, meat & bone meal, and feather meal (Paterson et al., 1996). Protein meals, through the heating process, usually have

protected protein in addition to the natural RUP. They can also contain a high amount of digestible energy and minerals, such as phosphorus, and because of these additional properties, a protein meal supplement can provide essential and adequate nutrients to the rumen microbes as well as requisite amino acids, minerals, and energy to the animal itself. An additional benefit is that protein meals can provide extended ammonia release to the rumen. This and the extra nutrients increase the live weight response when compared with urea. Protein meal intake does not displace forage in the diet like a starch/grain-based supplement can do. Forage intake can therefore increase with supplementation at practical levels and improve animal performance, whereas a supplement based largely on carbohydrates will displace the forage in the diet and depress intake (Hunter, 1991; Kartchner, 1980). Along with this, Owens et al. (1991) agreed that the lower quality of the forage, the more protein supplementation will complement and enhance forage utilization. In contrast, the higher quality the forage, the more likely supplement will displace forage in the rumen.

SUPPLEMENTATION CONSIDERATIONS

Timing

Wiley et al. (1991) noted when supplements were fed on alternate days to cows grazing low-quality forage, those supplements containing urea created a huge spike in ammonia concentration 3 to 6 hours after consumption compared with other supplements and controls. Soybean meal kept the concentration at more consistent levels than the supplement containing urea. This consistency may aid the rumen microbes by keeping the environment more stable instead of the large fluctuations seen when fed urea. Adams (1985) showed while supplementing a grain-based supplement, time of day impacted

steer performance while grazing Russian wildrye grass. The animals supplemented in the afternoon had greater average daily gain (ADG) and increased intake over animals not supplemented or supplemented in the morning. It is interesting to note the afternoon-supplemented steers performed better while grazing less time than the other treatments. This indicates, albeit the supplement was more energy than protein, consideration should be given to the time animals are supplemented while grazing forage so their habits are not disrupted in such a way that hurts their performance.

Supplement delivery on alternate days instead of daily may decrease intake of range forage as well as overall intake regardless of type (Villalobos et al., 1997). Heifers offered a low-starch energy supplement daily attained puberty quicker when consuming low-medium quality forages than heifers offered the same supplement 3 times per week. Daily supplementation reduced daily variation in daily nutrient intake, which provided the heifer a favorable rumen environment to develop reproductively (Moriel et al., 2012). This disagrees with Lardy and Endecott (2010) and Schauer et al. (2005) who concluded cattle grazing low-quality range may be supplemented protein 1 to 3 times weekly, instead of daily, with minimal consequence to the cow -- no decrease in intake or digestibility and greater convenience for the producer. Huston et al. (1996) also supports this with data that supplementing cows one half of their protein requirements with cottonseed meal over late winter while grazing native range is beneficial regardless of supplementation interval being daily, 3 times/week, or weekly. Kartchner (1980) supplemented cows 3 times per week with either a grain-based supplement or a protein (cottonseed meal) supplement and noted increased intakes with the protein supplement and depressed intake for the grain-supplemented cows.

Protein Antagonists

Cows grazing native, low-quality range show decreased intake and digestibility of the forages when corn is increased in the supplement. Cows lost more weight when ear corn was added to a protein supplement while grazing dormant range than cows just fed protein supplement alone (Sanson et al., 1990). As starch increases in a diet of cows consuming low-quality forage the microbes adjust from digesting cellulose to the newly added starch. This shifts the rumen to a greater percentage of starch digesters, which slows cellulose digestion and leads to less efficient cows that lose body condition while grazing dormant range. Morrison et al. (1991) supplemented fall-born heifers with a high amount of corn and cottonseed meal and noted significant gains after breeding while grazing dormant bermudagrass pasture when compared with a no supplement control or a low amount of the same supplement. Intake was not measured within this study, so it could not be determined if the increased corn level in the supplement depressed gain or not. Feeding low starch, high protein supplements can help keep the rumen digesting cellulose and keep the cow in better condition. Starch-digesting microbes out compete fiber-digesting microbes for degradable protein, which highlights the importance of feeding protein supplements low in starch so the fiber-digesting microbes have access to all the protein that is necessary (Paterson et al., 1996). The effect of a protein supplement on the forage can be quite variable. The quality of the forage and the type/ingredients of the supplement all have bearing. Grain supplementation to cows grazing dormant, winter range can decrease intake and digestibility of range forage instead of an increase in both intake and digestibility with a protein supplement (Kartchner, 1980). Feeding a supplement high in starch when the animal is consuming very low-quality forage can

negatively affect utilization, although intake was not affected when grazing late summer forage in the Nebraska Sandhills (Lardy et al., 1999). The opposite can be observed when animals grazing dormant winter forage are administered a low-starch protein supplement as intake and digestion improve (Bowman and Sanson, 1996). Owens et al. (1991) stated that starch can act as a nitrogen sink and reduce nitrogenous reserves in the animal.

PROTEIN REQUIREMENTS

Rumen

On a typical forage diet (CP between 5% and 12%) and under the assumption RDP is in adequate supply and not limiting to the rumen microbes, then the limiting factor for potential maximum animal growth are amino acids (Kerley, 2010). Dove et al. (2010) noted the protein content of green forage may meet requirements under grazing conditions unless the animals are at or near peak lactation. A challenge associated with this assumption and with grazing forages is the difference among range forage species as well as seasonality of quality and nutrient density and amount. For most producers the precision of predicting forage value is often quite low as well as the accuracy of predicting animal requirements. These two deficiencies cause a constraint when deciding what to supplement the animal with and how much. Nitrogen and sulfur, which are both needed to synthesize microbial protein, are often deficient in mature forages and this can reduce normal rumen microbe function. The supplementation of either nitrogen or sulfur to increase rumen concentration is only beneficial if all the other necessary nutrients used by the rumen microbes are in adequate supply and the sulfur or nitrogen are the primary limiting nutrients.

Voluntary intake of prairie hay (low protein value; generally $\leq 7\%$ CP) and particulate passage rate from the rumen increased in steers supplemented with cottonseed meal (McCollum and Galyean, 1985). This is supported by Guthrie and Wagner (1988), who also noted increased forage intake and particle passage rate are highly correlated. As soybean meal was increased in the supplement; protein digestibility, ruminal ammonia concentration, organic matter, dry matter, and ADF digestibility also increased. Similar findings by McCuiston et al. (2010) and Kartchner (1980) reported protein supplementation improved dry matter disappearance of poor-quality forage when that is the main diet. However, Judkins et al. (1985) showed protein supplementation of steers grazing blue grama pastures in late winter did not increase forage intake or alter botanical selectivity of the steers.

Bandyk et al. (2001) exhibited the infusion of degradable protein into the rumen of steers consuming low-quality hay increased forage intake more than the infusion of the same protein post-rationally. It was noted, however, that RDP infusion post-rationally did increase forage intake, but not as much as within the rumen. These results show protein is recycled from the GI tract and comes back into the rumen as ammonia that is utilized by rumen bacteria. Owens et al. (1991) noted as a result of this, the idea that post-ruminal N infusions and higher RUP supplementation increases forage intake, tissue protein or energy status may be regulating forage intake.

Reproduction

McSweeney et al. (1993) noted *Bos indicus* heifers responded better in terms of resumption of ovarian cycling to weaning of her calf than post-partum protein supplements. Supplemented females showed no difference in basal concentration of

luteinizing hormone nor of pulsatile release compared with unsupplemented heifers at 60 d post-partum. Funston et al. (2012) suggested supplementing yearling heifers grazing dormant range with protein so they might achieve modest weight gains; just enough to achieve puberty, begin cycling, and successfully become pregnant.

Certain amino acids along with other nutrients may affect reproduction by regulating the release of certain compounds such as GnRH (Lemenager et al., 1991). Heifers fed isocaloric diets, but one group was fed adequate protein and another was deficient in protein. Those fed adequate protein levels exhibited 89% estrus while only 63% of the deficient treatment exhibited estrus. The overall pregnancy rates were greater for the heifers fed sufficient protein (74%) than those fed at low levels (32%; Sasser et al., 1988). Patterson et al. (2003) showed increase in 2 year old pregnancy rates as well as heavier body weight at 2 year old fall pregnancy diagnosis when supplemented to meet metabolizable protein (MP) needs instead of CP needs during their first gestational (first calf) period as a heifer. Economic value of each female was also increased when protein was supplemented to meet MP vs. CP requirements. This shows protein plays an integral role in return to estrus and energy has a lessened effect since both adequate and deficient heifers received equal amounts of energy. Post-partum protein supplementation is beneficial to get females bred in first estrus by reducing postpartum interval.

Grazing poor-quality range can limit nutrients of the cow, especially during gestation. Meyer et al. (2010) provided RUP to nutrient-deficient cows during gestation. Supplementation of RUP increased serum essential amino acids, which can possibly protect the fetus from intrauterine growth restriction. Conversely, Karges et al. (1991a) concluded cows fed native range hay over winter were limited in RDP, but

supplementing with RUP showed little benefit, indicating the cow's protein needs were being met by the rumen microbes.

“Spike feeding” supplies a cow with a nutrient-dense supplement for the last two months of gestation, which ensures forage intake is not decreased and helps shorten the anestrous period post-calving (Hunter, 1991).

Lactation

Cows fed a high protein supplement (2.44 kg/d, 40%CP) during lactation helped them lose less body condition and weight, but possibly reduces progeny growth post-supplementation (Marston et al., 1995). This high protein supplementation did not affect pregnancy rates when compared with other energy supplements fed pre-partum to the same cattle.

Hunter (1991) demonstrated increasing amounts of protein meal supplemented to Hereford cows consuming low-quality hay also increased milk yield. Increasing supplement amounts increased forage intake, metabolizable energy intake, and reduced cow weight loss. If the increased demands for milk production are not met from the diet, then the animal will mobilize tissue protein for energy and milk production and the cow will lose weight and condition and sacrifice estrus until all nutrient requirements are met. Rumen degradable protein is the first lacking nutrient before energy or MP for summer calving females during late lactation and breeding in the Nebraska Sandhills. Supplemental RDP during the breeding season decreased weight loss and decreased body condition in females from breeding through the winter. Calf weights increased due to increased milk production from these supplemented females. In order to adequately calculate protein supplementation levels it is vital to properly estimate milk production,

protein degradability, forage intake and digestibility, and size and condition of the female (Lardy et al., 1999).

Growing Cattle

Brahman influenced calves grazing Ona stargrass pasture over winter that were supplemented showed significant average daily gain over those that were not. Non-supplemented calves just kept weight at maintenance or a very slight daily gain. Calves supplemented with protein at 1% BW showed satisfactory results and feeding any more elicited no added benefit. All calves, regardless of supplement treatment, experienced compensatory gain in the spring and summer months, but the supplemented calves were still heavier after these months (Horton et al., 1987).

Karges et al. (1991b) reported RDP was not limiting to yearling steers that grazed summer range in drought years. Feeding a RUP source improved average daily gain and was more limiting to performance than was RDP. Creighton et al. (2003) also noted no economic benefit to supplementing protein (RUP) to spring-born steers grazing through the summer, but summer-born steers on summer pasture experienced improved gains through the finishing phase.

Amino acids are extremely important for growing animals to produce lean tissue and lay down fat and muscle. Wilkerson et al. (1993) found the MP requirement for growing beef steers is 305 g/kg of live weight gain. Different protein combinations in a ration may provide the full array of necessary amino acids to maximize growth.

In summary, cattle grazing dormant forage are usually deficient in protein whether it be RDP or RUP. Protein is vital for the optimal functioning of the rumen as well as the performance and growth of the animal. Protein supplementation allows cattle

to utilize dormant, low-quality forages and feeds that would otherwise be un-usable. The rumen of the cow has a protein requirement itself as the microbes need ammonia to break down feeds and synthesize amino acids that pass further into the GI tract of the host. The supplementation of protein sources can effectively remedy deficiencies and better utilize these forages. These sources supply more protein to either the animal or the rumen and can offer different benefits depending on the requirements of the animal and forage value of the range being grazed. Certain circumstances in the beef production system cycle heighten protein requirements like gestation or lactation for mature females, or growth and attainment of puberty for steers and heifers respectively. Understanding these requirements is crucial to proper supplementation strategies and optimal performance of the animal.

ESTRUS SYNCHRONIZATION

The utilization of estrus synchronization can have many benefits such as increased conception at initial breeding whether it is to AI or natural service sires. Typically, these AI sires are of superior quality so getting increased pregnancy success initially can result in a more rapid improvement to a herd's breeding objectives. Increased pregnancy success in the early part of breeding season will result in more calves born in the first 21 d of calving. This can mean a more uniform calf crop, reduced labor inputs with a shorter calving season, and a reduced calving interval, which can increase the longevity of a female in the herd.

Gonadotropin-Releasing Hormone

Gonadotropin-releasing hormone (GnRH) is commonly used in a large proportion of estrus synchronization protocols for cattle. It stimulates the release of follicle-

stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary to aid in timing of ovulation to better achieve synchrony in beef females. Administration of GnRH agonist shows the ability to cause ovulation of a persistent first-wave dominant follicle and facilitate selection of a new preovulatory dominant follicle, which in turn increases estrus synchrony and increases pregnancy rates (Schmitt et al., 1996). Heifers injected with 100 µg GnRH vs. a saline solution had increased preovulatory LH and FSH surges at the peak and were shorter in duration as blood samples were collected every hour from 6 h before administration of GnRH until 12 h after. Circulating estradiol concentrations were maximal at the height of the LH surge through FSH peak and did not reach minimal levels until several hours post-FSH peak (Haughian et al., 2004).

The ability of females to get pregnant early in breeding season depends upon their cyclicity at first injection of GnRH. *Bos indicus* influenced cattle in a timed artificial insemination (TAI) system and administered GnRH upon insemination showed an increase in estrus expression and pregnancy percentage when compared with a Select-Synch protocol (GnRH on d 0 and PG 7 d later and heat detection and breeding on d 7 to 12). This suggests the effectiveness of GnRH administration at day of insemination to increase pregnancy rates in beef females (Lemaster et al., 2001). Pursley et al. (1995) identified the possibility to synchronize ovulation within an 8 h time window utilizing GnRH and PG and inseminate at a time when ovulation is known.

Twagiramungu et al. (1992) observed that administration of GnRH (2mL) on d 0 of a 10-d synchronization period reduced the number of females showing signs of estrus from d 0 to d 6. On d 6 those that had not showed estrus were given 2 ml of PGF. Females given GnRH showed increased synchronization rates and pregnancy rates over

the control (no GnRH) for d 6 to 10, though conception rates stayed consistent between both groups. This study suggests a 6 d time period from GnRH administration to PG to allow for maximum synchrony of beef females (Twagiramungu et al., 1992). Atkins et al. (2008) demonstrated heifers in the earlier stage of the estrus cycle (between d 1 and 10) that received GnRH for the first time had an improved synchrony effect and increased response to a second dose of GnRH to induce ovulation in a 2-dose system. The use of human chorionic gonadotropin (hCG) is not as effective as GnRH in a CO-Synch+CIDR protocol (Burns et al., 2008). This experiment utilized a double TAI system (re-synch cows with GnRH 26 d from initial AI, PG on d 33, GnRH and AI d 35) which would allow a producer to breed more cows with AI sires, but would have less total pregnancies as well as extend the calving season.

In a synchronization protocol that administers GnRH on d -9, PG on d -2, GnRH and AI on d 0, cows administered GnRH on d -9 and ovulated as a result had higher estradiol concentration on d 0 as well as larger follicles than females who did not ovulate in response to GnRH on d -9 (Jinks et al., 2013). Estradiol concentration on d 0 was positively correlated with follicle size. Jinks et al. (2013) utilized embryo transfer and showed donor cows with increased estradiol were more likely to yield an embryo and recipient cows with higher levels of estradiol on d 0 were more likely to become pregnant. Pursley et al. (1995) noted the administration of GnRH at AI in many protocols is to ovulate the preovulatory follicle at a designated time for optimum synchronization and for the purpose of increasing success to insemination. When comparing spontaneous vs. premature ovulation induced via GnRH in beef multiparous cows, Mussard et al. (2007) showed GnRH-induced ovulation of the dominant follicle reduced AI conception

rates as well as follicle size and luteal function. This emphasizes the importance of timing with estrus synchronization protocols using GnRH in a TAI model. Rushing the breed time or GnRH use will decrease fertility. Inducing ovulation with a GnRH agonist increased the turnover of mature follicles from growing follicles, but limited growth of large follicles, in both cyclic and acyclic cows (Twagiramungu et al., 1994).

As noted earlier, pregnancy success is highly correlated with estrus expression at the time of breeding. Small doses (5 µg) of GnRH at CIDR removal in a 7 d CO-Synch+CIDR protocol increased expression of estrus and shortened interval to estrus in young beef females (Rich et al., 2018). Cows expressing estrus have higher concentrations of estradiol than those showing no sign of estrus. These females exhibiting estrus also had increased estradiol concentrations around 6 h post-PG injection in a CO-Synch protocol and greater growth rate of estradiol concentrations. There is also a positive correlation between estradiol concentration and follicle diameter in cows expressing estrus and no correlation in females not expressing estrus (Perry et al., 2014). Estrus expression and body condition of mature cows had the most impact on pregnancy success when comparing various TAI protocols. Days postpartum did not impact estrus expression (Richardson et al., 2016).

Martinez et al. (2002) analyzed the difference of heifers randomly receiving either GnRH, porcine LH (pLH), or estradiol benzoate (EB) following PG in both CIDR and MGA protocols. All treatments demonstrated similar pregnancy rates. Exhibition of estrus was increased in heifers administered EB 24 h after PG and TAI 28 h later over heifers administered either pLH or GnRH at insemination.

A smaller dose of 5 µg GnRH is used at times to mimic a physiological LH pulse in beef females (Ginther and Beg, 2012). With this treatment females exhibit natural progesterone levels equivalent to those associated with a natural, unsolicited LH pulse. At this dosage, GnRH also increased estradiol concentration immediately following dosage and extended duration (0.5 h) in all luteal phases.

Estradiol

Heifers expressing estrus after a TAI protocol show increased accessory sperm numbers, further advanced stage embryos, and embryos of higher quality compared with heifers showing no signs of estrus (Larimore et al., 2015). This suggests higher estradiol concentrations increase sperm transport and improve the environment for embryo development and growth.

Estradiol concentrations in follicular fluid are more associated with follicle development in cattle than gonadotropin receptors (Bodensteiner et al., 1996). Treatment of cows with 1 mg estradiol cypionate (ECP) increased estradiol concentration similar to cows spontaneously expressing estrus with no injection. Cows with elevated estradiol levels exhibited a decrease in uterine pH at AI (d 0 in CO-Synch protocol), which increased sperm longevity. All cows, whether expressing estrus or not, had similar uterine pH levels 72 h after PG injection (Perry and Perry, 2008a). Injection of ECP also increased the number of females in standing estrus when injected 12 h after PG. Uterine pH is found to be lowest at standing estrus and greatest just prior to initiation of standing estrus (Perry and Perry, 2008b). As demonstrated by Larimore et al. (2016), exogenous GnRH increased the concentration of circulating estradiol for a short time. Animals with

naturally high levels of estradiol prior to TAI see an upregulation of steroidogenic pathways during a preovulatory period.

Fixed Time Artificial Insemination and Controlled Internal Drug Release (CIDR)

With the use of a 7 d CO-Synch+CIDR protocol with postpartum beef cows it was better to breed at 66 h instead of 54 h after CIDR removal and PG administration (Busch et al., 2008). Wilson et al. (2010) saw no difference between the 5 d and 7 d CO-Synch+CIDR protocols for estrus response, interval to estrus, or pregnancy rates, either in an estrus detection setting or with TAI. Using TAI with CO-Synch+CIDR yields similar results as other protocols of similar design that breed via estrus detection. Use of a CIDR improved pregnancy for a TAI system when compared with just a CO-Synch protocol (Larson et al., 2006). The only protocol similar without actual use of a CIDR was Select Synch with TAI (GnRH at d -7, PG d 0 then estrus detect and AI 12 h later, TAI everything else 84 h post-PG and administer GnRH). Producers can breed females using TAI with similar success as heat detection methods, which can reduce labor and inputs.

Long term CIDR protocols are often used with young beef females where CIDRs are placed for 14 d. Mallory et al. (2011) compared two such protocols side by side, both protocols using CIDR from d 0 to d 14 with PG administration on d 30 and GnRH and TAI 66-72 h later. One method administered GnRH 7 d before PG with TAI taking place 72 h later and the other method used no initial GnRH and TAI 66 h after PG. The results show similar pregnancy success overall with one protocol utilizing less inputs and labor than the other. This later method allows a producer to synchronize with less cattle handling and inputs while achieving similar pregnancy rates with a greater input and

labor model (Mallory et al., 2011). This also showed that when a CIDR is used, estrus can be synchronized in females with a single administration of PG and no GnRH 7 d. When looking at 2 CO-Synch TAI protocols for cows, one using CIDR and one without, females with a higher plasma progesterone concentration at PG administration showed increased estrus response and pregnancy success when inseminated 60 h post-PG. The protocol utilizing a CIDR increased plasma progesterone concentrations on d 7 of the protocol (PG administration), which improved overall synchrony by suppressing early estrus before PG injection. The CO-Synch method may allow females to ovulate early, before PG and TAI (Echternkamp and Thallman, 2011).

Prostaglandin

Prostaglandin $F_{2\alpha}$ (PG) is a fatty acid hormone administered to beef females as part of estrus synchronization protocols. Prostaglandin regresses a functional corpus luteum in the estrus cycle (Roche, 1974), and brings about estrus within approximately 3 d (Tervit et al., 1973).

Synchronizing cows for natural mating increased the number of cows calving in the first 21 d of calving season without decreasing pregnancy rates while shortening the breeding season to 45 d from 60 d (Larson et al., 2009). Bulls were turned out with cows at a ratio of 1:25. In the synchronized treatment, cows were administered PG 108 h later, while the non-synchronized. Weaning BW was similar between synchronized and non-synchronized groups.

Heifers had similar pregnancy rates and exhibition of estrus when using 2 mL (25 mg dinoprost tromethamine) of a high concentration PG product (HighCon Lutalyse-Zoetis Animal Health, Parsippany, NJ) versus 5 mL (25 mg dinoprost tromethamine) of

regular concentrate Lutalyse (Oosthuizen et al., 2018a). This has been shown with a 7 d CO-Synch+CIDR protocol as well as the 14 d MGA-PG protocol. The advantage of the HighCon product is the ability to inject females subcutaneously instead of the typical intramuscular injection that can cause lesions or other harmful injuries.

Presynchronizing young beef females before applying a 7 d CO-Synch+CIDR protocol by administering PG 7 d before inserting CIDRs shows no benefit to overall pregnancy success versus the typical CO-Synch+CIDR method (Oosthuizen et al., 2018b). Estrus expression was increased in pre-synchronized females before CIDR insertion, but estrus expression was decreased between CIDR removal and AI approximately 54 h later. Adding GnRH 7 d prior to PG in a MGA-PG protocol did not improve pregnancy success nor does adding GnRH to a TAI clean-up 80 h after estrus detection insemination protocol (Johnson and Day, 2004).

Keep in mind the role management and environment played in the results of a study. In many trials (Oosthuizen et al., 2018b; Larson et al., 2006) pregnancy rates differ significantly from location to location, but no difference between the treatment and control, regardless of what the study may be. This shows the importance of management of reproduction and the impact decisions can have on the fertility success of females regardless of synchronization protocol.

Melengestrol Acetate

Melengestrol acetate (MGA-Zoetis Animal Health, Parsippany, NJ) is fed at a rate of 0.5 mg/d for each female to suppress estrus. Feeding of MGA is approved only for heifers and labeled uses only include suppression of estrus in a feedlot or estrus synchronization setting. Females receiving a CIDR have shown the ability to ovulate and

initiate estrus with a normal luteal life span in a greater proportion than females treated with MGA or those not administered any treatment for estrus suppression. Cows administered a higher dose of MGA (4 mg) have increased normal luteal life spans than those treated with the normal dose (0.5 mg) (Perry et al., 2004).

When comparing MGA-PG vs. 14 d CIDR-PG, TAI and overall pregnancy rates in heifers were similar (Vraspir et al., 2013). Estrus detection was utilized as the clean-up method 15 to 25d following TAI and the number of heifers returning to estrus at this time was similar between treatments. The only difference observed was a higher percentage of MGA females becoming pregnant from the follow-up AI as opposed to the CIDR heifers. The MGA-PG protocol was more cost-effective method when analyzed in this study. Martinez et al. (2002) showed similar TAI pregnancy rates between MGA-PG and CIDR treated heifers both for 7 d with PG at removal and AI 48 h following. However, estrus expression was higher for females with a CIDR insert than MGA treatment.

Coleman et al. (1990) compared 3 synchronization protocols: feeding MGA alone for 21 d, MGA fed for 21 d followed 14 d later with PG injection, and 2 injections of PG 14 d apart. Long-term feeding of MGA alone (21 d) shows no benefit to increasing pregnancy success when compared with 2 injections of PG 14 d apart. Feeding MGA with a single PG injection 14 d after removing MGA showed similar pregnancy success to the dual PG administrations, but still higher pregnancy rates than feeding MGA alone. Estrus expression was similar between all three methods, but progesterone concentrations remained lowest for MGA alone before estrus and ovulation. Circulating estradiol levels also were highest at this same time period in MGA only fed females. For the MGA + PG

and dual PG groups progesterone levels were higher and estradiol levels lower before estrus than the MGA only group.

DNA TECHNOLOGIES

Genomic testing prevalence and available technologies are increasing. The ability to use a genomic panel to predict a phenotypic outcomes could benefit the entire animal production industry. Predicting a sire's breeding value through expected progeny differences (EPD), which are calculated in part from actual phenotypic data of offspring if available and from the genomic profile results of a test panel, can be invaluable to a producer aiming to improve certain traits and improve the cow herd (Garrick et al., 2009).

Inclusion of genomic test results can improve accuracy and reduce animal variation which can lead to more informed breeding selections for a producer. An entire genotyping (of whole herd) is not necessary to gain valuable information, but less than 25% of a pedigree genotyped might not be enough. By considering phenotypic records along with genotypic results jointly can increase confidence for selection decisions to make genetic progress within a herd (Spangler et al., 2007).

The use of genomic testing technology can correct parentage and eliminate misidentified offspring. Testing can also identify females that may have any negative disorders and give the producer the ability to eliminate those females before they are bred and spread that trait further into their herd. This technology has been especially helpful for the dairy industry which is heavily reliant on female production as replacements for the milking herd. Information leading to better selection of replacement females can make tremendous improvements for an industry (Davenport et al., 2018). Genetic testing

can help generate EPDs specific for the producer's own herd, which allows for better sire selection. A high-resolution panel test will reduce sire misidentification with a multi-sire breeding program and improve accuracy (Van Eenennaam et al., 2007a). A small number of sires can contribute more than half of the total income for a calf crop, so the value of genomic testing to identify those potential sires can be invaluable (Van Eenennaam et al., 2008).

By increasing selection intensity and as accuracy of genomic testing increases a producer can more than recoup the costs of DNA tests (Konig et al., 2009). Testing calf DNA for paternity showed no relationship between number of calves sired and bull age. In order for the DNA testing results to be profitable to a producer then the costs of testing need to be recouped by the value of information resulting from the tests (Van Eenennaam et al., 2014).

In a simulation by Weigel et al. (2012) of approximately 185,000 females across 100 dairies, it was determined regular genetic testing of females with a 3K density can be cost effective and justified. For a producer wanting to identify genetically superior animals to retain and raise and to cull inferior calves then it was best to perform the genetic tests before 2 months of age and cull the inferior females before any more expenses are allocated towards their development. For a producer that will retain all females regardless and would just like to know results from the DNA testing to make more accurate and informed breeding decisions then the genomic testing was best around 11 to 12 months of age. Weigel et al. (2012) identified the most cost-effective ages for testing to be as calves or yearlings and only noted profit from the genotyping of mature, lactating cows if they had very little or incomplete pedigree records.

When comparing phenotypic data to panel scores from a SNP Igenity genomic test it was found the two had low correlation, if any; some traits even had a weak negative correlation. Phenotypic data was collected via a GrowSafe feeding system (GrowSafe Systems Ltd., Airdrie, AB, Canada). Traits such as ADG, dry matter intake, feed efficiency, and residual feed intake were measured on yearling heifers as they were developed in a drylot situation. This study suggests these genomic panels show little evidence for effectively selecting replacement beef females as the panel appears a weak predictor of phenotypic traits (Damiran et al., 2018).

Genomic testing to predict female reproductive performance has been minimal as assessment is a long-term observation and reproduction is generally lowly heritable. Berry and Evans (2014) conducted a substantial analysis of correlation between performance traits and reproduction traits of cattle in Ireland. Correlation was found between muscularity traits, weight traits (live and carcass), and reproductive traits. Although correlation was identified for reproductive traits (from performance traits), the heritability of these traits was low. Producer-recorded traits such as weanling quality (subjectively scored by producer based on animal health and quality at weaning) and docility were also correlated illustrating the value of these producer-recorded phenotypic observations. Concern was expressed about the correlation of increased muscularity and reduced fertility not being addressed. Selection pressure on increasing performance and muscularity can unknowingly reducing reproductive potential of female offspring (Berry and Evans, 2014). There is some correlation between direct weaning weight and cow weight, but a negative correlation between maternal weaning weight and cow weight. Heritability is also fairly low for these traits (Mwansa et al., 2002)

In order to ensure integrity of these genomic tests, the National Beef Cattle Evaluation Consortium (NBCEC) has created a validation of tests to determine if genotypic claims match up with phenotypic results. The NBCEC has facilitated a partnership between the commercial genetic testing companies and those that own the physical DNA and phenotypic records (Quaas et al., 2006).

In a validation test conducted by the NBCEC it was found GeneSTAR (Bovigen LLC, Harahan, LA) Quality Grade test did not have any association with marbling, but GeneSTAR Tenderness and Igenity TenderGENE (Neogen Corporation, Lansing, MI) panels both showed strong association to results from Warner-Bratzler shear force tests. Selection of the marker genes used in this validation trial may increase tenderness (Quaas et al., 2006). The validation process is vital to the acceptance of these technologies. Several challenges exist as more markers enter the market including continual validation and suitable populations of cattle to perform such validations. Certain markers that have a large impact on one specific trait will usually impact a variety of others, which can create even more challenges as more testing is needed to increase accuracies of these markers (Van Eenennaam et al., 2007b).

In summary, beef production in the Nebraska Sandhills is a major contributor to the culture, community, and economy. The importance of production systems for these producers is vital for the success of the future of the beef industry as well as the sustainability and overall health of the environment and ecosystem that makes up this unique landscape. Taking advantage of technologies such as estrus synchronization and genomic testing or improved protein supplementation strategies can lead to increased

profit per animal with increased management. This holistic picture will lift the industry, prepare for the future of a growing planet, and increase cattle producer success.

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CHAPTER II
EFFICACY OF A SECOND INJECTION OF PROSTAGLANDIN F_{2α} IN
YEARLING BEEF HEIFERS FOLLOWING PREVIOUS ESTRUS
SYNCHRONIZATION

M.R. Erickson, K.C. Ramsay, and R.N. Funston

University of Nebraska, West Central Research and Extension Center, North Platte

69101

ABSTRACT: Angus-based, yearling beef heifers (322 kg) were utilized to determine how administering a second prostaglandin F_{2α} (PGF; Lutalyse, Zoetis Animal Health, Parsippany, NJ) injection affected heifers not previously responding to estrus synchronization. All heifers (n = 1,858) were exposed to a melengestrol acetate (MGA)–PGF protocol. Heifers were fed 0.5 mg/d MGA for 14 d. On d 32, fertile bulls were placed with heifers for 24 h. On d 33, bulls were removed and heifers were injected with PGF (5 mL i.m.) and an estrus detection patch was applied. Heifers were observed for estrus for 3 d and AI 12 h after detection of estrus. Heifers were considered in estrus when > 50% of the rub-off coating was removed from the patch. On d 37, heifers who did not show signs of estrus (n = 331) were placed with fertile bulls at a 1:33 bull to heifer ratio. After 3 d with bulls, heifers with greater than 50% of the rub-off coating removed from the patch (n = 151) were considered to have been bred and placed with the inseminated heifers. The remaining non-estrus heifers received either a second PGF injection (n = 90, SPG) or no injection (n = 90, CON) and remained with bulls for 4 d. On d 44, SPG and CON heifers with greater than 50% rub-off coating removed were considered bred and returned to the herd. Pregnancy diagnosis was conducted via

transrectal ultrasonography 47 d after SPG and CON were returned to the herd.

Percentage of heifers expressing estrus was greater ($P < 0.01$) for SPG treatment (60% vs. $23\% \pm 13\%$, SPG [n=53] vs. CON [n=21]). However, pregnancy rate was similar ($P = 0.38$) between treatments (34% vs. $52\% \pm 11\%$, SPG vs. CON). Administration of a second PGF injection to yearling beef heifers that didn't respond to an MGA-PGF protocol did increase estrus expression, but did not improve pregnancy rates.

Key Words: estrus synchronization, prostaglandin, rebreeding, heifers, return to estrus

INTRODUCTION

Estrus synchronization increases the number of females coming into estrus to begin breeding season. This subsequently increases the number of calves born in the first 21 d of calving. Shortening of the calving season allows producers to have a more uniform calf crop and require less labor during the calving season. Prostaglandin $F_{2\alpha}$ (PGF) can induce estrus and is commonly used to synchronize cattle for breeding either by natural service or artificial insemination (Larson et al., 2009). Prostaglandin causes luteolysis, which allow estrus synchronization, but is ineffective in the early stages of the estrous cycle (Odde, 1990).

When all females don't exhibit estrus after estrus synchronization there would be benefit for a method to re-synch females and bring them into estrus earlier than the natural 21 d cycle. This would enable more females the possibility to calve earlier in the calving season. Oosthuizen et al. (2018) followed a melengestrol acetate (MGA)-PGF protocol and administered a second dose of PGF 6 d after initial PGF injection to all females not detected in estrus during the estrus detection and AI period. These females were then placed with bulls at a 1:50 ratio for a 60 d breeding season. Overall pregnancy

rates were similar to heifers where GnRH and TAI was the method of clean-up 54 h after PGF then heifers placed with bulls at a 1:45 ratio for a 40 d breeding season.

The objective of this study was to determine the effectiveness of a second injection of prostaglandin $F_{2\alpha}$ to beef heifers failing to display estrus following an initial MGA-PGF estrus synchronization protocol. This is desirable for a producer not wanting to extend the breeding season into the second estrus cycle that might have a market for open heifers.

MATERIALS AND METHODS

Angus-based, yearling beef heifers ($n = 1,858$; 322 kg) managed at Rex Ranch, Ashby, NE were utilized for this study. Heifers were managed in 2 separate groups on the same ranch in adjacent pastures. All heifers were synchronized with an MGA–PGF protocol (Figure 2.1). Each heifer was offered 0.5 mg/d MGA via 0.45 kg/d of a distillers grain-based range supplement for 14 d. Supplement was fed on the ground to allow equal access to all females. On d 32, fertile bulls were placed with heifers for 24 h. Exposure to bulls is known to increase cycling among females (Hornbuckle II et al., 1995; Fernandez et al., 1996; Zalesky et al., 1984). On d 33, bulls were removed and all heifers received a PGF injection (5 mL i.m., Lutalyse, Zoetis Animal Health, Parsippany, NJ) and an estrus detection patch (Estroject, Rockway Inc., Spring Valley, WI) was applied. Following PGF, heifers were observed for estrus for 3 d and artificially inseminated (AI) 12 h after detection of estrus. Heifers were considered in estrus when greater than 50% of the rub-off coating was removed from the patch. On d 37, heifers who had not shown signs of estrus ($n = 331$) were placed with fertile bulls at a 1:33 bull to heifer ratio. After 3 d (d 40) with bulls, heifers with activated patches ($n = 151$) were considered bred and placed

with AI heifers. The remaining heifers who had still not shown estrus were randomly assigned to receive either a second PGF injection (5 mL i.m.; $n = 90$, SPG) or no injection ($n = 90$, CON) and remained with bulls for 4 d. On d 44, bulls were removed and SPG and CON heifers ($n = 74$) with activated patches were considered bred and returned to the main herd. Heifers not exhibiting estrus ($n = 106$) were removed from the herd. No clean-up breeding period was utilized at this time. Pregnancy diagnosis was conducted 47 d later (d 91) via transrectal ultrasonography (ReproScan, Winterset, IA). All heifers not becoming pregnant were removed from the herd.

Statistical Analysis

The Glimmix procedure of SAS Software (SAS Institute, Inc., Cary, N.C.) was used to analyze binary pregnancy rates. Heifer was considered the experimental unit. Any P -value ≤ 0.05 was deemed significant. Location (pasture) was treated as a random effect as the 2 locations were adjacent and environment was equivalent.

RESULTS AND DISCUSSION

Percentage of heifers expressing estrus was greater ($P < 0.01$) for SPG treatment (60% vs. $23\% \pm 13\%$, SPG [$n=53$] vs. CON [$n=21$]; Figure 2.2). Pregnancy rate was similar ($P = 0.38$) between treatments (34% vs. $52\% \pm 11\%$, SPG [$n=18$] vs. CON [$n=11$]; Figure 2.3). Although pregnancy rates were not affected by the second PGF, the increase in estrus expression warrants further research. The lack of power from this trial may be contributed by lack of females available on d 40. This was due to a large proportion of females being bred after initial AI and 3 d bull follow-up breeding. To improve this study a larger number of females would be necessary after the initial estrus synchronization to gain a better understanding of the result of a second administration of

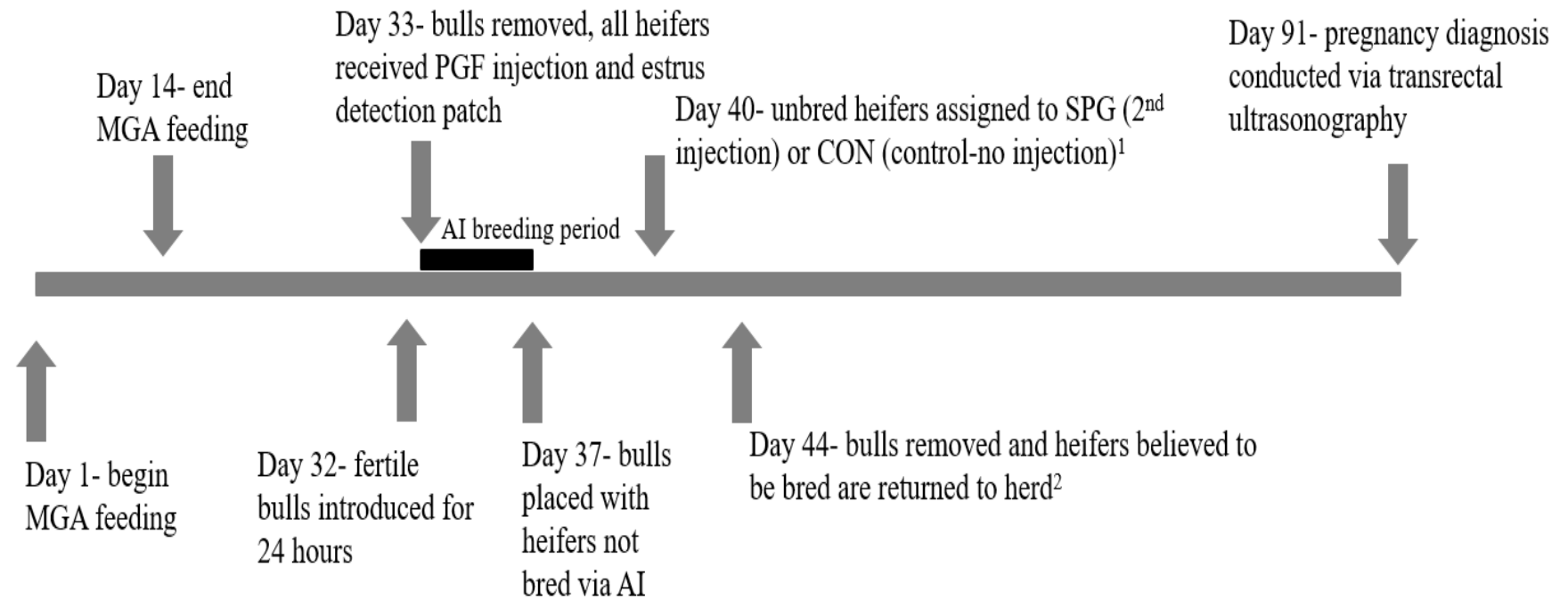
PGF. The producer in this experiment had an opportunity to sell all open heifers as feeder cattle and was not concerned with low pregnancy rates, thus why there was no follow-up bull breeding period for 45 to 60 d as would normally follow estrus synchronization and AI.

In this study/experiment/research, administration of a second PGF injection 7 d after the initial injection to yearling beef heifers that didn't respond to an MGA-PGF estrus synchronization protocol did increase the number of females that came into estrus, but did not improve pregnancy rates among those that were subsequently brought into estrus. The increase in estrus expression, but no increase in pregnancy rates could be attributed to a number of factors and further trials need to be conducted to increase understanding.

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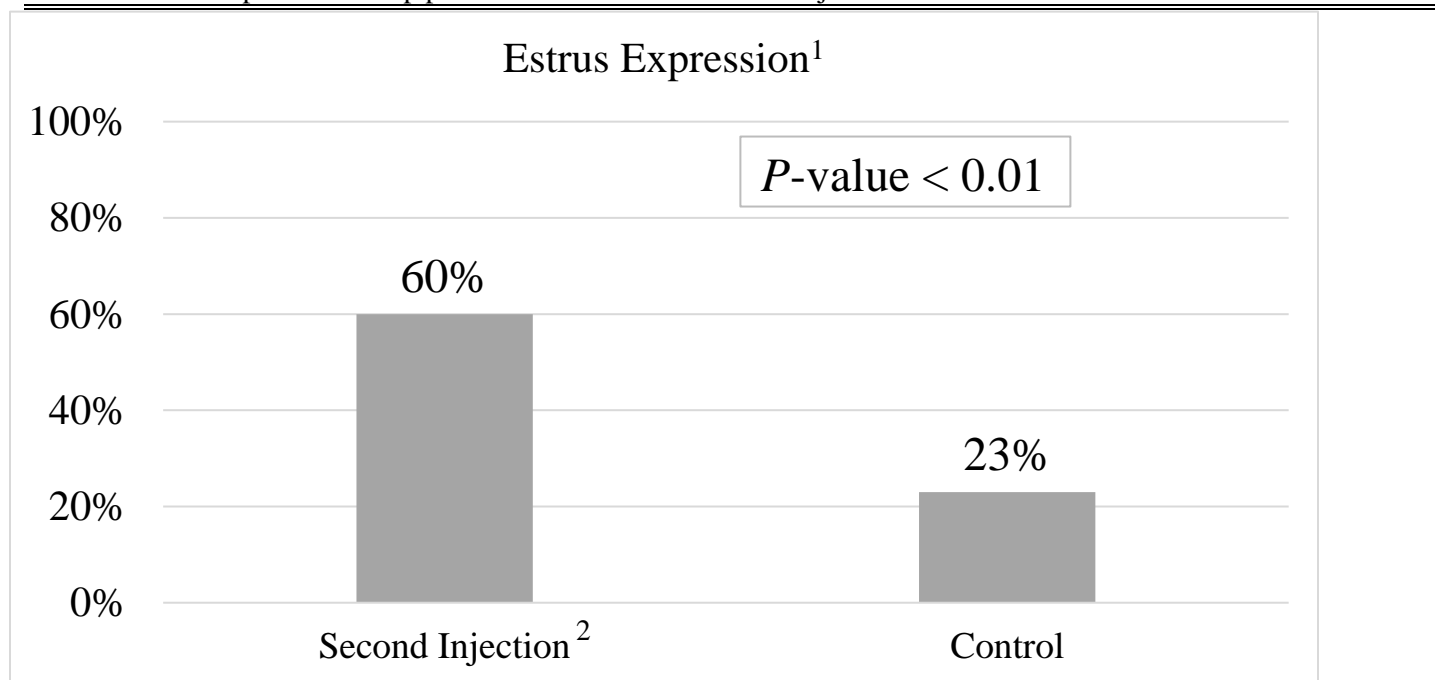
Figure 2.1 Timeline of melengestrol acetate-prostaglandin F_{2α} (MGA-PGF) protocol with treatment of PGF on d 40 for yearling heifers



¹SPG is treatment of a second injection of PGF on d 40 before a 4 d bull clean-up period

²Heifer was considered bred if estrus detection patch shows ≥50% activation (patch rubbed off)

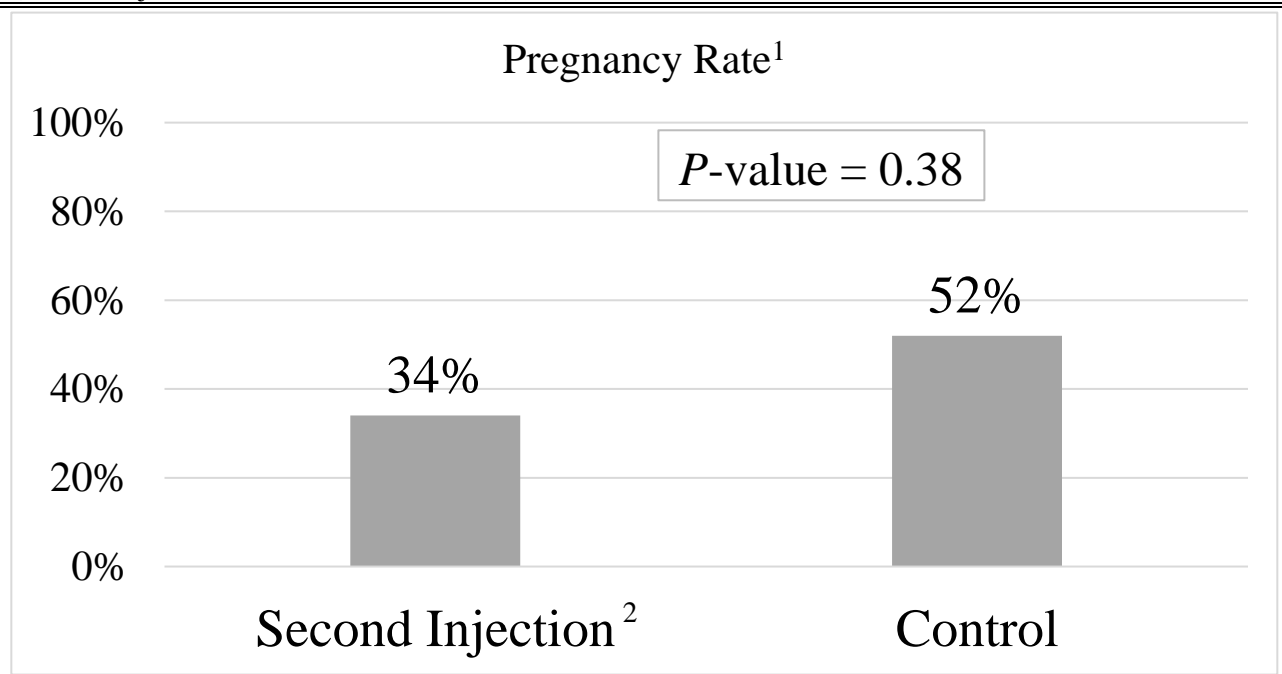
Figure 2.2 Percentage of heifers exhibiting estrus after melengestrol acetate-prostaglandin F_{2α} (MGA-PGF) and AI with 4 d follow-up bull clean-up period and treatment of second injection of PGF



¹Exhibition of estrus was determined via estrus detection patches (Estrotest; Rockway Inc., Spring Valley, WI). If $\geq 50\%$ was activated then heifer was considered in estrus.

²Treatment of PGF to any females not bred during initial estrus detect and AI period were assigned to receive either a second injection of PGF or not (Control) then placed with bulls for 4 days

Figure 2.3 Percentage of heifers pregnant from bull breeding after melengestrol acetate-prostaglandin F_{2α} (MGA-PGF) and AI with 4 d follow-up bull clean-up period and treatment of second injection of PGF (Second Injection, n = 18; Control, n = 11)



¹Percentage of females pregnant from the 4 d bull breeding period after initial MGA-PG protocol and estrus detect and AI

²Treatment of PGF to any females not bred during initial estrus detect and AI period were assigned to receive either a second injection of PGF or not (Control) then placed with bulls for 4 days

CHAPTER III

EFFECT OF LOW-DOSE GNRH INJECTION AT -72 H IN MGA-PGF ESTRUS SYNCHRONIZATION PROTOCOL

M.R. Erickson, D. Kelly, D. O'Hare, T.L. Meyer, and R.N. Funston

University of Nebraska, West Central Research and Extension Center, North Platte

69101

ABSTRACT: Beef heifers from 2 locations in central Nebraska were randomly assigned to 1 of 2 treatments: 0 or 5 µg gonadotropin-releasing hormone (GnRH) at prostaglandin F_{2α} (PGF) administration 72 h before artificial insemination (AI). Both locations utilized the melengestrol acetate (MGA)-PGF fixed-time AI (TAI) estrus synchronization protocol, giving a PGF injection 72 h prior to TAI. At the first location (L1; n=1,071; 382 ± 3 kg) every third heifer was assigned to receive an injection of GnRH (5 µg, TRT) and an injection of PGF. The remaining heifers received PGF and 0 µg GnRH (CON). At the second location (L2; n=447; 363 ± 7 kg), every other heifer was assigned TRT and estrus detection patches were applied to all heifers. At both locations, all heifers received 100 µg GnRH at TAI and patch scores were recorded at L2. At L1, heifers were observed for estrus behavior from 10 to 21 d post-TAI and inseminated if estrus was detected. Heifers pregnant from the second breeding were added to final pregnancy rate. Treatment did not ($P > 0.20$) improve TAI pregnancy rates (L1 TAI 56% (TRT) vs. 57%; L2 TAI 59% (TRT) vs. 53%) among the 2 herds. At L1, administering 5 µg GnRH at PGF increased ($P = 0.03$, 74% vs. 63%) pregnancy rates for those AI during the follow-up estrus detection. At L2, there was an association ($P < 0.01$) between observed patches rubbed (high patch activation score) and pregnancy in those heifers. Based on observed patch

scores, the treatment did not ($P = 0.79$) increase estrus activity among heifers. There was an ($P < 0.01$) effect of pen on patch scores, but no ($P = 0.96$) effect of pen on pregnancy rate.

Key Words: estrus synchronization, fixed-time AI, MGA-PG, heifer pregnancy, GnRH

INTRODUCTION

Artificial insemination (AI) allows producers to utilize superior genetics with a larger group of females and when done with estrus synchronization can create a more uniform and desirable calf crop. Breeding via AI alone with a single service does not produce the same pregnancy success as a typical 45 to 60 d breeding season with bulls. The challenge is getting all females to synchronize and come into estrus before AI and ovulate shortly thereafter. Estrus synchronization protocols are constantly being analyzed and improved in hopes of increasing pregnancy success to AI.

Small doses (5 μ g) of gonadotropin-releasing hormone (GnRH) at CIDR removal increased expression of estrus with 7 d CO-Synch + CIDR synchronization protocol; expression of estrus increased pregnancy rates. However, larger doses (10 μ g) may have negative impact and decrease estrus expression and pregnancy rates (Rich et al., 2018). A 5 μ g dose was used to mimic a natural physiological pulse of LH and increase estradiol (Ginther and Beg, 2012). This treatment has not been tested in conjunction with melengestrol-acetate (MGA) included in the estrus synchronization protocol.

The objective of this study was to determine if administering 5 μ g GnRH to young, beef females 72 h prior to insemination following an initial MGA-Prostaglandin $F_{2\alpha}$ (PGF) Fixed-Time AI (TAI) estrus synchronization protocol increased pregnancy rates over the former conventional protocol.

MATERIALS AND METHODS

Angus-based, commercial, yearling heifers ($n=1,518$) from 2 locations in central Nebraska were randomly assigned to 1 of 2 treatments, 0 (CON) or 5 μg (0.1 mL) GnRH (TRT; Factrel-Zoetis Animal Health, Parsippany, NJ) at prostaglandin $\text{F}_{2\alpha}$ (PGF) administration 72 h before AI. The MGA-PGF (MGA fed at 0.5 mg/hd per day for 14 d) TAI estrus synchronization protocol used at both locations is shown in Figure 3.1. One location followed up with heat detection and breeding.

Heifers at the first location (L1; $n=1,071$; 383 ± 3 kg) near Ainsworth, NE, were purchased by the producer and divided among 4 pens. Each pen was fed equivalent rations and followed the MGA-PGF protocol. Seventy-two hours before AI, every third heifer through the chute was injected i.m. with 5 μg GnRH (TRT) and all heifers received an i.m. injection of PGF (2mL; 25 mg dinoprost tromethamine, Lutalyse HighCon, Zoetis Animal Health, Parsippany, NJ). Heifers not receiving 5 μg were considered the control treatment (CON). The GnRH was administered with a 1-mL Tuberculin (TB) syringe i.m. All heifers received 100 μg (2 mL) of GnRH i.m. at TAI. After TAI, all heifers were observed 10 to 21 d later for expression of estrus and any heifers showing estrus were inseminated 12 h later. Pregnancy diagnosis of all heifers was performed approximately 45 d after TAI and again 45 d after the follow-up estrus detection period. Clean-up bulls were placed with open females after pregnancy diagnosis, and thus any pregnancies by natural service were not included in the data.

The second location (L2; $n=447$; 363 ± 7 kg) near Sutherland, NE, consisted of purchased and ranch-raised yearling, commercial heifers. Heifers were randomly assigned to 1 of 6 pens and followed the same MGA-PGF protocol as L1. Treatment of 5

μg GnRH was administered to every other heifer in the chute i.m. with a TB syringe 72 h before insemination and PGF was administered to every female. Estrus detection patches (Estroject; Rockway Inc., Spring Valley, WI) were placed on all heifers 72 h prior to breeding. Patch scores were recorded at AI based on a 1 to 4 scale (1: 0% rub-off coating removed, 2: < 50% activated, 3: \geq 50% activated, 4: patch missing). At AI, all heifers received 100 μg of GnRH i.m. No clean-up bulls were used. Pregnancy diagnosis was performed via rectal palpation approximately 55 d post-AI.

Statistical Analysis

Heifer was the experimental unit for each location and in combined data. For L1, the Glimmix procedure of SAS Software (SAS Institute Inc., Cary, NC) was used for TAI, follow-up, and final pregnancy analysis. Pen and AI tech were treated as random. For L2 the Glimmix procedure of SAS was used for TAI, and pen and AI tech were treated as random. Mixed procedure was used for pen effect on patch and treatment effect on patch. Glimmix procedure of SAS was used for combined data and location was treated as a fixed affect as well as a treatment \times location interaction.

RESULTS AND DISCUSSION

Treatment of 5 μg GnRH 72 h prior to insemination did not ($P = 0.70$ L1 and $P = 0.23$ L2) improve pregnancy rates among the 2 locations (Figure 3.2) or when data is combined (Table 3.1). There was no effect ($P = 0.60$) of location on treatment nor ($P = 0.23$) an interaction between treatment and location.

At location 2, TRT did not ($P = 0.79$) affect estrus detection patch score. Pregnancy rates were similar ($P = 0.64$) between TRT and CON within each patch score category (1- 29% vs. 26%; 2- 40% vs. 33%; 3- 71% vs. 66%; 4- 57% vs. 56%; TRT vs.

CON, respectively). There was an ($P < 0.01$) association between patch score and pregnancy rate, which was to be expected as estrus expression (patch activated) is highly correlated with pregnancy success (Figure 3.3). There was a ($P = 0.01$) pen effect on patch score (Figure 3.4), which indicates a synchrony affect within each pen; however, pregnancy rates were similar ($P = 0.96$) among the pens (Figure 3.5).

Follow-Up AI Period

Location 1 showed the administration of 5 µg GnRH improved ($P = 0.03$) pregnancy rates (74% vs. 63% TRT vs. CON, respectively) for those inseminated during the follow-up heat check period, after the initial time breeding. There was no ($P = 0.20$) increase in heifers not conceiving after the initial TAI that expressed estrus and were rebred for the treatment (68%) than control (62%) at L1 (Table 3.2). The treatment did not statistically ($P = 0.11$) improve pregnancy rates overall at L1 (78% TRT vs. 74% CON) although, numerically an increase in pregnancy like this can be substantial for a producer.

These results indicate the addition of a low dose (5 µg) of GnRH at PGF injection 72 h prior to AI does not enhance pregnancy success above what the typical MGA-PGF synchronization protocol will do when utilized with TAI. Increased pregnancy rates were not shown with administration of a low dose of GnRH similar to Rich et al. (2018) when utilized in similar fashion, but in a 7 d CO-Synch+CIDR protocol and GnRH administered at CIDR removal. However, an increase in estrus expression was noted when 5 µg GnRH was administered and a decrease observed with a higher dose (10 µg) with both mature cows and nulliparous, yearling heifers; no such effect was observed in this study.

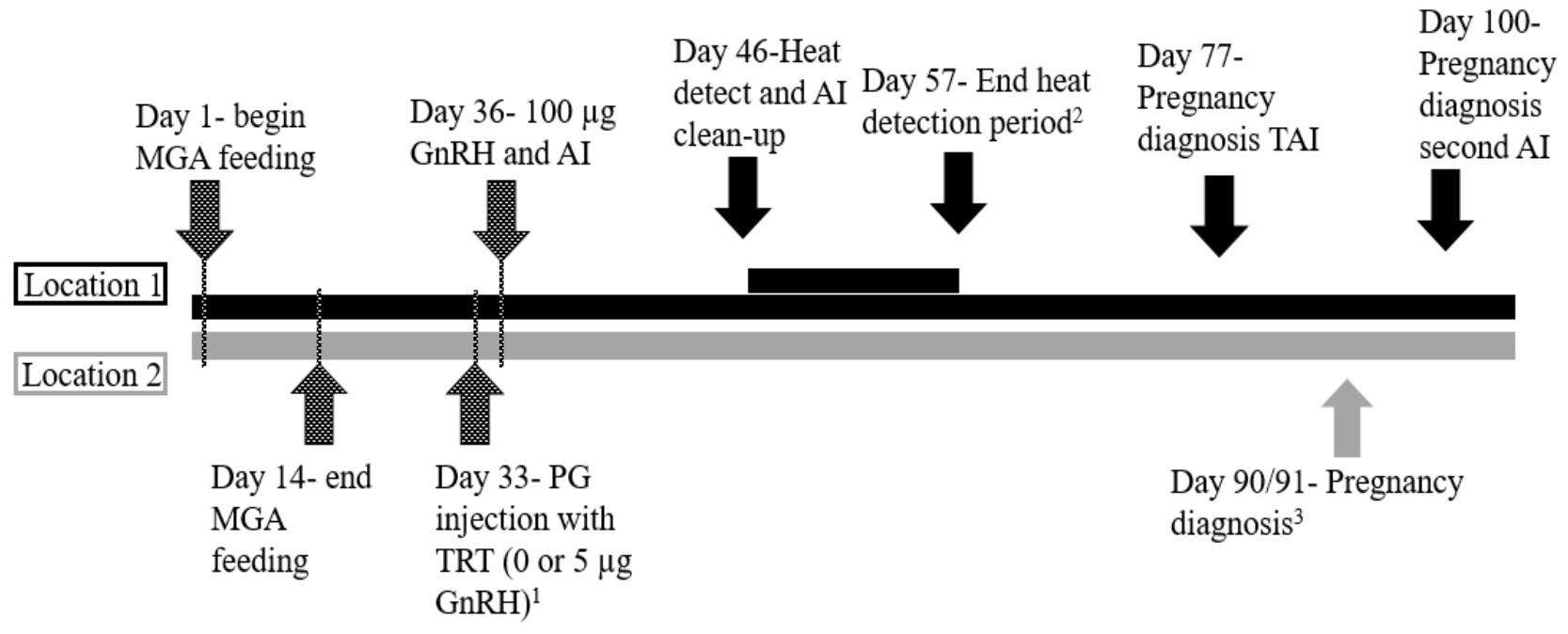
The increase in pregnancy success to the second round of AI, with estrus detection of those females treated with 5 µg GnRH, leads to the consideration of the amount of time after administration to breeding and if that needs altering. Twagiramungu et al. (1992) observed heifers injected with GnRH on d 0 in a 10 d synchronization protocol had a decrease in estrus expression from d 0 to 6 when compared with females not injected with GnRH. However, there was an increase in estrus expression from d 6 to 10 for those treated with GnRH compared with the control group, which might indicate a delay in interval to expression with the administration of GnRH; although pregnancy rates remained similar between treatment and control. These results are more similar to what was found in this study.

In summary, 5 µg of GnRH administered at PGF injection 72 h prior to AI in a MGA-PGF synchronization protocol does not increase pregnancy rates or estrus expression in yearling, beef females bred with TAI; however, may influence return to estrus in those that don't conceive to AI.

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Figure 3.1 Timeline of a melengestrol acetate-prostaglandin (MGA-PG) synchronization protocol at 2 separate locations with treatment of 5 μ g gonadotropin-releasing hormone (GnRH) 72 h prior to artificial insemination (AI)

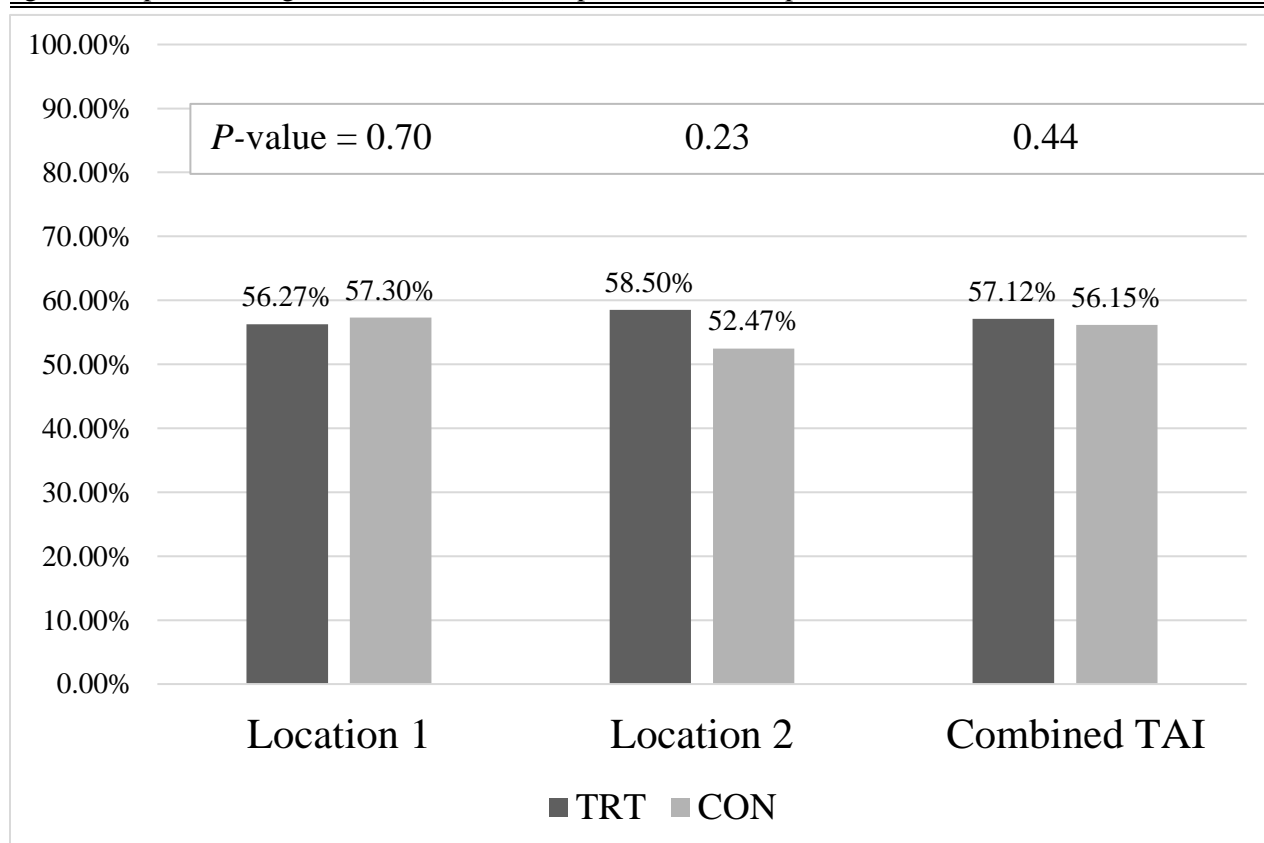


¹Administration of 5 μ g GnRH as treatment or 0 μ g as control administered i.m. via 1 mL tuberculin syringe simultaneous with PG administration

²Location 1 utilized a follow-up estrus detection and AI period from 10 to 21 d following initial fixed-time AI (TAI)

³Pregnancy diagnosis was conducted via rectal palpation at both locations by licensed veterinarians

Figure 3.2 Pregnancy rates of yearling heifers after melengestrol acetate-prostaglandin (MGA-PG) synchronization protocol with fixed-time AI (TAI) and administration of 5 μ g (TRT) or 0 μ g (CON) gonadotropin-releasing hormone (GnRH) 72 h prior to AI at 2 separate locations and total combined¹

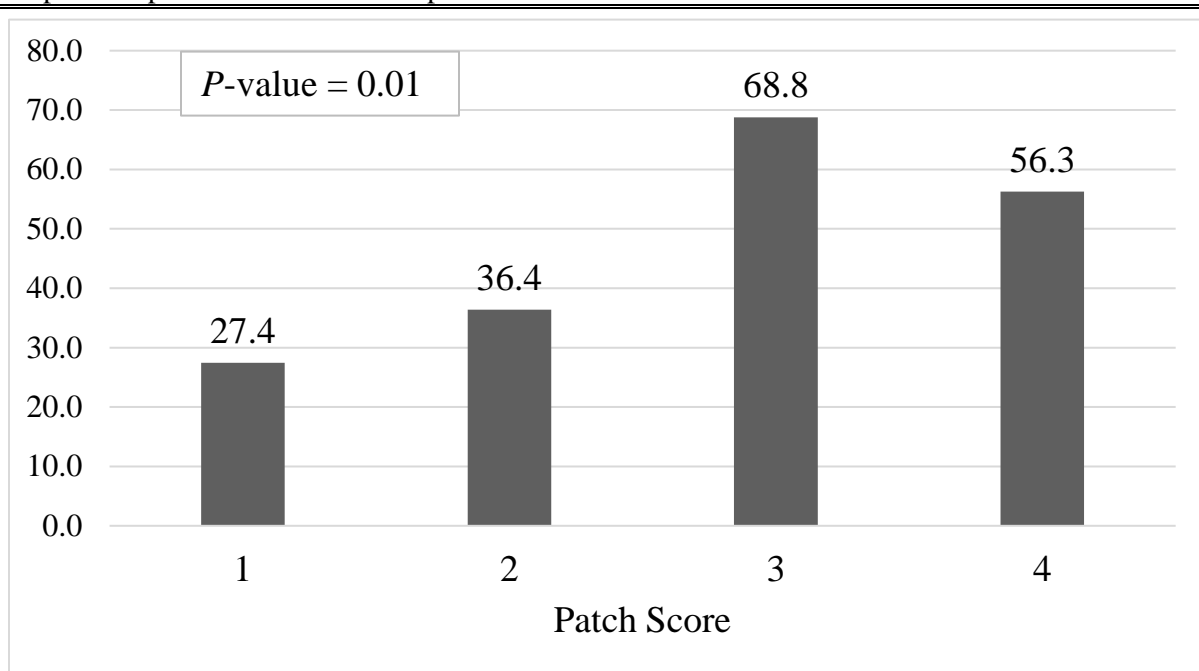


¹Combined pregnancy percentage of all heifers from TAI among both locations

Table 3.1 Addition of 5 µg gonadotropin-releasing hormone (GnRH) 72 h prior to AI in melengestrol acetate-prostaglandin (MGA-PGA) fixed-time AI (TAI) protocol at 2 separate locations

| <u>Location 1</u> | <u>GnRH</u> | <u>No GnRH</u> | <u>P-value</u> |
|-------------------|-------------|----------------|----------------|
| <i>n</i> | 359 | 712 | |
| TAI Pregnancy % | 56.27 | 57.3 | 0.70 |
| <u>Location 2</u> | | | |
| <i>n</i> | 224 | 223 | |
| TAI Pregnancy % | 58.48 | 52.47 | 0.23 |
| <u>Combined</u> | | | |
| <i>n</i> | 583 | 935 | |
| TAI Pregnancy % | 57.12 | 56.15 | 0.44 |

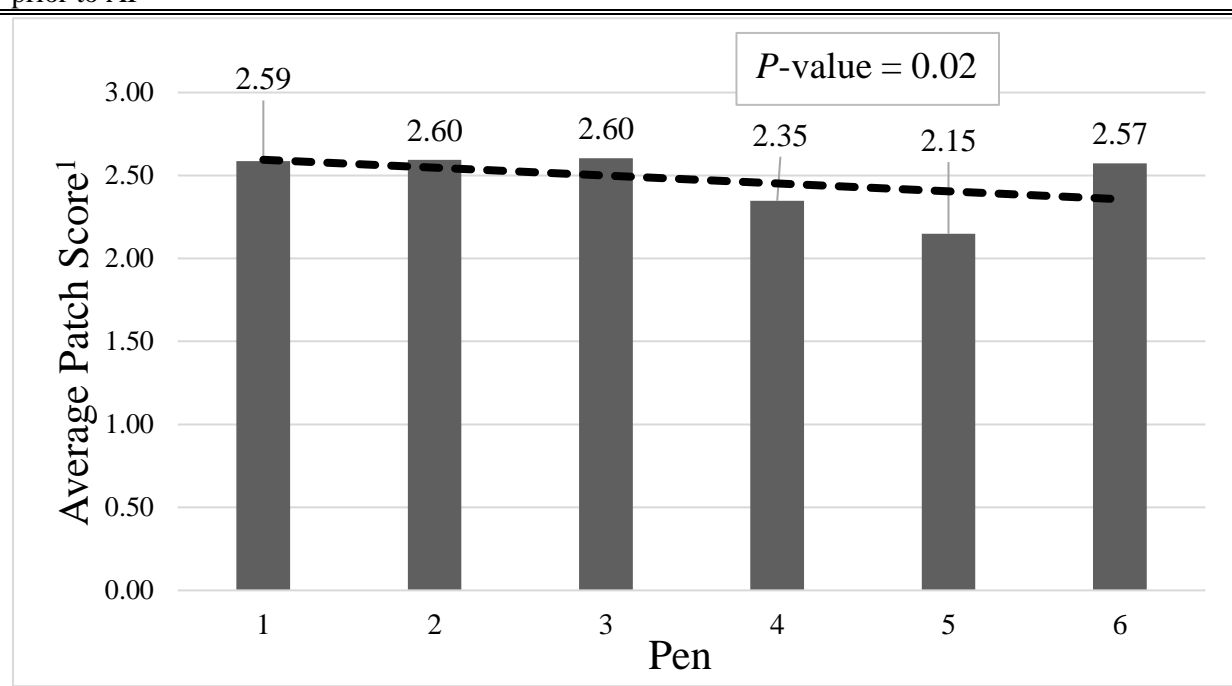
Figure 3.3 Pregnancy rates (percentage) of yearling heifers after melengestrol acetate-prostaglandin (MGA-PG) synchronization protocol with fixed-time AI (TAI) and administration of 5 µg (TRT) or 0 µg (CON) gonadotropin-releasing hormone (GnRH) 72 h prior to AI based on their patch scores¹ of patches² placed on tailhead 72 h prior to AI and scores recorded at AI



¹Scale of 1 to 4 (1: not activated, 2: <50% activated, 3: ≥50% activated, 4: patch missing)

²Estroject; Rockway Inc., Spring Valley, WI

Figure 3.4 Estrus detection patch² scores (average in each randomized pen) of yearling heifers after melengestrol acetate-prostaglandin (MGA-PG) synchronization protocol with fixed-time AI (TAI) and administration of 5 µg (TRT) or 0 µg (CON) gonadotropin-releasing hormone (GnRH) 72 h prior to AI



¹Scale of 1 to 4 (1: not activated, 2: <50% activated, 3: ≥50% activated, 4: patch missing)

²Estrotest; Rockway Inc., Spring Valley, WI

Figure 3.5 Pregnancy rates of yearling heifers after melengestrol acetate-prostaglandin (MGA-PG) synchronization protocol with fixed-time AI (TAI) and administration of 5 μ g (TRT) or 0 μ g (CON) gonadotropin-releasing hormone (GnRH) 72 h prior to AI based on their randomized pen assignment

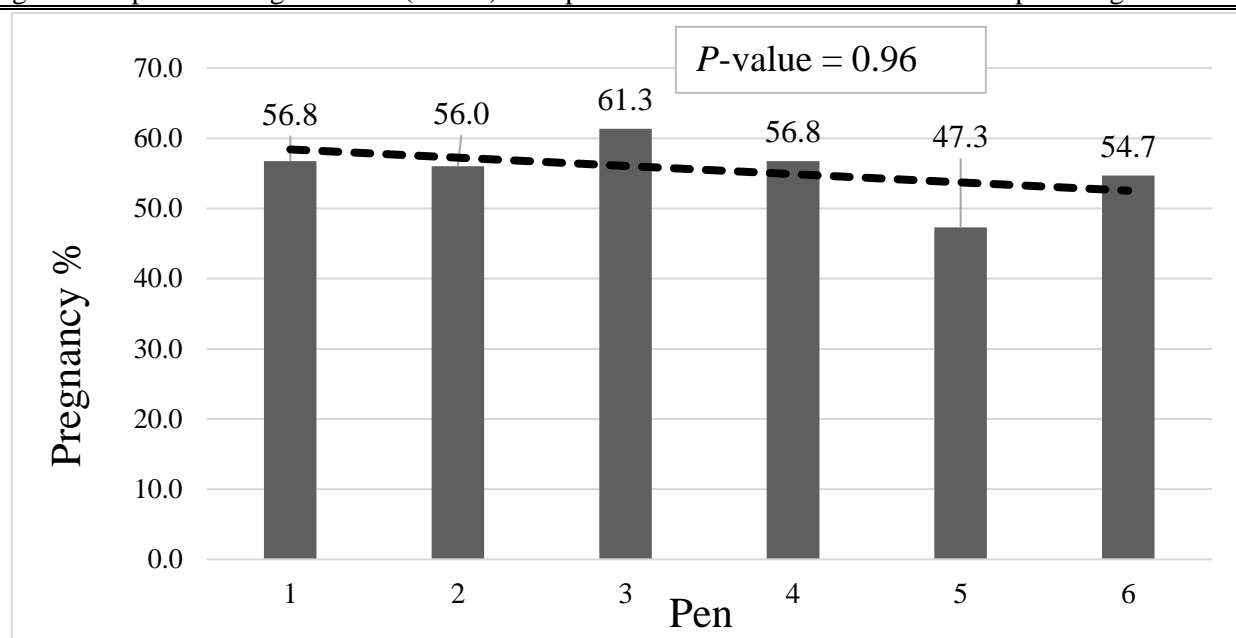


Table 3.2 Addition of 5 µg gonadotropin-releasing hormone (GnRH) 72 h prior to AI in melengestrol acetate-prostaglandin (MGA-PGA) fixed-time AI (TAI) protocol with AI clean-up period 10-21 days following TAI

| | GnRH ¹ | | No GnRH ² | | <i>P</i> -value |
|--|-------------------|------------|----------------------|------------|-----------------|
| | <i>n</i> | % Pregnant | <i>n</i> | % Pregnant | |
| 1st AI (TAI) | 359 | 56.27 | 712 | 57.30 | 0.70 |
| 2nd AI (Estrus detection) ³ | 107 | 73.83 | 187 | 63.10 | 0.03 |
| Return to estrus ⁴ | | *68.15 | | *61.51 | 0.20 |
| AI total ⁵ | 359 | 78.27 | 712 | 73.88 | 0.11 |

¹Treatment of 5 µg GnRH 72 h prior to AI

²Control group receiving no dose of GnRH 72 h before AI

³Heifers observed 10 to 21 days post-TAI and rebred via AI 12 h after estrus detection

⁴Percentage of heifers exhibiting estrus during the estrus detection period and brought in for AI

*Not a pregnancy percentage, but percentage of 'open' heifers showing estrus during estrus detection period

⁵Combined total of all heifers at L1 pregnant from AI

CHAPTER IV

COMPARISON OF GENOMIC PREDICTOR SCORES TO RESPECTIVE MATERNAL PHENOTYPIC TRAITS IN BEEF FEMALES

M.R. Erickson, J.R. Tait, M.L. Spangler, J.A. Musgrave, and R.N. Funston

University of Nebraska, West Central Research and Extension Center, North Platte

69101

ABSTRACT: Hair follicle DNA samples were collected from 414 beef (average 5/8 Red Angus, 3/8 Simmental) female calves born from 2009 to 2012 at the Gudmundsen Sandhills Laboratory and analyzed with a genomic test (Igenity, Gold panel, Neogen GeneSeek Operations, Lincoln, NE). Phenotypic data from these females was compiled and used in a regression analysis to validate the use of these genomic scores and predictors for phenotypic outcomes. Regression with birth body weight (BW) showed the genomic score for birth BW is a significant ($P < 0.01$) predictor. Within the same model, dam age and birth year had an effect ($P \leq 0.01$) on birth BW. Birth BW tended ($P = 0.09$) to differ between calving season with calves born slightly heavier (35 kg vs. 33 kg; May vs. March, respectively) in the May calving season. Dam age and calving season impacted ($P < 0.01$) weaning BW with March-born calves being heavier at weaning (211 kg vs. 192 kg; March vs. May, respectively; March calves average 8 d older at weaning compared to May calves) for all 4 models analyzed. Calving-ease direct was a ($P < 0.01$) predictor when analyzed separately in a model, and the genomic score for milk was not a ($P = 0.27$) predictor of weaning BW when in a model on its own. The model results for heifer pregnancy showed dam age ($P = 0.31$) and birth year ($P = 0.11$) were not significant while calving seasons showed differences ($P = 0.01$) in heifer pregnancy rates

(74% vs. 62%, March vs. May, respectively). The genomic score for heifer pregnancy showed no ability ($P = 0.75$) as a predictor for phenotypic heifer pregnancy. The stayability model showed birth year and calving season ($P < 0.01$) affecting female longevity and their ability to stay in the herd with March-born heifers producing 2.3 calves vs. 1.7 for May-born heifers over a 5-yr period. Dam age did not affect ($P = 0.16$) stayability and the genomic score for stayability was not a predictor ($P = 0.88$) for female longevity and the ability to produce a calf every year to stay in the herd. The genomic scores for birth BW and calving-ease direct are predictors for birth BW and weaning BW, respectively. The genomic scores of heifer pregnancy and stayability are not significant predictors for actual heifer pregnancy and female longevity or stayability in the herd.

Key Words: phenotypic traits, genomic predictors, longevity, stayability

INTRODUCTION

Raising a replacement female can be large cost for producers in the cow-calf industry. They require inputs and management, which can be seen as an investment if that female remains in the herd producing a calf year after year until she has paid for those investments and more. Reproductive failure can result from many factors, but regardless, many producers will disqualify a female from remaining in the herd after just one failure to produce a calf. If this happens early in the female's life then investment value is lost. Determining which females to retain as replacements can be challenging for many producers. Any valid information leading to superior selection of replacement females can generate greater improvements in the cattle industry (Davenport et al., 2018). Using phenotypic records along with genotypic information can increase confidence in selection decisions (Spangler et al., 2007). Knowing pedigree may increase confidence in the

decision process, but newer technology available in genomic testing may have a greater impact allowing producers to make a more informed decision by keeping heifers with a higher probability of staying in the herd. Clark et al. (2005) discussed the economic importance and value of a cow's second pregnancy and how it may be more important than how many females become pregnant as a heifer. Genomic predictors for longevity or stayability may help producers identify and select these females earlier and thereby reduce inputs into unwanted, inferior females.

The objective of this study was to determine a valid predictor of the longevity of a heifer calf before it is bred and whether or not the genomic predictive scores have any association with their corresponding phenotypic traits.

MATERIALS AND METHODS

Phenotypic data was taken from heifer calves born at the Gudmundsen Sandhills Laboratory (GSL) near Whitman, NE, from the years 2009 to 2012. In 2009, all calves born were in a March calving season and a May calving herd was organized. In 2010 and 2011, hair samples were taken from both March- and May-born calves. In 2012, hair samples were only taken from the March calving herd. Samples were collected soon after birth when body weight (BW) was measured and other information recorded. These samples were collected as hair with follicles pulled from the tail and placed in a DNA hair sample card. Samples were kept together and excess hair trimmed from the edges. Samples were also collected from a combination of AI (semen samples) and natural service sires (hair samples). For the 2009 calves only 1 of 12 possible sires was available, 3 of 11 possible sires were available for 2010 calves, 3 of 11 possible sires available for 2011 calves, and for 2012 calves 8 of 19 possible sires were available.

After weaning, heifers were developed until first breeding at approximately 15 months of age. Each female was kept within the calving system (March or May) it was born into, retained on the ranch, and only removed for reproductive failure. Records were kept on all females and calving information taken for 5 subsequent years to determine their longevity in the herd. If a female never became pregnant as a yearling then it received a 0 for heifer pregnancy, and received a 0 from that point forward as it was removed from the herd. Stayability was defined as the number of consecutive successful calving events for that female up to 5. For each calf that female had over its possible 5 years she was given 1 point per calf for a possible of 5 total points (Table 4.1). Any calving data past 5 years were not utilized in this study.

Hair samples from 414 heifer calves were genotyped with the Igenity Gold panel (Neogen GeneSeek Operations, Lincoln, NE; Neogen Corporation, Lansing, MI). This panel uses SNP as markers to calculate genomic scores on a 1-10 scale (Figure 4.1) for 13 traits; 7 maternal traits: birth weight, calving ease direct, calving ease maternal, docility, heifer pregnancy, milk, and stayability; 2 performance traits: average daily gain and residual feed intake; and 4 carcass traits: tenderness, USDA marbling score, ribeye area, and fat thickness.

Different and various treatments were applied to these females from birth and throughout the years observed. Many of these treatments were applied to their dams based on age and their calving season. For some contemporary groups many different treatments were applied which resulted in minimal animals per group. Variation was reduced as much as possible through statistical models chosen.

Statistical Analysis

The heifer was the experimental unit in this design. The Glimmix procedure of SAS Software (SAS Institute, Inc., Cary, N.C.) was used to perform the regression analysis to determine the effect of the genomic test scores on the observed phenotypic traits. All models included calving season, age of dam, and birth year as independent variables along with the genomic scores that corresponded to the dependent variable for that model. Calving season and birth year were included in the models to reduce variability from year to year as well as between the two different calving seasons as many environmental factors impact performance differently for each season. Dam age was also included in regression models to eliminate the variability in differences of calves born to older cows that might be larger compared to calves born to young females. We feel the addition of dam age, calving season, and birth year adequately reduce variation of treatments aforementioned to acceptable levels without breaking down experimental units to low and undesirable levels. A P -value ≤ 0.05 was considered significant. A P -value > 0.05 , but ≤ 0.10 would be considered a tendency.

The regression analysis was performed using 4 phenotypic traits as dependent variables: birth BW, weaning BW, heifer pregnancy, and stayability (total pregnancies out of a possible 5 years). These were observed and previously recorded for each heifer that was genotyped.

RESULTS AND DISCUSSION

Regression coefficients align with the given P -values and can be found in the tables for their corresponding models. Regression with birth BW showed the genomic score for birth BW is a predictor ($P < 0.01$, Table 4.2). Within the same model, dam age

and birth year affected ($P \leq 0.01$) birth BW. Birth BW tended ($P = 0.09$) to differ between calving season with calves born slightly heavier (35 kg vs. 33 kg; May vs. March, respectively) in the May calving season. Weaning BW was broken into 4 separate models to analyze 3 different genomic scores, one for each genomic score and one including all 3 (Table 4.3). This was performed to estimate the impacts from each of the scores separately and all together. The genomic predictor scores used with weaning BW regression were milk score, calving-ease direct, and calving-ease maternal. These were chosen as calving-ease usually relates to weaning weight as the more calving-ease an animal has, the less BW the offspring will have overall (Gutiérrez et al., 2007). Milk score was also chosen as it is generally positively correlated with weaning BW (Mallinckrodt et al., 1993). Dam age and calving season impacted ($P < 0.01$) weaning BW with March-born calves heavier at weaning (211 kg vs. 192 kg; March vs. May, respectively) for all 4 models analyzed. March heifers were weaned an average of 8 d older compared to May heifers (224 d old vs. 216 d old). Birth year varied within all of the models, but remained significant ($P < 0.05$) within all models. The model containing all 3 genomic predictor scores demonstrated calving-ease direct as a ($P < 0.01$) predictor for weaning BW and milk score tending ($P = 0.06$) to be a predictor. Calving-ease maternal was not ($P = 0.35$) a predictor for weaning BW within this model; however, when put in the model with only calving season, dam age, and birth year, it was a ($P = 0.01$) predictor of weaning BW. Calving-ease direct was ($P < 0.01$) a predictor within the model of its own, and the genomic score for milk was not a ($P = 0.27$) predictor of weaning BW when it was the only genomic score fitted in the model.

The model results for heifer pregnancy showed dam age ($P = 0.31$) and birth year ($P = 0.11$) having little effect while calving seasons showed differences ($P = 0.01$) in heifer pregnancy rates (74 vs. 62%, March vs. May, respectively; Table 4.1). The genomic score for heifer pregnancy showed no ability ($P = 0.75$) as a predictor for phenotypic heifer pregnancy (Table 4.4). The stayability model showed birth year and calving season ($P < 0.01$) affecting female longevity and the ability to stay in the herd with March-born heifers producing 2.3 calves vs. 1.7 for May-born heifers over 5 yr. Dam age did not affect ($P = 0.16$) stayability and the genomic score for stayability was not a predictor ($P = 0.88$) for female longevity and the ability to produce a calf every year (Table 4.5).

It is not uncommon for these genomic predictor scores to show no association to their corresponding phenotypic traits as Quaas et al. (2006) noted one genomic testing panel showing no association with its corresponding marbling trait. This is possible due to the immeasurable amount of factors that can affect any one trait in an animal. There can be challenges pinpointing which genomic markers accurately predict a corresponding phenotype, so our findings are not surprising in this study (Van Eenennaam et al., 2007).

In summary, the genomic scores for birth BW and calving-ease direct are significant predictors for birth BW and weaning BW, respectively. Calving-ease maternal may be a predictor for weaning BW. The genomic score for milk tends to be a predictor for weaning BW. The genomic scores of heifer pregnancy and stayability are not predictors for actual heifer pregnancy and female longevity or stayability in the herd, respectively.

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quantitative beef quality traits. Validation of commercial DNA tests for quantitative beef quality traits 85:891–900.

Table 4.1 Average of phenotypic traits of heifer calves born in each production year in two different calving seasons¹

| | <i>N</i> | Birth WT ² | Wean WT ³ | Total Preg ⁴ | Heifer PG ⁵ |
|------------|----------|-----------------------|----------------------|-------------------------|------------------------|
| March 2009 | 61 | 34.4 | 211.2 | 2.2 | 0.64 |
| March 2010 | 68 | 33.2 | 211.6 | 2.8 | 0.74 |
| May 2010 | 58 | 35.1 | 187.0 | 1.6 | 0.58 |
| March 2011 | 67 | 34.2 | 221.4 | 2.5 | 0.78 |
| May 2011 | 66 | 33.9 | 197.0 | 1.7 | 0.65 |
| March 2012 | 94 | 31.8 | 198.6 | 1.7 | 0.78 |
| All March | 290 | 33.4 | 210.7 | 2.3 | 0.74 |
| All May | 124 | 34.5 | 192.0 | 1.7 | 0.62 |

¹Location managed two separate calving herds; March and May

²Birth body weight (BW) average of females in the contemporary group in kg

³Weaning BW average of females in the contemporary group in kg (March calves wean at average 224 d old vs. 216 d old for May calves)

⁴Average of number of pregnancies per female out of possible 5 years

⁵Average number of females (as percentage) successfully pregnant at first opportunity (yearling heifer)

Table 4.2 Regression model analyzing genomic predictor scores with Birth WT as dependent variable and others listed as independent variables

| Model | Reg. Coef. | <i>P</i> -value |
|-------------------------------|------------|-----------------|
| Calving Season ¹ | -1.6316 | 0.0916 |
| Dam Age ² | 0.7340 | 0.0001 |
| Birth Year | -1.0754 | 0.0166 |
| GS BirthWT Score ³ | 3.5171 | <.0001 |

¹Comparison of two separate calving seasons; March or May

²The effect of the age of the dam at the calf's birth

³The Igenity predictor score for birth BW

Table 4.3 Regression models analyzing genomic predictor scores with Weaning BW as dependent variable and others listed as independent variables

| Model | Reg. Coef. | <i>P</i> -value | Model | Reg. Coef. | <i>P</i> -value | Model | Reg. Coef. | <i>P</i> -value | Model | Reg. Coef. | <i>P</i> -value |
|-----------------------------|---------------|-----------------|---------------------|---------------|-----------------|--------------------|---------------|-----------------|--------------------|---------------|-----------------|
| Calving Season ¹ | 45.6221 | <0.0001 | Calving Season | 45.6466 | <0.0001 | Calving Season | 45.3657 | <0.0001 | Calving Season | 46.5926 | <0.0001 |
| Dam Age ² | 8.9351 | <0.0001 | Dam Age | 9.3322 | <0.0001 | Dam Age | 9.1736 | <0.0001 | Dam Age | 8.9426 | <0.0001 |
| Birth Year | -5.5249 | 0.0407 | Birth Year | -6.8554 | 0.0122 | Birth Year | -5.9762 | 0.0290 | Birth Year | -5.9036 | 0.0284 |
| GS Milk Score ³ | 3.9983 | 0.0557 | GS Milk Score | 2.3111 | 0.2698 | GS CEM Score | -5.7243 | 0.0115 | GS CED Score | -8.2258 | <0.0001 |
| GS CEM Score ⁴ | -2.3500 | 0.3460 | | | | | | | | | |
| GS CED Score ⁵ | -7.9721 | 0.0006 | | | | | | | | | |

¹Comparison of two separate calving seasons; March or May

²The effect of the age of the dam at the calf's birth

³The Igenity predictor score for milk

⁴The Igenity predictor score for calving ease-maternal

⁵The Igenity predictor score for calving ease-direct

Table 4.4 Regression model analyzing genomic predictor scores with Heifer PG as dependent variable and others listed as independent variables

| Model | Reg. Coef. | <i>P</i> -value |
|-----------------------------|------------|-----------------|
| Calving Season ¹ | -0.5892 | 0.0113 |
| Dam Age ² | -0.0488 | 0.3110 |
| Birth Year | -0.1778 | 0.1133 |
| GS HPRG Score ³ | -0.0296 | 0.7538 |

¹Comparison of two separate calving seasons; March or May

²The effect of the age of the dam at the calf's birth

³The Igenity predictor score for heifer pregnancy

Table 4.5 Regression model analyzing genomic predictor scores with Total Preg as dependent variable and others listed as independent variables

| Model | Reg. Coef. | <i>P</i> -value |
|-----------------------------|------------|-----------------|
| Calving Season ¹ | 0.3170 | <0.0001 |
| Dam Age ² | 0.0210 | 0.1606 |
| Birth Year | -0.1120 | 0.0009 |
| GS Stay Score ³ | 0.0048 | 0.8784 |

¹Comparison of two separate calving seasons; March or May

²The effect of the age of the dam at the calf's birth

³The Igenity predictor score for stayability (female longevity in the herd)

Figure 4.1 Genomic predictor scores from the Igenity Gold Panel with Igenity Scores used as predictors to compare other animals with their respective scores¹

| Igenity Genetic Effects Table | | | | | | | | | | | | | |
|-------------------------------|-----------------|---------------------|-----------------------|----------|------------------|--------|-------------|--------------------|----------------------|----------------|---------------------|-------------|---------------|
| | Maternal Traits | | | | | | | Performance Traits | | Carcass Traits | | | |
| Igenity Scores | Birth Weight | Calving Ease Direct | Calving Ease Maternal | Docility | Heifer Pregnancy | Milk | Stayability | Average Daily Gain | Residual Feed Intake | Tenderness | USDA Marbling Score | Ribeye Area | Fat Thickness |
| | (lbs.) | (%) | (%) | (%) | (%) | (lbs.) | (%) | (lbs.) | (lbs.) | (lbs. WBSF) | (USDA marb. units) | (sq. ins.) | (in.) |
| 10 | 11.3 | 23.9 | 23.9 | 22.7 | 13.1 | 35.1 | 29.9 | 0.35 | 2.1 | -1.15 | 142 | 1.8 | 0.21 |
| 9 | 10.0 | 21.2 | 21.2 | 19.8 | 11.6 | 31.2 | 26.8 | 0.31 | 1.8 | -1.00 | 126 | 1.6 | 0.18 |
| 8 | 8.8 | 18.6 | 18.6 | 17.4 | 10.2 | 27.3 | 23.6 | 0.27 | 1.6 | -0.95 | 110 | 1.4 | 0.16 |
| 7 | 7.5 | 15.9 | 15.9 | 15.0 | 8.7 | 23.4 | 20.5 | 0.23 | 1.4 | -0.75 | 95 | 1.2 | 0.14 |
| 6 | 6.3 | 13.3 | 13.3 | 12.7 | 7.3 | 19.5 | 17.3 | 0.19 | 1.1 | -0.60 | 79 | 1.0 | 0.12 |
| 5 | 5.0 | 10.6 | 10.6 | 10.3 | 5.8 | 15.6 | 14.2 | 0.15 | 0.9 | -0.55 | 63 | 0.8 | 0.09 |
| 4 | 3.8 | 8.0 | 8.0 | 7.9 | 4.4 | 11.7 | 11.0 | 0.12 | 0.7 | -0.40 | 47 | 0.6 | 0.07 |
| 3 | 2.5 | 5.3 | 5.3 | 5.4 | 2.9 | 7.8 | 7.9 | 0.08 | 0.5 | -0.20 | 32 | 0.4 | 0.05 |
| 2 | 1.3 | 2.7 | 2.7 | 2.9 | 1.5 | 3.9 | 4.7 | 0.04 | 0.2 | -0.10 | 16 | 0.2 | 0.02 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

¹Adapted from Neogen Corporation (Lansing, MI)

CHAPTER V

COMPARING MARCH AND MAY CALVING SYSTEMS IN THE

NEBRASKA SANDHILLS

M.R. Erickson, D.L. Broadhead, J.A. Musgrave, and R.N. Funston

University of Nebraska, West Central Research and Extension Center, North Platte

69101

ABSTRACT: Three production years for March (n=503) and May (n=301) calving, Red Angus-based cows and their offspring from the Gudmundsen Sandhills Laboratory (GSL), Whitman, NE, were evaluated. Steer progeny were evaluated through harvest and carcass data collected. All March-born steers entered the feedlot approximately 14 d after weaning (calf-fed). After a backgrounding period of approximately 136 d, May steers were either calf-fed or grazed overwinter until late summer, then entered the feedlot (yearling-fed). Calf birth body weight (BW) and breeding BW (calf BW at dam's breeding) were ($P < 0.01$) greater for May calves over March (36 ± 0.3 kg vs. 35 ± 0.2 kg and 97 ± 0.9 kg vs. 79 ± 0.7 kg, May vs. March, respectively); however, adjusted weaning BW was greater ($P < 0.01$) for March calves (227 ± 1.1 kg vs. 194 ± 2 kg). Pregnancy rates (89% vs. 91%), weaning rates (96% vs. 94%), calving interval, calving difficulty, and calf vigor were similar ($P > 0.10$) between systems. Udder score was greater ($P < 0.01$) for March cows (3.32 ± 0.03 vs. 3.01 ± 0.05). Compared with March calf-fed steers, May calf-fed steers had greater ($P < 0.01$) hot carcass weight (HCW) (408 ± 5.6 kg vs. 377 ± 2.1 kg), longissimus muscle area (LMA) (38 ± 0.6 cm² vs. 35 ± 0.3 cm²), marbling (494 ± 11.8 vs. 477 ± 5.9), and backfat (1.7 ± 0.06 cm vs. 1.5 ± 0.03 cm). May yearling steers had greater ($P < 0.01$) HCW (436 ± 6 kg vs. 377 ± 2.1 kg), LMA (39

$\pm 0.5 \text{ cm}^2$ vs. $35 \pm 0.3 \text{ cm}^2$), marbling (566 ± 15.3 vs. 477 ± 5.9), and backfat (1.7 ± 0.1 cm vs. 1.5 ± 0.03 cm) compared with March calf-feds. Increased HCW and other carcass traits most likely due to the differing backgrounding systems between the steers born in each calving season.

Key Words: March calving, May calving, calving seasons, steer systems

INTRODUCTION

Selecting a calving season can be one of the most influential factors for a successful beef production system. Numerous factors play into selecting a season to calve including weather, available labor and feed resources, potential market for calves and open cows, breeding season, etc. Decisions about when to calve will differ from location to location as well as the specific goals of the producer with their cattle herd. Sprott et al. (2001) emphasized the importance of making the decision according to the calving site based on weather, heat stress, forages, and other factors directly tied to the specific location of each operation. Adams et al. (1996) stated the importance of synchronizing cow's nutrient needs with the available forage nutrients by changing calving and weaning dates to fit the landscape. This can reduce feed and supplementation costs thereby increasing profitability.

The objective of this study is to analyze and compare March and May calving seasons in the Nebraska Sandhills to identify the differences and if any advantages exist of one system over the other.

MATERIALS AND METHODS

Data from 3 production years were utilized from 2 calving herds in the Nebraska Sandhills. Red Angus-based cows from the Gudmundsen Sandhills Laboratory near

Whitman, NE, were managed to calve either in March or May. All cows were at least 3 yr of age or older. The number of cows varied each year with 503 March calving and 301 May calving cows used in this analysis. Cattle numbers varied each year for March-calving (n=194, n=160, and n=149 for yr 1, 2, and 3 respectively) and May-calving (n=105, n=106, and n=90 for yr 1, 2, and 3 respectively) herds. Average calving date was March 24 for the March herd and June 5 for the May herd. March cows calved in a drylot and May cows calved on native range.

All steer calves from the March herd entered the feedlot as calf-feds after a 14 d backgrounding period. May-born steer calves began a 136-d development/backgrounding period at weaning. Upon completion of the developmental period, half of the steers entered the feedlot as calf-feds and the remainder grazed native upland range for approximately 129 d before entering the feedlot as yearlings. All steers were harvested when they were visually assessed to have approximately 1.3 cm backfat depth and carcass quality data collected.

Statistical Analysis

This Mixed procedure of SAS Software (SAS Institute, Inc., Cary, N.C.) was used to analyze all continuous variables including weights and carcass values. Calving system and age of dam were the independent variables. Year was treated as a random effect. Binary variables (pregnancy rate, calving rate, weaning rate, calf sex) required the use of GLIMMIX procedure of SAS Software.

RESULTS AND DISCUSSION

The average first calving date for March was March 5 with 82% of the calves born in the first 21 d. The May herd began calving on average of May 9 with 85% of the

calves born within the first 21 d. Calf birth body weight (BW) and calf breeding BW (BW at dam's breeding) were ($P < 0.01$) greater for May calves over March (35.5 ± 0.3 kg vs. 35 ± 0.2 kg and 97 ± 0.9 kg vs. 79 ± 0.7 kg respectively); however, adjusted weaning BW (205 d) was greater ($P < 0.01$) for March calves (227 ± 1.1 kg vs. 194 ± 2 kg, Table 5.1).

Pregnancy rates (89% vs. 91%), weaning rates (96% vs. 94%), calving interval, calving difficulty, and calf vigor were similar ($P > 0.10$) between systems. Udder score was greater ($P < 0.01$), based on scale of 1 (poor udder) to 5 (exceptional udder) for March cows (3.32 ± 0.03 vs. 3.01 ± 0.05 , Table 5.2).

Compared with March calf-fed steers, May calf-fed steers had greater ($P < 0.01$) hot carcass weight (HCW) (408 ± 5.6 kg vs. 377 ± 2.1 kg), longissimus muscle area (LMA) (38 ± 0.6 cm² vs. 35 ± 0.3 cm²), marbling (494 ± 11.8 vs. 477 ± 5.9), and backfat (1.7 ± 0.06 cm vs. 1.5 ± 0.03 cm, Table 5.3). May yearling steers had greater ($P < 0.01$) HCW (436 ± 6 kg vs. 377 ± 2.1 kg), LMA (39 ± 0.5 cm² vs. 34 ± 0.3 cm²), marbling (566 ± 15.3 vs. 477 ± 5.9), and backfat (1.7 ± 0.1 cm vs. 1.5 ± 0.03 cm) compared with March calf-feds (Table 5.4). It is interesting to note that although the March steers were heavier at weaning, the May steers exhibit greater HCW. This might suggest these May born steers compensate in the feedlot to a degree, but is most likely due to the increased time in a backgrounding system prior to feedlot entry.

These results agree with findings of other researchers that it is not a simple answer of one system being superior in all instances. Many factors must be considered when identifying a successful calving season. Leesburg et al. (2007) reported in the northern Great Plains, early spring, May, or summer calving seasons all showed similar

profitability and no single combination of calving system/calf marketing was superior. The only significance from this study was retained ownership of a fall calving herd benefited significantly more over the other seasons. May et al. (1999) showed the lowest feed inputs for May and June calving over February and March. A concern with June calving is extending lactation into fall requiring additional supplementation or hay to meet nutrient requirements. Grings et al. (2007) demonstrated no difference in heifer pregnancy rates between late winter, early spring, or late spring calving systems in the northern Great Plains. This study showed the flexibility and wide array of available options a producer has to select for success. When comparing March and June calving in the Nebraska Sandhills, Adams et al. (2001) showed switching from a March to a June calving system reduced the amount of hay fed as well as labor needs, but increased protein supplement needs for the June cows. Weaning rates were similar between both systems, but the March born calves had approximately 70 pound increased weaning weights over June born calves of similar age. June was selected in the Sandhills of Nebraska to best match cow nutrient needs with nutrients in grazed forages.

In a survey of producers conducted by Schulz et al. (2016) it was found selection of calving season is based heavily on weather and 1/3 of participants cited tradition as their reason of calving season selection. Little reasoning was placed on availability of forages/feeds or marketability of calves or open cows.

Body condition of the cow is very important and needs to be closely monitored throughout the production year. The cow condition at certain times can indicate a correct calving season for location. Osoro and Wright (1992) found higher body condition score (BCS) at calving was more significant at affecting reproductive performance than BCS at

breeding. Higher BCS at calving also helped to shorten calving interval or the time between a calf and the subsequent calf born to the same cow.

An important consideration when selecting a calving season is getting as many cows to calve during the first 21 d as possible. Heifers that calve in the first 21 d have increased longevity and increased weight of calf weaned (Cushman et al., 2013). Heifers born in the first 21 d have increased pregnancy rates and higher body weights, but lower birth body weights and average daily gain than heifers born in later calving periods. Carcass quality is also increased for calves born in the first 21 d over those born later (Funston et al., 2012). Bourdan and Brinks (1983) added calving date should be a more important selector than calving interval. They stated calving interval indirectly selects for delayed maturity as well as later calving.

Lancaster et al. (2014) noted the importance of previous management strategies and how that influences the initial finishing body weight which carries through and affects finishing performance. This is a possible explanation for our findings of the all May-born steers finishing with greater carcass quality and weight compared to the March-born steers. The exposure to a longer backgrounding period for May steers, approximately 136 d vs. 14 d, may have highly influenced feedlot performance compared to March steers. Gardine et al. (2019) agrees with these findings that a backgrounding period before entry to the feedlot increases final HCW compared to calves that directly enter the finishing phase after weaning. Another difficulty presented was the ability to harvest steers accurately when 1.3 cm backfat is achieved. With low numbers of animals it is difficult to adequately sort cattle to uniform pens which can then be harvested at uniform endpoints. Another goal was to reduce the amount of yield grade 4 carcasses so

feeding to ensure all steers reached 1.3 cm backfat warranted concern of others becoming over-fat.

In summary, selection of calving season is best assessed specifically by each producer at his/her own location. Peak forage nutrients vary as well as complementary forages and access to stockpiled feeds. By synchronizing peak nutrient requirements of the cow with peak forage quality, a producer can mitigate cost and the amount of forage used per cow and increase potential for profitability.

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Table 5.1 Comparison of calf performance in March and May calving systems.

| | March | SEM | May | SEM | <i>P</i> -value | |
|----------------------------------|--------|------|--------|------|---------------------|----------------------|
| | | | | | System ¹ | Cow Age ² |
| <i>N</i> | 493 | | 301 | | | |
| Birth wt, kg | 35.12 | 0.21 | 35.45 | 0.29 | 0.02 | 0.01 |
| Breeding wt, kg | 78.57 | 0.71 | 97.11 | 0.90 | 0.01 | 0.01 |
| Weaning wt, kg | 242.34 | 1.31 | 200.47 | 1.64 | 0.01 | 0.01 |
| Adj weaning wt ³ , kg | 226.69 | 1.11 | 193.61 | 2.02 | 0.01 | 0.01 |
| Calving difficulty ⁴ | 1.04 | 0.01 | 1.00 | 0.01 | 0.05 | 0.27 |
| Calf vigor ⁵ | 1.04 | 0.01 | 1.00 | 0.01 | 0.16 | 0.29 |
| Calf sex ⁶ | 0.54 | 0.02 | 0.49 | 0.03 | 0.10 | 0.80 |

¹*P*-value of calving system²*P*-value of age of cow³Adjusted 205 d weaning weight⁴Calving difficulty score on scale of 1 to 5: 1 = unassisted, 2 = easy pull, 3 = hard pull, 4 = surgical removal, 5 = abnormal presentation⁵Vigor of the calf shortly after birth on scale of 1 (nursed immediately, strong) to 5 (dead on arrival)⁶Average sex of calf born in herd (0 = female, 1 = male)

Table 5.2 Comparison of cow performance in two different calving systems.

| | | March | SEM | May | SEM | <i>P</i> -value | |
|---------------------------|----------|--------|------|--------|------|---------------------|----------------------|
| | | | | | | System ⁸ | Cow Age ⁹ |
| | <i>n</i> | 503 | | 301 | | | |
| Cow Age ¹ | | 5.83 | 0.08 | 4.70 | 0.08 | - | - |
| Calving wt, kg | | 503.10 | 2.86 | 459.94 | 2.95 | 0.01 | 0.01 |
| Calving BCS ² | | 5.18 | 0.03 | 4.87 | 0.03 | 0.01 | 0.13 |
| Breeding wt, kg | | 469.47 | 2.56 | 490.05 | 3.35 | 0.01 | 0.01 |
| Breeding BCS | | 4.90 | 0.03 | 5.74 | 0.03 | 0.01 | 0.01 |
| Wean wt, kg | | 500.12 | 2.51 | 441.85 | 3.43 | 0.01 | 0.01 |
| Wean BCS | | 5.37 | 0.03 | 4.70 | 0.04 | 0.01 | 0.01 |
| Preg ³ | | 0.91 | 0.01 | 0.89 | 0.02 | 0.74 | 0.16 |
| Calving Rate ⁴ | | 0.98 | 0.01 | 1.00 | 0.00 | 0.05 | 0.46 |
| Wean Rate ⁵ | | 0.94 | 0.01 | 0.96 | 0.01 | 0.64 | 0.17 |
| Julian DOB ⁶ | | 82.60 | 0.56 | 145.37 | 0.59 | - | - |
| Udder Score ⁷ | | 3.32 | 0.03 | 3.01 | 0.05 | 0.01 | 0.06 |

¹Average age of cows in the herd²Body condition score based on scale of 1 (emaciated) to 9 (extremely obese)³Percentage of cows pregnant that were given opportunity to breed⁴Percentage of cows that gave birth to a calf that were diagnosed as pregnant⁵Percentage of cows that weaned a calf of those who gave birth to a calf⁶Average calving date of herd based on Julian calendar⁷Average udder score of cow at calving on scale of 1 (worst) to 5 (best)⁸*P*-value of calving system⁹*P*-value of age of cow

Table 5.3 Comparison of carcass data between March and May calving systems: calf-fed steers

| | | March Calf ¹ | SEM | May Calf ² | SEM | <i>P</i> -value | |
|---------------------------|--|-------------------------|------|-----------------------|-------|---------------------|----------------------|
| | | | | | | System ⁸ | Cow Age ⁹ |
| <i>n</i> | | 258 | | 43 | | | |
| HCW ³ , kg | | 377.09 | 2.14 | 407.99 | 5.58 | 0.01 | 0.01 |
| CYGrade ⁴ | | 3.06 | 0.05 | 3.11 | 0.1 | 0.47 | 0.75 |
| LMA ⁵ | | 34.93 | 0.28 | 38.16 | 0.56 | 0.01 | 0.52 |
| MARB ⁶ | | 477.03 | 5.94 | 494.12 | 11.75 | 0.01 | 0.63 |
| BACKFAT ⁷ , cm | | 1.45 | 0.03 | 1.65 | 0.06 | 0.01 | 0.7 |

¹March-born steers entering feedlot as a calf-fed²May-born steers entering feedlot as a calf-fed³Hot carcass weight⁴Carcass yield grade on scale of 1 to 5⁵Longissimus muscle area in cm⁶Marbling score of carcass: higher = better⁷Depth of backfat between 12th and 13th rib at harvest⁸*P*-value of calving system⁹*P*-value of age of cow

Table 5.4 Comparison of carcass data between March and May calving systems:
March calf-fed vs. May yearling

| | March Calf ¹ | SEM | May Yearling ² | SEM | <i>P</i> -value | |
|---------------------------|----------------------------|------|------------------------------|-------|---------------------|-------------------------|
| | | | | | System ⁸ | Cow Age ⁹ |
| <i>n</i> | 258 | | 48 | | | |
| HCW ³ , kg | 377.09 | 2.14 | 436.26 | 6.01 | 0.01 | 0.21 |
| CYGrade ⁴ | 3.06 | 0.05 | 3.26 | 0.13 | 0.06 | 0.7 |
| LMA ⁵ | 34.93 | 0.28 | 38.98 | 0.49 | 0.01 | 0.75 |
| MARB ⁶ | 477.03 | 5.94 | 566.11 | 15.32 | 0.01 | 0.94 |
| BACKFAT ⁷ , cm | 1.45 | 0.03 | 1.68 | 0.09 | 0.01 | 0.63 |

¹March-born steers entering feedlot as a calf-fed

²May-born steers entering feedlot as a yearling

³Hot carcass weight

⁴Carcass yield grade on scale of 1 to 5

⁵Longissimus muscle area in cm

⁶Marbling score of carcass: higher = better

⁷Depth of backfat between 12th and 13th rib at harvest

⁸*P*-value of calving system

⁹*P*-value of age of cow

