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**The Prevalence and Impact of Dairy/Beef Crosses on Cattle
Producers in New Hampshire**

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Sustainable Agriculture and Food Systems

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Agriculture, Nutrition, and Food Systems

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Abstract

Recent years had seen a significant rise in the use of beef semen on dairy cows in the United States. This trend was not widely understood, especially as it related to dairy farmers in New Hampshire. A survey was sent out by mail to the ninety-seven dairy farms in New Hampshire. Participants could return the survey using the included envelope or they could participate online using the link or QR code included in the survey packet. There were thirty-seven responses to the survey. Thirty-two out of thirty-seven respondents bred beef semen to their dairy cows. Twenty-one of these respondents raised dairy x beef on their farms and twenty-six planned to continue breeding dairy x beef. The most common breeds used in dairy x beef crosses were Holstein and Angus. 24% of respondents began breeding dairy x beef in 2000 or before, 8% began between 2001 and 2013, and 68% began between 2014 and 2023. The average size of dairies surveyed was 101 - 200 dairy cattle. The three most common reasons cited for breeding dairy x beef were increased income, consumer demand, and easier conception. Dairy farmers received a higher price on average for a dairy x beef calf than for a conventional bull calf. Farmers weaned dairy x beef calves at an average of 12 weeks. Farmers did not seem to finish their dairy x beef cattle on different feed than they were grown on. The average slaughter age was 18 - 20 months. Most dairy x beef meat was marketed direct to the consumer by the whole carcass, half carcass, or by the piece. The average amount a farmer would receive for a whole animal after direct marketing its meat was \$3,423. The average amount a farmer would receive for a live dairy x beef animal was \$1,767.

Introduction

In a typical dairy operation bulls are a low value asset. As they cannot produce milk themselves, they are ushered off of dairies as soon as possible, and when brought to market, they go for extremely low prices (Berry, 2021). Additionally, dairy bulls are not valuable to beef farms as farmers would rather put money and energy into their beef steers who are optimized for meat production. There are two conventional uses for dairy bulls one is veal, the other is raising them as dairy beef (Creutzinger et al., 2021). However, dairy animals raised for beef often do not finish to a grade comparable to beef cattle and therefore received a lower price when sold (Holden & Butler, 2018).

In order to increase the value of dairy bull calves, farmers began breeding their best cows with sexed semen to get higher quality females. Sexed semen has been treated in such a way as to almost entirely separate out sperm that would bear a female and sperm that would bear a male (Holden & Butler, 2018). This allowed dairy farmers to ensure their best producing cows will have daughters and be able to improve the genetics of the herd. Previously, dairy operations were not able to be so selective when choosing replacement cows, and the entire herd, from the worst to the best producers, would have their progeny contribute to the herd. This coupled with new calf genetic testing has allowed for increased selection of cattle and could result in higher profits for dairy farmers (Hjortø et al., 2015).

Additionally, farmers across the country have begun to breed beef semen on dairy cattle to produce dairy x beef cross calves. This can be seen by looking at beef and dairy semen sales. In 2017 roughly 2.5 million units of beef semen were sold, and have increased in 2021 to 8 million units (Geiger 2019, 2022). Meanwhile, dairy semen sales have decreased by 6.7% (Cadloff, 2022). This occurred while milk production has continued to increase, suggesting that a

large portion of beef semen is going to dairy operations to be used instead of conventional dairy semen (NASS, 2022).

Beef on dairy calves can also contribute to the refinement of dairy herd genetics, as lower producing dairy cows can be bred with beef semen, therefore allowing farmers to select against these cow's genes, while still allowing the cows to produce milk (Poock et al., 2022). These calves can also be sold for a significantly higher price (Berry, 2021). An initial interview with former UNH Organic Research Dairy manager, Ryan Courtwright, revealed that after trucking and sales costs he often has to pay \$5 at auction for a Jersey bull calf, but he could sell dairy x beef bulls to private buyers for \$100 (Courtwright, 2022).

Although the interview with Courtwright demonstrated an increase in dairy bull prices when using beef semen, recent research has been less promising (Courtwright, 2022). A simulated budget model comparing three breeding scenarios wherein the third scenario bred excess cows with beef semen found that it was only more profitable than breeding conventional dairy bulls when the price of beef was high (McCulloch et al., 2013). Another study simulated the effect of genetic drift on a dairy herd when breeding lower producing dairy cows to beef and found that using beef semen in this way would only be productive in herd-specific cases (Ettema et al., 2017).

Despite these findings, a shift to dairy x beef crosses has been seen across the country. The national heifer count, or number of female cows not yet bred, was down by 10% since 2018, suggesting more beef/dairy bulls have been bred and sold off dairies (Geiger, 2022). Nationally the demand for dairy beef crosses may continue to increase due to recent droughts in the West causing farmers to cull their beef cows in huge numbers (Swenson, 2022). This will decrease the availability of beef cattle in the next few years and could drive beef prices higher. However, the

data collected so far on the phenomenon of dairy x beef hybrids has been largely from the west where dairy operations look very different from the ones in New Hampshire. There had been no research done on the prevalence of this kind of crossbreeding in New Hampshire, which beef breeds dairy farmers are using, or economic results beyond conventional dairy bull calf value.

Methods

An electronic survey developed using Qualtrics™ was sent out to all 97 dairy farms in New Hampshire. The addresses of all the farms in New Hampshire were obtained with the help of Dr. Pete Erickson, the NH Dairy Production Specialist for UNH Cooperative Extension. A paper copy of the survey was sent to them with a return envelope, as well as a web address, and a QR code to access the survey online. The survey was sent out the week of March 13th, 2023 with the intention that it would reach dairy farmers before they became too busy in the spring to respond.

The questions for the survey were devised after conducting several in person and telephone open ended interviews with stakeholders who have interest in NH dairy/beef crosses, namely farmers, butchers, and researchers. The questions are provided in Appendix I.

The data was collected in Qualtrics™ and analyzed in (Microsoft Excel, 2022; Microsoft Corporation, Redmond, WA). All the data was self reported from respondents. There were 37 responses to the survey, which is a 38% response rate.

Results

a. Overview

Thirty-two respondents answered that they bred beef semen to their dairy cows (Table 1). Thus, at least one third of dairy farms in New Hampshire were producing dairy x beef calves. Five respondents answered that they did not breed dairy x beef. Of the five farms who did not breed dairy x beef, only one had considered it, but they did not due to the high price of beef semen, the labor required, and the cost of the extra feed. 87% of respondents who had bred dairy x beef calves said that they will continue breeding dairy x beef, while the other 13% said they were unsure (Table 2).

Table 1. The number of New Hampshire dairies who breed dairy x beef compared to the number who do not, and the number of farms that did not reply. There were 37 responses.

NH Dairies on Breeding Dairy/Beef		
	Respondents	Percent
Breed Dairy/Beef	32	33%
Do Not Breed Dairy/Beef	5	5%
No Reply	60	59%

Table 2. Responses from New Hampshire dairy farmers who have bred dairy x beef on if they will continue to breed dairy x beef. There were 30 responses.

NH Dairies on the Future of Breeding Dairy/Beef		
	Respondents	Percent
Plan to Continue to Breed Dairy/Beef	26	87%
Do Not Plan to Continue to Breed Dairy/Beef	0	0%
Unsure if They will Continue to Breed Dairy/Beef	4	13%

When respondents were asked what they did with their dairy x beef calves, they replied with four options: raise the calves on their farm, sell the calves at auction, or sell the calves to private buyers inside or outside of New Hampshire (Table 3). All of these options were popular, with raising the dairy x beef calves on farm being the most popular. 21 respondents raised dairy x beef calves on their farms.

Table 3. Responses from New Hampshire dairy farmers who have bred dairy x beef on what they do with the calves. Respondents were allowed to chose more than one option. There were 58 responses.

What is Done with Dairy/Beef Calves	
Option	Respondents
Raise the calves on your farm	21
Sell the calves to a private buyer in NH	13
Sell the calves to a private buyer outside of NH	8
Sell the calves at auction	16

Of the farmers who breed dairy x beef, Holstein was the most common dairy breed used, at 43%, followed by Jersey, Ayrshire, Milking Shorthorn, and then a dairy cross (Figure 1). There was one instance of each of the following dairy breed crosses: Holstein x Jersey, Swiss x Holstein x Jersey, Holstein x Angus, and Holstein x Hereford.

Angus was the most common beef breed used in dairy x beef crosses, with 39% of respondents breeding Angus semen with their dairy cows (Figure 2). After Angus, Hereford and Wagyu were most popular, with 20% and 9% of farmers using the breeds respectively. There was one instance of each of the following beef breed crosses: Angus x Hereford, Angus x Simmental, and Beefmaster. The “Other” category includes one response for each of the following breeds: North Devon, Brahman, and Speckle Park.

Dairy Breeds Used in Crosses

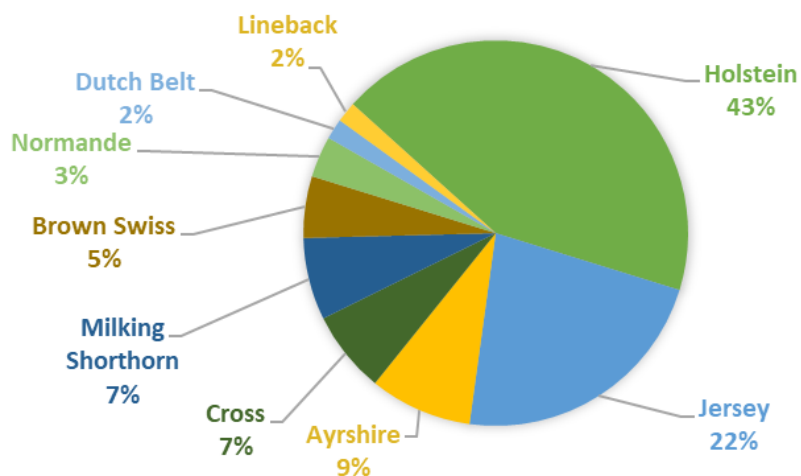


Figure 1. A pie chart depicting dairy breeds used in dairy x beef crosses. Respondents were allowed to chose more than one response. There were 58 responses.

Beef Breeds Used in Crosses

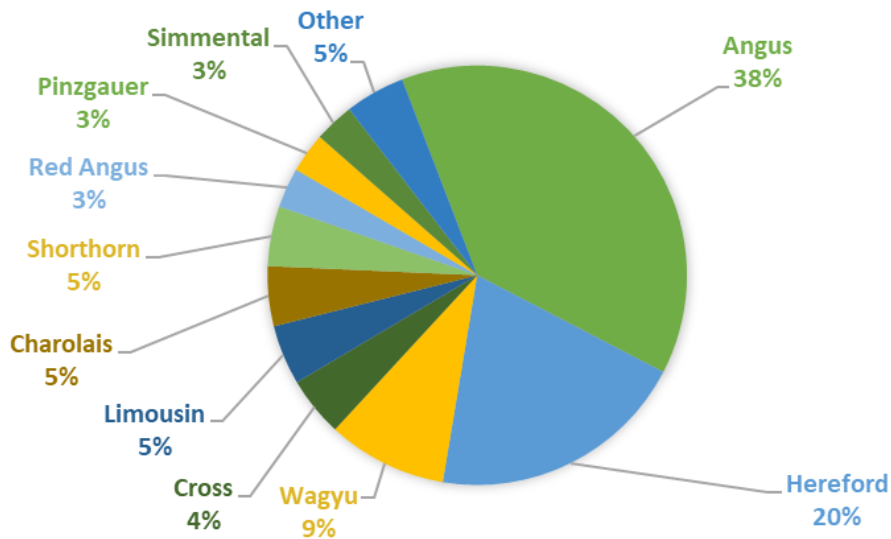


Figure 2. A pie chart depicting beef breeds used in dairy x beef crosses. Respondents were allowed to chose more than one response. There were 65 responses.

24% of respondents began breeding dairy x beef in 2000 or before, with one farm beginning in the 1960s (Figure 3). Only two respondents began breeding dairy x beef between 2000 and 2013. One began in 2003, and the other began in 2010. The remaining 68% of farms began breeding dairy x beef in 2014 or later, with the average year being 2017-2018.

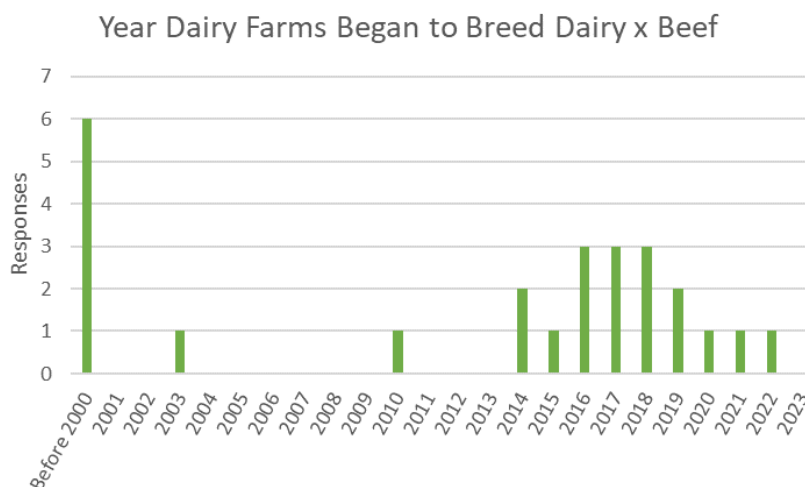


Figure 3. A bar graph depicting the year New Hampshire dairy farmers began breeding dairy x beef. There were 25 responses.

New Hampshire dairy farmers were also surveyed on the size of their dairy operation measured by how many dairy cattle they owned (Figure 4). The most common farm size was 101 - 200 head of cattle, followed by 300+. 42% of the farms surveyed had between 1 and 100 cattle, while the other 58% of farms had 101 or more cattle.

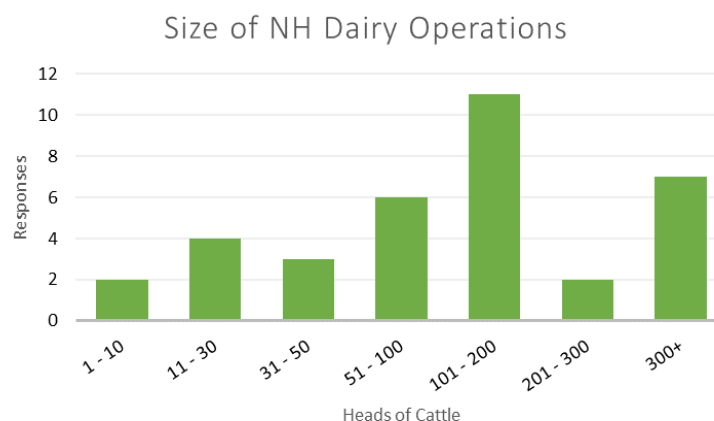


Figure 4. A bar graph depicting the size of dairy farms in New Hampshire by head of cattle. There were 35 responses.

There were 9 reasons farmers listed for why they began to breed dairy x beef (Figure 5). The three most prominent were increased income, consumer demand, and easier conception. The other reasons included easier calving, farmers wanting beef cows, transitioning out of dairy, downsizing dairy, cow welfare, and not having a need for replacement heifers.

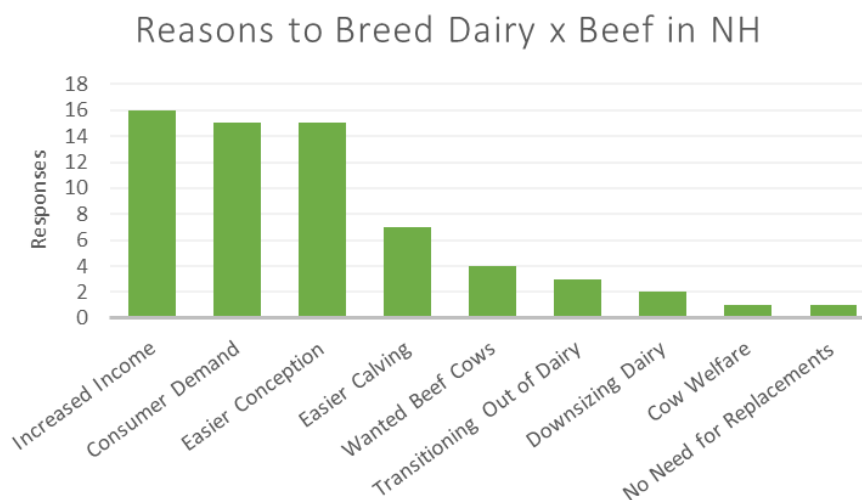


Figure 5. A bar graph describing reasons farmers in New Hampshire breed dairy x beef crosses. Respondents were allowed to choose more than one response. There were 64 responses.

Farmers were asked how much they typically received for a conventional bull calf and for a dairy x beef calf (Figure 6). 68% of respondents said they received \$101 or more for a dairy x beef calf. 25% of respondents said they received \$101 or more for a conventional dairy bull calf. This would suggest that on average farmers receive more money for dairy x beef calves than they do for conventional dairy bull calves.

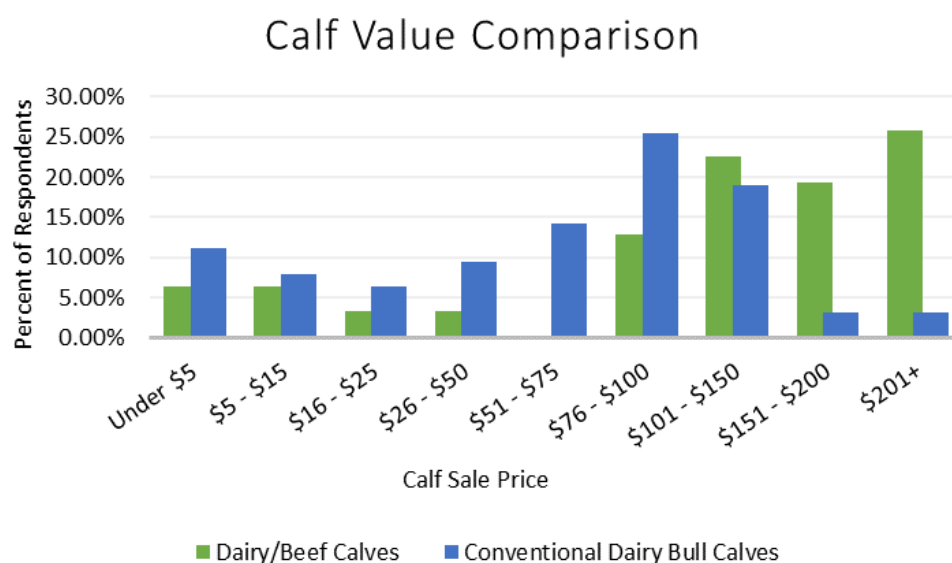


Figure 6. A bar graph depicting the sale price for dairy x beef calves vs conventional dairy bull calves. Respondents were allowed to choose more than one response. There were 31 responses for dairy x beef calf sale prices, and 63 for conventional dairy bull calf sale prices.

b. Raising Dairy x Beef

Farmers had varying responses to how long they fed milk to dairy x beef calves (Figure 7). The average amount of time farmers reported feeding dairy x beef calves milk was 12 weeks, but it was not uncommon for them to be fed milk for less time than that, or for significantly longer. Two farmers wrote in explaining they fed milk for 6-7 months and 6+ months.

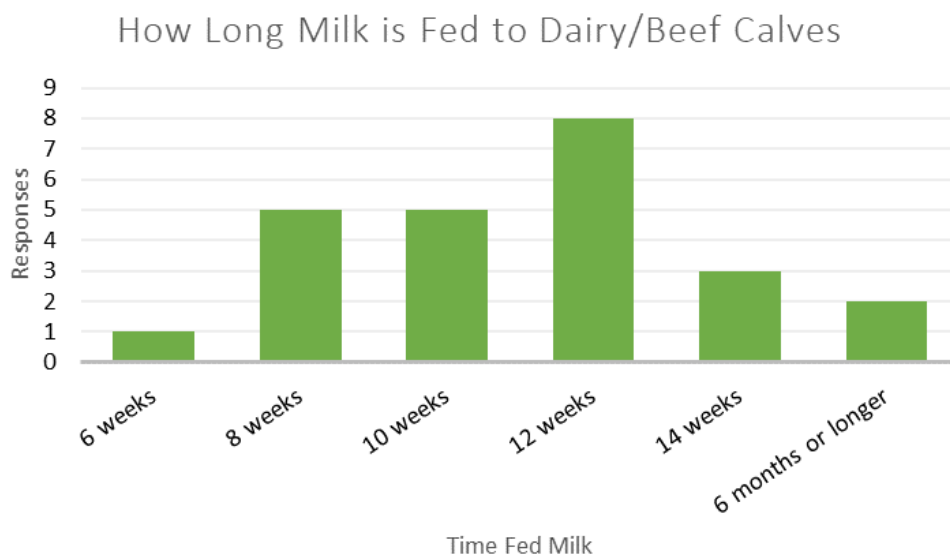


Figure 7. A bar graph depicting the amount of time NH dairy farmers fed milk to their dairy x beef calves. Respondents were allowed to chose more than one response. There were 24 total responses.

Farmers were asked about their grower feed choices and their finishing feed choices, and the two were compared (Figure 8). Dry hay, pasture, and corn silage were the most popular forage choices for dairy farmers raising dairy x beef cattle in New Hampshire. A commercial pellet was the most popular grain choice. Few dairy farmers in New Hampshire appeared to feed dairy x beef cattle a different ration for finishing. Several respondents specifically wrote that they did not feed a different finishing ration. The Total Mixed Ration (TMR) category includes farmers who described feeding leftover dairy TMR to their dairy x beef crosses and farmers who fed the same TMR they gave to their dairy cows.

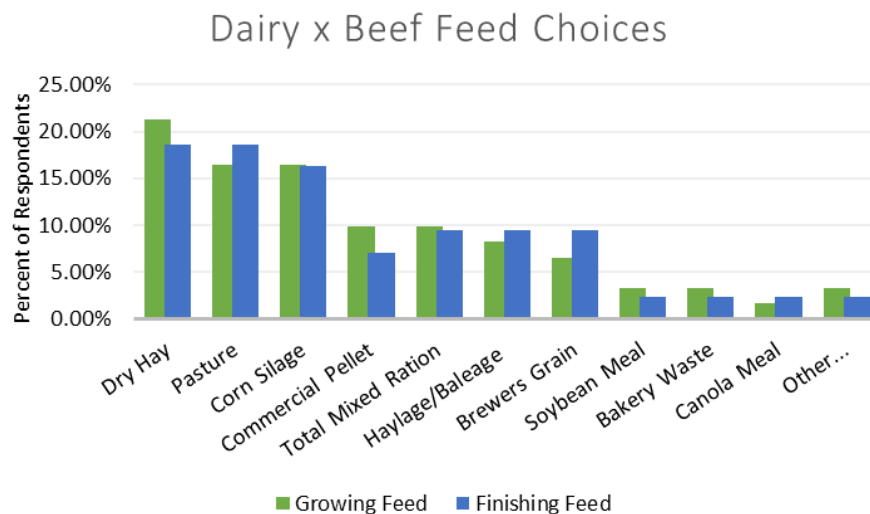


Figure 8. A bar graph of New Hampshire dairy farmers feed choices for dairy x beef crosses while they are growing and to finish them. Respondents were able to chose more than one response. There were 61 responses for growing feed choices. There were 43 responses for finishing feed choices.

The average age of dairy x beef at slaughter was between 18 and 20 months (Figure 9). Slaughtering at 20-24 months was also a popular decision. No farmers reported slaughtering dairy x beef under 14 months. Three farmers reported slaughtering dairy x beef over two years of age.

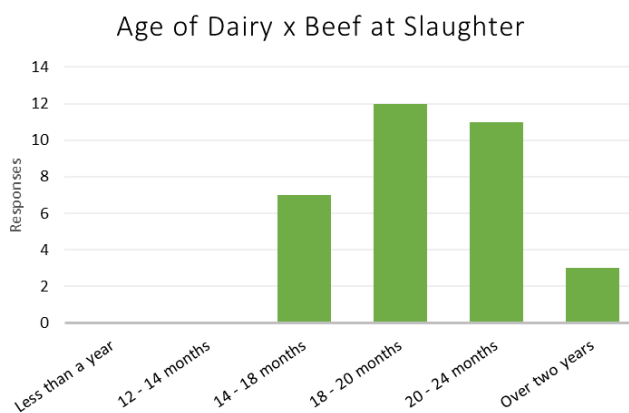


Figure 9. A bar graph depicting the age of dairy x beef cattle at slaughter raised at New Hampshire dairies. Respondents were able to chose more than one response. There were 29 responses.

Dairy x beef raised on New Hampshire dairies was primarily marketed directly to the consumer (Figure 10). Farmers direct marketed their dairy x beef, by the whole, half, and quarter carcass, and by the piece. Additionally, farmers marketed directly to restaurants, directly to butchers, and they sold their dairy x beef cows at auction.

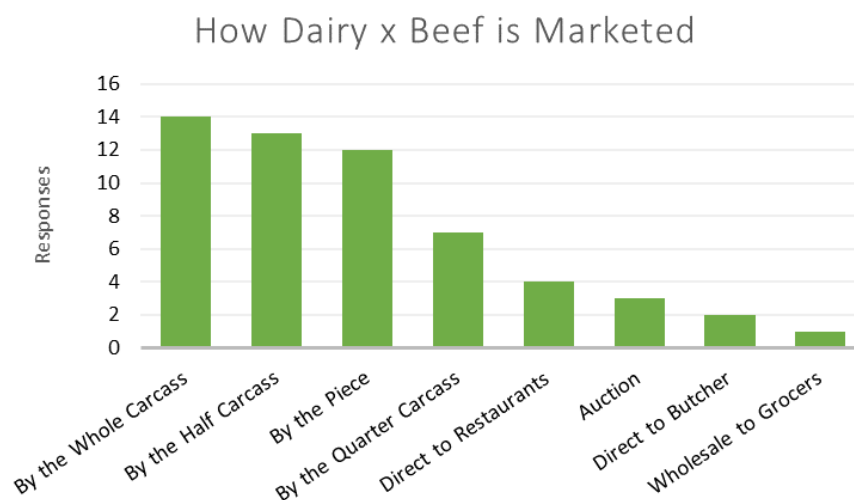


Figure 10. A bar graph describing how dairy x beef is marketed and sold. “By the whole carcass”, “by the half carcass”, “by the piece”, and “by the quarter carcass” were all described at “direct to the consumer” in the survey. Respondents were able to chose more than one response. There were 53 responses.

When farmers marketed directly to the consumer, either by the piece, the half, the quarter, or by the whole cow the estimated average amount they received for the whole animal was \$3,423 (Table 4). Additionally, there were two responses given as price per lb of the carcass: \$3 per lb, and \$6-7 per lb. When farmers sold their dairy x beef animals live at the age of 1 to 2 years they received an average of \$1,767 or \$2.33 per lb (Table 5). One respondent replied that they received \$350 when selling a live dairy x beef animal between the ages of 1 and 2 years. This response was not included in the average as it was believed that this was either the amount they

would receive for a dairy x beef calf, or the net amount they would make from the animal, and not the gross amount they would receive.

Table 4. Thirteen New Hampshire dairy farmers provided the average gross income from one dairy x beef animal in dollars when it was direct marketed to consumers either by the piece, the half, the quarter, or by the whole cow.

**Denotes responses that were given as a range.*

Gross Income from One Dairy/Beef Animal Direct Marketed to Consumers in Dollars
2,200
2,400
2,400
3,000*
3,200
3,500*
3,500*
3,500
3,800
4,000
4,000
4,500
4,500
Average: 3,423

Table 5. New Hampshire dairy farmers estimation of the average gross income from one dairy x beef animal sold live between the ages of 1 and 2 years in dollars. There were 4 responses given as the income from a whole animal and 3 given as a price per lb of a whole animal.

**Denotes responses that were not included in the average.*

Gross Income from One Live Dairy/Beef Animal Between the Ages of 1 and 2 in Dollars					
Whole Animal	350*	1,300	2,000	2,000	Avg: 1,767
Price per lb	4	1.50	1.50	--	Avg: 2.33

Discussion

86% of respondents reported that they bred beef semen to their dairy cattle, however this percentage was likely not applicable to the entire population of dairy farms in New Hampshire (Table 1). It is believed that at least some of the farms who did not respond to the survey did so because they did not breed dairy x beef and therefore thought it would not be relevant to them. Regardless, this research elucidated that at least one third of dairy farms in New Hampshire bred beef semen to their dairy cattle. This was a significant portion of the dairy farms in New Hampshire and was valuable information for dairy farmers and researchers to have.

Research done to determine diversification strategies of small New England dairies surveyed 10 dairies in New Hampshire and Vermont. Of those 10 farms, 5 reported selling either “culled beef” or “beef” (Snorek et al., 2023). While no conclusions could be drawn regarding the number of farms in the mentioned survey who bred dairy x beef, it demonstrated the shift towards beef production in New England dairies. A survey of 69 dairy farms in Wisconsin, Michigan, and Iowa was conducted and it revealed that 53 of them used beef semen on their dairy cattle (Halfman & Sterry, 2019). However, this study targeted farms thought to likely be breeding dairy x beef, and so it is not an accurate representation of the population’s breeding habits. That said, there were still 53 dairies in Wisconsin, Michigan, and Iowa who bred dairy x beef ranging in size from 100 or less cattle to more than 1,000. A study of Californian dairies revealed 81% of respondents had used beef semen on their dairy cows (Pereira et al., 2022). However, this survey’s response rate was 13.9%, and so no conclusions could be drawn about the prevalence of dairy x beef crosses across the entire state. Still, it suggested the practice was widespread.

The two mentioned studies complimented this research done in New Hampshire. Dairy x beef crosses were found to be prevalent across all farm sizes (Halfman & Sterry, 2019; Figure 4). 65% of respondents who bred dairy x beef in New Hampshire raised their dairy x beef calves on their farms and marketed them as finished cattle (Table 3). This was significantly different from the dairies in Wisconsin, Michigan, and Iowa, of which only 20% raised dairy x beef calves to finishing, and the dairies in California, of which 19.4% raised calves (Halfman & Sterry, 2019; Pereira et al., 2022).

The most common beef breeds used by dairy farmers in New Hampshire were Angus, Hereford, and Wagyu, followed by Limousin, Charlois, and Shorthorn (Figure 2). A survey of dairies in Wisconsin, Michigan, and Iowa breeding dairy x beef found their most common beef breeds to be Angus, Lim-Flex, Limousin, SimAngus, and Simmental (Halfman & Sterry, 2019). A study of Holstein and Jersey inseminations in the US found the most common beef breeds to be Angus, Limousin, Simmental, Crossbred Beef, and Wagyu (Lauber et al., 2023). A survey of dairy producers in California found the most common beef breeds used to be Angus, Limousin, Wagyu, and Charolais (Pereira et al., 2022). Angus was the most common beef breed used in all of these studies, but the next most common breed varied. This study of New Hampshire was the only one with a significant portion of Hereford, and no significant amount of beef crosses, such as Lim-Flex or SimAngus. The study of midwestern dairies found no significant use of Wagyu semen, despite the fact that it accounted for 1.6% of beef inseminations nationally, and 10% of dairy x beef crosses in California (Lauber et al., 2023; Pereira et al., 2022). Several New Hampshire dairy farmers used Wagyu semen as well. Limousin semen was used in a higher amount in the midwest and nationally, than it was in New Hampshire.

The increase in dairy x beef crosses in New Hampshire can be attributed to farmers increasing the economic value of their bull calves, decreasing their excess dairy heifers, diversifying their farm income, and capitalizing on consumer interest in local beef (Figure 5). Increasing income is of the utmost importance for NH dairy farmers. A study of 10 New Hampshire and Vermont dairies found that dairy farmers in this region do not see dairy farming as a viable source of income on its own (Snorek et al., 2023). This research on dairy x beef in New Hampshire has shown that one way farmers may increase income is by selling dairy x beef calves. On average, respondents received more for their dairy x beef calves than for conventional dairy bull calves (Figure 6). Additionally, farmers make an average of \$3,423 when selling dairy x beef meat direct to the consumer and an average of \$1,767, or \$2.33 per lb when selling the dairy x beef animal live (Table 4, Table 5).

As mentioned previously, large simulated budget models from Denmark and Colorado had found that breeding dairy x beef to sell the calves was only profitable under certain circumstances (Ettema et al., 2017; McCulloch et al., 2013). These simulations used sexed semen on the cows with superior genetics, and beef semen on the others. The amount of sexed semen vs beef semen used was dependent on the study. McCulloch et al. found breeding beef to their lower producing cows to be unprofitable due to the higher amount dairy replacements could be sold for (McCulloch et al., 2013). Ettema et al. found breeding beef to their lower producing cows to be unprofitable under Danish circumstances (Ettema et al., 2017). Additionally, they found that if the goal was to increase the genetic level of the herd, one could receive the same results by selling the heifers of the cows with the lowest genetic potential. A third study, from Wisconsin, found that breeding dairy x beef calves was profitable when used in conjunction with sexed semen, when dairy x beef calves would sell for more than conventional calves, and when a

willingness to buy calves existed (Cabrera, 2022). A fourth study, from Germany, found that using dairy x beef cross breeding in combination with sexed semen resulted an average increase in profits of €79.42 per cow per year (Pahmeyer & Britz, 2020). Finally, a study from France found that the most profitable scenarios always used sexed semen in combination with beef semen (Bérodier et al., 2019).

These studies were varied on their support of breeding dairy x beef for increased income. A few things may account for this discrepancy. First, beef and dairy prices likely differ between New Hampshire and the populations these simulations were based on. Second, New Hampshire dairies tend to be very small, while dairies in Denmark and the midwestern US, where breeding dairy x beef was found to be less profitable, are quite large (Christensen, 2021). Additionally, 65% of the dairy farms in New Hampshire breeding dairy x beef raise the calves on farm (Table 3). This is significantly different from the above research, as the dairy x beef crosses were being sold as calves (Ettema et al., 2017; McCulloch et al., 2013; Cabrera, 2022). For large specialized dairy farms it may be impractical to diversify into beef production, but for family farms in New Hampshire, it may be a necessity. A study of 10 small New Hampshire and Vermont dairies done to determine their diversification strategies found that dairy farming by itself was not seen as a feasible way to make ends meet (Snorek et al., 2023). Because of this farmers diversified their products, practices, and marketing in a way not typically done by large dairies. Finally, the simulations compared the profitability of dairy x beef calves against dairy replacement calves, and found replacements to be more profitable. This study of New Hampshire dairies compared the profitability of dairy x beef calves against conventional dairy bull calves and found dairy x beef to be more profitable.

While selling dairy replacement calves may be more profitable than selling dairy x beef calves in the midwest, in New Hampshire there is hardly a market for more dairy animals, as some of the few dairies we do have are shrinking (Figure 5). Two stakeholder interviews supported this, as they felt the biggest reason for breeding dairy x beef was the oversaturation of heifers in the market caused by the adoption of sexed semen. As dairies began to breed more of their cows with sexed semen there was a major influx of dairy replacements causing a decrease in the sale price of these calves (McWhorter et al., 2020). Additionally, research found that there was an oversupply of dairy replacements in the US (Overton & Dhuyvetter, 2020). Because of these factors it was more profitable for dairy farms in New Hampshire to breed with beef and sexed semen than with just sexed semen.

Easier conception was listed as one of the biggest reasons farmers surveyed began to breed dairy x beef calves (Figure 5). This sentiment was shared by former UNH Organic Research Dairy manager, Ryan Courtwright, as well as other interviewees (Courtwright, 2022). Additionally, the survey of dairy farms in Wisconsin, Michigan, and Iowa found that 80% of farms surveyed cited “failure to conceive after bred with dairy semen” as a criteria used to select cows for breeding with beef sires (Halfman & Sterry, 2019). Dairy farmers in California supported this as well, citing “reproductive performance” as one of the most significant reasons to chose to breed a cow to beef (Pereira et al., 2022).

Despite farmers choosing to breed dairy x beef because of conception rates, previous research found a slight decrease in the rate of conception by beef sires (McWhorter et al., 2020). However, the researchers hypothesized that the national data around dairy x beef conception may be skewed as it is often done with cows who have failed to conceive previously. No other research was found comparing the rates of conception between dairy and beef sires on dairy

cattle, however, two studies had been done regarding the fertility of beef and dairy sires based on breeding data available in Ireland and Canada. The study from Canada found that beef sires from the breeds Angus, Belgian Blue, Charlois, Hereford, Limousin, and Simmental, had higher fertility solutions than dairy sires from the breeds Holstein, Ayrshire, Brown Swiss, and Canadienne (Doormaal, 1993). Jersey sires were an exception to this, and had relatively high fertility solutions. The study from Ireland found that Charolais, Limousin, and Simmental bulls had the worst fertility (Berry et al., 2011). Additionally, in Ireland Holstein-Friesian bulls with a high percentage of Holstein had low fertility rates (Berry et al., 2011). Herefords and Belgian Blues had the highest fertility of the beef breeds, and Angus bulls tended to be fairly average. This research also hypothesized that the data may be skewed as beef semen is often used on dairy cows with known fertility issues. There is a clear need for more research in this area, as the belief that beef breeds have higher rates of conception with dairy cows seems to be widely held throughout the country, yet there has been no data in the last 20 years to support this.

There is an obvious trend present when looking at the year dairy farmers surveyed began to breed dairy x beef (Figure 3). Between 2001 and 2013 only two farms reported that they began breeding dairy x beef. Between 2014 and 2023, 17 farms reported that they began to breed dairy x beef. The Statistical Uniform Price of Federal Milk Marketing Order 1 was examined between the years of 2009 and 2017, but no obvious pattern was found correlating milk price to the rise in dairy x beef breeding (Federal Milk Marketing Order 1, n.d.). 2009 and 2016 were found to have a particularly low Statistical Uniform Price. If the low price of milk in 2009 caused farmers to breed dairy x beef, it was not obvious from this study. It is more plausible that the continuation of breeding dairy x beef was in part caused by the low milk prices in 2016, but this is also speculation (Federal Milk Marketing Order 1, n.d.).

Sexed semen and beef semen are often used in tandem on dairy cows. Sexed semen allows farmers to obtain replacement heifers from only their best producing cows, meaning the worse producing animals can be bred to beef (Hohenboken, 1999). Sexed semen use had been increasing steadily in the United States, one study found that in 2007 sexed semen was used on heifers 9% of the time, and that increased to 31% in 2015 (Hutchison & Bickhart, 2016). Another study found the use of sexed semen in Holsteins increased from 11% in 2019 to 32.1% in 2021 (Lauber et al., 2023). From the data available it could not be determined how well the use of beef semen and sexed semen correlated, but the two practices did generally gain popularity at the same time. It was discussed previously how the rise of sexed semen may have impacted dairy farmers in New Hampshire to breed to beef.

Dairy farmers in New Hampshire who raise dairy x beef animals do not seem to be finishing their crosses with a different feed from their growth diet (Figure 8). If farmers were to feed a finishing ration, their animals may reach a higher maximum weight and have better carcass quality with higher fat deposition (Vickers & Stewart, 2019). Interviews with New Hampshire dairy farmers revealed that some fed their dairy x beef along side dairy animals from birth to slaughter. It would be valuable information to ascertain how common this practice is among dairy farmers raising dairy x beef. While it may not be feasible for all dairy farmers to feed a different ration to their beef animals, it may help to increase yields and profit. One of the most influential feed strategies for raising dairy x beef was ensuring adequate colostrum intake (Creutzinger et al., 2021; Felix, n.d.; Renaud & Pardon, 2022). After that, experts recommended feeding a diet high in carbohydrates, such as a diet made of 50-80% corn. Additionally, corn silage is recommended as a forage, as it is high in energy, while providing the biomass needed for a healthy rumen (Comerford et al., 1992; Felix, n.d.) It may be beneficial to ascertain what

sorts of diets New Hampshire farmers want to be feeding their cows-- pasture or grain based, so Cooperative Extension can make the appropriate feeding recommendations.

The typical weaning age for dairy calves is 6-9 weeks, while farmers raising dairy x beef in New Hampshire report weaning at an average of 12 weeks (Jones & Heinrichs, 2019, Figure 7). On average, dairy farmers in New Hampshire slaughter their dairy x beef animals between 18 and 24 months, with a larger percent slaughtering between 18 and 20 months (Figure 9). In the US slaughter age is typically between 15 and 28 months, but can get down to 12 months, or over 30 (Drouillard, 2018). New Hampshire dairy farmers, therefore, seem to be at about the middle of the road for slaughter age of their beef cattle. Cattle can vary greatly in size at any particular age. It may be beneficial to study the average weights of New Hampshire dairy x beef at slaughter in conjunction with the diets they are fed. This could help fuel feed decisions based on carcass yield.

Lack of processing options in New Hampshire was mentioned by all stakeholders interviewed for this research. Previous research on beef producers in New Hampshire, Vermont, and Maine had also revealed this major limitation (Enzien, 2022). At the time of this research, there were only three USDA inspected meat processing facilities in New Hampshire (New Hampshire Farm Bureau Federation, n. d.). Because of this, farmers needed to schedule their slaughter dates months to over a year in advance. This meant cattle that would be at the optimum weight a few months later get slaughtered too early, and cattle who have been ready for months get slaughtered too late. As New Hampshire dairies operate on such slim margins, it is often detrimental to have put money, in the form of feed, into an animal who will not improve any further. For farmers to actually increase their income by breeding beef to their dairy cows there need to be more options for slaughtering facilities in New Hampshire.

Four dairy farms replied to the survey explaining they could not fill it out as they had retired from dairy farming. Additionally, five respondents listed either “transitioning out of dairy” or “downsizing dairy” as a reason for breeding dairy x beef (Figure 5). This may suggest a decrease in the number of New Hampshire dairies in the coming years. While one may speculate on why this change is occurring, it may be more useful to interview New Hampshire dairy farmers. A study of ten dairies in New Hampshire and Vermont found that farmers did not see dairy farming a viable source of livelihood on its own (Snorek et al., 2023). The farmers in the mentioned study, diversified their income through value added products, such as flavored milks and cheeses, and non-dairy products and by-products, such a beef. Additionally, several of these farms had transitioned to organic milk or hay production, which they felt was helpful in the fluctuating milk market. Small organic dairies have been shown to have slightly higher returns than small conventional dairies, and the organic milk price is known to be more stable than the conventional milk price (Su, 2016; Walsh et al., 2020). Another study, from Wisconsin, found that dairy farms who diversified to breed dairy x beef were more able to overcome challenging dairy market conditions (Li & Cabrera, 2019). As the dairy market is a volatile one, it is often necessary for New Hampshire dairy farms to diversify or risk closure.

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Appendix

Appendix I. Dairy x Beef Survey

1. What is the size of your dairy operation in heads of cattle?
 - 1-10
 - 11-30
 - 31-50
 - 51-100
 - 101-200
 - 201-300
 - 300+

2. How much would you typically get for a conventional dairy bull calf?
You may select more than one response.
 - Nothing
 - Under \$5
 - \$5 - \$15
 - \$16 - \$25
 - \$26 - \$50
 - \$51 - \$75
 - \$76 - \$100
 - \$101 - \$150
 - \$151 - \$200
 - \$201+

3. Do you, or have you previously, bred any of your dairy cattle with beef semen?
 - Yes
 - No

4. If you have never bred your dairy cattle to beef, have you considered it?

- N/A - I have bred my dairy cattle to beef
- Yes
- No

You may end the survey if you selected no.

5. If you have never bred your dairy cattle to beef, but you've considered it, what are some of the reasons?

You may select more than one response.

- N/A - I have bred my dairy cattle to beef
- Increased income
- Increased bull calf welfare
- Easier calving
- Cow welfare
- Easier conception
- Consumer demand
- Other... _____

6. If you have not breed your dairy cows to beef, what were some of the reasons?

You may select more than one response.

- N/A - I have bred my dairy cattle to beef
- Price of beef semen being too high
- Price of beef cattle being too low
- Price of dairy heifers being high
- Price of feed being too high
- Required too much labor
- Loss of purebred dairy genetics
- Lack of slaughter/processing options
- Other... _____

If you have never bred dairy cows to beef you may end the survey here.

7. If you stopped breeding your dairy cattle to beef, why?

You may select more than one response.

- N/A - I did not stop breeding beef to my dairy cows

- Price of beef semen being too high
- Price of beef cattle being too low
- Price of dairy heifers being high
- Price of feed being too high
- Requires too much labor
- Loss of purebred dairy genetics
- Lack of Slaughter/Processing Options
- Other... _____

8. Why did you begin to breed dairy x beef calves?

You may select more than one response.

- Increased income
- Increased bull calf welfare
- Easier calving
- Cow welfare
- Easier Conception
- Consumer Demand
- Transitioning out of dairy
- Other... _____

9. Is breeding dairy x beef something you will continue on your farm?

- Yes
- No
- Unsure

10. What breed(s) of dairy cow do you use in dairy x beef crosses?

You may select more than one response.

- Ayrshire
- Brown Swiss
- Dutch Belt
- Guernsey
- Holstein
- Jersey
- Milking Shorthorn
- Cross, Please Specify... _____
- Other... _____

11. What breed(s) of beef do you use?

You may select more than one response.

- Angus
- Belted Galloway
- Brahman
- Charolais
- Dexter
- Gelbvieh
- Hereford
- Highland
- Limousin
- Shorthorn
- Simmental
- Wagyu
- Cross, Please Specify... _____
- Other... _____

12. What year did you start breeding beef to your dairy cattle?

13. If you currently breed dairy cattle to beef, or previously have, what do you do with the calves?

You may select more than one response.

- Raise the calves on your farm
- Gift the calves to others
- Sell the calves to a private buyer in NH
- Sell the calves to a private buyer outside of NH
- Sell the calves at auction
- Other... _____

14. If you raise your dairy x beef crosses, how long do you keep them before slaughter?

You may select more than one response.

- N/A - I do not raise dairy x beef crosses

- Less than a year
- 12 - 14 months
- 14 - 18 months
- 18 - 20 months
- 20 - 24 months
- Over two years

15. How long do you feed milk to your dairy x beef calves?

You may select more than one response.

- N/A - I do not raise dairy x beef crosses
- 6 weeks
- 8 weeks
- 10 weeks
- 12 weeks
- 14 weeks
- Other... _____

16. If you raise your dairy x beef crosses, what do you feed them after weaning?

You may select more than one response.

- N/A - I do not raise dairy x beef crosses
- Dry Hay
- Pasture
- Corn Silage
- Brewers Grain
- Whole Corn
- High Moisture Corn
- Commercial Pellet
- Soybean Meal
- Canola Meal
- Bakery Waste
- Leftover TMR
- Other... _____

17. If you raise your dairy x beef crosses, what do you feed them to finish them?

You may select more than one response.

- N/A - I do not raise dairy x beef crosses
- Dry Hay

- Pasture
- Corn Silage
- Brewers Grain
- Whole Corn
- High Moisture Corn
- Commercial Pellet
- Soybean Meal
- Canola Meal
- Bakery Waste
- Leftover TMR
- Other... _____

18. How do you market your dairy x beef crosses if you raise them to slaughter?

You may select more than one response.

- N/A - I do not raise dairy x beef crosses
- Auction
- Direct to consumer by the piece
- Direct to consumer whole carcass
- Direct to consumer by the half carcass
- Direct to consumer by the quarter carcass
- Direct to restaurants
- Direct to butcher
- On farm restaurant/event
- Other... _____

19. If you sell live beef dairy crosses between the ages of 1 and 2 years what is the price you typically get for one?

20. If you market your dairy beef crosses directly to consumers (either by the piece or by the half/quarter carcass) how many dollars does one animal typically generate?

21. If you sell dairy x beef calves what is the typical price you get for a calf less than 2 weeks old?

You may select more than one response.

- N/A - I don't sell dairy x beef calves
- Under \$5
- \$5 - \$15
- \$16 - \$25
- \$26 - \$50
- \$51 - \$75
- \$76 - \$100
- \$101 - \$150
- \$151 - \$200
- \$201+

End of Survey