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PRODUCTION AND MANAGEMENT: *Original Research*

Effects of Holstein and beef-dairy cross breed description on the sale price of feeder and weaned calf lots sold through video auctions

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ABSTRACT

Objective: Our objective was to determine 1) the value of Holstein feeder steer lots compared with steer lots of other breed descriptions, 2) the value of beef-dairy cross weaned steer calves compared with either Holstein weaned calves or weaned calves of other breed descriptions, and 3) the value of beef-dairy cross weaned steers and heifers compared with weaned steers and heifers of other beef breed descriptions sold through video auctions.

Materials and Methods: Data on 14,075 feeder steer lots sold in 211 auctions from 2010 through 2018, 763 weaned steer calf lots, and 1,125 weaned steer and heifer calf lots sold via 7 auctions in 2020 and 2021 were used. Separate multiple-regression models using backward selection were developed for feeder cattle, weaned steer, and weaned steer and heifer calf lots. The 5 breed group categories used were English-English crossed, English-Continental crossed, Brahman influenced, Holstein, and beef-dairy crossed (weaned calves).

Results and Discussion: Breed description of feeder steer, weaned steer calf, and weaned steer and heifer calf lots affected sale price ($P < 0.0001$). Among feeder steer lots, Holsteins sold for the lowest ($P < 0.05$) sale price ($110.56/45.36 kg of BW) compared with all other breed groups. Among weaned steer calves, beef-dairy crossed lots sold for the second lowest ($P < 0.05$) price ($147.62/45.36 kg of BW), though greater than Holsteins. Among weaned steer and heifer calves, beef-dairy crosses sold for less than ($P < 0.05$; $136.39/45.36 kg of BW) all other breed groups.

Implications and Applications: Beef-dairy crosses have a greater value prospect than Holstein steers in the beef supply chain.

Key words: beef cattle, beef on dairy, data analytics, multiple-regression model, sale price

INTRODUCTION

Though contributing significantly to domestic beef production, dairy calves incur discounts compared with beef calves (Ledbetter, 2018). Dairy-type carcasses receive high quality grades (Fairbairn and Felix, 2020) and provide a year-round supply of beef but have poor feed conversion and DP, gut health issues, and light-muscled carcasses (Grant et al., 1993). In recent years, a major packer of Holsteins ended slaughter of Holstein fed steers (Jibben, 2017), further decreasing their value.

Increased use of sex-sorted semen enables selective matings by dairy producers while offering flexibility in breeding decisions for production of replacement females and non-replacement offspring (Holden and Butler, 2018). Increasingly, dairy producers use beef semen to mate some breeding females, creating beef-dairy crosses, to add value to calves entering the beef chain (Scanavez and Mendonça, 2018; Penhorwood, 2019; Berry, 2021). The National Association of Animal Breeders reported a 23% increase in domestic beef semen unit sales from 2019 to 2020 and 44% increase from 2018 to 2019 indicating increased beef semen use in dairy and beef breeding programs alike (NAAB, 2021).

Bovine semen companies and breed associations have worked to identify ideal beef bulls as mates for dairy cows with selection criteria often including calving ease, fertility, growth, and value indices (Select Sires, 2019; ABS, 2020). Likewise, branded programs such as HOLSim, developed between Holstein USA and the American Simmental Association (Bechtel, 2020) for Holstein-Simmental crossed calves, have arisen to facilitate production of high-quality beef-dairy cross calves.

As beef-dairy calf production increases, opportunities to measure beef-dairy cross calf value exists. Data available on feeder and weaned calves sold through video auctions enabled evaluation of 3 distinct but related research objectives on dairy feeder steer and beef-dairy cross calf value relative to other breed categories. Our objectives were to 1) determine relative value of Holstein feeder steers compared with steers of other breed descriptions, 2) deter-

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mine relative value of beef-dairy cross weaned steer calves compared with either Holstein weaned calves or weaned calves of other breed descriptions, and 3) determine value of beef-dairy cross weaned steers and heifer calves compared with weaned steer and heifer calves of other beef breed descriptions.

MATERIALS AND METHODS

Data Collection

Because we had 3 distinct research objectives to address and data available to effectively answer those research question changed over time and in relation to relevant industry changes, we have described the data collection and analyses processes according to the research objectives addressed. For example, by nature of the needs and structure of the dairy industry, few, if any, Holstein feeder heifer lots were sold via this video auction. Thus, only lots of feeder steers were included in analyses comparing value of Holsteins to feeder steers of other breed descriptions. Additionally, for example, it has only been in recent years that weaned calves marketed via this video auction have been described as "beef-dairy cross" within the lot descriptions for sale and beef-dairy cross calves of both sexs have been available for sale; hence, those comparisons were made in data available from 2020 and 2021 sales that were not available in earlier years.

Feeder Steer Lots: Holstein Feeder Steers Compared with Feeder Steers of Other Breed Descriptions

Information describing factors about feeder steer lots sold through a livestock video auction service (Superior Livestock Auction, Fort Worth, TX) was obtained from the auction service in an electronic format from 2010 to 2018. Data obtained included descriptions of the lots as provided by the seller and a representative of the livestock auction service including whether they considered the lot to be calves or feeders (only feeder steer lots were included in this analysis).

Information available for each lot of feeder steers were auction year, geographical region of the United States where the lot originated, breed description of the lot, health protocol administered to the lot, the amount of weight variation within the lot, frame score of the lot, flesh score of the lot, implant status, whether the lot qualified for a USDA-approved Age and Source Verification program, freight adjustment status, whether the steers had horns, number of animals in the lot, base weight of the lot, the number of days between auction and forecasted delivery dates, and sale price of the lot ($/45.36 kg). The specific and current requirements of each of the video auction service's special health and management programs are available at www.SuperiorLivestock.com.

Data provided by the livestock auction service included breed descriptions for each lot. A lot breed description was developed between the seller and a representative for the auction service. We subsequently categorized each lot of feeder steers into 1 of 4 breed description groups: 1) English-English cross with no Brahman influence, 2) English-Continental cross with no Brahman influence, 3) Brahman influenced, and 4) Holstein. Only single-sex lots of feeder steers were included in the analyses. Lots of mixed sex or lots of heifer feeder cattle were excluded from the analysis because of the lack of mixed-sex and heifer-only Holstein lots.

Weaned Steer Calf Lots: Holstein Weaned Steer Calves Compared with Beef-Dairy Cross Weaned Steer Calves and Steer Calves of Other Breed Descriptions

Information describing lots of weaned steer calves sold during the summer of 2020 and January of 2021 was collected via the sale catalogs provided by the auction service. The sale price of the lot was collected by viewing the sale results on the auction service's internet site and recording the sale price of each lot that was sold in the auction service's video auctions. Lots of Holstein steers were sold through a special video sale, Holstein steer and dairy auctions. Holstein steer auctions that were either one week prior or one week after the catalog sales were used to obtain data for the Holstein steers in the weaned calf steer lot analyses.

The descriptive pieces of information collected for each lot of weaned steer calves were auction date, number of calves in the lot, base weight of the lot, geographical region of the United States where the lot originated, breed description of the lot, health protocol administered to the lot, weight variation within the lot, frame score of the calves in the lot, flesh score of the calves in the lot, presence of horns, whether the calves had been implanted with a growth-promoting implant, whether the lot qualified for the Verified Natural Beef program, whether the lot qualified for a USDA-approved Age and Source Verification program, whether the lot qualified for one of the Superior Certified Natural programs, the slide type and weight stop combination, whether the lot was considered an oversized lot, whether the lot met the requirements for Beef Quality Assurance, whether the lot qualified for the Global Animal Partnership GAP 4 program, whether the lot qualified for the Black Angus Verified Beef program, whether the lot qualified for BeefCare, whether the lot was enrolled in the Superior Progressive Genetics program, whether the calves were tested to be free of being persistently infected with bovine viral diarrhea, the number of days between auction date and planned delivery, whether the lot qualified for the Top Dollar Angus program, whether the lot qualified for the VitaFerm Raised program, and the sale price of the lot ($/45.36 kg).

Data provided by the livestock auction service included breed descriptions for each lot. A lot breed description was determined by the seller working with a representa-

tive for the auction service. We subsequently categorized each lot of weaned steer calves into 1 of 5 breed description groups: 1) English-English cross with no Brahman influence, 2) English-Continental cross with no Brahman influence, 3) Brahman influenced, 4) beef-dairy cross, and 5) Holstein. Only single-sex lots of weaned steer calves were included in the analysis. Mixed-sex and heifer calf lots were excluded from the analysis because few mixed-sex and heifer-only Holstein lots were sold. Only weaned steers were included in the analysis because the beef-dairy cross lots and Holstein lots were weaned.

Weaned Steer and Heifer Calf Lots: Beef-Dairy Cross Steer and Heifer Calves vs. Beef Calves of Other Breed Descriptions

Information describing lots of weaned calves sold during the summer of 2020 and January of 2021 was collected via the sale catalogs provided by the auction service. The sale price of each lot was recorded from the sale results posted on the auction service's publicly available website.

Descriptive pieces of information collected for each lot of weaned calves were auction date, number of calves in the lot, base weight of the lot, sex of calves in the lot, geographical region of the United States where the lot originated, breed description of the lot, health protocol administered to the lot, weight variation within the lot, frame score and flesh score of the calves in the lot, presence of horns, whether the calves had been implanted with a growth-promoting implant, whether the lot qualified for the Verified Natural Beef program, whether the lot qualified for the Non-Hormone Treated Cattle program, whether the lot qualified for a USDA-approved Age and Source Verification program, whether the lot qualified for one of the Superior Certified Natural programs, the slide type and weight stop combination, whether the lot was considered an oversized lot, whether the lot met the requirements for Beef Quality Assurance, whether the lot qualified for the Global Animal Partnership GAP 1 or 4 program, whether the lot qualified for the GainSmart program, whether the lot qualified for the Verified Grass-fed program, whether the lot qualified for the IGS Feeder Profit Calculator, whether the lot qualified for the Cattle Feeder Preferred program, whether the lot qualified for the Non-GMO program, whether the lot qualified for the Black Angus Verified Beef program, whether the lot qualified for BeefCare, whether the lot was enrolled in the Superior Progressive Genetics program, whether the calves were tested to be free of being persistently infected with bovine viral diarrhea, the number of days between auction and planned delivery, whether the lot qualified for the Top Dollar Angus program, whether the lot qualified for the AngusLink program, whether the lot qualified for the Charolais Advantage program, whether the lot qualified for the Balancer Edge program, whether the lot qualified for the VitaFerm Raised program, and the sale price of the lot ($/45.36 kg).

Data provided by the livestock auction service included breed descriptions for each lot. Lot breed description was determined by the seller working with a representative for the auction service. We subsequently categorized each lot of weaned calves into 1 of 4 breed groups: 1) English-English cross with no Brahman influence, 2) English-Continental cross with no Brahman influence, 3) Brahman influenced, and 4) beef-dairy cross. Single-sex lots of weaned steer or heifer calves were included in the analyses. Mixed-sex calf lots were excluded from the analysis because few mixed-sex lots were sold, and only weaned calves were included in the analysis because the beef-dairy cross lots and Holstein lots were weaned.

Statistical Analyses

For each research objective, separate multiple-regression models were developed and a backward selection procedure was used to quantify the effects of factors on the sale price of either feeder steer lots, lots of weaned steer calves, or lots of weaned steer and heifer calves (Kleinbaum et al., 1988). Factors included in each multiple-regression model are explained within each subsection described. At each step of the multiple-regression model backward selection procedure, the variable with the largest nonsignificant *P*-value was removed from the model. The MIXED procedure of SAS (version 9.4, SAS Institute Inc.) was used for the analyses. A value of $P < 0.05$ was required for a fixed effect to remain in the model. In all models, to prevent multicollinearity between the linear and quadratic terms (base weight and number of head), each of these 2 factors was centered at zero by subtracting the overall means of the factor from the value of that factor for each lot (King et al., 2006).

Feeder Steer Lots: Holstein Feeder Steers Compared with Feeder Steers of Other Breed Descriptions. Within feeder steer lots, to understand wether value differences of Holstein feeder steers as compared with feeder steers of other breed descriptions existed during this time and whether value differences changed between 2010 and 2018, 4 separate statistical analyses were conducted with these data. First, we compared the value of Holstein feeder steers to feeder steers of other breed descriptions with all data from 2010 to 2018. Then, to determine potential change in relative value of Holstein feeder steer lots from 2010 through 2018, data were analyzed in 3-yr increments, including 2010 to 2012, 2013 to 2015, and 2016 to 2018.

The fixed effects for feeder steer lots included in the original multiple-regression models were 1) auction year, 2) geographical region of lot origin, 3) health protocol administered to the lot, 4) amount of weight variation within the lot, 5) breed description, 6) frame score, 7) flesh score, 8) presence of horns, 9) implant status, 10) Source and Age Verification, 11) freight adjustment status, 12) size of lot (linear term), 13) size of lot (quadratic term), 14) base weight (linear term), 15) base weight (quadratic term),

Table 1. Nonadjusted means, medians, and ranges for factors describing single-sex lots of feeder steers sold through 211 Superior Livestock Auction video sales from 2010 through 2018

Factor	Mean ± SD	Median	Range
Number of steers in the lot	121.1 ± 110.3	70	17–1,680
Base weight of the lot (kg)	363.2 ± 50.6	374.2	99.8–580.6
Number of days from auction to forecasted delivery	30.8 ± 38.2	15	0–287
Price per 45.36 kg ($)	145.80 ± 33.77	141.00	68.00–333.00

and 16) number of days between auction and planned delivery. This model was also adjusted for the random effect of auction date nested within auction year.

Weaned Steer Calf Lots: Holstein Weaned Steer Calves Compared with Beef-Dairy Cross Weaned Steer Calves and Steer Calves of Other Breed Descriptions. The fixed effects for weaned steer calf lots included in the original multiple-regression model were 1) auction date, 2) geographical region of lot origin, 3) health protocol administered to the lot, 4) amount of weight variation within the lot, 5) breed description, 6) frame score, 7) flesh score, 8) presence of horns, 9) implant status, 10) Source and Age Verification, 11) qualified for one of the Superior Certified Natural programs, 12) Beef-Care program, 13) Beef Quality Assurance program, 14) Superior Progressive Genetics status, 15) slide and weight stop combination, 16) whether lots were sold in oversized truck loads, 17) Verified Natural Beef program, 18) size of lot (linear term), 19) size of lot (quadratic term), 20) base weight (linear term), 21) base weight (quadratic term), and 22) number of days between auction and planned delivery. Only lots originating from the Rocky Mountain/North Central and South Central regions of the United States were included in the analysis because of few beef-dairy lots originating from other regions (West Coast, Northeast, and Southeast) sold via this auction service within the time frame of this analysis. The Non-Hormone Treated Cattle program was not included in the original model because it was almost totally confounded with the Verified Natural Beef program. Top Dollar Angus, Black Angus Verified Beef, and GAP 4 were removed from the original model. Beef-dairy and Holstein steers have no or very few lots in these programs. Bovine viral diarrhea persistently infected status and VitaFerm Raised were not included in the original models because of the small number of lots in these programs.

Weaned Steer and Heifer Calf Lots: Beef-Dairy Cross Steer and Heifer Calves vs. Beef Calves of Other Breed Descriptions. The fixed effects for weaned steer and heifer calf lots included in the original multiple-regression model were 1) auction date, 2) sex of the lot, 3) geographical region of lot origin, 4) health protocol administered to the lot, 5) amount of weight variation within the lot, 6) breed description, 7) frame score, 8) flesh score, 9) implant status, 10) Source and Age Verification, 11) qualified for one or both of the Non-Hormone Treated Cattle and the Verified Natural Beef programs, 12) Beef-Care program, 13) Beef Quality Assurance program, 14) Superior Progressive Genetics status, 15) slide and weight stop combination, 16) whether lots were sold in oversized truck loads, 17) size of lot (linear term), 18) size of lot (quadratic term), 19) base weight (linear term), 20) base weight (quadratic term), and 21) number of days between auction and planned delivery. Only lots originating from the Rocky Mountain/North Central and South Central regions of the United States were included in the analysis because of few beef-dairy cross lots originating from other regions (West Coast, Northeast, and Southeast) sold via this auction service within the time frame of this analysis. Top Dollar Angus, Black Angus Verified Beef, AngusLink, GAP 1, GAP 4, Charolais Advantage, and Balancer Edge were removed from the original model as beef-dairy cross lots could not qualify for these programs. Superior Certified Natural and VitaFerm Raised were not included in the original model because there were no beef-dairy cross lots enrolled in these programs. Bovine viral diarrhea persistently infected status, GainSmart, Verified Grassfed, IGS Feeder Profit Calculator, and Non-GMO were not included in the original models because of the small number of lots in these programs.

RESULTS AND DISCUSSION

Nonadjusted means, SD, medians, and ranges of continuous variables describing lots of feeder steers, lots of weaned steer calves, and lots of weaned steer and heifer calves are summarized in Table 1, Table 2, and Table 3, respectively. The effect of breed description on the sale price of lots of feeder steers is presented in Table 4. The nonadjusted mean sale price of Holstein feeder steer lots and the percentage discount for 3-yr increments are presented in Table 5. Effects of breed description on the sale price of lots of weaned steer calves are presented in Table 6, and effects of breed description on the sale price of lots of weaned steer and heifer calves are presented in Table 7.

Table 2. Nonadjusted means, medians, and ranges for factors describing single-sex weaned steer calf lots sold through 7 Superior Livestock Auction video sales in 2020 and 2021

Factor	Mean ± SD	Median	Range
Number of steers in the lot	124.7 ± 75.4	98	20–800
Base weight of the lot (kg)	278.9 ± 59.1	283.5	95.3–442.3
Number of days from auction to forecasted delivery	60.0 ± 49.9	57	0–205
Price per 45.36 kg ($)	151.86 ± 20.19	151.00	81.00–228.00

Feeder Steer Lots: Holstein Feeder Steers Compared with Feeder Steers of Other Breed Descriptions

Data were analyzed from 14,075 lots of feeder steers sold via 211 video auctions through Superior Livestock Auction from 2010 through 2018. Mean weight and number of steers in lots analyzed were 363.2 ± 50.6 kg of BW and 121.1 ± 110.3 head, respectively (Table 1).

Of the 16 fixed effects, 15 were significant and included in the final model for lots of feeder steers sold from 2010 through 2018. Breed description of the lot, auction year, geographical region of lot origin, health protocol administered to the lot, amount of weight variation within the lot, frame score, flesh score, implant status, whether or not the lot was source and age verified, freight adjustment status, size of lot (linear term), size of lot (quadratic term), base weight (linear term), base weight (quadratic term), and number of days between auction and planned delivery all affected ($P < 0.05$) feeder steer sale price. The presence of horns did not affect sale price ($P = 0.43$).

From 2010 through 2018, English-English cross feeder steer lots sold for the greatest ($P < 0.05$) sale price ($152.39/45.36 kg of BW; Table 4). English-Continental cross feeder steer lots sold for the second greatest ($P < 0.05$) sale price ($150.61/45.36 kg of BW). Brahman-influenced feeder steer lots sold for the third greatest ($P < 0.05$) sale price ($148.75/45.36 kg of BW). Holstein lots of feeder steers sold for the lowest ($P < 0.05$) sale price ($110.56/45.36 kg of BW).

To determine potential change in relative value of Holstein feeder steer lots from 2010 through 2018, data were analyzed in 3-yr increments. A separate analysis was performed for each 3-yr increment. For 2010 through 2012, of the 16 fixed effects, 14 were significant and included in the final model. Implant status ($P = 0.68$) and freight adjustment status ($P = 0.14$) did not affect sale price for lots sold from 2010 through 2012. For the second 3-yr increment, 2013 through 2015, of the 16 fixed effects, 13 were significant and included in the final model. The presence of horns ($P = 0.27$), frame score ($P = 0.07$), and freight adjustment status ($P = 0.054$) did not affect sale price in the second year increment. The third year increment, 2015 through 2018, included 8 fixed effects in the final model. Health protocol ($P = 0.16$), presence of horns ($P = 0.08$), frame score ($P = 0.13$), implant status ($P = 0.88$), freight adjustment status ($P = 0.21$), the quadratic effect of base weight ($P = 0.93$), and number of days between auction and planned delivery ($P = 0.33$) did not affect sale price for the year increment 2015 through 2018.

In all 3-yr increments, Holstein feeder lots sold for the lowest ($P < 0.05$) sale price compared with the other breed descriptions of beef steer lots (Table 4). The mean discount of Holstein feeder steer lots relative to other breed descriptions was $33.19/45.36 kg of BW in 2010 through 2012, $42.96/45.36 kg of BW in 2013 through 2015, and the greatest in 2016 through 2018 at a mean discount of $46.24/45.36 kg of BW.

In an effort to determine whether the gap in value of Holstein feeder steers as compared with feeder steers of other breed descriptions grew or remained the same over time, we evaluated those differences in 3-yr increments from 2010 to 2018. From 2010 through 2012, the mean sale price for lots of feeder steers of beef breed descriptions was $126.82/45.36 kg of BW and lots of Holstein feeder steers were discounted 26.9% (Table 5). From 2013 through

Table 3. Nonadjusted means, medians, and ranges for factors describing weaned steer and heifer calf lots sold through 7 Superior Livestock Auction video sales in 2020 and 2021

Factor	Mean ± SD	Median	Range
Number of steers in the lot	123.4 ± 75.4	98	20–800
Base weight of the lot (kg)	280.5 ± 44.8	283.5	95.3–430.9
Number of days from auction to forecasted delivery	61.2 ± 51.1	57	0–205
Price per 45.36 kg ($)	150.65 ± 17.06	149.50	110.00–228.00

Table 4. Sale price of Holstein feeder steer lots relative to other breed descriptions sold through 211 Superior Livestock Auction video sales from 2010 through 2018[1]

Breed description	Number of lots	LSM of sale price ($/45.36 kg of BW)	Regression coefficient
2010 to 2018			
English-English cross	3,829	152.39[a]	41.83
English-Continental cross	4,310	150.61[b]	40.05
Brahman influenced	4,945	148.75[c]	38.19
Holstein	991	110.56[d]	0.00
2010 to 2012			
English-English cross	1,252	128.10[a]	34.47
English-Continental cross	1,562	126.81[b]	33.18
Brahman influenced	2,185	125.56[c]	31.93
Holstein	282	93.63[d]	0.00
2013 to 2015			
English-English cross	1,171	182.43[a]	44.82
English-Continental cross	1,485	180.46[b]	42.85
Brahman influenced	1,630	178.83[c]	41.22
Holstein	373	137.61[d]	0.00
2016 to 2018			
English-English cross	1,465	145.62[a]	47.84
English-Continental cross	1,359	144.47[b]	46.69
Brahman influenced	1,283	141.97[c]	44.19
Holstein	360	97.78[d]	0.00

[a–d]Prices without a common superscript differ ($P < 0.05$) within years.

[1]Breed description affected sale price ($P < 0.0001$). Within each analysis (2010 to 2018, 2010 to 2012, 2013 to 2015, and 2016 to 2018), each multiple-regression model was adjusted for the random effect of auction date nested within auction year.

2015, the mean sale price of feeder steers of breed descriptions other than Holstein was $180.57/45.36 kg of BW and lots of Holstein feeder steers were discounted 24.3%. From 2016 through 2018, the mean sale price of feeder steers of breed descriptions other than Holstein was $144.02/45.36 kg of BW and Holstein feeder steers incurred, on average, a 33.2% discount.

Table 5. Least squares means sale price of feeder steer lots and the mean and percentage discounts of Holstein feeder as compared with English-English cross, English-Continental cross, and Brahman influenced steer lots for each 3-yr increment

Breed description	Number of lots	LSM of sale price ($/45.36 kg of BW)	Mean discount ($/45.36 kg of BW)	Percentage discount (%)
2010 to 2012				
English-English cross, English-Continental cross, and Brahman influenced	4,999	126.82		
Holstein	282	93.63	33.19	26.2
2013 to 2015				
English-English cross, English-Continental cross, and Brahman influenced	4,286	180.57		
Holstein	373	137.61	42.96	24.3
2016 to 2018				
English-English cross, English-Continental cross, and Brahman influenced	4,107	144.02		
Holstein	360	97.78	46.24	32.1

Table 6. Effect of breed description on the sale price of weaned steer calf lots sold through 7 Superior Livestock Auction video sales in 2020 and 2021

Breed description	Number of lots	LSM of sale price ($/45.36 kg of BW)	Regression coefficient
English-English cross	270	165.18[a]	52.14
English-Continental cross	197	160.38[b]	47.34
Brahman influenced	111	155.54[c]	42.50
Beef-dairy cross	94	147.62[d]	34.58
Holstein	91	113.04[e]	0.00

[a–e]Means within a factor without a common superscript differ ($P < 0.05$).

The greater relative percentage discount in sale price of Holstein feeder steers as compared with beef breed categories from 2016 to 2018 (33.2% discount) compared with earlier years (26.9 and 24.3% discount in 2010 to 2012 and 2013 to 2015, respectively) is likely partially in response to key events in the beef value chain. In December 2016 a major packer announced a decision to no longer slaughter Holstein steers (Jibben, 2017; Schweihofer, 2017). It has been well documented that Holstein feeder cattle are less feed efficient and have a lower DP than beef feeder cattle (Grant et al., 1993; Ledbetter, 2018; Coyne et al., 2019). Perhaps, though, in this time of growth of beef-on-dairy production, there is also opportunity for segments of the beef value chain to capitalize on what some may deem as a more consistent and predictable Holstein feeder steer while knowledge gaps about growth performance and carcass quality and consistency of beef-dairy cross cattle are being filled. Berry (2021) suggested opportunity for beef-on-dairy production systems to help meet growing global demand for animal protein with a more favorable environmental footprint in comparison with a straight dairy fed steer or heifer scenario.

It is clear that advancements in, and subsequently great adoption of, reproductive technologies in the dairy industry such as sexed semen and embryo transfer have enabled dairy producers to selectively produce replacement females from genetically superior females (Holden and Butler, 2018) and facilitate producer flexibility in breeding decisions for the remaining females in the herd (Berry, 2021). The discount for Holstein lots and the apparent lessening interest in feeding dairy-type steers has resulted in many dairy producers using beef semen in lower quality dairy cows (Gould and Lindquist, 2018; Scanavez and Mendonça, 2018; Penhorwood, 2019). Domestic beef semen sales drastically increased by 59% from 2017 to 2018, primarily as a result of use in dairy cows and heifers (Geiger, 2019). By inseminating genetically inferior dairy cows with beef semen, the offspring is a beef-dairy cross, potentially adding value to the calves entering the beef chain compared with a traditional Holstein steer (Gould and Lindquist, 2018; Scanavez and Mendonça, 2018; Penhorwood, 2019).

Weaned Steer Calf Lots: Holstein Weaned Steer Calves Compared with Beef-Dairy Cross Weaned Steer Calves and Steer Calves of Other Breed Descriptions

Data were analyzed from 763 lots of weaned steer calves sold via 7 video auctions through Superior Livestock Auction in 2020 and 2021. Mean weight and number of steer calves in lots analyzed were 278.9 ± 59.1 kg of BW and 124.7 ± 75.4 head, respectively (Table 2).

Of the 22 fixed effects, 9 were considered significant and included in the final model for lots of weaned steer calves. Breed description of the lot, auction date, flesh score of the lot, whether the lot qualified for one of the Superior Certified Natural programs, whether the lot qualified for the Verified Natural Beef program, size of the lot (linear

Table 7. Effect of breed description on the sale price of weaned steer and heifer calf lots sold through 7 Superior Livestock Auction video sales in 2020 and 2021

Breed description	Number of lots	LSM of sale price ($/45.36 kg of BW)	Regression coefficient
English-English cross	441	155.15[a]	18.79
English-Continental cross	321	151.09[b]	14.70
Brahman influenced	181	146.20[c]	9.81
Beef-dairy cross	182	139.39[d]	0.00

[a–d]Means within a factor without a common superscript differ ($P < 0.05$).

term), base weight of the lot (linear term), base weight of the lot (quadratic term), and number of days between auction and planned delivery affected ($P < 0.05$) calf sale price. Implant status ($P = 0.91$), presence of horns ($P = 0.67$), oversized truck loads ($P = 0.65$), Superior Progressive Genetics status ($P = 0.62$), Beef Quality Assurance program ($P = 0.60$), Source and Age Verified ($P = 0.48$), frame score ($P = 0.27$), region of origin ($P = 0.27$), BeefCare program ($P = 0.22$), health protocol ($P = 0.10$), the quadratic effect of lot size ($P = 0.07$), weight variation within the lot ($P = 0.07$), and slide and weight stop combination ($P = 0.08$) did not affect the sale price of lots of weaned steer calves.

For lots of weaned steer calves, English-English cross lots of steer calves sold for the greatest ($P < 0.05$) sale price ($165.18/45.36 kg of BW) compared with all other breed descriptions (Table 6). English-Continental cross steer calf lots sold for the second greatest ($P < 0.05$) sale price at $160.38/45.36 kg of BW. Brahman-influenced lots of steer calves sold for the third greatest ($P < 0.05$) sale price ($155.54/45.36 kg of BW) compared with all other breed descriptions. Beef-dairy cross lots of steer calves sold for a greater ($P < 0.05$) sale price ($147.62/45.36 kg of BW) than Holstein lots of steers calves, which sold for the lowest ($P < 0.05$) sale price ($113.04/45.36 kg of BW) compared with all other breed descriptions.

Weaned Steer and Heifer Calf Lots: Beef-Dairy Cross Steer and Heifer Calves vs. Beef Calves of Other Breed Descriptions

Data were analyzed from 1,125 lots of weaned steer and heifer calves sold via 7 video auctions through Superior Livestock Auction 2020 and 2021. Mean weight and number of steer and heifer calves in lots analyzed were 280.5 ± 44.8 kg of BW and 123.4 ± 75.4 head, respectively (Table 3).

Of the 21 fixed effects, 11 were considered significant and included in the final model for lots of weaned steer and heifer calves. Breed description of the lot, auction date, sex of the lot, health protocol administered to the lot, flesh score of the lot, whether the lot qualified for one or both of the Non-Hormone Treated Cattle and the Verified Natural Beef programs, size of lot (linear term), size of lot (quadratic term), base weight (linear term), base weight (quadratic term), and number of days between auction and planned delivery all affected ($P < 0.05$) calf sale price. Implant status ($P = 0.78$), oversized truck loads ($P = 0.63$), Source and Age Verified ($P = 0.59$), region of origin ($P = 0.50$), Superior Progressive Genetics status ($P = 0.51$), BeefCare program ($P = 0.29$), frame score ($P = 0.23$), weight variation within the lot ($P = 0.09$), Beef Quality Assurance program ($P = 0.05$), and slide and weight stop combination ($P = 0.05$) did not affect the sale price of lots of weaned steer and heifer calves.

English-English cross weaned calf lots sold for the greatest ($P < 0.05$) sale price ($155.15/45.36 kg of BW) compared with all other breed descriptions (Table 7). English-Continental cross weaned calf lots sold for the second greatest ($P < 0.05$) sale price at $151.09/45.36 kg of BW. Brahman-influenced lots of weaned calves sold for the third greatest ($P < 0.05$) sale price ($146.20/45.36 kg of BW) compared with all other breed descriptions. Beef-dairy cross lots of weaned calves sold for the lowest ($P < 0.05$) sale price ($136.39/45.36 kg of BW) compared with all other breed descriptions.

The value of the beef-dairy cross steer lots was $34.58/45.36 kg of BW greater than that of the Holstein steer lots, clear added value for a weaned beef-dairy cross steer as compared with a weaned Holstein steer, yet only $7.92/45.36 kg less than that of Brahman-influenced weaned steer calf lots. Although there were no lots of Holsteins heifers, thus no lots of Holsteins were included in the analysis of weaned steer and heifer lots, beef-dairy cross lots sold for $9.81/45.36 kg of BW less than Brahman-influenced calves. There have been estimations reported of the perceived value of a beef-dairy cross animal (Heslip, 2020; Myers, 2020), although there are no values reported in the literature for lots of weaned calves sold through video auction. The estimations of added value for a beef-dairy cross compared with a Holstein reported in popular press range from approximately $100 to $150 per head (Heslip, 2020; Myers, 2020).

As the beef-dairy cross segment of the industry continues to develop, there will be more research supporting the ideal beef breed, or type of bull, for dairy cows. Berry (2021) has comprehensively reviewed the converging factors contributing to growing global interest in beef-on-dairy production and emphasized the importance of validated decision-support tools for producer use in navigating management decisions. In recent years, there have been enhanced efforts by semen companies and breed associations to identify the ideal bulls as mates for dairy cows. Many of these programs focus selection criteria on fertility, calving ease, growth traits, and value indices (Select Sires, 2019; ABS, 2020; Alta, 2020; Genex, 2020). During the summer of 2020, the American Angus Association released 2 value indices ranking Angus bulls for use on either Holstein or Jersey cows (American Angus Association, 2020). We can expect considerable growth in coming years in knowledge regarding "best practices" for beef-on-dairy matings, health and nutritional management of beef-dairy cross calves, and perhaps more clarity regarding value of beef-dairy cross calves at all segments of the production chain. Likewise, marketing strategies of industry organizations in the beef-dairy cross space are evolving. Many semen companies have created a branded program for calves produced from bulls in their lineup (Select Sires, 2019; ABS, 2020; Alta, 2020; Genex, 2020). In 2019 Holstein USA and the American Simmental Association partnered to create a marketing program, HOLSim, for Holstein, Simmental cross calves (Bechtel, 2020), for example.

Identification of specific beef breeds and sires within breeds for production of consistent and superior quality

beef-dairy cross calves has been advocated as key for future studies (Berry, 2021; Johnson and Fuerniss, 2021). The animals included in these analyses represented semi-truck load lots as they were sold through a video auction service. The value of the beef-dairy cross in this study represents a steer or heifer approximately at the weight of weaning for a traditional beef breed steer. The value of the beef-dairy cross at other stages of production as well as calf nutritional and health management strategies need further investigation.

APPLICATIONS

Breed description of feeder steer, weaned steer calf, and weaned steer and heifer calf lots affected sale price of lots sold through video auction. Holstein feeder steer lots and Holstein weaned steer calf lots sold for less than lots of all other breed descriptions. Both beef-dairy weaned steer calf lots and weaned steer and heifer calf lots sold for less than lots with beef breed descriptions. Although lots of beef-dairy cross weaned steers had greater value than lots of Holstein steers, beef-dairy crosses were much closer in value to the traditional beef breed descriptions, which may incentivize continued use of beef semen in dairy females. With continued and increasing use of beef semen in dairy females, ongoing assessment and reporting of value differences in beef and beef-dairy cross animals across production segments is warranted. Research is also needed to understand how the beef-dairy cross animal performs through all segments of modern beef production to inform decision-makers regarding value and management practices.

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