Strategic Beef Cattle Herd Development

2021 D1

Project Lead:	Manitoba Beef & Forage Initiatives
MBFI Location(s):	Brookdale Farm, Johnson Farm, and First Street Pasture
Start Date:	2019 Status: In Progress

Contents

Acknowledgements

Thank you to Don Guilford for the initial work and concept of creating a herd plan integrating hybrid vigour into herd management. We would also like to thank Neogen for their in-kind support through reduced analysis fees to support the continued genetic analysis of the MBFI breeding herd. On-farm demonstrations like this case study and daily operations at MBFI would not be possible without grant funding from the Province of Manitoba and Government of Canada through the Canadian Agricultural Partnership.

1. MBFI Herd Development

1.1 Introduction

Herd development is a key consideration for every cow-calf producer to improve profitability on the farm. The backbone to the on-farm demonstration studies at Manitoba Beef & Forage Initiatives (MBFI) is the year-round cow-calf operation. Through broad consultation and discussion, production goals and desirable herd traits were identified for the context and needs of MBFI. Through the establishment of this case study, MBFI is documenting progress toward our production goals and showcasing tools for decision making that can be used universally in herd improvement.

Decision making tools assist in maintaining consistent practices and achieving set goals. MBFI has implemented strategies for breeding stock selection and culling to ensure desired production traits are retained in the herd. Breeding decisions made today affect weaning metrics of calves a year and a half later. They also affect heifers in the herd available for retention as replacements, and these heifers will not have their first calf until age two – almost three years after the original breeding decision. Breeding stock selection has long-term effects in the herd and herd development benefits from goal setting.

MBFI is a relatively new farming operation, with the first group of cows purchased in December 2015. The MBFI breeding herd being developed needs to thrive under conditions and the management practices in place. Development of MBFI raised replacements and purchase of bred heifers has been ongoing to build the herd and align the breeding herd traits to the grazing management systems being studied. Focus has been on dam development for moderately framed cows with low maintenance requirements to perform in extensive grazing with high fertility and mothering traits for calving in April – May.

One tool selected for improved profitability of the MBFI herd is hybrid vigour. Hybrid vigour or heterosis, is the improved performance of the crossbred offspring over the potential of the parents[1]. Hybrid vigour improves maternal traits such as longevity and reproduction as well as production traits such as growth[1]. Demonstration of a strategic crossbreeding program is taking place over two phases. The first is working to build a maternal Black Angus foundation breeding group that is bred to produce replacement Black Angus and F1 Black Baldy heifers. The second phase will evaluate the terminal breeding of the F1 Black Baldy breeding group against a rotating continental breed sire for a three-way cross for calf performance growth.

Application of new technologies offer a wide variety of tools that can be used to inform management decisions for herd development. Genomic testing is becoming more popular and can identify breed composition or genes for fat deposition and carcass tenderness. Technology that measures cow reproduction and health is becoming more widely available for beef producers.

This project develops and analyzes the use of several tools, including technology, selection strategies, and culling strategies in developing a herd to suit chosen production goals.

1.2 Objectives

This project will showcase a variety of selection and management tools to develop and grow a forage-based herd for increased profitability.

1. Use technology to enhance herd management, breeding stock selection, breeding management
2. Select breeding stock to enhance the crossbreeding program
3. Apply a crossbreeding program to the MBFI herd
4. Utilize a culling strategy to improve herd performance
5. Evaluate the terminal calf crop

This section will characterize the herd for further discussion later report sections.

1.3 Record Collection

1.3.1 Production Records

MBFI collects records throughout the production cycle to aid in decision making.

Calving, for each calf:

- Calf birth date
- Calf birth weight
- Calf sex
- Calving ease
- Dam teat and udder scores
- Calving cycle

Weaning, for each calf:

- Weaning date
- Weaning weight

Pregnancy check, for each cow:

- Pregnancy check results
- Weight
- Culling reason for sold cows

Year-round:

- Cattle sales and reason for culling if applicable
- Grazing strategy for each animal
- Breeding season dates
- Animal health records
- Weights
- Body condition score for animals over 1 year old[5]
- Cattle deaths

Production metrics collected are compiled and used to calculate values such as average daily gain and the 205-day adjusted weaning weight (Section 6. TERMINAL CALF Crop). Calf weaning weight is compared to dam weights taken in November of the same year as % of Dam Weight.

These values are used in decisions regarding breeding management, breeding stock selection, and culling.

1.3.2 Genomic Testing

Tail hair samples are collected for new cows in the herd and replacement heifers. These samples are sent to Neogen Canada for analysis.

Genomic analysis has changed as different options become available, so younger cows have had a wider selection of analyses performed.

Tail hair samples are analyzed for the following:

- Breed composition
- Leptin
- Carcass
- Igenity® Beef profile

Genomic testing has not yet occurred on any bred heifers born in 2020 or bred cows purchased in 2020.

1.4 Herd Background

1.4.1 Herd Numbers

MBFI is increasing the number of cows onsite in addition to improving production and conformation traits. MBFI is working toward the goal of maintaining 150 cow-calf pairs. Table 1-1 details changes in cow numbers since 2018.

Table 1-1. Changes in cow numbers since 2018.

	2019	2020	2021
Number of cows expected to calve	118	142	138
Number of cows bred at MBFI	111	126	134
Number of heifers bred at MBFI	18	17	10
Number of cows sold in the fall	23	21	15
Number of bred heifers purchased	36	16	6
Number of cows wintered	142	138	135

Bull numbers have increased in tandem with the increase in cow numbers. Table 1-2 details changes in bull numbers since 2018.

Table 1-2. Changes in bull numbers since 2018.

	2019	2020	2021
Number of bulls wintered	5	3	4
Number of bulls purchased	0	3	3
Number of bulls for breeding	5	6	7
Number of bulls sold or died	2	2	1
Number of bulls to winter	3	4	6

Table 1-3. Location of cattle by class for summer grazing, excluding breeding season.

		Brookdale Farm	Johnson Farm	First Street Pasture
2019	Pairs	50	3	60
	Replacement heifers	0	18	0
	Bulls	0	5	0
2020	Pairs	50	4	75
	Replacement heifers	0	17	0
	Bulls	0	6	0
2021	Pairs	50	0	85
	Replacement heifers	0	10	0
	Bulls	0	7	0

Cows are split between sites for summer grazing (Table 1-3). The Brookdale Farm is one 640-acre block of higher productivity land and includes perennial and annual fields. Johnson and First Street Pastures are marginal land with lower productivity. Most paddocks are in perennial forage with a few exceptions.

Figure 1-1 shows that in 2021, most breeding cows at MBFI are four years of age or younger (E-H Cows). This is largely due to concentrated purchases of young breeding stock. Cow numbers for each age cohort by year are detailed in Appendix I (Table 1-9). Further discussion of why changes occurred can be found in Section 3 **BREEDING STOCK SELECTION** and Section 5 **CULLING STRATEGY**.

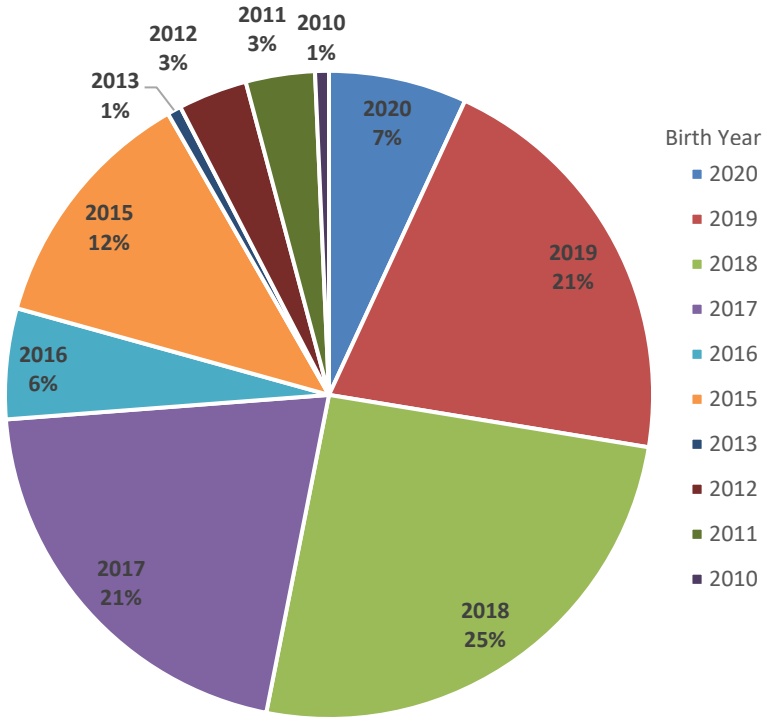


Figure 1-1. Percent of herd in each age cohort in 2021.

1.4.2 Breeding Management

MBFI aims to keep a tight breeding season of 45 days. Actual number of days may vary by one to three days due to labour availability. Calving timing is targeted to begin with bred heifers in the first week of April, and mature cows starting two weeks later. MBFI does not have extensive barns for calving earlier in winter, and it is an expectation that calving on grass will be largely unassisted. At MBFI a tight calving season is required to ensure pairs are in place to start spring grazing studies to accommodate research requirements.

From 2019-2021, cows at the Brookdale Farm were equally split between two grazing strategies: a high-density quick rotation, and a continuous grazing pasture. Each group of 25 pairs had one bull for the breeding season (Table 1-4). The cows on First Street Pasture were run in one group, with a desired cow:bull ratio of 25:1 to 30:1. Breeding season at First Street Pasture was extended in 2019 due to concerns about conception rates from observed poor health in the herd. In 2020, three bulls were put out with the herd; one bull was removed after one week for aggressive behaviour toward other bulls, so only two bulls were out for most of the season.

Replacement heifers are exposed to the bull fifteen days earlier than the mature cows to give them more time to recover after having their first calf and before they are exposed to the bull for their second breeding season[2].

Table 1-4. Breeding season summary 2019-2021.

		Date of bull turn-out	Date bulls removed from herd	Length of Breeding Season	Number of cows	Number of bulls	Bull breed
2019	Heifers	July 5	August 19	45	18	1	Black Angus
	Brookdale cows	July 19	September 3	46	50	2	Black Angus
	First Street cows	July 19	September 16	59	60	2	Black Angus
2020	Heifers	July 5	August 19	45	17	1	Hereford
	Brookdale cows	July 20	September 3	45	50	2	Black Angus
	First Street cows	July 20	September 3	45	75	2*	Black Angus
2021	Heifers	July 5	August 23	49	10	1	Black Angus
	Brookdale cows	July 21	September 3	44	49	2	Black Angus, Hereford
	First Street cows	July 21	September 3	44	85	3	Black Angus

*This group began with three bulls, but one was removed after one week for aggressive behaviour toward other bulls during breeding.

1.4.3 Production Summary

Cow Conformation

Good udder conformation is correlated with cow longevity, calf gains, and reduced labour[3]. Cow udders are scored 24-48 hours after calving at the same time as the calf is tagged and weighed. Teats and

udders are each given a score out of 9, with 1 the lowest possible score and 9 the highest possible score (Figure 1-5, Appendix I).

To display the data, teat and udder scores were summed. Each udder was then categorized as follows:

- Excellent – 15-18
- Good – 11-14
- Fair – 7-10
- Poor – 6 or less

More udders score Excellent or Good in 2021 as compared to 2019 (Figure 1-2). Emphasis on udder conformation during culling and dam udder during replacement heifer selection have contributed to overall better udders in the herd (Section 3 **BREEDING STOCK** Selection and Section 5 **CULLING** Strategy).

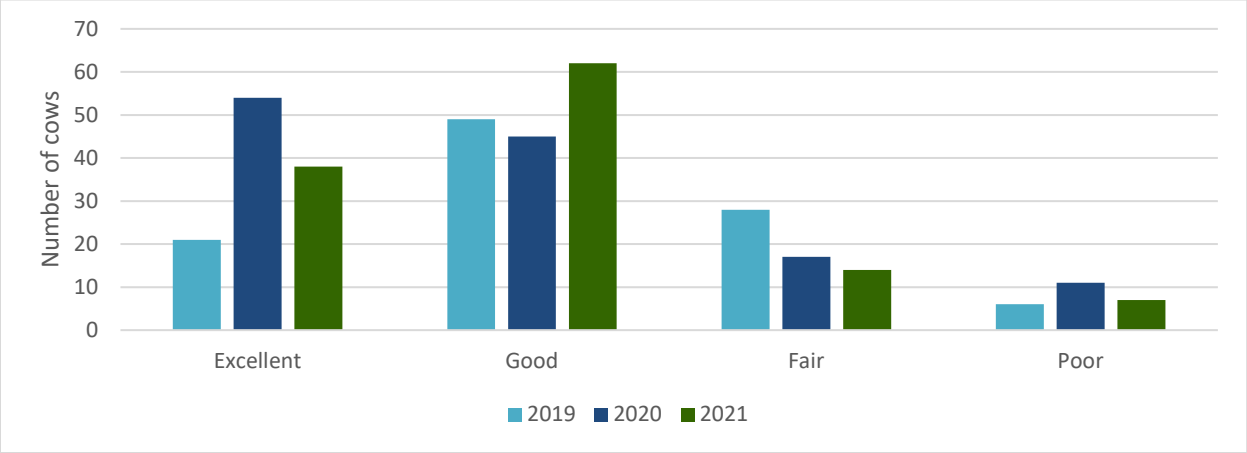


Figure 1-2. Teat and udder conformation 2019-2021. Number of cows sampled is 104, 127, and 121 for 2019, 2020, and 2021 respectively.

Udders score high on first calf heifers and decrease as cows age. The E cow cohort (born 2017) was chosen as a demonstration as there are a large number of cows in that cohort and they had their first calf in 2019 (Figure 1-3). For this age cohort, almost all udders were classified as Excellent or Good in 2019 and 2020 (first and second calves). By 2021 (third calf) the first Poor udder has shown up in this age cohort. The number of Excellent udders has decreased substantially and Good udders have increased. During 2019-2021 no cows from the E cohort were sold for poor udder conformation.

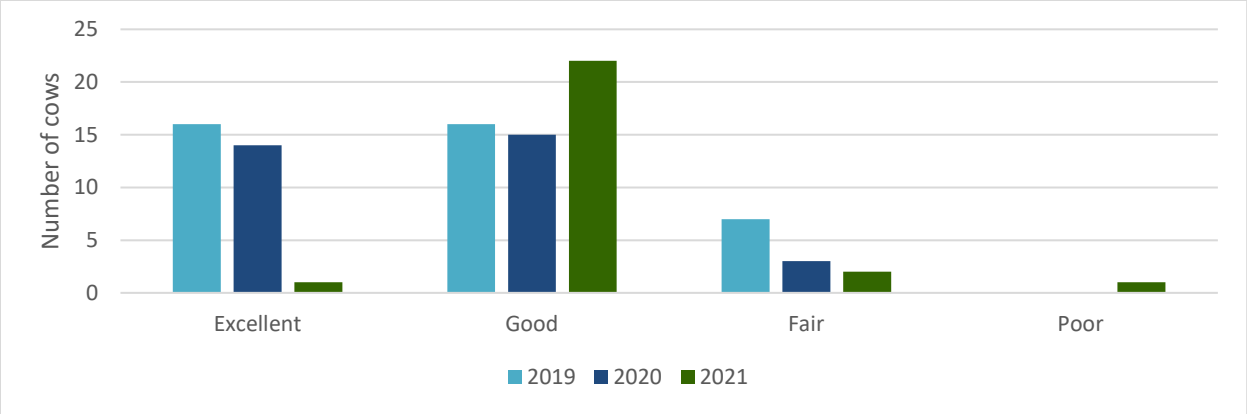


Figure 1-3. Teat and udder conformation for the E cow cohort 2019-2021. Number of cows sampled is 29, 32, and 26 cows for 2019, 2020, and 2021 respectively.

Calving Assists

Cows are monitored throughout the calving season for signs of calving distress. If the cow is in distress or does not proceed normally with calving within one hour, staff intervene to increase the probability of a live calf. Calving assists are tracked as they increase labour during calving season and may indicate changes are needed in bull selection or nutrition management[4].

Calving assists are classified as:

- No assist – cow calves normally on her own
- Easy assist – calf can be pulled by hand
- Hard assist – calf is pulled with the assistance of the calving jack
- Malpresentation – calf is not in the normal (front feet first) position. Malpresentations include one or more feet back, head back, upside down, backwards, and breech.
- Cesarian – the calf cannot be pulled, and the cow is taken to a veterinarian for cesarian section

The number of first calf heifers increased after 2018 from 18 to 44, 52, and 30 for 2019, 2020, and 2020 respectively. Most interventions occurred with first calf heifers. In mature cows the interventions were largely due to malpresentations.

More assists occurred in 2020 compared to the other years (Table 1-6). Many of the first calf heifers were not dilated fully and required assistance to birth a live calf. Most of the calves assisted were determined to be in distress due to meconium in the water bag, so staff decreased time to intervention.

Table 1-6. Calving Ease 2017-2021.

Calving Season	Calf Cohort	Number of calves				
		No assist	Easy assist	Hard assist	Malpresentation	Cesarian
2017	E calves	80	1	0	0	1
2018	F calves	78	0	1	3	0
2019	G calves	110	1	2	2	0
2020	H calves	122	5	10	2	0
2021	J calves	127	0	5	5	0

Reproductive Efficiency

Table 1-7. Changes in calf numbers from breeding to weaning

	2017	2018	2019	2020	2021
Number of cows exposed	105	108	137	129	143
Number of cows open	21	16	13	10	13
Number of cows sold for management*	0	6	6	13	8
Number of bred heifers purchased	0	0	0	36	16
Number of calves expected	84	86	118	142	138
Number of abortions between preg-check and calving	1	3	1	4	1
Number of cow deaths prior to calving	0	1	1	1	1
Calf death <24 hours**	1	0	3	7	4
Number of twins	0	1 set; 2 live calves	1 set; 1 live calf	2 sets; 2 live calves	5 sets; 5 live calves
Bottle calves sold	0	1	0	0	1
Number of live calves to raise on-farm	82	82	114	132	136
Calf deaths 24 hours – weaning	1	0	0	0	2
Number of calves weaned	81	82	114	132	134
Total weight of all calves weaned (lb)***	45,487	44,348	60,967	64,276	74,591

** includes disposition, health, etc. See Section 5* **CULLING STRATEGY** *for more information*

*** includes twins born DOA*

****weights of calves from purchased bred heifers are included*

As part of herd development from 2019-2021, MBFI aimed to increase the number of cow/calf pairs onsite. This was done by purchasing bred heifers and managing cull cows (Section 5 **CULLING STRATEGY**). Consistent breeding stock selection and culling management should lead to lower open rates and fewer cows sold for management reasons over the years. However, MBFI is still in the beginning stages of herd development and has not yet reached this point.

Number of open cows, number of cows sold for management reasons, number of live calves, and calf gain over the summer and fall all influence the total pounds of calf weaned each year (Table 1-7). For example, only two more calves were weaned in 2021 compared to 2020. However, there were fewer winter abortions, more calves survived their first 24 hours, and calves gained more weight between birth and weaning (Table 1-5).

Calves born earlier are generally heavier at weaning and produce more income for the producer[5]. Calving cycle is determined by the date the herd begins calving. If there is one lone calf followed by several days of no calves, this date is not considered the start of herd calving. When more than one calf comes on consecutive days, the first date is considered the first day of calving (Table 1-8, Appendix I). Breeding groups with different breading season start dates are considered separately.

Each calving cycle is 21 days. Industry benchmark is 60% of the herd calved in the first cycle[5]. At MBFI, bulls are rarely out for more than 45 days, so number of third cycle calves is very low. Lowest number of calves occurred in the first cycle occurred in 2017 (Figure 1-4). This was expected as the calving season

was moved one month earlier compared to 2016 (Table 1-8, Appendix I). The largest percent of the herd calved in the first cycle in 2020; this number has decreased in 2021 (Figure 1-4).

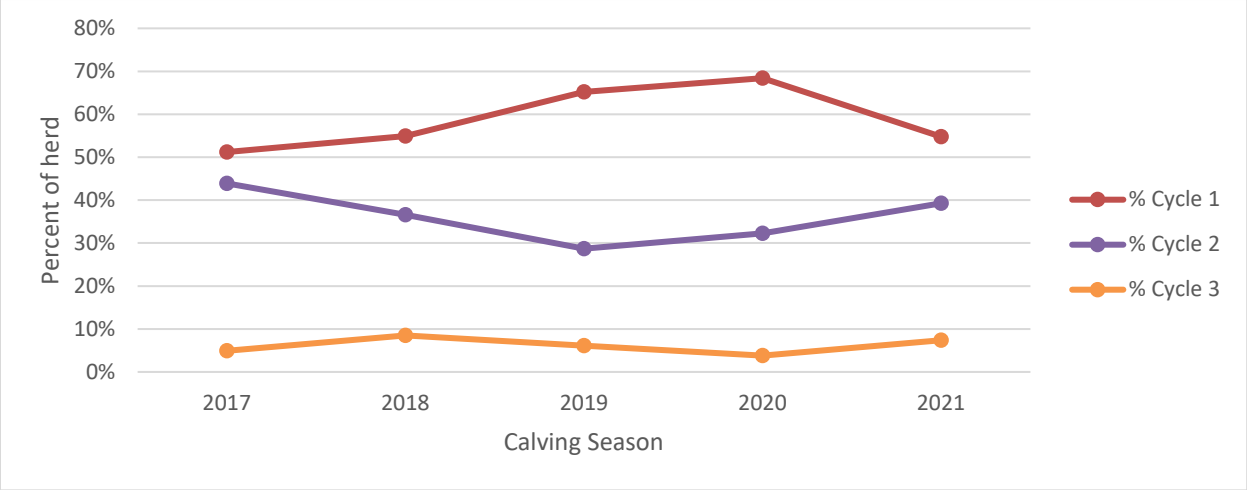


Figure 1-4. Percent of herd calved in each calving cycle 2017-2021.

Calf Production

Number of calves weaned has increased from 2017 to 2021 (Table 1-5). Birth weights have seen only small variations between years. Weaning weights and average daily gain (ADG) vary between years. In 2017 and 2018, calves were weaned the first week of December. In 2019-2021, calves were weaned early November.

Calf weight as % Dam weight was highest in 2021 (Table 1-5). This is a combination of higher weaning weights and a greater proportion of younger cows, who are still growing and therefore smaller.

Table 1-5. Calf production summary 2017-2021.

Calving Season	Number of calves expected	Number of live calves	Average Birth Weight (lb)	Weaning Date	Average age at weaning (days)	Number of calves weaned	Average Weaning Weight (lb)	Average ADG (lb/day)	Average % Dam Weight at Weaning	205-day adjusted Weaning Weight (lb)
2017	82	82	83.0	Dec 4	208	81	562	2.30	43.5%	582
2018	86	82	84.0	Dec 3	208	81	548	2.22	44.4%	566
2019	118	115	84.5	Nov 8	187	114	535	2.41	42.5%	610
2020	142	133	82.8	Nov 10	193	132	487	2.10	43.0%	544
2021	138	136	83.5	Nov 8	187	134	557	2.53	45.2%	629

1.5 References

1 – Garcia M, Chapman CK, Despain D. Applying Principles of Crossbreeding to maximize hybrid vigour. April 2019. Utah State University Extension; 2019 April. AG/Animal Health/2019-01pr.

2 – Beef Cattle Research Council. Replacement Heifers – Money, Management, And Momentum. Beef Cattle Research Council. 2019 Sep 18. [accessed 2022 Feb 17]. https://www.beefresearch.ca/blog/replacement-heifers-money-management-and-momentum/

3 – Rasby R. A guide to udder and teat scoring beef cows. University of Nebraska-Lincoln. [accessed 2018 Nov 25]. https://beef.unl.edu/learning/udder_score.shtml

4 – Campbell J. It's important to know when to intervene during calving. Western Producer. 2021 Mar 18. [accessed 2022 Feb 17]. https://www.producer.com/livestock/its-important-to-know-when-to-intervene-during-calving/

5 – Beef Cattle Research council. Record keeping and benchmarking: Level 2. Beef Cattle Research Council. [accessed 2022 Feb 17]. https://www.beefresearch.ca/resources/recordkeeping/level-two.cfm

1.6 Appendix I

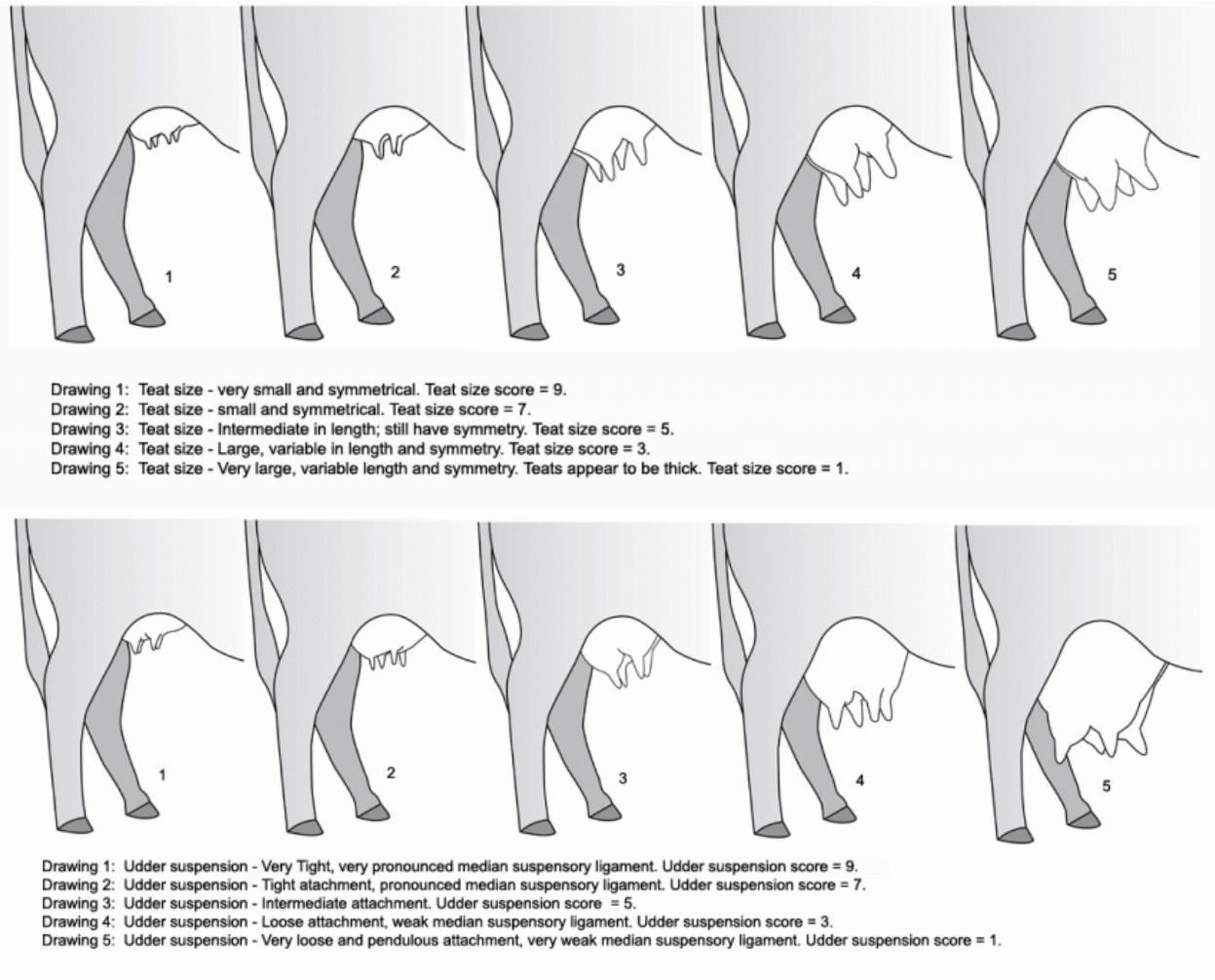


Figure 1-5. Teat and udder scoring guide[3].

Table 1-8. Calving cycles by year and breeding group.

Year	Group	Start Date First Cycle	Second Cycle	Third Cycle
2021	Purchase 1	18-Mar-21	08-Apr-21	29-Apr-21
	MBFI Heifers	11-Apr-21	02-May-21	23-May-21
	Purchase 2	20-Apr-21	11-May-21	01-Jun-21
	Mature	17-Apr-21	08-May-21	29-May-21
2020	Heifers	03-Apr-20	24-Apr-20	15-May-20
	Mature	17-Apr-20	08-May-20	29-May-20
2019	Heifers	08-Apr-19	29-Apr-19	20-May-19
	Mature	24-Apr-19	15-May-19	05-Jun-19
2018	All	19-Apr-18	10-May-18	31-May-18
2017	All	19-Apr-17	10-May-17	31-May-17
2016	All	27-May-16	17-Jun-16	08-Jul-16

Table 1-9. Changes in breeding stock numbers 2017-2019.

		2017			2018			2019			2020			2021		
Year born	Cohort	Age	Number exposed to bull	Number retained for winter	Age	Number exposed to bull	Number retained for winter	Age	Number exposed to bull	Number retained for winter	Age	Number exposed to bull	Number retained for winter	Age	Number exposed to bull	Number retained for winter
2020	H Cows	-	-	-	-	-	-	-	-	-	-	-	-	1	10	16*
2019	G Cows	-	-	-	-	-	-	-	-	-	1	17	30**	2	30	30
2018	F Cows	-	-	-	-	-	-	1	18	52***	2	46	39	3	38	35
2017	E Cows	-	-	-	1	52	44	2	41	36	3	33	30	4	30	24
2016	D Cows	1	26	18	2	18	15	3	14	12	4	10	9	5	8	8
2015	C Cows	2	40	36	3	35	31	4	28	23	5	22	19	6	18	17
2014	B Cows	3	0	0	4	0	0	5	0	0	6	0	0	7	0	0
2013	A Cows	4	1	1	5	1	1	6	1	1	7	1	1	8	1	1
2012	Z Cows	5	19	16	6	16	13	7	14	8	8	6	4	9	4	2
2011	Y Cows	6	12	10	7	10	10	8	9	7	9	7	5	10	5	5
2010	X Cows	7	3	2	8	2	1	9	1	1	10	1	1	11	1	0
2009	W Cows	8	7	3	9	3	3	10	2	2	11	0	0	12	0	0
	Total		**108**	**86**		**137**	**118**		**128**	**142**		**143**	**138**		**144**	**135**

*6 bred heifers purchased

**16 bred heifers purchased

***36 bred heifers purchased

2. Technology in the Beef Herd

2.1 Introduction

New technologies are continually becoming available and barriers to adopting on commercial farms are steadily decreasing. Depending on the technology approach it may have a high start up cost with the return of adding capacity to assist in decision-making and improve overall profitability in the long-term. For example, technology can track patterns in production and enable producers to select cows most suited for their local environment and production system. MBFI is showcasing several types of technology and documenting their use in herd management.

Genomics is the study of structure, function, evolution, and mapping of DNA and the genetic make-up of animals[1]. Genes are inherited from the parents though variation occurs through single nucleotide polymorphisms (SNP). The environment influences gene expression, so the genetic potential from the parents may not be fulfilled. Many production traits are influenced by hundreds of genes. Selection based on one gene is not encouraged. However, the development of tools such as the Igenity® Beef profile, which identifies genetic potential for a number of production traits, can aid in producer decision making on multiple genes[2].

In cattle, genomic testing is currently being used to identify breed composition, parentage, specific genes, or evaluate complex traits by whole genome analysis. Breed composition can characterize the hybrid vigour of the herd or of specific animals. Regulation of appetite and fat deposition has been found to be controlled by the leptin gene[1]. One of the leptin genotypes is TT which has been shown to enhance deposition of back and intermuscular fat (marbling) more quickly than cattle with CT (moderate) or CC (lean) classes. The leptin TT genotype are also more likely to have increased weaning weight and dam longevity due to maintained body condition. The calpastatin gene influences beef tenderness and is inherited directly from the parents[1].

On-animal monitoring of cattle is increasing in popularity and moving from dairy cattle into beef production as well. The SenseHub system uses ear tags that monitor body temperature. Data is transmitted to software that uses an algorithm to interpret the raw data to determine health alerts, animal heat cycles, and can be used to detect early pregnancy or suspected abortions[3].

2.2 Objectives

The objectives of utilizing technology in the herd are to characterize the herd to assist with:

1. Replacement heifer selection
2. Culling strategy
3. Breeding management

2.3 Methods

2.3.1 Genomic Testing

Tail hair samples are collected from breeding stock. All breeding stock were sampled in 2019, and new breeding stock are sampled as they are added to the herd. Samples are collected as described by Neogen and sent to Neogen for analysis. Tail hairs sent in 2019 were analyzed for breed composition and the leptin gene. Tail hairs sent in 2020 were analyzed for breed composition, leptin, tenderness, and profiled through the Neogen Igenity® Beef profiles. Genomic analysis has not yet occurred on any cows born in 2020, purchased cows born in 2019, or bulls purchased in 2021.

Table 2-1. Number of animals sampled for genomic analysis, 2019-2020.

	Number of animals sampled	
Birth Year	2019	2020
2019	0	17
2018	18	33
2017	39	0
2016	12	0
2015	23	0
2013	1	0
2012	12	0
2011	8	0
2010	1	0
2009	2	0
Bulls – all ages	5	3
Total	**121**	**53**

Figure 2-1. Tail hair sampling. June 27, 2019. Photos by Jordan Dickson.

2.3.2 On-Animal Monitoring

A SenseHub monitoring station commenced set-up at the Johnson Farm in April 2021. This system uses ear tags to monitor animals and alert producers when cows enter heat[3]. All animals selected for tagging with an eSense tag were summered at Johnson Farm or First Street Pasture.

2. The best place for the eSense Flex Tag is directly on the center line, ½, of the ear.

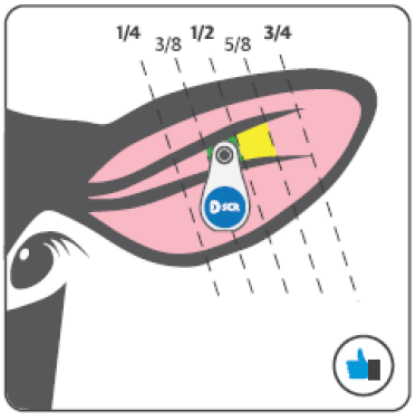


Figure 2-2. eSense tag placement[3].

SenseHub eSense tags were applied to 24 yearling heifers in early May 2021 (Figure 2-2). Heifers were tagged to monitor them as they came into first heat cycles. Thirty-six mature cows were tagged in late May 2021. Number of mature cows were selected proportionate to their age cohort. Cows with good reproductive efficiency, maternal lines in the herd, and docile cows were preferred.

Table 2-2. Number of cows tagged with eSense tags.

Birth Year	Age in 2021	Number of cows
2020	1	10
2018	3	9
2017	4	13
2016	5	3
2015	6	7
2012	9	2
2011	10	2

Figure 2-3. eSense tag in a replacement heifer. May 31, 2021. Photo by Leah Rodvang.

2.4 Genomic Testing

2.4.1 Breed Composition

Bulls have been primarily purchased from Black Angus breeders, either purebred or commercial (Figure 2-3). This is to aid in the development of a maternal Black Angus Herd (Section 3 **Breeding Stock** Selection). One Hereford bull was purchased in 2020 to begin a crossbreeding program (Section 4 **Application of the Crossbreeding** Program). Bulls active from 2016-2021 are included in Figure 2-3 (Table 2-5, Appendix II).

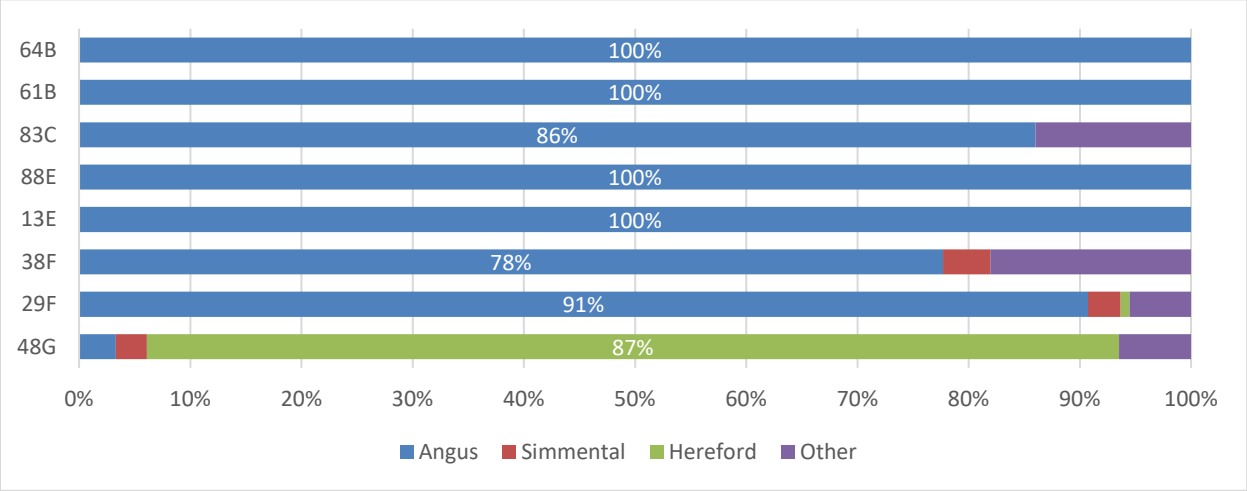


Figure 2-4. Breed composition of bulls active from 2019-2021. Bulls purchased in 2021 are not shown.

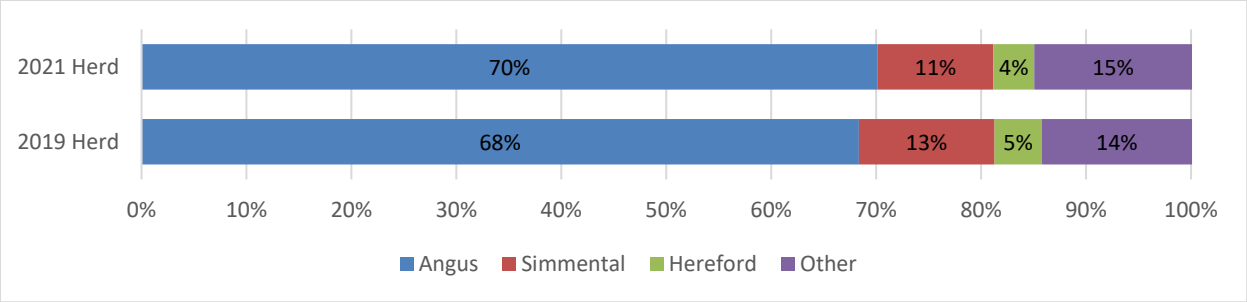


Figure 2-5. Overall breed composition of the herd in 2019 and 2021.

The breed composition of the cow herd is primarily Angus (Figure 2-4). Many cows have Simmental or Hereford influence; other breeds show up in small amounts. Between 2019 and 2021, there has been a small increase in the percentage of Angus genetics in the herd, with a corresponding decrease in the amount of Simmental. This is due to purchase of commercial straight-bred Black Angus bred heifers and the culling of older cows (Figure 2-5). We are not currently culling breeding stock for sale based on their breed composition (Section 5 **CULLING STRATEGY**).

Beginning in 2019 with the selection of replacement heifers from both the MBFI herd and from outside sources, an emphasis was placed on Black Angus to build a foundation herd prior to crossbreeding (Section 4. **APPLICATION OF THE CROSSBREEDING PROGRAM**). Proportion of Angus varies between age cohorts but is higher in the younger cows (Figure 2-5). Replacement heifers developed and bred at MBFI from 2016-2019 have Black Angus sires (Figure 2-3). The 2019 cohort in Figure 2-5 does not include the purchased bred heifers from 2021 (Table 2-6, Appendix II).

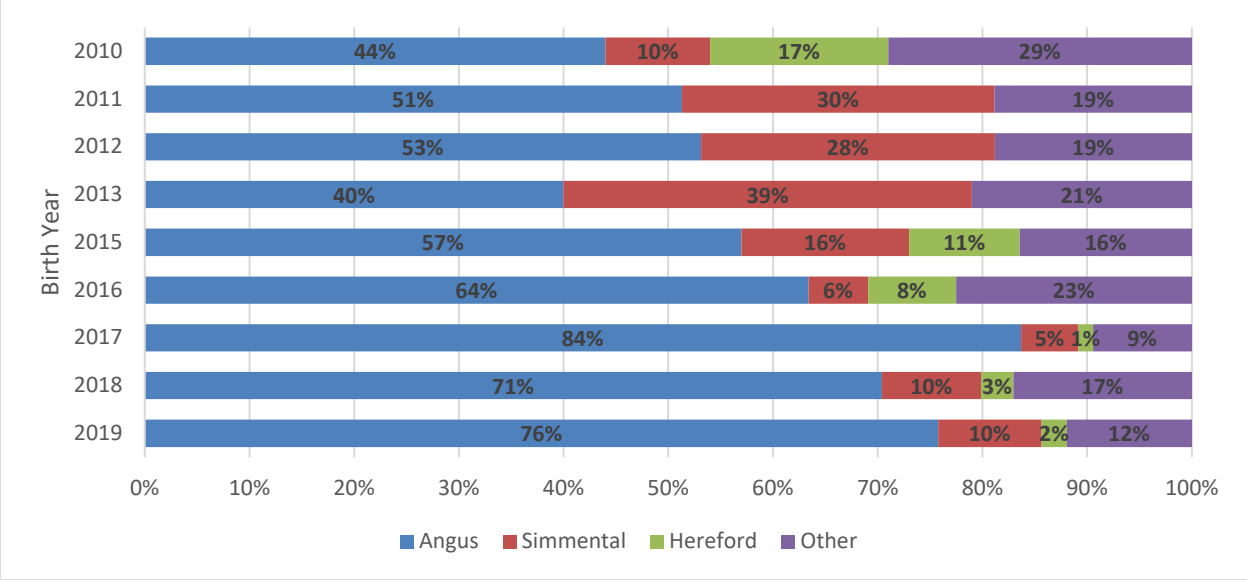


Figure 2-6. Breed composition by cow birth year in 2021.

2.4.2 Carcass Traits

Leptin gene identification has been performed on 152 breeding females at MBFI (Table 2-2). Seven bulls have been tested. The TT genotype indicates improved carcass traits compared to CC cattle, with CT being moderate between the TT and CC genotypes.

Table 2-3. Results of leptin analysis on breeding stock.

Genotype	Number of cows	Number of bulls
TT	51	2
CT	67	4
CC	34	1

In the 2021 herd, most cows had the CT genotype (Figure 2-6). Of the four bulls from the 2021 herd sampled, three bulls had the CT genotype and one bull had the TT genotype.

Fifty-three animals were tested for three tenderness indicators, Calpain316, Calpain 4751, and CAST. Neogen uses the resulting genotypes to assign a tenderness score to each animal (Table 2-4). Tenderness score indicates the tenderness genetic potential from 1 (tough) to 10 (tender)[4].

Table 2-4. Results of genetic potential for tenderness.

Tenderness Score	Number of cows	Number of bulls
1	0	0
2	0	0
3	1	0
4	15	0
5	4	2
6	9	0
7	12	1
8	2	0
9	6	0
10	1	0

2.4.3 Igenity® Beef Profile

Igenity® Beef profiles have been completed on 47 cows and 3 bulls. Igenity® Beef profiles evaluate the genetic potential for many traits (Figure 2-9, Appendix II)[5]. These traits are combined to create a Production Index and a Maternal Index (Figure 2-7). Both are tools developed for selection of cattle based on multiple traits. The production index favours maternal, production, and carcass traits, and is intended for selection of replacement heifers. The maternal index favours maternal traits such as fertility, longevity, and calf weaning weight, and is designed for selecting replacement heifers in production systems where calves are sold shortly after weaning. Scores are given out of 10, with 10 indicating the highest genetic potential.

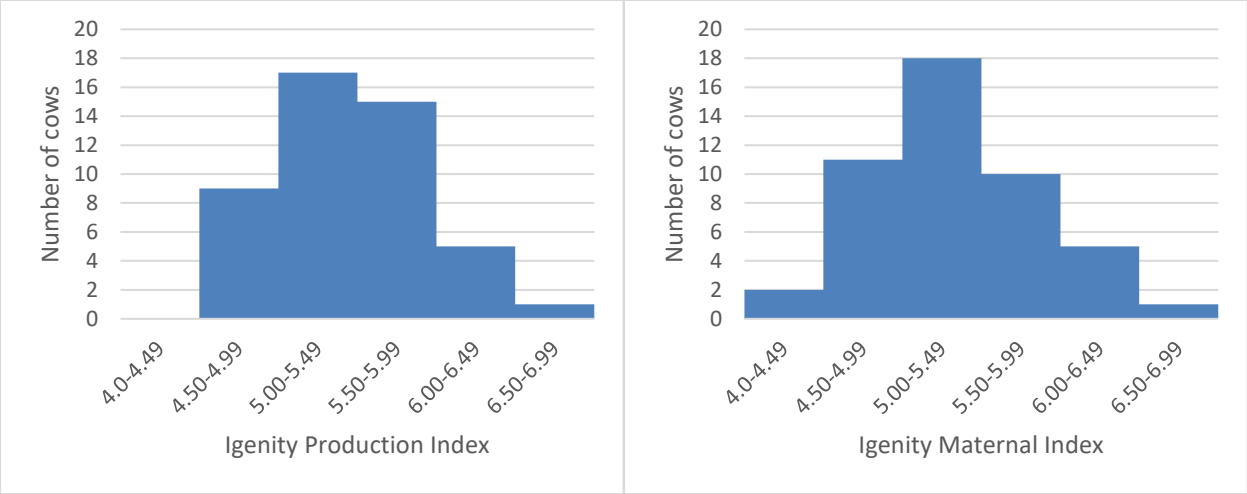


Figure 2-7. Results of Igenity® analysis for Production Index (left) and Maternal Index (right).

2.5 On-animal Monitoring

In 2021, MBFI began setting up a SenseHub monitoring system to monitor cows on pasture. The focus of this demonstration is on breeding, by monitoring heat cycles. Some data has been collected but has been interrupted due to difficulty building data collection and transmission stations for the field.

Cattle with ear tags must be near a collection station once per day for data transmission. Figure 2-8 shows four bred heifers from February 2022. Data was collected when cows came to the corral for water. If an animal does not come near enough to a collection station, data for the day is not collected and is seen as gaps in the data. Other potential issues include the tag turning into the ear and getting stuck.

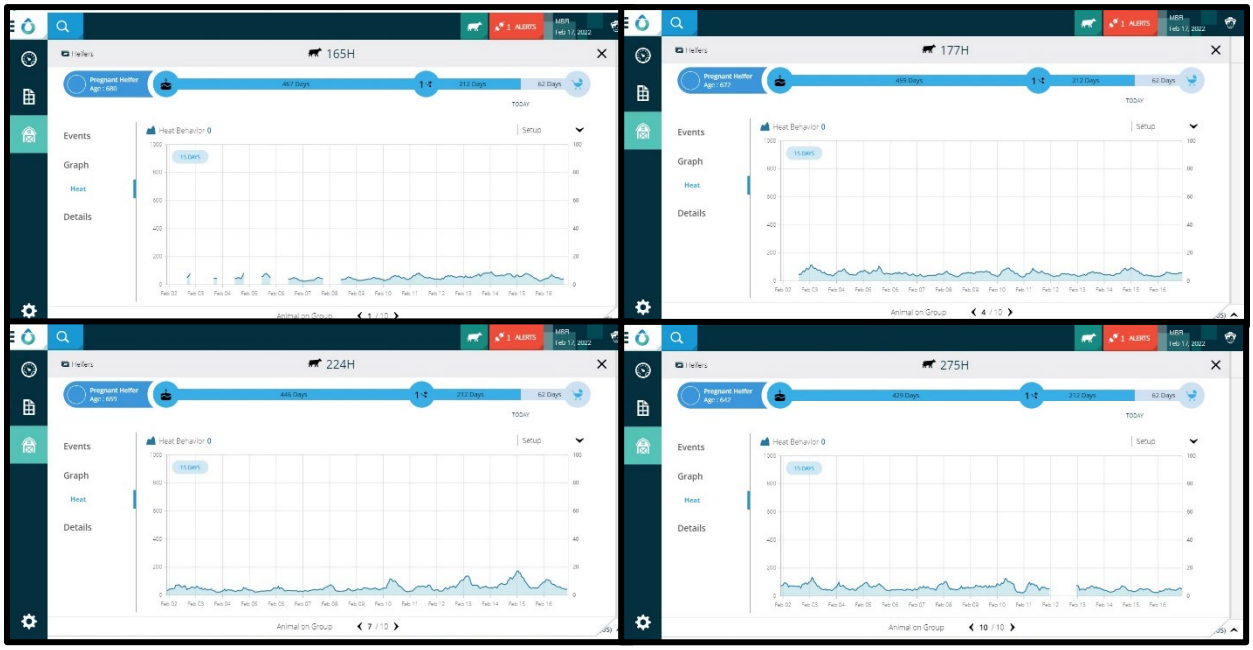


Figure 2-8. Heat graphs for four bred heifers as displayed on the SenseHub interface.

2.6 Summary

MBFI is in the beginning stages of herd development. Genetic traits were considered for selection of replacement heifers in 2021 (J cohort) (Section 3 **BREEDING STOCK SELECTION**). However, our herd conformation is currently not to a sufficient standard to begin to cull based on information from genomic sampling or animal monitoring. In the future, genomic testing may be used for breeding management, such as selecting breeding groups and assigning bulls. On-animal monitoring will provide information regarding cow estrus cycles and provide early alerts for return to estrus, conception, and abortions.

2.7 References

1 – Beef Cattle Research Centre. Genomics. Beef Cattle Research Centre. 2020 Oct 9. [accessed 2022 Jan 28]. https://www.beefresearch.ca/research-topic.cfm/genomics-56

2 – Neogen. Igenity® Beef Handbook: The path of confidence. Igenity. 2020. [accessed 2022 Jan 7]. https://www.neogen.com/categories/igenity-profiles/igenity-beef/

3 – SenseHub User Guide revision 4.3. SCR by Allflex LTD. 2018. [updated 2020 Jul; accessed 2021 Apr 19].

4 – Neogen. Tenderness/Leptin. Neogen. [accessed 2022 Feb 18]. https://www.neogen.com/categories/livestock-genetic-traits-conditions/tenderness-leptin/

5 – Neogen. Igenity® Beef. Neogen. [accessed 2022 Feb 18]. https://www.neogen.com/categories/igenity-profiles/igenity-beef/

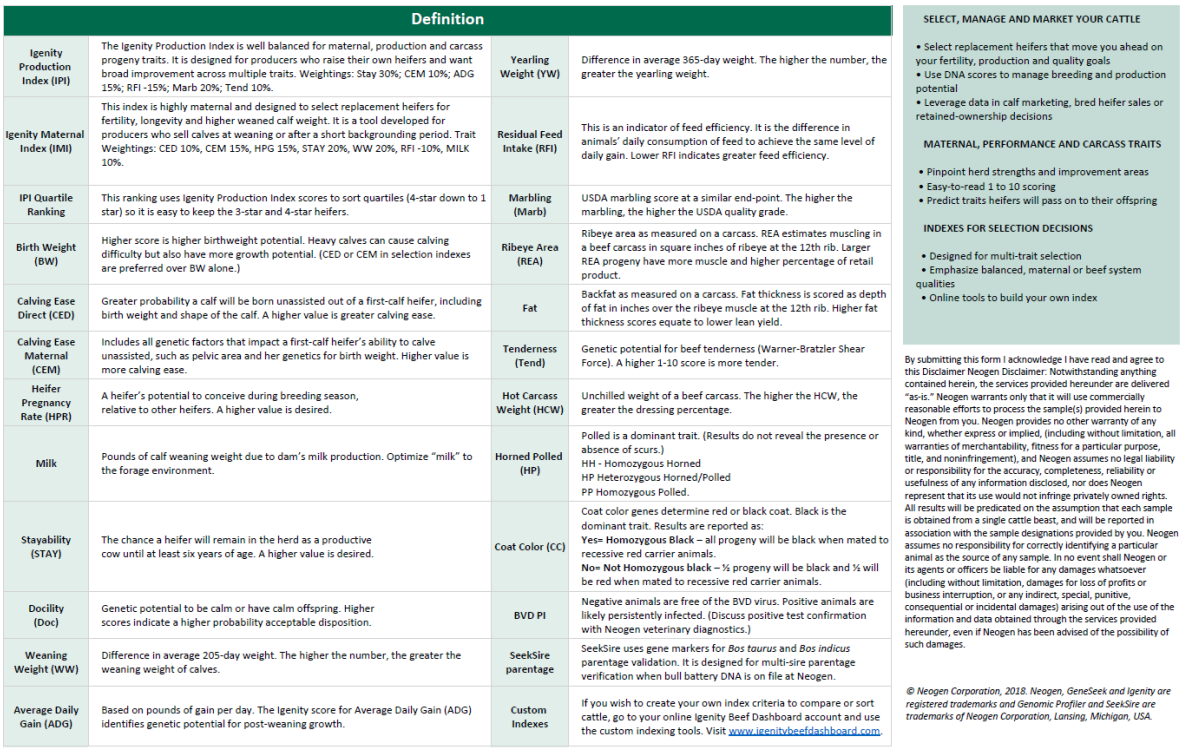
2.8 Appendix II

Table 2-5. Breed and active dates of bulls utilized from 2019-2021.

Bull ID	Primary breed	Active dates
64B	Black Angus	Active 2016-2019
61B	Black Angus	Active 2016-2019 and 1 week in 2020
83C	Black Angus	Active 2016-2020
88E	Black Angus	Active 2018-2019
13E	Black Angus	Active 2018-2021
38F	Black Angus	Active 2020-2021
29F	Black Angus	Active 2020-2021
48G	Hereford	Active 2020-2021

Table 2-6. Number of animals sampled for genomic trait analysis in the 2021 herd.

Age cohort	Breed Composition	Leptin	Tenderness	Igenity® Profile	Total Number in Herd
G Cows	14	14	14	14	30
F Cows	38	38	27	27	38
E Cows	30	29	0	0	30
D Cows	7	7	0	0	8
C Cows	18	18	0	0	18
A Cows	1	1	0	0	1
Z Cows	4	4	0	0	4
Y Cows	5	5	0	0	5
X Cows	1	1	0	0	1
Bulls	4	4	3	3	7



Definition			
Igenity Production Index (IPI)	The Igenity Production Index is well balanced for maternal, production and carcass progeny traits. It is designed for producers who raise their own heifers and want broad improvement across multiple traits. Weightings: Stay 30%; CEM 10%; ADG 15%; RFI -15%; Marb 20%; Tend 10%.	**Yearling Weight (YW)**	Difference in average 365-day weight. The higher the number, the greater the yearling weight.
Igenity Maternal Index (IMI)	This index is highly maternal and designed to select replacement heifers for fertility, longevity and higher weaned calf weight. It is a tool developed for producers who sell calves at weaning or after a short backgrounding period. Trait Weightings: CED 10%, CEM 15%, HPG 15%, STAY 20%, WW 20%, RFI -10%, MILK 10%.	**Residual Feed Intake (RFI)**	This is an indicator of feed efficiency. It is the difference in animals' daily consumption of feed to achieve the same level of daily gain. Lower RFI indicates greater feed efficiency.
IPI Quartile Ranking	This ranking uses Igenity Production Index scores to sort quartiles (4-star down to 1 star) so it is easy to keep the 3-star and 4-star heifers.	**Marbling (Marb)**	USDA marbling score at a similar end-point. The higher the marbling, the higher the USDA quality grade.
Birth Weight (BW)	Higher score is higher birthweight potential. Heavy calves can cause calving difficulty but also have more growth potential. (CED or CEM in selection indexes are preferred over BW alone.)	**Ribeye Area (REA)**	Ribeye area as measured on a carcass. REA estimates muscling in a beef carcass in square inches of ribeye at the 12th rib. Larger REA progeny have more muscle and higher percentage of retail product.
Calving Ease Direct (CED)	Greater probability a calf will be born unassisted out of a first-calf heifer, including birth weight and shape of the calf. A higher value is greater calving ease.	**Fat**	Backfat as measured on a carcass. Fat thickness is scored as depth of fat in inches over the ribeye muscle at the 12th rib. Higher fat thickness scores equate to lower lean yield.
Calving Ease Maternal (CEM)	Includes all genetic factors that impact a first-calf heifer's ability to calve unassisted, such as pelvic area and her genetics for birth weight. Higher value is more calving ease.	**Tenderness (Tend)**	Genetic potential for beef tenderness (Warner-Bratzler Shear Force). A higher 1-10 score is more tender.
Heifer Pregnancy Rate (HPR)	A heifer's potential to conceive during breeding season, relative to other heifers. A higher value is desired.	**Hot Carcass Weight (HCW)**	Unchilled weight of a beef carcass. The higher the HCW, the greater the dressing percentage.
Milk	Pounds of calf weaning weight due to dam's milk production. Optimize "milk" to the forage environment.	**Horned Polled (HP)**	Polled is a dominant trait. (Results do not reveal the presence or absence of scurs.) HH - Homozygous Horned HP Heterozygous Horned/Polled PP Homozygous Polled.
Stayability (STAY)	The chance a heifer will remain in the herd as a productive cow until at least six years of age. A higher value is desired.	**Coat Color (CC)**	Coat color genes determine red or black coat. Black is the dominant trait. Results are reported as: **Yes= Homozygous Black** – all progeny will be black when mated to recessive red carrier animals. **No= Not Homozygous black** – ½ progeny will be black and ½ will be red when mated to recessive red carrier animals.
Docility (Doc)	Genetic potential to be calm or have calm offspring. Higher scores indicate a higher probability acceptable disposition.	**BVD PI**	Negative animals are free of the BVD virus. Positive animals are likely persistently infected. (Discuss positive test confirmation with Neogen veterinary diagnostics.)
Weaning Weight (WW)	Difference in average 205-day weight. The higher the number, the greater the weaning weight of calves.	**SeekSire parentage**	SeekSire uses gene markers for *Bos taurus* and *Bos indicus* parentage validation. It is designed for multi-sire parentage verification when bull battery DNA is on file at Neogen.
Average Daily Gain (ADG)	Based on pounds of gain per day. The Igenity score for Average Daily Gain (ADG) identifies genetic potential for post-weaning growth.	**Custom Indexes**	If you wish to create your own index criteria to compare or sort cattle, go to your online Igenity Beef Dashboard account and use the custom indexing tools. Visit www.igenitybeefdashboard.com.

SELECT, MANAGE AND MARKET YOUR CATTLE

- Select replacement heifers that move you ahead on your fertility, production and quality goals
- Use DNA scores to manage breeding and production potential
- Leverage data in calf marketing, bred heifer sales or retained-ownership decisions

MATERNAL, PERFORMANCE AND CARCASS TRAITS

- Pinpoint herd strengths and improvement areas
- Easy-to-read 1 to 10 scoring
- Predict traits heifers will pass on to their offspring

INDEXES FOR SELECTION DECISIONS

- Designed for multi-trait selection
- Emphasize balanced, maternal or beef system qualities
- Online tools to build your own index

Figure 2-7. Traits assessed in Igenity® Beef profiles. Included with results.

3. Breeding Stock Selection

3.1 Introduction

Current breeding stock impact profitability of the calf crop and potential future replacements. Replacement heifer selection affects herd genetics, future calf performance, and cow longevity[1]. Bull selection has considerable impact on calf performance and genetics for future replacement heifers as bulls sire many calves per season. Explicit herd management goals are essential for long-term improvement of overall herd metrics.

Development of replacement heifers represents a significant annual investement[2]. Depending on an individual's annual cost of production, it can take an average of five to six marketed calves from a heifer to pay back the cost of development. Choosing replacement heifers that will breed early, deliver a healthy calf, and rebreed increases the profitability of that cow and sets her up for future calving seasons. Herd management practices, including nutrition programs and preventative health programs, further improve the chances of retaining a replacement heifer in the herd for years[1,2].

Herd management at MBFI currently has two broad goals. The first goal is to increase the size of the cow herd. The second is to build a straight-bred Black Angus maternal breeding group to use as a foundation for a crossbreeding strategy. Purchase of Black Angus bred heifers in 2020 and 2021 fulfill both goals. Replacement heifers selected from the herd are also selected with herd goals in mind. Larger numbers of heifers are selected in later years. Evaluation of dams, production, and health records contribute to heifer selection. Bull purchases are intended to improve calf performance and conformation of potential replacement heifers.

To assist in achieving production and crossbreeding goals, MBFI has developed a set of criteria for selecting breeding stock from internal and external sources.

3.2 Objectives

Use breeding stock selection to:

1. Create a base herd – primarily straight-bred Black Angus
2. Use heifer selection to improve herd conformation traits
3. Use genomic and performance indicators to select replacement heifers
4. Evaluate heifer development

3.3 Criteria for breeding stock selection

3.3.1 Replacement heifers from within the herd

Production records are maintained for all animals throughout their time at MBFI. The following records are collected for each potential replacement heifer:

- Parentage – Dam and Sire (when known)
- Dam linage
- Breed composition as determined by genomic testing
- Sire EPDs (when sire is known)
- Genetic traits (Igenity® Beef profile, carcass traits)

- Dam udder
- Dam feet
- Dam longevity and any sisters retained in the herd
- Dam weights and Body Condition Score
- Dam management group during conception of the heifer
- Birth date – in which calving cycle was the heifer born
- Calf management group
- Performance as a calf – birth weight, weaning weight, average daily gain
- Feed strategy after weaning

Some calves are from multi-sire breeding groups, so sire is not known. At this time, no parentage testing has taken place.

The following criteria were chosen in 2018 for selecting female breeding stock (in reference to Canadian national average for Black Angus breed):

- Body conformation; moderate frame (Frame 5)
- 60% of height is in body depth
- Udder soundness; score 5 or higher
- Milk; moderate
- Feet soundness; ideal 5 for claw set and foot angle
- Birth weight, weaning weight, and yearling weight (moderate to above average)
- Dam characteristics of the above
- Health history

Three additional criteria were assessed when selecting replacement heifers. The first was calving cycle; heifers were selected from the first cycle or early in the second cycle. Calf weight at weaning as a percent of dam weight was considered to assist in bringing the overall herd average closer to 50%. The third criterium was dam breed composition and was a primary driver of selection in 2021. Higher percentages of Angus are preferred to assist in building the straight-bred Black Angus foundation herd.

In practice some of these criteria presented difficulties. No frame measurements have been conducted at this time, so only visual assessments of body conformation occurred. Milk and feet soundness were likewise only qualitatively assessed.

Unexpected factors challenged heifer selection. In 2019, only heifers raised at the Brookdale site were chosen as there were concerns about the nutrition and health status of heifers raised at First Street. This reduced the pool of potential replacements from 49 to 25. In 2021, fifteen replacement heifers were sold prior to breeding due to disposition, reducing heifer numbers from 25 to 10 (Table 3-1).

Table 3-1. Replacement heifer numbers 2018-2021.

Cohort	Birth Year	Number retained after weaning	Number sold prior to breeding	Reason for sale	Number exposed to bull
F heifers	2018	18	0	-	18
G heifers	2019	18	1	Poor health	17
H heifers	2020	25	15	Disposition	10

J heifers	2021	28	n/a	n/a	n/a

Feeding and grazing strategies changed through the years (Table 3-2). High open rates in 2017 and 2018 prompted concerns that replacement heifers were not sufficiently developed at time of first exposure to a bull, so 12% protein pellets were supplemented after weaning, beginning with the F cohort. The D and E cohorts spent time on First Street as yearling heifers. The F, G, and H cohorts were kept on the higher quality forage at the Johnson Farm for summer. Starting in winter 2019-2020, all young cows were moved to Brookdale after pregnancy check for higher quality winter and summer feed. The D & E cows spent Year 2, their second exposure with their first calves at foot, on First Street. Poor health in 2019 and lower quality forage prompted a management change in 2020 and younger cows were kept at Brookdale for Year 2.

Table 3-2. Feeding & grazing strategies for each cow cohort from weaning until the second calving season.

		After Weaning	Year 1 (1st exposure – 1st calf)		Year 2 (2nd exposure – 2nd calf)	
Cohort	Birth Year	Winter	Summer Grazing	Winter Feeding	Summer Grazing	Winter Feeding
H Cows	2020	Supplemented protein pellets	Johnson Farm, 2+ days per move	Corn and bale grazing	-	-
G Cows	2019	Supplemented protein pellets	Johnson Farm, 2+ days per move	Corn and bale grazing	Brookdale Farm	Corn and bale grazing
F Cows	2018	Supplemented protein pellets	Johnson Farm, 2+ days per move	Corn grazing	Brookdale Farm	Corn and bale grazing
E Cows	2017	Hay	First Street & Johnson Farm	Bale grazing	First Street Pasture	Bale grazing
D Cows	2016	Hay	First Street	Bale grazing	First Street Pasture	Bale grazing

3.3.2 Replacement heifers from external sources

When selecting bred heifers for purchase, an emphasis was placed on straight-bred Black Angus cows with moderate frames and deep bodies. An evaluation of the source herd was performed prior to purchase. Thirty-six bred F heifers were purchased in early 2020, sixteen bred G heifers were purchased in late 2020, and six bred H heifers were purchased in late 2021.

3.3.3 Bull purchases

Bulls have been purchased from purebred Black Angus, commercial Black Angus, and Hereford herds (Table 3-3). A qualitative evaluation of conformation was paired with an evaluation of Expected Progeny Differences (EPDs)[3]. Bulls were selected for EPDs close to the breed average. All bulls were purchased at two years of age or younger.

Table 3-3. Bull purchases 2020-2021.

Year	Number Purchased	Breed
2020	2	Black Angus
2020	1	Hereford
2021	3	Black Angus

3.4 Discussion

3.4.1 Replacement heifer selection

Replacement heifer selection is designed to improve the overall herd. As the overall cow herd improves in conformation and production characteristics, more stringent selection criteria can be applied. The increased number of calves raised at MBFI every year has increased the pool of potential replacement heifers.

Table 3-4. Average dam age of retained replacement heifers

Birth Year	Age (years)
2018	5.1
2019	6.1
2020	3.4
2021	4.1

Average dam age of replacement heifers changed from 2018 to 2021 (Table 3-4). In 2018 and 2019 the dams were older, producing larger calves with better body condition. In 2019 younger cows were all at First Street and their calves were not chosen due to health concerns. In 2020 and 2021 more replacement heifers were chosen from younger cows as they fit both criteria of higher percentage Angus and good body conformation. By 2020, MBFI had cows onsite that had been conceived and raised at MBFI or purchased to fit the herd management plan and these younger cows were producing calves that fit production and conformation goals.

Table 3-5 compares weight characteristics of replacement heifers to those of all heifers from that year. Birth weight, weaning weight, average daily gain, and percent of dam weight at weaning are all higher for replacement heifers than for the average of all heifers in the herd. The higher weaning weights and average daily gain of replacement heifers from 2019 compared to the other years is likely due to selecting heifers only from older cows and only heifers raised on the higher quality forage at Brookdale Farm.

Calf weight at weaning as a percent of the dam weight has increased from 2018 to 2021 (Table 3-5). This is partially due to reduced dam weights and increased weaning weights and partially due to the younger dams in 2020 and 2021 who have not yet reached their mature weights.

Table 3-5. Weight characteristics of replacement heifers

	Birth Weight (lb)		Weaning Weight (lb)		Average Daily Gain (lb/day)		% of Dam Weight at Weaning	
Birth Year	Replacement Heifers	All Heifers	Replacement Heifers	All Heifers	Replacement Heifers	All Heifers	Replacement Heifers	All Heifers
2018	78	72	562	519	2.24	2.10	44.6%	42.2%
2019	87	81	615	537	2.57	2.34	44.3%	42.4%
2020	84	81	512	473	2.16	2.03	46.1%	42.3%
2021	80	81	570	545	2.52	2.49	46.7%	43.5%

Replacement heifers are chosen from dams that calved in the first cycle or early in the second cycle to maximize the number of heifers that conceive after their first exposure to a bull (Table 3-6)[2]. The total number of calves born in the first cycle influences the number of potential replacement heifers and is another reason to maintain a tight breeding and calving season.

Table 3-6. Number of replacement heifers born in each calving cycle.

		Number of replacement heifers		
Cohort	Birth Year	Born in the 1st cycle	Born in the 2nd cycle	Total
F Heifers	2018	18	0	18
G Heifers	2019	15	2	17
H Heifers	2020	19	6	25
J Heifers	2021	20	8	28

Dam breed composition was not a priority until selection of replacement heifers in 2021. There is a noticeable change in number of dams above 50% Angus in the H heifers (Table 3-7). This is partially due to a higher number of calves selected from younger cows, which have an overall higher proportion of Angus (FIGURE 2-6). In 2021, only one calf with a dam less than 50% Angus was selected; this heifer had exceptional body conformation and a purebred Angus sire.

Sires for all replacement heifers from 2018, 2019, and 2020 were Black Angus. In 2021, four replacement heifers had Hereford sires. For all four calves, dams were over 50% Angus.

Table 3-7. Number of dams and percent of breed composition Angus.

		Breed Composition		
Birth Year	Number of dams sampled	>80% Angus	50-80% Angus	<50% Angus
2018	12*	2	5	5
2019	18	1	8	9
2020	25	9	12	4
2021	28	16	11	1

** Six dams from 2018 were not sampled.*

Dam udders are assessed prior to selecting replacement heifers. Cow udders are assessed 24-48 hours after calving based on criteria for teats and udders (FIGURE 1-5). A scale of 1-9 is used for both teats and udders, with 9 being the ideal score and is reported as {teat score, udder score}. The udder score from the previous calving season is used for each replacement heifer (see **1.4 HERD BACKGROUND** for an overview).

The number of replacement heifers selected from dams with good udders is increasing due to previous selection based on udder conformation (Table 3-8) (Section 5 **CULLING STRATEGY**). In addition, younger cows score higher. The lower average dam age in 2020 and 2021 boosts the number of dams with high udder scores.

Table 3-8. Number of dam udder scores 5,5 or better.

Year Born	Number of dams sampled	Number 5,5 or better	Percent 5,5 or better
2018	13	9	69.2%
2019	18	12	66.7%
2020	25	22	88.0%
2021	28	26	92.9%

While no quantitative evaluation has occurred, dams are assessed for feet soundness, body conformation, and longevity. Strong maternal lines are developing within the herd and heifers with good mothers, grandmothers, and sisters are given careful consideration.

Real world challenges have occurred when selecting heifers. One obstacle has been reduction of potential replacement heifers due to health and disposition concerns. However, a shift toward chosen traits, including breed and udder conformation, has occurred. As more replacement heifers are selected from high quality dams, other selection criteria such as Igenity® scores (**2.4.3 IGENITY® BEEF PROFILE**) and sire EPDs can be assessed. Quantitative evaluation of body conformation and foot scoring can also be included.

3.4.2 Replacement heifer development

The first group of calves born were born at MBFI in 2016. These calves were from purchased bred cows. The first set of calves bred and born at MBFI were the E cohort. This section will consider calves born and raised at MBFI in 2016, 2017, 2018, 2019, and 2020 (D, E, F, G, and H cohorts respectively).

Bred heifers were purchased in January 2020, October 2020, and December 2021 (born 2018, 2019, and 2020). These heifers are included in data collected from their arrival, including weights, open rate, culling numbers, and calf performance data.

Replacement heifers are tracked over the first two seasons to observe where weight changes occurred (Figure 3-1). Weaning weights vary. Heifers born in 2018, 2019, and 2020 are heavier at their first breeding. These groups were fed supplemental 12% protein pellets over the winter. This increased weight is still observed at the first pregnancy check. However, by the second exposure, the weights are less variable between age cohorts. Average daily gain and current weight as a percent of mature weight show similar trends to measured weight as shown in Figure 3-1. Most weight change occurs between weaning and first breeding, and the heifers born in 2018, 2019, and 2020 gain weight faster until the 1st pregnancy check, when weights evened out between cohorts.

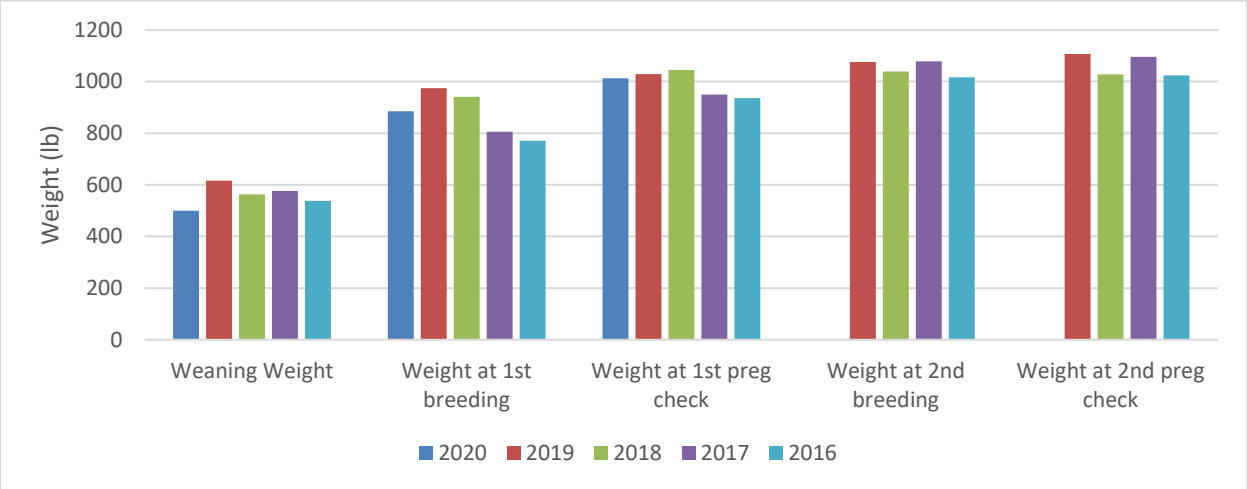


Figure 3-1. Average actual weights of heifers during development by cow birth year.

Open rates vary by cohort (Table 3-9). In the heifers born in 2016 and 2017, concerns about nutrition and development were raised about high open rates after the first exposure to the bull. The replacement heifers born in 2018, 2019, and 2020 were managed differently (Table 3-2). All heifer breeding groups are single sire groups. The largest group was 27 heifers with one bull (half the 2017-born heifers in their first season). The smallest breeding group was the 2020-born heifers in Year 1 (Table 1-4, 1.4.2 BREEDING MANAGEMENT). Following their first calf, cows were in single or multi-sire breeding groups depending on project and farm requirements.

High open rates occurred in the 2018-born cows in Year 2 and the 2017-born cows in Year 4. The open 2018-born cows in Year 2 were not the same cows with difficult assisted births. Nutrition for summer grazing was a concern for five of the seven open 2018-born cows that year. The high number of open 2017-born cows in Year 4 was surprising, though we did note that a difficult first two winters combined with poor health in Year 2 may have lasting effects. The very high open rate in the 2016-born cohort in Year 1 is likely a combination of winter ration nutrition, summer grazing nutrition, and being a younger age at breeding (Table 1-9, Appendix I).

Table 3-9. Open rate of developing cows by cohort, where Year 1 is the first year heifers are exposed to the bull. Reported as Open% (Number open/number exposed).

Birth Year	Year 1	Year 2	Year 3	Year 4	Year 5
2020	0% (0/10)	-	-	-	-
2019	12% (2/17)	7% (2/29)	-	-	-
2018	11% (2/18)	15% (7/46)	5% (2/38)	-	-
2017	15% (8/52)	2% (1/41)	6% (2/33)	17% (5/30)	-
2016	31% (8/26)	11% (2/18)	7% (1/14)	10% (1/10)	0% (0/8)

When comparing pregnant and open replacement heifers after their first exposure to the bull, there was no difference in weights during the breeding season (Figure 3-2). However, body weight only shows a portion of the animal development and misses other nutrition and health markers that impact onset of cycling. Utilization of technology such as the eSense tags (**2.5 ON-ANIMAL MONITORING**) may provide further insights into why certain heifers are open after their first exposure to a bull.

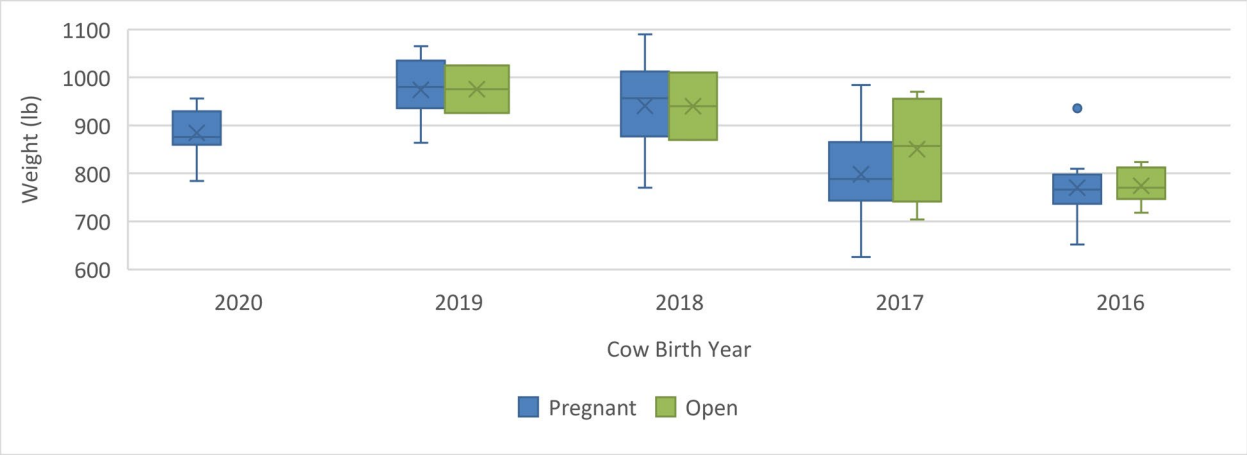


Figure 3-2. Weights at first exposure to a bull and result of the first pregnancy check for each age cohort.

The primary loss of young female breeding stock is to open cows (Table 3-11, Appendix III). In 2020, a difficult calving season led to a large number of cows sold as they did not have a live calf at foot for the summer grazing season (Section 5 **CULLING STRATEGY**). The heifers born in 2018, 2019, and 2020 have a higher retention rate in Year 1, when they are first exposed to the bull (Figure 3-3), caused by the lower open rate (Table 3-9). The entire cohort is included in the base number, which includes the purchased bred heifers. More data collected in the future will strengthen trends; currently there appears to be a large drop in percent of the original cohort after pregnancy check in Year 2 (the year they raise their first calf). Though other factors may confound this observation, it appears that higher retention from the original cohort in Year 1 increases retention in following years.

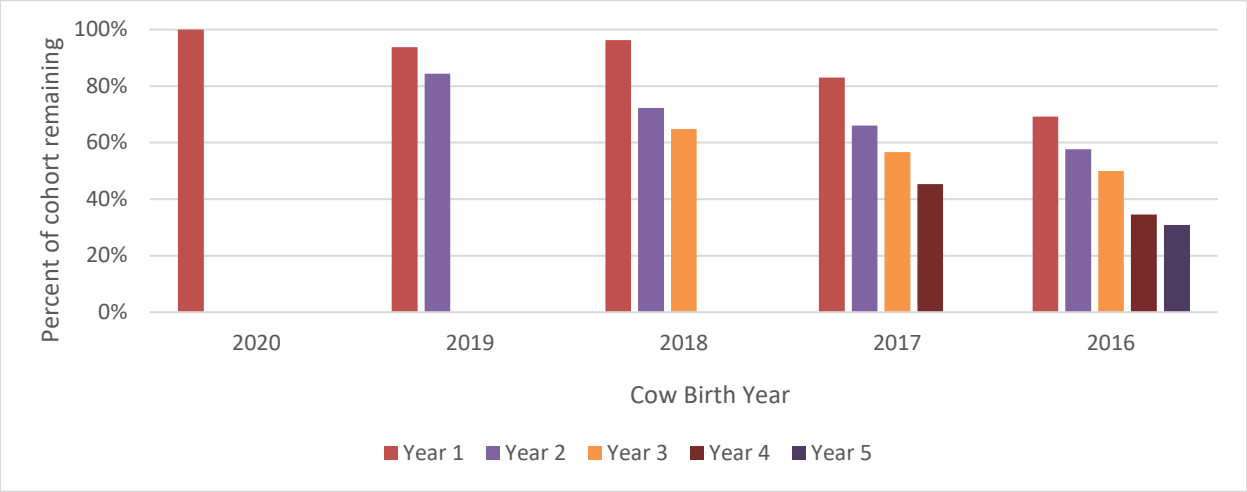


Figure 3-3. Percent of original cohort remaining after pregnancy check each year, where Year 1 is the first year heifers are exposed to the bull.

Choosing replacement heifers born in the first cycle and keeping a tight breeding season aids in establishing cohorts that calve consistently in the first cycle[2]. Heifers also require 80-100 days after their first calf to be ready for rebreeding, so having most heifers calve in the first cycle increases the chance

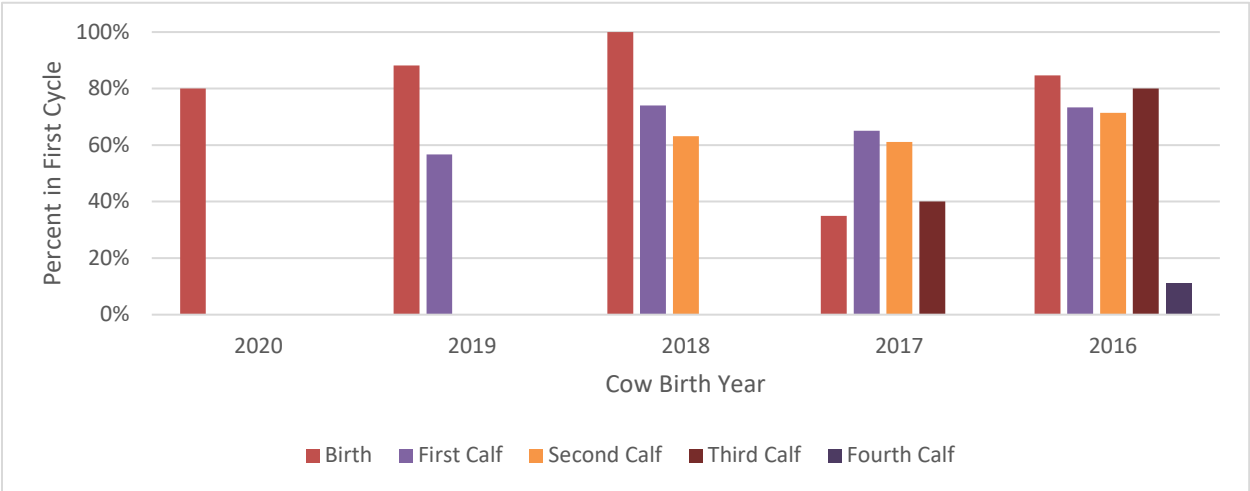


Figure 3-4. Percent of cohort in the first calving cycle from birth to fourth calf. Each cohort is compared to the number of cows calved in that year. (Note: The E, F, and G Cows included purchased cattle with no information about which calving cycle they were born in and are included from First Calf.

of conception for the second calf. There is no consistent trend between age cohorts in percent calving in the first cycle (Figure 3-4). Percent calving in the first cycle can go up between years. Cows born in 2017, who had a low percent of births from the first cycle, were comparable to other cohorts for their first calf. As cows age and more cohorts are developed, this data may show more consistent trends.

For the entire herd, 2021 had a low percentage of the herd that calved in the first cycle (Figure 1-4). In 2021, the 2019-born cows had their 1st calf, the 2018-born cows had their 2nd calf, the 2017-born cows had their 3rd calf, and the 2016-born cows had their 4th calf. All cohorts saw a drop compared to the previous year, though the 2018-born cows dropped the least.

3.5 References

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3.6 Appendix III

Table 3-10. Number of cows born or calved in each calving cycle.

		Birth		First Calf			Second Calf			Third Calf			Fourth Calf		
Cohort	Birth Year	1st	2nd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
H Cows	2020	8	2	-	-	-	-	-	-	-	-	-	-	-	-
G Cows*	2019	15	2	17	12	1	-	-	-	-	-	-	-	-	-
F Cows*	2018	18	0	37	12	1	24	12	2	-	-	-	-	-	-
E Cows*	2017	7	13	28	12	3	22	14	0	12	14	4	-	-	-
D Cows	2016	22	4	11	2	2	10	3	1	8	1	1	1	7	1

**Purchased cows are not included in the birth numbers; they are included from the first calf numbers.*

Table 3-11. Gains and losses in number of cows by cohort.

Age	Reasons for changes	D Cows	E Cows	F Cows	G Cows	H Cows
Heifer calves	Number retained for replacements	26	20	18	18	25
	Number sold prior to breeding	0	0	0	1	15
	Number replacement heifers purchased	0	33	0	0	0
1st breeding	Number exposed to bull	26	53	18	17	10
	Number died prior to preg check	0	1	0	0	0
	Number open	8	8	2	2	0
	Number sold for herd management	0	0	0	1	0
	Number of bred heifers purchased	0	0	36	16	6
	Number expected to calve 1st season	18	44	52	30	16
	Number of abortions	3	0	2	0	-
	Number died prior to calving	0	0	0	0	-
	Number sold no live calf	0	1	3	0	-
	Number of live calves	15	43	47	30	-
2nd breeding	Number exposed to bull	18*	43	47	30	-
	Number died prior to preg check	0	0	1	1	-
	Number open	2	1	7	2	-
	Number sold for herd management	1	7	0	0	-
	Number expected to calve 2nd season	15	35	39	27	-
	Number of abortions	0	0	1	-	-
	Number died prior to calving	1	0	0	-	-
	Number sold no live calf	0	2	0	-	-
	Number of live calves	14	33	38	-	-
3rd breeding	Number exposed to bull	14	33	38	-	-
	Number died prior to preg check	0	0	0	-	-
	Number open	1	2	2	-	-
	Number sold for herd management	1	1	1	-	-
	Number expected to calve 3rd season	12	30	35	-	-
	Number of abortions	0	0	-	-	-
	Number died prior to calving	1	0	-	-	-
	Number sold no live calf	1	0	-	-	-
	Number of live calves	10	30	-	-	-
4th breeding	Number exposed to bull	10	30	-	-	-
	Number died prior to preg check	0	0	-	-	-
	Number open	1	5	-	-	-
	Number sold for herd management	0	1	-	-	-
	Number expected to calve 4th season	9	24	-	-	-
	Number of abortions	0	-	-	-	-
	Number died prior to calving	0	-	-	-	-
	Number sold no live calf	1	-	-	-	-
	Number of live calves	8	-	-	-	-

**3 cows did not have a live calf but were exposed to the bull regardless.*

4. Application of the Crossbreeding Program

4.1 Introduction

Crossbreeding programs are designed to take advantage of heterosis, the increased genetic potential of the offspring compared to the two parent lines[1,2]. Heterosis, or hybrid vigour, improves lowly heritable traits, such as longevity, more quickly than selection[3]. Strengths of different breeds and local production resources must be matched when creating a crossbreeding program. Dams should be selected for good maternal traits and maintenance requirements, while sires are selected for developing replacement heifers and overall calf performance[2]. Hybrid vigour is more apparent in highly different breeds; however, it is essential to consider production resources and climate when selecting breeds.

Choosing a crossbreeding program requires knowledge of local production resources, climate, designated breeding goals, and a pasture management plan. Breeds that thrive in the local production system will contribute more to the herd. Explicit herd goals can be met by choosing breeds that excel in the desired traits. A pasture management plan is essential as part of breeding management.

MBFI began a crossbreeding program to take advantage of hybrid vigour and demonstrate tools producers may use in their own breeding programs. Breeding and production records paired with technology such as genomic breed composition analysis support the herd management and are used to assess changes made over time.

4.2 Objectives

The application of a crossbreeding strategy is demonstrated through the following:

1. Develop a straight-bred herd for maternal development and replacement selection
2. Develop a crossbred program for maternal development and replacement selection
3. Evaluate calf crop of straight-bred and crossbred calves

4.3 Goals and breed selection

Initial goals for the crossbreeding program are to improve herd capacity for fertility, longevity, and calf performance. Cows able to thrive on a forage-based diet through Manitoba's harsh winter improve overall profitability.

A base herd of Black Angus was chosen for maternal and growth traits and its comparability to other research herds in western Canada. Hereford was selected for the first crossbreeding groups to take advantage of maternal and reproductive traits as well as feed efficiency. Both breeds thrive on forage-based diets and are suited to Manitoba winters. Studies have found Hereford-Angus cross calves weigh more at weaning compared to Angus-Angus calves[4,5]. Crossbred cows show advantages in longevity and weaning weights compared to straight-bred cows[5].

MBFI runs two farm stations, with cows split between sites for summer grazing and breeding. Two mature breeding groups, one with primarily straight-bred Black Angus cows and the other with higher percentage of crossbred cows algins with current grazing research requirements. The herds will be as follows:

- Straight-bred Black Angus cows (breeding season at Brookdale Farm)
    - Bred to Hereford (F1 Black Baldy calves), or
    - Bred to Black Angus
- Crossbred Angus cows – terminal calf crop (breeding season at Johnson Farm and First Street Pasture)
    - Bred to Black Angus, or
    - Bred to Hereford (in phase 2 will bring in terminal cross with rotating continental sires)

This will produce straightbred and crossbred calves for calf crop evaluation. It will also produce straight-bred Angus and crossbred Angus-Hereford heifers for potential retention as breeding stock.

Bull purchases have been primarily Black Angus to focus on increasing the number of straight-bred Angus cows in the herd. One Hereford bull was purchased in 2020 for crossbreeding.

4.4 Application of breeding strategy

The original herd purchased for MBFI in 2015 and 2016 included a mix of breeds with a Black Angus emphasis.

To develop a commercial Angus herd, replacement heifer purchases have focused on Black Angus herds. Heifers with high percentages of Angus in their parentage are preferred for replacement breeding stock (**3.3 Criteria for breeding stock selection**).

The MBFI herd is almost entirely composed of cows with over 50% Angus (Table 4-1). With emphasis on selection of replacement heifers with Angus parentage, the number of young cows over 75% Angus has increased.

Table 4-1. Number of cows at each level of Angus (2021 herd)

	Percent Angus				Total number
Birth Year	Less than 25%	25-50%	50-75%	75% or higher	of cows
2019	0	0	6	8	14
2018	1	3	15	19	38
2017	0	0	8	22	30
2016	0	1	4	2	7
2015	0	8	8	2	18
2013	0	1	0	0	1
2012	0	2	1	1	4
2011	0	2	3	0	5
2010	0	1	0	0	1
Entire Herd	1	18	45	54	118

Breeding management is closely tied to grazing management and requirements from other projects. Cow-calf pairs are split between two sites for summer grazing, Brookdale Farm and First Street Pasture. Older cows with more variable breed composition are managed on the lower productivity pasture at First Street Pasture. Younger cows graze the higher productivity pasture at Brookdale Farm to ensure enhanced nutrition while they are growing and raising a calf. All cows are expected to thrive on a forage-based diet.

Most cows are 50% or greater Angus by breed composition (Figure 4-1). All cows under 50% Angus have been exposed to an Angus bull. Cows above 50% Angus are exposed to Angus bulls to produce potential replacement heifers with high proportion of Angus in their breeds.

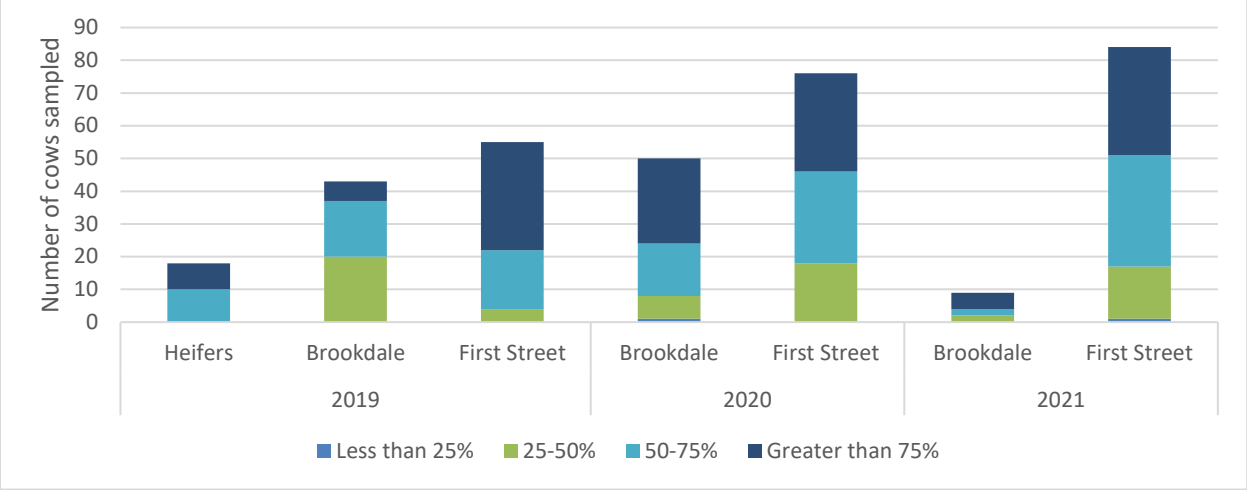

Figure 4-1. Number of cows by percent Angus in breeding groups exposed to Angus bulls.

The Hereford bull has been paired with young cows with a higher percentage of Angus (Table 4-2). In 2020 the Hereford bull was put in a breeding group with the replacement heifers, who had Black Angus sires. In 2021 the Hereford bull was paired with a group including some cows with mixed breeds and some straightbred Black Angus cows.

Table 4-2. Number of cows exposed to Hereford bull by proportion of Angus.

	Percent Angus			
Breeding Season	Less than 25%	25-50%	50-75%	75% or higher
2020	0	0	8	9
2021	0	0	9	16

The increased number of cows with high proportion of Angus in their breed make-up allows more flexibility in breeding management. Building herd conformation and changing the overall breed composition of the herd is a long-term project. MBFI is currently at a good point to select high proportion Angus cows to be bred to Hereford. The J calf cohort, born in 2021, is the first cohort with Hereford sires. From the 2021 calf crop, only four of the 28 replacement heifers had Hereford sires meeting the F1 Black Baldy criteria. It will take several years to build a consistent breeding group of F1 Black Baldy dams for phase 2 terminal three-way cross with continental sires for increased calf performance. Breeding crossbred cows back to Angus will be carried out in the short term. Genetic testing may provide background information to get us there sooner.

Genomic testing for breed composition is occurring in all breeding stock. Breed composition is already being used to select replacement heifers and, in the future, may play a roll in determining breeding groups. Breed composition analysis can also be used to evaluate the calf crop sold after weaning (Section 6 **TERMINAL CALF CROP**).

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4.6 Appendix IV

Table 4-3. Breeding group information with number of cows by proportion of Angus.

		% Angus					Number of cows	
Year	Breeding Group	<25%	25-50%	50-75%	>75%	Bull Breed	Exposed	With known breed composition**
2019	Heifers	0	0	10	8	Black Angus	18	18
	Brookdale Group 1	0	11	10	2	Black Angus	25	23
	Brookdale Group 2	0	9	7	4	Black Angus	25	20
	First Street	0	4	18	33	Black Angus	60	55
2020	Heifers	0	0	8	9	Hereford	17	17
	Brookdale Group 1	0	4	7	14	Black Angus	25	25
	Brookdale Group 2	1	3	9	12	Black Angus	25	25
	First Street	0	18	28	30	Black Angus	78	76
2021	Heifers*	-	-	-	-	Black Angus	10	0
	Brookdale Group 1	0	0	9	15	Hereford	25	24
	Brookdale Group 2	0	2	2	5	Black Angus	25	9
	First Street	1	16	34	33	Black Angus	85	84

**This group of heifers has not had breed composition analyzed yet*

***Number of cows with known breed composition may be smaller than number of cows exposed due to sampling error or cows not yet sampled.*

5. Culling Strategy

5.1 Introduction

Culling strategies are an essential management tool for beef producers. Culling strategies improve profitability of the operation, reduce the number of cows with undesirable traits, and eliminate problem cattle. The primary source of income for a cow/calf operation is calf sales. Any cows that are not raising calves to sale or are raising poor calves are impacting the bottom line. In general, culling is more effective at getting rid of problem cattle rather than progressing the herd toward the ideal cow but eliminating problems will improve overall herd metrics[1].

Producers should determine culling strategies to suit their operations. Similar criteria are recommended in several sources, including open cows, reproductive efficiency, disposition, and structural soundness[1,2,3,4]. Raising cows that work with the local environment and management system of the farm requires attention to open cows, calf weaning weights, calving problems, calving cycles, cow disposition, and cow structural soundness.

Cows may be open at pregnancy check for several reasons. Assuming the bull soundness was not the issue, failure to conceive indicates cow is not a good fit for the operation[2]. Poor calf performance due to the cow's mothering ability or calving problems also indicate the cow is not suitable for the system. Structurally unsound cows are more likely to have health events or die between culling assessment and weaning their next calf, all of which affects farm profitability.

An explicit culling plan aids in decision making about selling cows. Record keeping of problems and following the culling strategy ensures these problems are reduced. In times of drought a defined culling strategy can help make difficult decisions on choosing which cattle to sell and ensure the best cattle are retained on the farm[3].

In establishing this case study the culling criteria were evaluated in conjunction with the goals of the herd development plan and sorted into priority order for culling female breeding stock at MBFI. Goals of the herd plan include moderately framed, high fertility, sound udders and feet, and moderate body condition maintenance. Stringent culling paired with targeted replacement selection (Section 3 BREEDING STOCK SELECTION) help MBFI achieve herd goals more directly.

5.2 Objectives

1. Develop a defined culling strategy
2. Utilize a defined culling strategy

5.3 Culling Strategy

Production records, calving records, and health records are collected throughout the year. Each cow's personal history is used to determine her priority for culling.

There are two times per year when cows are sold:

1. The first cull date is after calving season. Any cow without a live calf will be marketed.
2. The second cull date is after weaning. Post-weaning culling decisions will be made in the following order of priority described below until the target culling rate (%) is reached.

Almost all cows are sold at one of these two times. On occasion cows are sold at different times for health reasons. All sold and dead cows are included when determining culling rate.

The culling decisions will be made in the following order:

1. No live calf after calving season. This includes cows that aborted over the winter and cows whose calves died prior to summer pasture turnout.
2. Disposition – aggressive animals will not be tolerated at MBFI. Safety is the number one priority at MBFI, especially as MBFI hosts staff, summer students and tour groups of variable cattle handling ability.
3. Open – any cows that come in open after fall pregnancy check will be culled.
4. Structural & health soundness – all cows must be in good health to continue to raise big, healthy calves. Condition and structure will be evaluated based on the MBFI scoring criteria (Appendix III).
    a. Condition[5] – Cattle that are unable to maintain condition through the summer will be culled. Body Condition Score should be above 2.5 for most of the summer as specified in the Animal Care Protocols.
    b. Udder – Cows with udder problems or Teat or Udder Scores of 3 or less will be culled.
    c. Feet, legs, and hips – Cows exhibiting problems in the feet (eg. lameness), legs, or hips. Culls will occur for Mobility Scoring of 2 or less, Foot Scoring (Claw Set and Foot Angle outside of 3-7)
    d. Eyes – Cows with Cancer Eye or other chronic eye conditions will be culled.
    e. Frame Score – moderately framed cows are preferred
    f. Other health issues – Cattle with other chronic health issues will be culled.
5. Calf performance and mothering ability – Cows will be judged on their calf rearing ability. Cows with assisted birthing will be marked for review. The goal of calf weighing 50% of the cow's body weight at weaning is considered. Any cows with mothering issues will be noted for review .
6. Reproductive efficiency – breeding back in 80 days or less. With a 285-day gestation this should have a cow calve consistently within a one-year window. Cows under this interval will be noted for review.
7. Phenotype – Cattle who do not fit the MBFI cattle conformation criteria or have desirable genetics will be culled.

In accordance with the order of the culling criteria, cull numbers are evaluated from the beginning of calving season. Dead cows are included as they contribute to the decrease in breeding stock numbers.

To improve the herd, cows are culled until the desired cull rate is reached. In 2019 and 2020, the desired cull rate was 20%. From 2021 onward, desired cull rate is 10-15%. An exact rate is not specified to leave

room for higher-than-average open rates, drought conditions, and other management considerations. Cull rate will be adjusted to maintain appropriate herd numbers. Once criteria 1-3 are fulfilled, further culling will be based on criteria 4-7.

5.4 Application of culling criteria

5.4.1 Culling numbers

In several instances, a cow fit several culling criteria, such as calf performance *and* udder conformation *and* foot soundness. In these instances, she was classified at the highest priority. Several cows came up open and were also in poor health or condition; they were classified as Open.

Prior to 2019, no cows were sold after calving season as No Live Calf due to unspecified culling strategies.

Culling rates are reset April 1 every year. The baseline number for culling rate of mature cows is the number of cows expected to calve. The baseline number for culling rate of heifers is the number of heifers exposed to a bull. Table 5-1 shows classes of cull cows to date. A defined culling strategy did not exist until 2019, so culling criteria were applied to cull cows from 2017 and 2018 retroactively.

Table 5-1. Number of cows culled each year based on culling criteria. Culling criteria were applied to cows in 2017 and 2018 retroactively.

		2017	2018	2019	2020	2021
No live calf		0	0	2	10	2
Disposition		1	0	6	3	0
Open		14	13	11	13	11
Health	Body Condition	0	0	1	0	0
	Udder	3	3	3	2	0
	Feet, legs, hips	0	0	2	1	1
	Eyes	1	0	1	1	0
	Frame Score	0	0	0	0	0
	Other health issues	3	1	3	3	2
Calf performance & mothering ability		1	2	0	0	1
Reproductive efficiency		0	0	0	0	0
Phenotype		0	0	0	0	0
Died		0	2	1	4	2
Total number culled or died		**23**	**21**	**30**	**37**	**19**
Number of cows expected to calve each spring		**82**	**86**	**118**	**142**	**138**
Number of replacement heifers exposed that summer		**26**	**53**	**18**	**17**	**10**
Culling rate*		**21.3%**	**15.1%**	**22.1%**	**23.3%**	**12.8%**

$$* \, Culling\ rate\ (\%) = \frac{(Total\ number\ culled\ or\ died)}{(Number\ of\ cows\ expected\ to\ calve) + (Number\ of\ replacement\ heifers\ exposed)} \times 100$$

The number of cows culled for health reasons, especially udder conformation, eyes, and other health issues, are relatively consistent from 2017-2021, even prior to the defined culling strategy (Table 5-1). Application of the culling strategy primarily changed numbers in cows sold with no live calf and cows

sold for disposition. Farm profitability, human safety, and fulfillment of research requirements have benefitted from the application of these criteria.

5.4.2 Practical Considerations

The application of the culling criteria as proposed came up against a number of real-life challenges (Table 5-1). These challenges almost always occurred because the target culling rate was reached early, usually due to the number of cows without a calf after calving or the number of cows open after breeding.

A large number of winter abortions paired with a very difficult calving season for the bred heifers in 2020 led to 10 cows being sold after the calving season (Table 5-1). This number is excessive compared to any other year. In 2020, there was also a larger number of dead cows as well as many open cows. Therefore, in 2020 cows culled for disposition or structural soundness were only culled because they were actively hazardous to human safety, or their health was declining.

In practice, No live calf, Open, and Health were the primary criteria for culling. The criteria were used as follows:

1. No live calf - from 2019 on, all cows without a calf at foot at the start of summer grazing were culled.
2. Disposition – only cows displaying extremely aggressive behaviour were culled. Cows with minor aggression during calving are noted and other management techniques are used to keep staff safe. At this point in the herd development, open cows and health issues were higher priority for culling.
3. Open – open cows are always sold.
4. Health:
    a. Body Condition – cows sold for body condition had to be very poor with little likelihood of improvement. Low body condition score often came with an open diagnosis at pregnancy check; these cows were classified as Open as that criterium is higher on the priority list.
    b. Udder – Cows classified under udder conformation were primarily culled for udder issues, including mastitis or newborn calves requiring assistance
    c. Feet, legs, hips – no feet or mobility scoring has occurred. Cows are culled for this criterium when feet, legs, or hips are qualitatively assessed to impact mobility.
    d. Frame Score – As no quantitative assessment of frame scores has occurred, we have not culled any cows based on frame score.
    e. Other health issues – This criterium is primarily used for respiratory issues or reoccurring health problems impacting cow performance.
5. Calf performance & mothering ability – only applied to cows who abandoned their calves or dried up mid-summer, except for one cow who fit multiple culling criteria (2021).
6. Reproductive efficiency was not considered. In practice, the tight breeding season at MBFI keeps the calving season short. Any cows unable to breed back within the 45-day season come up as

open and are sold. This criterium may be more useful for management systems where bulls are with cows for more than 63 days.

7. Phenotype – the MBFI herd is not sufficiently developed to begin culling on cow phenotype
8. Dead – dead cows are included due to their impact on the decrease in breeding stock

It is expected that as the herd improves fertility, performance, and conformation traits, the future culling criteria will shift emphasis to calf performance.

5.5 References

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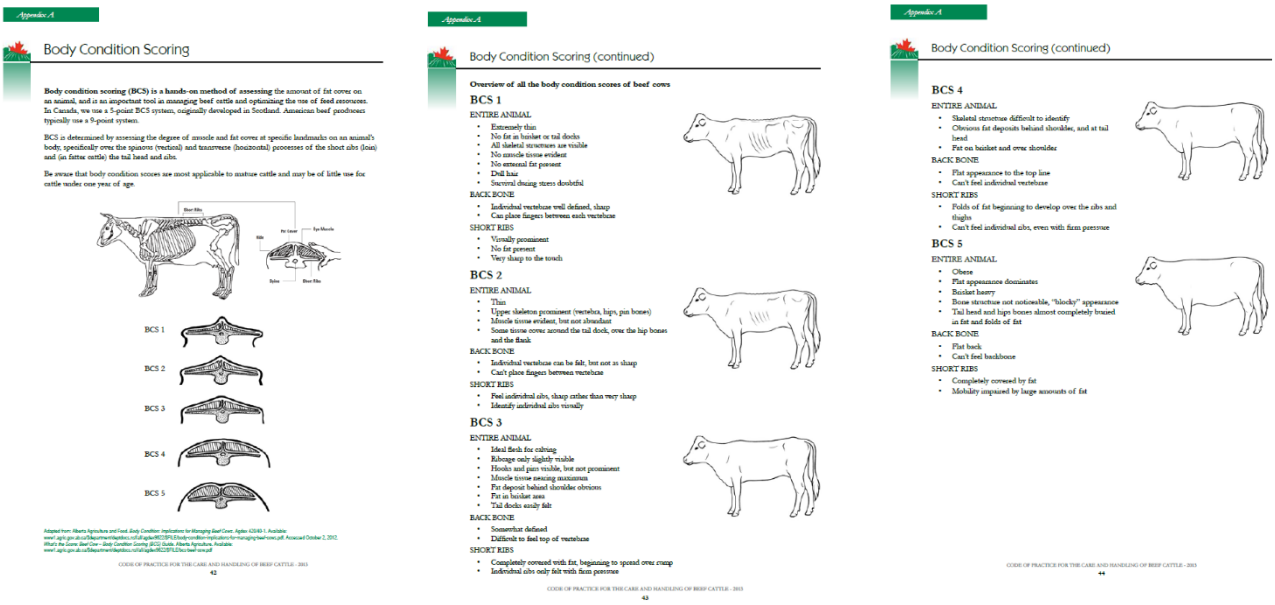
5.6 Appendix V



Appendix A

Body Condition Scoring

Body condition scoring (BCS) is a hands-on method of assessing the amount of fat cover on an animal, and it an important tool in managing beef cattle and optimizing the use of feed resources. In Canada, we use a 5-point BCS system, originally developed in Scotland. American beef producers typically use a 9-point system.

BCS is determined by assessing the degree of muscle and fat cover at specific landmarks on an animal's body, specifically over the spinous (vertical) and transverse (horizontal) processes of the short ribs (loin) and (in fattac cattle) the tail head and ribs.

Be aware that body condition scores are most applicable to mature cattle and may be of little use for cattle under one year of age.

BCS 1

BCS 2

BCS 3

BCS 4

BCS 5

Adapted from: Alberta Agriculture and Food, *Body Condition: Implications for Managing Beef Cows*, Agdex 420/60-1. Available: www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex9023/$FILE/body-condition-implications-for-managing-beef-cows.pdf. Accessed October 2, 2012. *What's the Score: Beef Cow – Body Condition Scoring (BCS) Guide*. Alberta Agriculture. Available: www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex9023/$FILE/bcs-beef-cow.pdf

Appendix A

Body Condition Scoring (continued)

Overview of all the body condition scores of beef cows

BCS 1

ENTIRE ANIMAL
- Extremely thin
- No fat in brisket or tail docks
- All skeletal structures are visible
- No muscle tissue evident
- No sensorial fat present
- Dull hair
- Survival during stress doubtful

BACK BONE
- Individual vertebrae well defined, sharp
- Can place fingers between each vertebrae

SHORT RIBS
- Virtually prominent
- No fat present
- Very sharp to the touch

BCS 2

ENTIRE ANIMAL
- Thin
- Upper skeleton prominent (vertebra, hips, pin bones)
- Muscle tissue evident, but not abundant
- Some tissue cover around the tail dock, over the hip bones and the flank

BACK BONE
- Individual vertebrae can be felt, but not as sharp
- Can't place fingers between vertebrae

SHORT RIBS
- Feel individual ribs, sharp rather than very sharp
- Identify individual ribs visually

BCS 3

ENTIRE ANIMAL
- Ideal flesh for calving
- Ribcage only slightly visible
- Hooks and pins visible, but not prominent
- Muscle tissue nearing maximum
- Fat deposit behind shoulder obvious
- Fat in brisket area
- Tail docks easily felt

BACK BONE
- Somewhat defined
- Difficult to find top of vertebrae

SHORT RIBS
- Completely covered with fat, beginning to spread over rump
- Individual ribs only felt with firm pressure

Appendix A

Body Condition Scoring (continued)

BCS 4

ENTIRE ANIMAL
- Skeletal structure difficult to identify
- Obvious fat deposits behind shoulder, and at tail head
- Fat on brisket and over shoulder

BACK BONE
- Flat appearance to the top line
- Can't feel individual vertebrae

SHORT RIBS
- Folds of fat beginning to develop over the ribs and thighs
- Can't feel individual ribs, even with firm pressure

BCS 5

ENTIRE ANIMAL
- Obese
- Flat appearance dominates
- Brisket heavy
- Bone structure not noticeable, "blocky" appearance
- Tail head and hips bones almost completely buried in fat and folds of fat

BACK BONE
- Flat back
- Can't feel backbone

SHORT RIBS
- Completely covered by fat
- Mobility impaired by large amounts of fat

Figure 5-1. Body condition scoring guide[6].

6. Terminal Calf Crop

6.1 Introduction

Calf sales are the primary source of income for cow-calf producers. Herd development goals should support the production of the calf crop. Goal setting improves long-term farm productivity and profitability[1]. Tools discussed in previous sections support the development of calves for sale after weaning.

Record keeping provides baselines from which new targets can be set[1]. Technology provides insight into cow genetics and reproduction, which can help with breeding management (Section 2 TECHNOLOGY IN THE BEEF HERD). Selection and development of breeding stock directly impact the calf crop (Section 3 BREEDING STOCK SELECTION). Cows with good maternal traits and body conformation produce larger, healthier calves. A crossbreeding program to increase hybrid vigour of the herd improves maternal traits and calf weights (Section 4 APPLICATION OF THE CROSSBREEDING PROGRAM). A culling strategy removes problems and reduces expenses for cows producing no calves or poor calves (Section 5 CULLING STRATEGY).

Production records can be compared with various tools to indicate which management strategies and breeding stock are producing superior results.

6.2 Objectives

1. Evaluate calf production
2. Compare production metrics by dam genetic indicators, including breed composition, carcass traits, and Igenity® Beef profiles
3. Compare production metrics by sire genetic indicators, including breed composition, carcass traits, and Igenity® Beef profiles

6.3 Methods

6.3.1 Calf production

Throughout a calf's life, the following records are collected and contribute to the final evaluation:

- Birth date
- Birth weight
- Calf sex
- Dam ID
- Dam age
- Sire ID or sire group
- Weaning date
- Weaning weight

Weaning dates have varied by year. In 2017 and 2018, weaning occurred the first week of December. In 2019-2021, weaning occurred early to mid November. Weaning date is important information as it contributes to total gain.

Average daily gain (ADG) is used to compare calf production and is calculated by the formula:

$$ADG = \frac{(Weaning\ Weight - Birth\ Weight)}{(Weaning\ Date - Birth\ Date)}$$

When evaluating the calf crop by year or site, actual weaning weights or average daily gain are compared as farm income depends on the actual weight of the weaned calf. Often, the actual weaning weights are compared as that is the unit being sold.

To minimize differences due to calf sex and cow age, 205-day adjusted weaning weights are used for comparisons based on genetic indicators or sires.

To calculate the 205-day adjusted weaning weight, an adjustment factor based on the cow age and calf sex is required (Table 6-1)[2]. These adjustment factors only apply to calves weighed in pounds.

Table 6-1. Adjustment factors for calculating 205-day adjusted weaning weights.

Age of Dam at Birth of Calf	Male	Female
2	+60	+54
3	+40	+36
4	+20	+18
5-10	0	0
11 and older	+20	+18

The formula for calculating 205-day adjusted weaning weight is[2]:

$$205 - day\ adjusted\ weaning\ weight = ADG\ x\ 205 + Birth\ weight + Adjustment\ factor$$

Calf weight as a percent of dam weight is calculated from the calf actual weaning weight and the cow's weight in November of the same year.

$$\%\ Dam\ Weight = (Calf\ actual\ weaning\ weight) \div (Dam\ November\ weight)$$

6.3.2 Genomic Testing

Genomic information is determined from tail hair samples sent to Neogen Canada and analyzed for breed composition, carcass traits, and Igenity® Beef traits (**2.3.1 GENOMIC TESTING**). This information is tied to individual cows for use in evaluating production.

For each cow, the production traits (weaning weight, ADG) of their progeny are averaged. This average is compared to that animal's genomic indicators.

Fewer bulls have had full genomic analysis, so each calf is considered individually to that bull's genomic traits.

6.4 Discussion

6.4.1 Calf Production

Calf weaning weights and average daily gains have changed by year (Table 6-2). Weaning weights were highest in 2021, but they were lowest in 2020 so change has not been linear. Calf weight as % Dam weight was highest in 2021. This is a combination of higher weaning weights and a greater proportion of younger cows, who are still growing and therefore smaller.

Table 6-2. Calf production summary 2017-2021.

Calving Season	Number of calves expected	Number of live calves	Average Birth Weight (lb)	Weaning Date	Average age at weaning (days)	Number of calves weaned	Average Weaning Weight (lb)	Average ADG (lb/day)	Average % Dam Weight at Weaning	205-day adjusted Weaning Weight (lb)
2017	82	82	83.0	Dec 4	208	81	562	2.30	43.5%	582
2018	86	82	84.0	Dec 3	208	81	548	2.22	44.4%	566
2019	118	115	84.5	Nov 8	187	114	535	2.41	42.5%	610
2020	142	133	82.8	Nov 10	193	132	487	2.10	43.0%	544
2021	138	136	83.5	Nov 8	187	134	557	2.53	45.2%	629

Average calf gain (ADG) varies by year (Figure 6-1). This data is not separated by management group, which may be a confounding factor (Figure 6-2). From 2017-2019 the older cows were on the best forage producing larger calves and the young cows were on poorer quality forage producing smaller calves. This would account for the larger variation in average daily gain in those years.

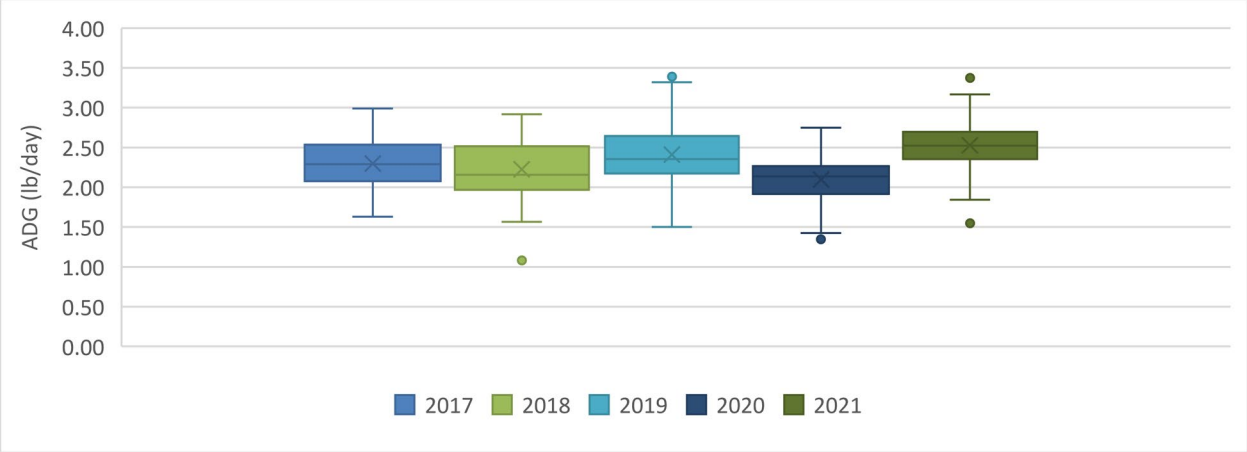


Figure 6-1. Calf average daily gain by year.

First Street Pasture is more marginal land than Brookdale Pasture and produces lower quality forage. To better match production resources, herd management changed in 2020 to allocate older cows to First Street Pasture. This has produced calves of more similar weights regardless of summer pasture (Figure 6-2). As the crossbreeding program develops, weaning weights by summer grazing management will produce insight into how production resources match the crossbreeding strategy (Section 4 **APPLICATION OF THE CROSSBREEDING PROGRAM**).

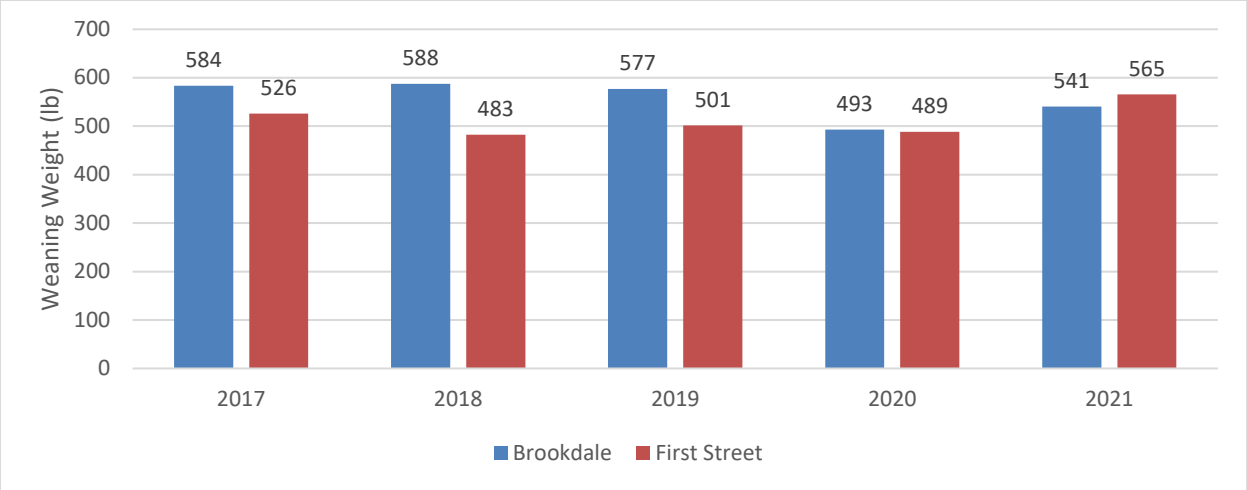


Figure 6-2. Average actual weaning weight of calves by site and year.

In 2021, over half the calves were between 500-600 pounds at weaning (80 out of 134). The number of heavy calves was similar to other years and the number of light calves decreased (Figure 6-2). Calves were older at weaning in 2017 and 2018, but weaning age was similar in 2019-2021 (Table 6-2).

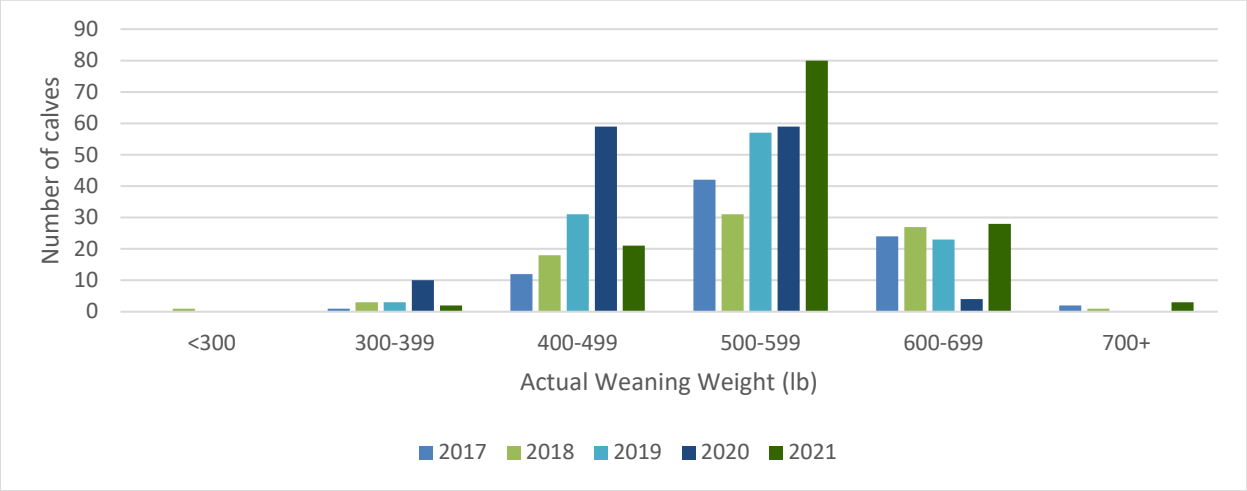


Figure 6-3. Number of calves at each range of weaning weights.

6.4.2 Calf production by dam genetic markers

Breed composition

Dam vigour score was used for comparing calf weights as an approximation of hybrid vigour. As the current herd does not have a consistent breed composition (FIGURE 2-6. BREED COMPOSITION BY COW AGE COHORT IN 2021.), vigour score was preferred as a comparison. Comparison of average actual calf weaning weight to the dam's vigour score shows only a loose upward trend (Figure 6-4). Variation around the trend line is high, suggesting that vigour score is only one of many factors affecting calf weaning weight. Other factors affecting calf weaning weight include age at weaning, dam age, summer grazing management, and sire genetics.

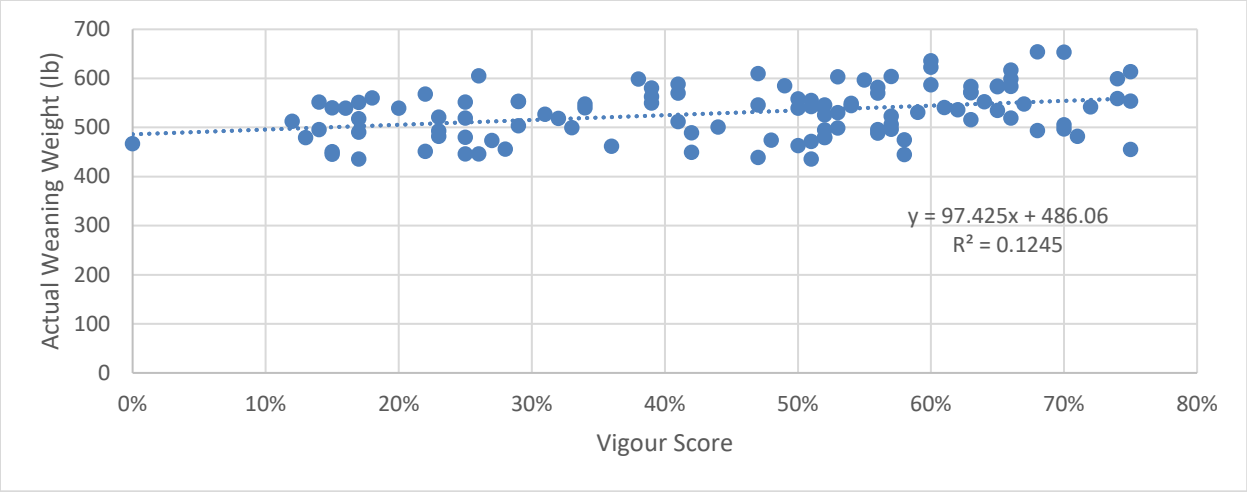


Figure 6-4. Average calf actual weaning weight by vigour score of dam.

Carcass Traits

Leptin genotypes are compared to 205-day adjusted weaning weights. In this case, adjusted weaning weights are used to reduce differences due to dam age and calf sex. The TT genotype indicates improved carcass traits compared to the CT or CC genotypes[3]. While there are differences in means of adjusted weaning weights, overall, 205-day adjusted weaning weight does not change between dam leptin scores (Figure 6-5). Following these calves to slaughter may show faster overall gain on the calves whose dams have the TT genotype.

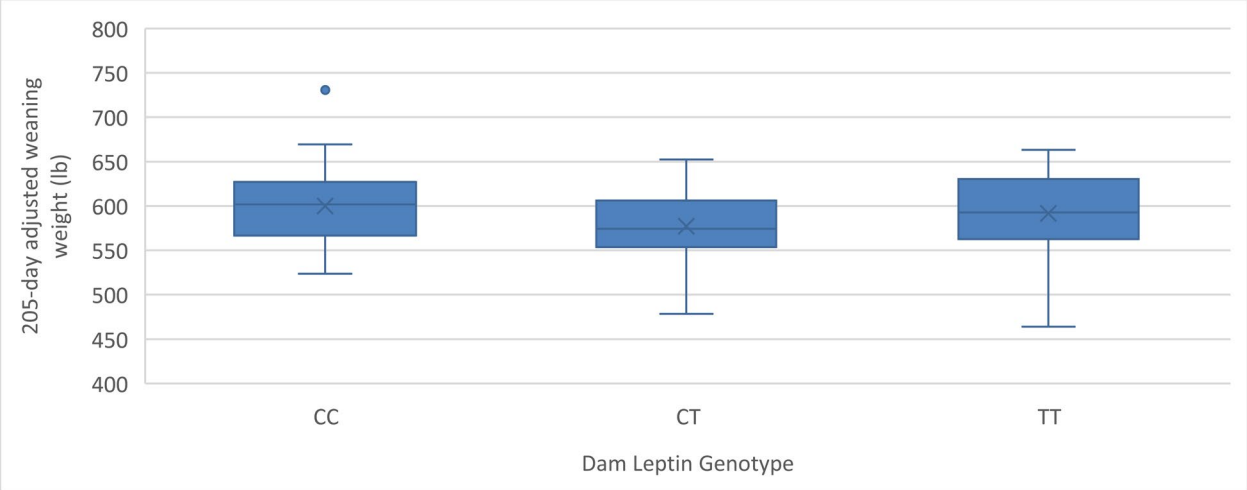


Figure 6-5. 205-day adjusted weaning weights by cow leptin genotype.

Igenity® Beef Profiles

As of 2021, only 46 cows have been analyzed using Igenity® Beef Indices. These cows have only had one to two calves, so data presented is preliminary. This section focuses on the Maternal Index as we are evaluating calves at weaning.

Maternal Index result and average calf 205-day weaning weights do not show a consistent pattern at this point (Figure 6-6).

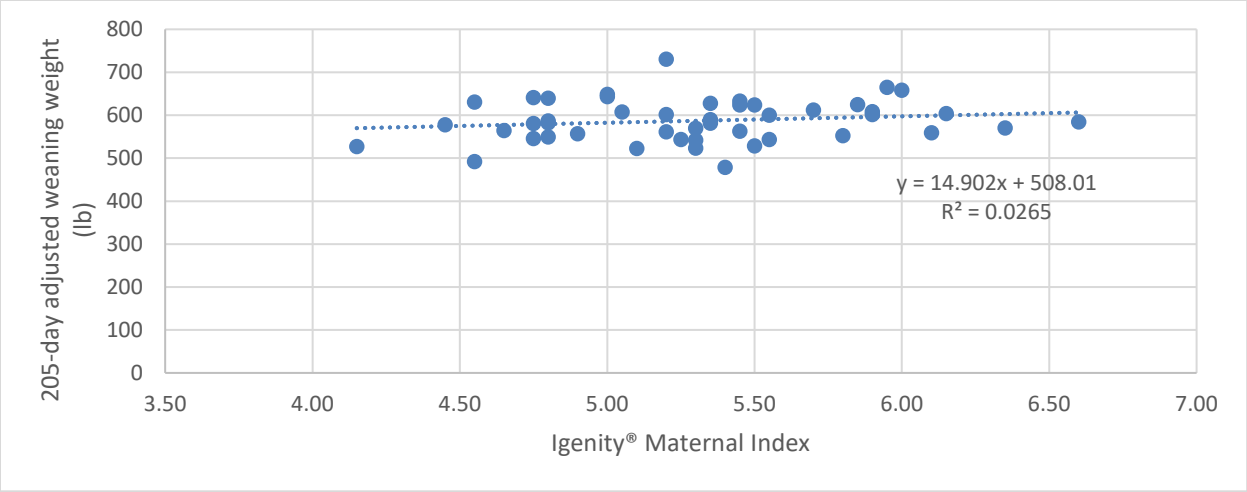


Figure 6-6. Average 205-day weaning weight of calves by dam Igenity® Beef Maternal Index.

Milk score, which indicates pounds of weaning weight due to the dam's milk production, shows a lot of overlap in the 205-day weaning weights between scores (Figure 6-7). There is also substantial overlap in 205-day adjusted weaning weights compared to the Weaning Weight score (Figure 6-8). Further sampling and more calves per cow sampled may show clearer trends in future years.

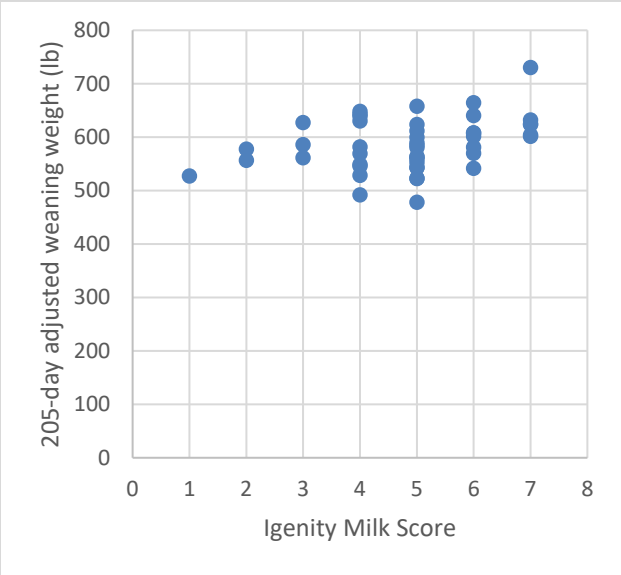


Figure 6-7. Average calf 205-day adjusted weaning weight by dam Igenity® Milk Score.

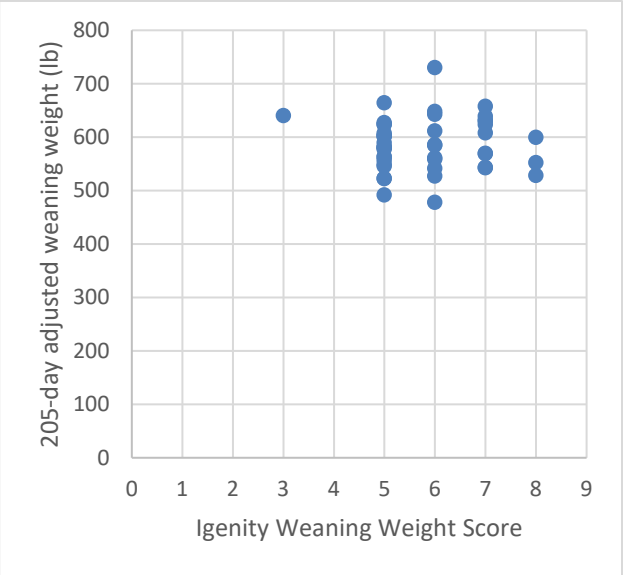


Figure 6-7. Average calf 205-day adjusted weaning weight by dam Igenity® Weaning Weight Score.

6.4.3 Calf production by sire genetic markers

When looking at weaning weights compared to sire genetic indicators, 205-day weaning weights are used to adjust for calf age, dam age, and calf sex.

Breed Composition

Only one calf cohort, born in 2021, has had calves with Hereford sires. At weaning, there were 24 calves with Hereford sires and 110 calves with Black Angus sires. There is complete overlap of average 205-day

adjusted weaning weights by sire breed (Figure 6-9). Adding future years of calves with Hereford sires may show clearer trends. In the future, confounding factors such as grazing management will need to be considered as well.

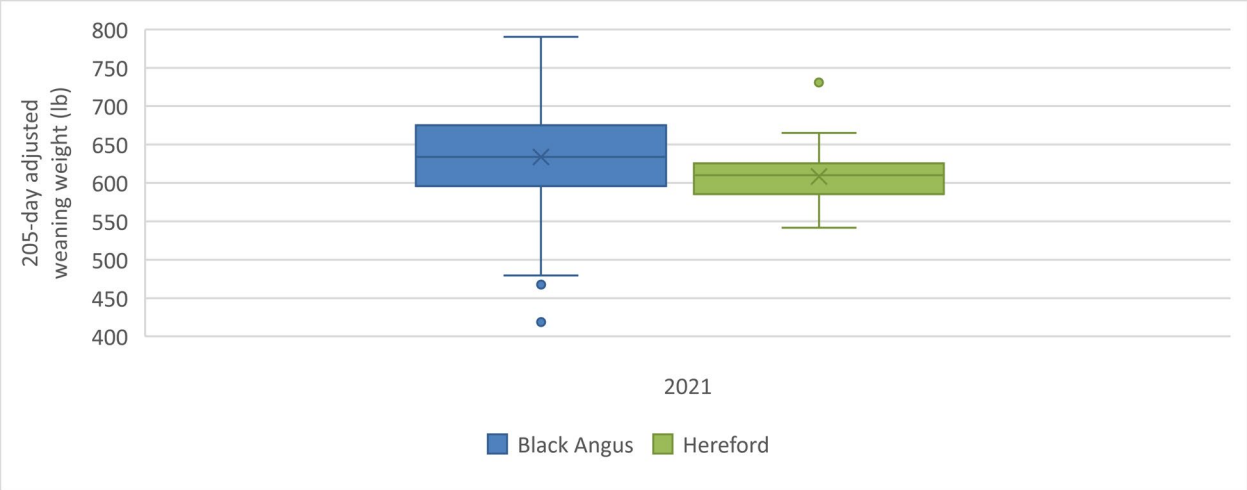


Figure 6-8. Calf 205-day adjusted weaning weight by sire breed.

Carcass Traits

Calf weights overlap for all sire leptin genotypes (Figure 6-10). For CC, CT, and TT sire leptin genotypes, 56, 113, and 95 calves were evaluated respectively. Only calves from single sire herds were included. Following calves through finishing may show different results.

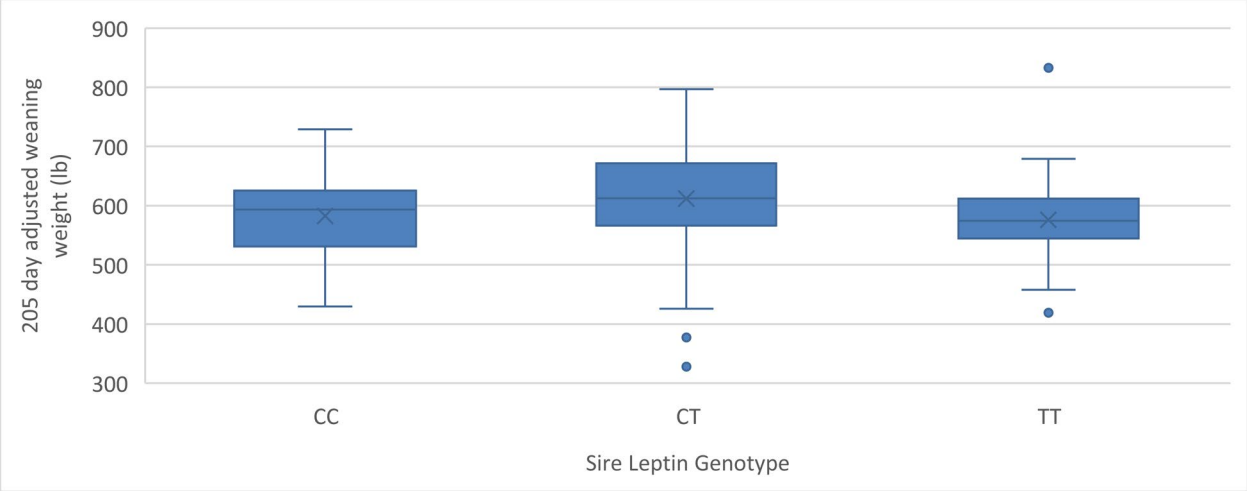


Figure 6-9. Calf 205-day adjusted weaning weights by sire leptin genotype.

Igenity® Beef Profiles

Only three bulls have been sampled for Igenity® Beef analysis, and these bulls have only had one crop of calves weaned. Despite having the highest Maternal Index, 48G has the lowest Weaning Weight Score, which may have influenced calf weights (Table 6-3).

Table 6-3. Breed and Igenity® Beef profile for three bulls.

Bull	Number of calves	Breed	Igenity® Maternal Index	Igenity® Weaning Weight Score	Igenity® Milk Score
48G	14	Hereford	5.10	1	4
29F	23	Black Angus	4.95	4	5
39F	17	Black Angus	4.85	4	3

Bulls 29F and 38F produced larger calves at weaning than 48G (Figure 6-11). Breed, other genetic factors, dam genetics, dam management, and calf management may all influence calf weaning weights. Sample size for each bull is small due to only one year of data collected. These results are preliminary and are to be taken with caution.

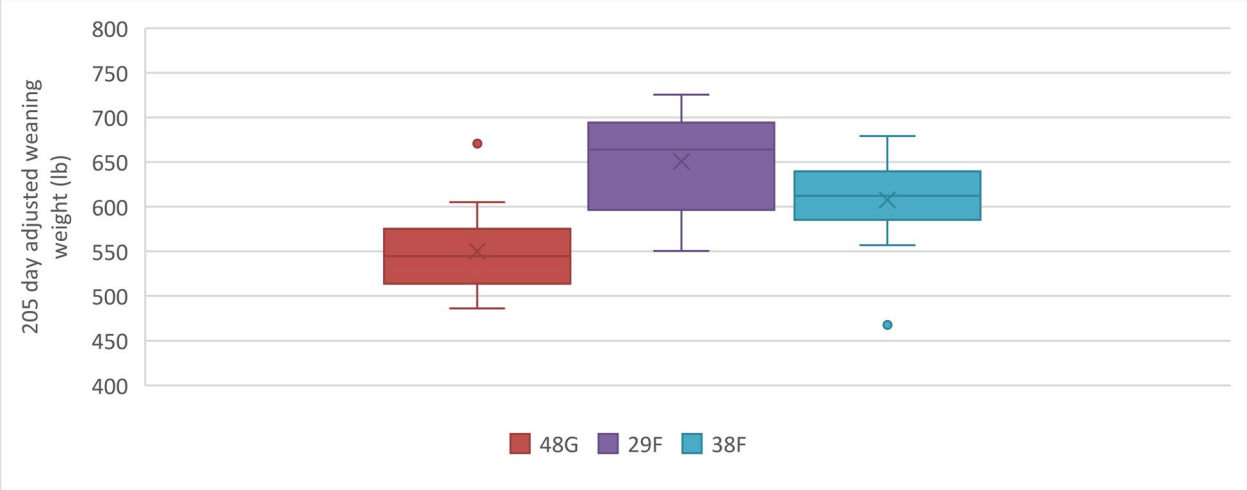


Figure 6-10. Calf 205-day adjusted weights by sire.

6.5 References

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6.6 Appendix VI

Table 6-4. Weight characteristics of weaned calves by year.

Year	Weaning Date	Average age at weaning (days)	Number of calves	Average Daily Gain (lb/day)		Actual Weaning Weight (lb)		205-day adjusted Weaning Weight (lb)		Percent Dam Weight	
				Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev
2017	Dec 4	208	81	2.30	0.30	562	69	582	57	43.5%	6.2%
2018	Dec 3	208	81	2.22	0.34	548	82	566	65	44.4%	6.6%
2019	Nov 8	187	114	2.41	0.37	535	75	610	71	42.6%	6.5%
2020	Nov 10	193	132	2.10	0.26	487	62	544	54	43.0%	7.3%
2021	Nov 8	187	134	2.53	0.29	557	67	629	58	45.2%	6.4%

Table 6-5. Weight characteristics of weaned calves by summer management site.

Year	Summer Grazing Management	Average Dam Age	Number of calves	Average Daily Gain (lb/day)		Actual Weaning Weight (lb)		205-day adjusted Weaning Weight (lb)	
				Mean	StDev	Mean	StDev	Mean	StDev
2017	Brookdale	4.6	50	2.40	0.29	584	68	586	61
	First Street	2.3	31	2.13	0.23	526	56	574	49
2018	Brookdale	5.3	50	2.38	0.28	588	64	592	56
	First Street	2.7	31	1.97	0.27	483	67	524	58
2019	Brookdale	5.9	51	2.65	0.38	577	78	645	82
	First Street	2.5	60	2.22	0.23	501	54	582	47
2020	Brookdale	2.4	50	2.03	0.25	493	58	548	52
	First Street	4.6	78	2.15	0.26	489	61	545	55
2021	Brookdale	2.5	48	2.37	0.20	541	51	617	42
	First Street	5.0	86	2.61	0.31	565	74	636	65

Table 6-6. Weight characteristics of weaned calves by sire.

Bull	Breed	Active Breeding Seasons	Number of known calves	Leptin Genotype	Igenity® Maternal Index	Average Daily Gain (lb/day)		Actual Weaning Weight (lb)		205-day adjusted Weaning Weight (lb)	
						Mean	StDev	Mean	StDev	Mean	StDev
61B	Black Angus	2016-2020	59	CT	-	2.51	0.50	579	92	613	95
64B	Black Angus	2016-2019	56	CC	-	2.38	0.32	549	73	583	71
83C	Black Angus	2016-2020	60	TT	-	2.25	0.29	517	60	579	64
13E	Black Angus	2018-2021	35	TT	-	2.15	0.17	501	53	571	36
88E	Black Angus	2018-2019	22	-	-	2.20	0.19	503	47	584	43
29F	Black Angus	2020-2021	23	CT	4.65	2.59	0.23	564	51	651	51
38F	Black Angus	2020-2021	17	CT	4.85	2.41	0.17	546	46	608	50
48G	Hereford	2020-2021	14	CT	5.65	2.28	0.23	516	60	550	50

Definition			
Igenity Production Index (IPI)	The Igenity Production Index is well balanced for maternal, production and carcass progeny traits. It is designed for producers who raise their own heifers and want broad improvement across multiple traits. Weightings: Stay 30%; CEM 10%; ADG 15%; RFI -15%; Marb 20%; Tend 10%.	**Yearling Weight (YW)**	Difference in average 365-day weight. The higher the number, the greater the yearling weight.
Igenity Maternal Index (IMI)	This index is highly maternal and designed to select replacement heifers for fertility, longevity and higher weaned calf weight. It is a tool developed for producers who sell calves at weaning or after a short backgrounding period. Trait Weightings: CED 10%, CEM 15%, HPG 15%, STAY 20%, WW 20%, RFI -10%, MILK 10%.	**Residual Feed Intake (RFI)**	This is an indicator of feed efficiency. It is the difference in animals' daily consumption of feed to achieve the same level of daily gain. Lower RFI indicates greater feed efficiency.
IPI Quartile Ranking	This ranking uses Igenity Production Index scores to sort quartiles (4-star down to 1 star) so it is easy to keep the 3-star and 4-star heifers.	**Marbling (Marb)**	USDA marbling score at a similar end-point. The higher the marbling, the higher the USDA quality grade.
Birth Weight (BW)	Higher score is higher birthweight potential. Heavy calves can cause calving difficulty but also have more growth potential. (CED or CEM in selection indexes are preferred over BW alone.)	**Ribeye Area (REA)**	Ribeye area as measured on a carcass. REA estimates muscling in a beef carcass in square inches of ribeye at the 12th rib. Larger REA progeny have more muscle and higher percentage of retail product.
Calving Ease Direct (CED)	Greater probability a calf will be born unassisted out of a first-calf heifer, including birth weight and shape of the calf. A higher value is greater calving ease.	**Fat**	Backfat as measured on a carcass. Fat thickness is scored as depth of fat in inches over the ribeye muscle at the 12th rib. Higher fat thickness scores equate to lower lean yield.
Calving Ease Maternal (CEM)	Includes all genetic factors that impact a first-calf heifer's ability to calve unassisted, such as pelvic area and her genetics for birth weight. Higher value is more calving ease.	**Tenderness (Tend)**	Genetic potential for beef tenderness (Warner-Bratzler Shear Force). A higher 1-10 score is more tender.
Heifer Pregnancy Rate (HPR)	A heifer's potential to conceive during breeding season, relative to other heifers. A higher value is desired.	**Hot Carcass Weight (HCW)**	Unchilled weight of a beef carcass. The higher the HCW, the greater the dressing percentage.
Milk	Pounds of calf weaning weight due to dam's milk production. Optimize "milk" to the forage environment.	**Horned Polled (HP)**	Polled is a dominant trait. (Results do not reveal the presence or absence of scurs.) HH - Homozygous Horned HP Heterozygous Horned/Polled PP Homozygous Polled.
Stayability (STAY)	The chance a heifer will remain in the herd as a productive cow until at least six years of age. A higher value is desired.	**Coat Color (CC)**	Coat color genes determine red or black coat. Black is the dominant trait. Results are reported as: **Yes= Homozygous Black** – all progeny will be black when mated to recessive red carrier animals. **No= Not Homozygous black** – ½ progeny will be black and ½ will be red when mated to recessive red carrier animals.
Docility (Doc)	Genetic potential to be calm or have calm offspring. Higher scores indicate a higher probability acceptable disposition.	**BVD PI**	Negative animals are free of the BVD virus. Positive animals are likely persistently infected. (Discuss positive test confirmation with Neogen veterinary diagnostics.)
Weaning Weight (WW)	Difference in average 205-day weight. The higher the number, the greater the weaning weight of calves.	**SeekSire parentage**	SeekSire uses gene markers for *Bos taurus* and *Bos indicus* parentage validation. It is designed for multi-sire parentage verification when bull battery DNA is on file at Neogen.
Average Daily Gain (ADG)	Based on pounds of gain per day. The Igenity score for Average Daily Gain (ADG) identifies genetic potential for post-weaning growth.	**Custom Indexes**	If you wish to create your own index criteria to compare or sort cattle, go to your online Igenity Beef Dashboard account and use the custom indexing tools. Visit www.igenitybeefdashboard.com.

SELECT, MANAGE AND MARKET YOUR CATTLE

- Select replacement heifers that move you ahead on your fertility, production and quality goals
- Use DNA scores to manage breeding and production potential
- Leverage data in calf marketing, bred heifer sales or retained-ownership decisions

MATERNAL, PERFORMANCE AND CARCASS TRAITS

- Pinpoint herd strengths and improvement areas
- Easy-to-read 1 to 10 scoring
- Predict traits heifers will pass on to their offspring

INDEXES FOR SELECTION DECISIONS

- Designed for multi-trait selection
- Emphasize balanced, maternal or beef system qualities
- Online tools to build your own index

Figure 6-11. Traits assessed in an Igenity® Beef Profile. Included with results.