



Survey of the use of beef semen in dairy herds in Pennsylvania and nearby states

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Abstract

Because dairies across the United States have rapidly adopted breeding to beef breed sires, the use of beef semen has increased dramatically in recent years. The objective of this survey was to gather information about the use of beef semen by dairy producers in the Northeast United States to generate beef × dairy cattle for beef markets. The survey was conducted using the services of the Center for Survey Research at the Pennsylvania State University—Harrisburg campus. Respondents had two options for returning their responses: 1) mail the paper survey to CSR in the postage-paid business-reply envelope included in the mailing, or 2) complete the survey online via an open-access web survey link. A total of 669 surveys were received and a final number of 617 surveys were included in the responses based on completeness and validity of the responses. Because of the broad electronic distribution, a true response rate cannot be calculated. Of these, 463 (75.0%) were completed via returned paper survey, and 154 (25.0%) were completed via web, between November 9, 2021 and February 16, 2022. Of the 617 respondents, 539 were from Pennsylvania. Due to the large variations in returned survey copies by state, results are reported without state separation. Across all respondents, 69.7% reported milking 100 or fewer cows and over 90% of collected responses reported Holsteins as the predominant dairy breed in the Northeast. Only 18.8% of the respondents did not currently, nor plan to, breed with beef semen. Deciding which beef bulls to use on Northeast dairy farms was primarily based on the recommendation of the semen sales representative (54.5%) and the price of the semen purchased (42.3%). In addition, 89.7% of respondents cited using Angus genetics in their beef bull selections. However, there was no difference in reported profitability of crossbreeding between respondents who indicated using other beef breeds vs. those who indicated just using Angus ($P \geq 0.19$). In conclusion, using beef sires on dairy females, regardless of the breed of beef sire, adds value to the resulting progeny from dairy farms in the Northeast.

Key words: beef, breeding, crossbred, dairy, sire selection

INTRODUCTION

The domestic sale of beef semen units in the United States has increased dramatically in recent years (NAAB, 2022). The simultaneous reduction in the use of dairy semen, without a corresponding decrease in cow numbers, suggests that U.S. dairies are the primary end users of this beef semen. The use of beef semen in dairy cattle is not a new concept (Adersson and Lindhe, 1973); rather, it is the rapid rise in beef semen use in recent years that has garnered interest.

Surveys have been conducted in various parts of the United States and the world to determine the implications of increased beef semen use. Most reports of economic gain resulting from the increased sale of beef semen were in international studies (Dal Zotto et al., 2009; Berry et al., 2021). In fact, most of the data regarding beef-sired calves on dairies in general comes from international studies (e.g., Ettema et al., 2017; Berry et al., 2019; Berry 2021; Bittante et al., 2020). The most notable U.S. report on beef × dairy crossbred cattle was a survey conducted in California. Pereira et al. (2022) reported that 81% of the dairies surveyed in California were using beef semen in their dairy cows and 76.7% of the variation in day-old calf price was explained by dairies that had contracts with calf raising operations that purchase and raise

male dairy and male and female beef × dairy calves (i.e., calf ranches). The authors concluded that beef × dairy breeding has greatest financial returns when contracts with calf ranches are available.

In the Northeast region of the United States, dairies are much smaller than the average dairy size in CA, and few large calf growers exist. Thus, the objective of this survey was to gather information about the use of beef semen by dairy producers in the Northeast United States to generate beef × dairy cattle for beef markets.

MATERIALS AND METHODS

The Northeast Beef × Dairy Survey was conducted using the services of the Center for Survey Research (CSR) at the Pennsylvania State University, simply referred to as Penn State, University at Harrisburg. The study protocol and survey instrument were covered under study number 00018129 by Penn State's Office for Research Protections. The study was classified as exempt. The survey tool was developed through the cooperation of the authors with the CSR. All data were collected between November 9, 2021 and February 16, 2022.

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Data Collection

A combination of mail, web, and other recruitment methods was used to distribute the survey to potential respondents.

Mail Recruitment

The CSR mailed an invitation letter, a paper survey, and a postage-paid business-reply envelope to an address list of 6,508 dairy producers that were provided by the research team obtained from various organizational mailing lists and deduplicated by the CSR. The mailing was sent on November 12, 2021. In an effort to gather as many returned surveys as possible, respondents had two options for returning their responses: 1) mail the paper survey to CSR in the postage-paid business-reply envelope included in the mailing, or 2) complete the survey online via an open-access web survey link.

Web Recruitment

Survey invitations were sent via email lists to dairy producers throughout the Northeast on extension lists, through newsletters, and via industry contacts. The email invited respondents to complete the survey online via an open-access web survey link and it used similar recruiting language to the invitation letter sent in the mailing. Because of the broad distribution of the email information, the total number of email invitations sent to potential respondents is unknown.

Additional Recruitment

Finally, the CSR created further recruitment materials that could be shared during conferences (postcards) and presentations (PowerPoint slide) with researchers, educators, nutritionists, and other members of the dairy industry. These materials invited respondents to complete the survey online via an open-access web survey link and/or share the link with other dairy producers. Social media was also used to invite respondents to complete the survey using an open-access web survey link.

Extra paper copies of the survey and postage-paid business-reply envelopes were also printed and provided to contacts who could invite dairy producers to complete the survey in person. Those who were provided a paper copy of the survey could mail the completed paper survey to CSR in a postage-paid business-reply envelope or complete the survey online via an open-access survey link.

Strategy to Increase Survey Participation

For dairy producers who wished to participate, the CSR offered a drawing for one of four \$50 Visa gift cards. Respondents were able to fill out the entry form at the end of the survey.

Survey Response

A total of 617 completed surveys were received. Of these, 463 (75.0%) were completed via returned paper survey, and 154 (25.0%) were completed online. Due to the open-access nature of the survey, the total number of invited respondents is unknown. Therefore, it is not possible to calculate a response rate for this survey. However, the two largest states surveyed included PA and NY representing 470,000 and 630,000 dairy cows, respectively.

Data Preparation and Analysis

All completed paper survey responses were entered into Qualtrics by a member of the CSR project team and verified for accuracy by a senior staff member of the CSR project team. Analytical tools in Qualtrics were used to generate means separation where appropriate.

The CSR also conducted a quality review of all submitted survey responses. Responses that were ineligible due to reported age or geography (under 18 years of age or outside of the Northeast United States) were not included in the final dataset. Partial web surveys that the respondent started but did not complete were also considered. Partial responses were removed from the dataset if the respondent closed the survey before reaching Q7 (45 responses); partial responses that completed Q7 or beyond were left in the dataset (20 responses). One other web response, which contained nearly identical answers to another response submitted a few minutes prior, was removed as a duplicate.

From the remaining 669 responses, the CSR engaged the research team in a discussion about several additional responses that were suspected to be poor quality based on a number of indicators (e.g., open-ended responses appearing computer generated, invalid street addresses on raffle entry). Responses were reviewed on a case-by-case basis. Of these, 52 were removed (7.8%), leaving 617 responses in the final dataset. That said, the actual n per question varied based on response rates to individual questions.

The following should be taken into account when reviewing the survey results:

1. Web respondents were required to provide an answer to the first two questions (age and state) to determine eligibility. Web respondents who were not eligible to participate due to these criteria were redirected to a screen that indicated that they were not eligible and thanked for their time. Respondents who returned a paper survey without an age or a state were assumed to be eligible because the paper survey stated that completion of the survey implied that the respondent had read the eligibility information.
2. When multiple responses were selected on a paper survey for questions in which only one response should have been chosen, all responses selected were recorded as text in the "Other" open-ended box, if applicable, or were left blank if there was no box to record text.

Prior to the results and discussion, the research team acknowledges the following limitations for the Northeast Beef × Dairy Survey: Potential respondents were not selected from the population at random; rather, potential respondents were invited to participate by the various recruitment methods outlined above. As a result, responses are representative only of those who chose to participate from the generated means outlined above and may not be representative of all dairy producers in the Northeast United States. Further, despite offering multiple ways to complete the survey, CSR did not receive a completed survey for every dairy producer that was mailed, emailed, or otherwise provided a survey invitation. Because the answers from these non-respondents could be different from those who did participate, non-response bias exists.

RESULTS

Of the 617 respondents to the survey, 539 (87.4%) of those respondents were from Pennsylvania. The state with the second most respondents was Vermont with 19 respondents (3.1% of all responses). The only difference between responses from PA and the rest of the Northeast was due to farm size. Respondents in PA were more likely to milk 100 cows or less than farmers in the rest of the northeast (Figure 1). This result may be a result of reduced distribution in these other states, considering the demographics of the dairy industry in the Northeast were not expected to be different; but, because of the vast online distribution, we can only speculate the cause of this response. However, due to the low number of responses from CT, DE, MA, ME, MD, NH, NJ, NY, RI, and VT, the remainder of survey results were not separated by state.

Across all respondents, 69.7% reported milking 100 or fewer cows. Only 18 respondents, or 2.9% of the response pool, reported milking more than 500 cows. There was no difference between smaller farms (<100) and larger farms (101+) in reported dairy breeds used ($P \geq 0.07$; data not shown). When asked “What breed(s) of dairy cows do you currently milk?”, over 90% of collected responses selected Holsteins as the predominant breed in the Northeast.

The primary purpose of this survey was to gauge the use of beef semen in dairy herds across the Northeast region. Of the 611 responses gathered regarding the use of beef semen, 467 respondents (76.4%) currently use beef semen and 29 (4.7%) plan to use beef semen in their dairy herds in the future (Figure 2). Only 115 respondents, or 18.8%, of the dairy herds in the Northeast do not currently, nor plan to, breed their dairy cattle with beef semen. Additionally, 424 of the respondents that currently use beef semen to breed their dairy cattle responded to a question regarding profitability.

Of those 424 that responded, 374 respondents (88.2%) cited making additional profit by generating beef × dairy crossbred progeny.

When producers were asked what factors influenced their choice of beef bulls for breeding to dairy cows, they most commonly cited reasons for selecting specific bulls were 1) based on the recommendation of the semen sales representative (54.5%) and 2) the price of the semen purchased (42.3%; data not shown). Very few dairy farms respondents to this survey used breeding values, like EPDS, or cleanup bulls (9.5% and 13.5% of respondents, respectively).

Females selected for breeding beef semen were selected for a variety of reasons. Dairy producers in this survey of the Northeast breed were more likely to breed cows than heifers with beef semen. The majority of cows selected to breed with beef semen were considered “hard to breed” (74.3%; Table 1) and were inseminated using beef semen after their 3rd service with dairy semen. Other selections for beef matings include cows selected on Net Merit or cows that produce less milk; primarily the bottom 10–20% of milk producers in the herd.

There were 456 responses to the question regarding the breed of beef bull used in dairies in the Northeast. The majority, 89.7% of respondents, report using Angus genetics in their beef bull semen selections. Other major breeds identified by respondents were Limousin (11.2%), Simmental (9.4%), Hereford (7.7%), and Charolais (5.3%). A total of 10.5% of respondents identified using other breeds in their operations. Larger farms (farms milking more than 100 cows) were more likely to use Limousin ($P < 0.01$), Simmental ($P = 0.03$), and Charolais ($P < 0.001$) bulls than farms milking less than 100 cows (Figure 3). Respondents who indicated they used multiple beef breeds were more likely to report that they profited \$100 per calf sold or more, than respondents who indicated just one beef breed ($P = 0.03$; data not shown). However,

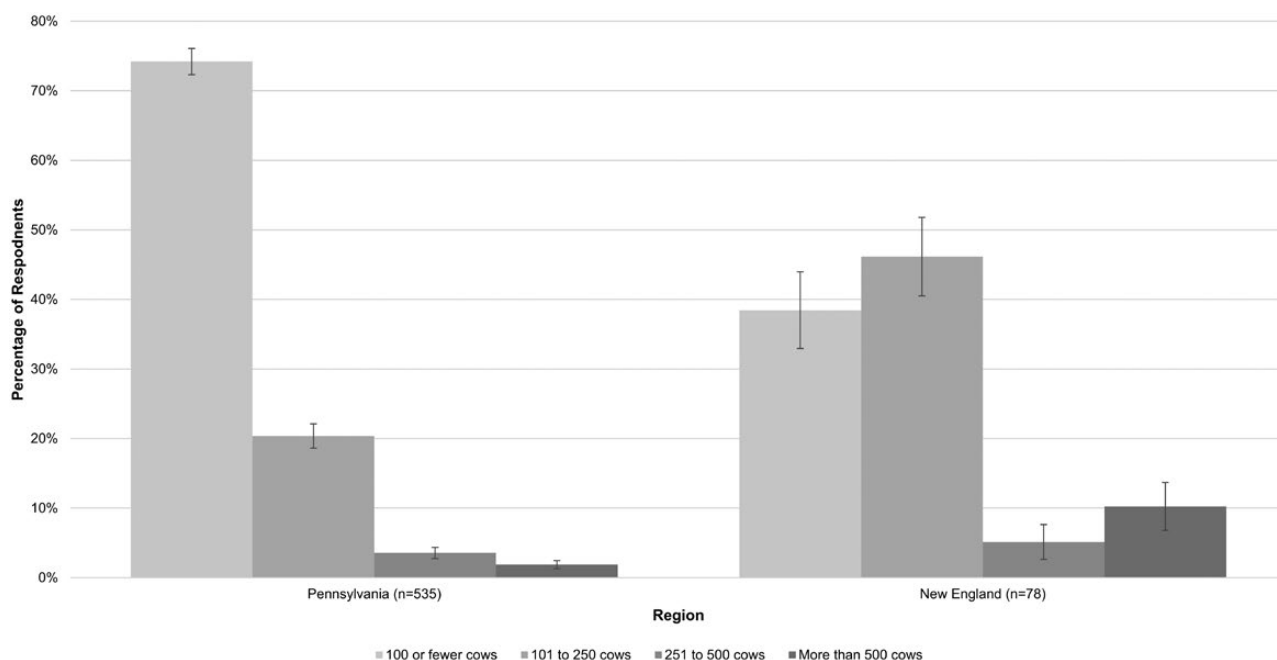


Figure 1. Average size of dairy farms in PA compared with the rest of the Northeast (including Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont). There were more small dairy farms (less than 100 cows) when compared with larger dairy farms in PA than in the rest of the Northeast. Error bars denote the standard error from the mean.

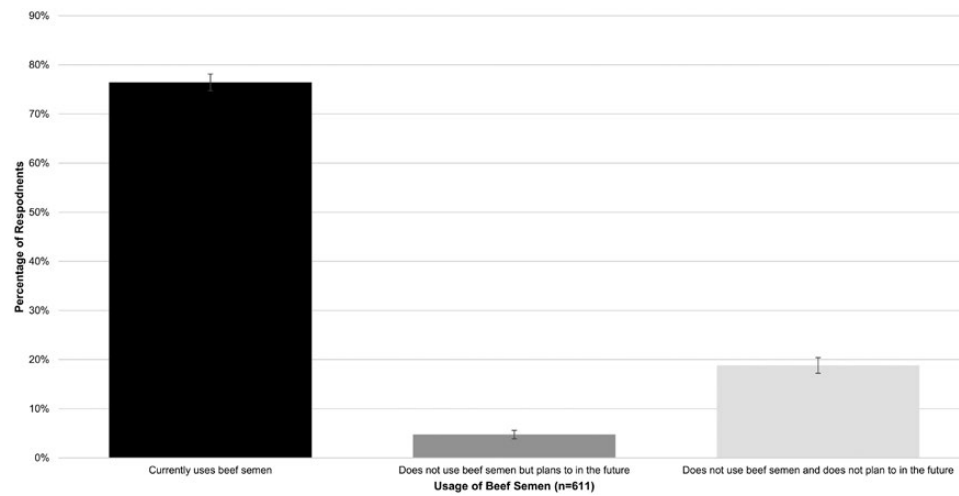


Figure 2. Use of beef semen on dairy farms in the Northeast. The majority of dairy farms in the Northeast either use or plan to use beef semen in their dairy cows. Error bars denote the standard error from the mean.

Table 1. How dairy farmers in the Northeast use beef semen in breeding dairy cattle

	Cows ¹	Heifers	Both cows and heifers
How do you decide which animals are bred with beef semen?	<i>n</i> = 214	<i>n</i> = 19	<i>n</i> = 225
Genetics	20.6%	26.3%	37.3%
How do you determine which animals are bred with beef semen based on genetics?	<i>n</i> = 42	<i>n</i> = 5	<i>n</i> = 80
Net merit	33.3%	20.0%	30.0%
Genomic panel	23.8%	80.0%	15.0%
Sire catalogs	16.7%	40.0%	16.3%
Advice from semen sales representative	16.7%	40.0%	15.0%
Other	42.9%	0.0%	48.8%
Lower producing cows	55.6%	0.0%	66.2%
How do you determine which cows are lower producing?	<i>n</i> = 110	<i>n</i> = 0	<i>n</i> = 140
Net merit	6.4%	N/A	1.4%
Bottom 10% of lactation	28.2%	N/A	26.4%
Bottom 20% of lactation	27.3%	N/A	29.3%
Bottom 30% of lactation	20.9%	N/A	17.1%
Bottom 40% or 50% or lactation	9.1%	N/A	12.9%
Other	8.2%	N/A	12.9%
Females that are hard to get bred to dairy bulls	74.3%	47.4%	79.1%
After which service do you determine that a female is hard to breed?	<i>n</i> = 159	<i>n</i> = 8	<i>n</i> = 172
After the 2nd service	15.7%	25.0%	16.9%
After the 3rd service	47.8%	50.0%	48.3%
After the 4th service or later	28.3%	25.0%	21.5%
Other	8.2%	0.0%	13.4%
Other	11.2%	31.6%	15.6%

¹These responses represent a crosstabulation of questions. The first question asked respondents to select the type of animal they breed to beef semen, either cows, heifers or both cows and heifers. Responses to a series of question regarding how those females were selected make up the percentage of responses. Respondents could select all of the choices that applied their operations; thus, response rates exceed 100%.

there was no difference in profitability between respondents who used Angus only, compared with all other respondents (those who used multiple breeds or any other single breed; $P = 0.19$; Figure 4).

There were 448 responses regarding the sale of beef × dairy progeny from the dairy farm. Of those, 64.1% report selling calves before 1 week of age; 2.5% report selling calves between

1 and 4 weeks of age; 5.1% report selling calves at weaning; 6.9% report selling calves after weaning; and 10.9% report finishing calves for sale as slaughter cattle (Table 2). Those respondents who reported selling calves before 1 week of age were less likely to report a profit of \$100 or more per animal compared with those respondents who reported other times of sale ($P = 0.01$; data not shown). Of the 155 respondents

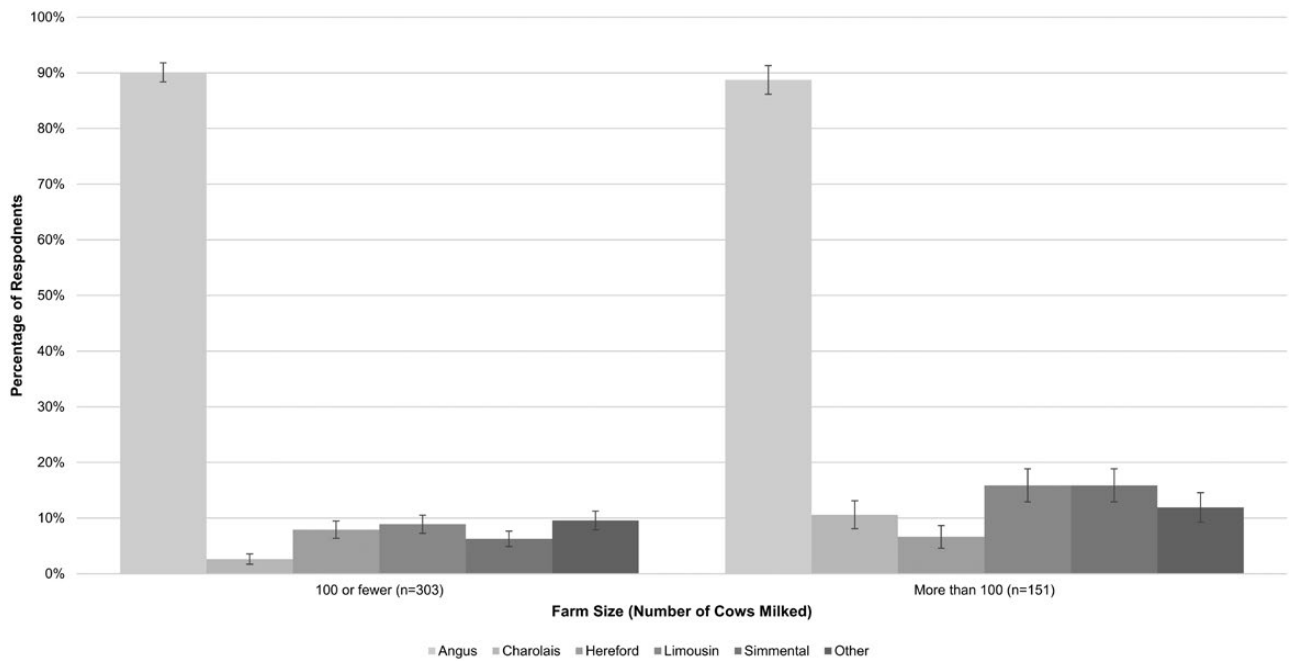


Figure 3. Beef bull chosen based on farm size in the Northeast. Larger farms (farms milking more than 100 cows) were more likely to use Limousin ($P < 0.01$), Simmental ($P = 0.03$), and Charolais ($P < 0.001$) bulls than farms milking less than 100 cows. Error bars denote the standard error from the mean.

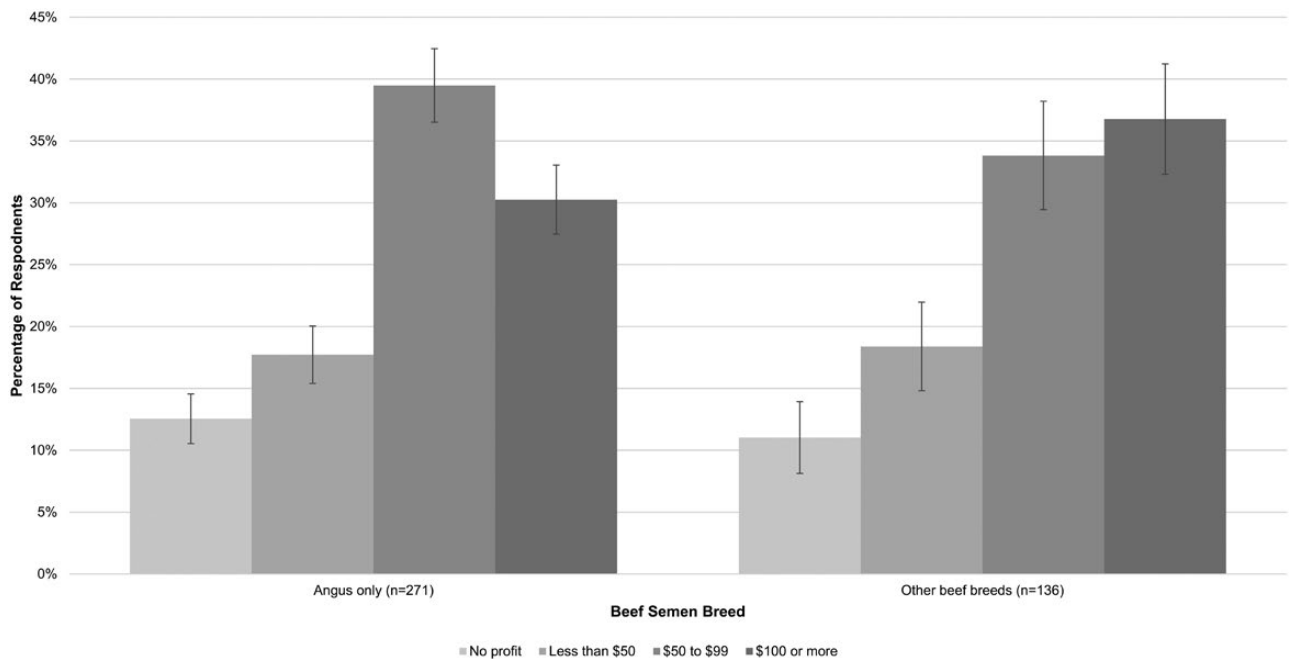


Figure 4. Profit margin reported by beef breed used on the dairy farm in the Northeast. There was no difference in profitability between respondents who used Angus only, compared with all other respondents (those who used multiple breeds or any other single breed; $P = 0.19$). Error bars denote the standard error from the mean.

that reported keeping calves through weaning, the majority (54.2%) wean calves between 8 and 9 weeks of age while 23.2% wean calves older than 10 weeks and 13.5% wean calves before 8 weeks of age.

Nutritional management of beef × dairy calves has not been widely studied. In the interest of addressing profitability of the enterprise, cross-tabulations regarding nutritional management and reported profit were used to evaluate opportunities for profit potential. Only 59.4% of respondents to the survey

report colostrum feeding of beef × dairy progeny (Table 3). Most dairy farms surveyed (63.8%) use at least some waste milk to manage beef × dairy preweaned calves. Of those using milk replacers, respondents report a mean fat content of 22% (range = 20% to 30%) and protein content of 21% (range = 15% to 40%). Most respondents selling preweaned calves, (85.3%) also supply starter grain to preweaned calves, and 31.4% of respondents provide long-stem hay to preweaned calves. Postweaning nutrition of calves varies. Only 133

Table 2. Age at which crossbred beef × dairy calves are sold from the dairy farm in the Northeast

Sale method (<i>n</i> = 448)	Percentage	SE, %
Before 1 week of age	64.1	2.3
Between 1 and 4 weeks of age	2.5	0.7
At weaning	5.1	1.0
At 182 to 227 kg after weaning	6.9	1.2
When finished for slaughter	10.9	1.5
Other	10.5	1.4

Table 3. Nutritional management of beef × dairy calves on dairy farms pre- and post-weaning in the Northeast

	Percentage ¹	SE, %
Prewaning liquid feeds (<i>n</i> = 160)		
Colostrum	59.4	3.9
Waste milk	63.8	3.8
Milk replacer	41.3	3.9
Other	15.0	2.8
Prewaning solid feeds (<i>n</i> = 156)		
Starter grain	85.3	2.8
Cow refusals	9.6	2.4
Long stem hay	31.4	3.7
Other	10.3	2.4
Postweaning solid feeds (<i>n</i> = 133)		
Starter grain	15.8	3.2
Cow refusals	33.1	4.1
Long stem hay	54.1	4.3
Other	24.1	3.7

¹Respondents could select all that applied to their operations, thus, percentages exceed 100.

respondents managed beef × dairy calves postweaning and the primary feed reported was long-stem hay (54.1% of respondents).

DISCUSSION

Respondents from the Northeast were heavily skewed toward Pennsylvania. This is not surprising as PA has a large, active Extension education program for dairy producers and the team advertised the survey heavily. However, it does mean that the results reported herein may better represent PA farms. The bulk of the dairy farms in the Northeast is located in PA and NY (78.5% of Northeast dairy farms; [NASS, 2010](#)). Responses came from more smaller farms compared with larger farms, with 69.7% of respondents reporting milking 100 cows or less. These responses do align with demographic data collected in major dairy states in 2017 that reported 81% of the farms in PA had fewer than 100 head of milk cows, despite continued consolidation of small dairy farms across the United States ([Macdonald et al., 2020](#)). Again, similar to other regions (Halfman and Sterry, 2019) the majority of respondents in the Northeast reported Holstein as the dairy breed of choice.

The primary purpose of this survey was to gauge the use of beef semen in dairy herds across the Northeast region. The use of beef semen in the United States has increased dramatically in recent years, to the point that 8.7 million units of beef semen were sold in 2021 compared with just 2.5 million units sold in 2016 ([NAAB, 2022](#)). Dairies have rapidly adopted breeding with beef semen. [Pereira et al. \(2022\)](#) reported that 81% of the dairies surveyed in California were using beef semen in their dairy cows and 76.7% of the variation in day-old calf price was explained by dairies that had contracts with calf-ranches. While fewer respondents in the Northeast report using beef semen (76.4% compared with the 81% adoption in CA), an additional 4.7% of respondents reported they plan to use beef semen in future dairy breedings. Combining those currently using with those that plan to use would put adoption of this new mating strategy of dairy producers on par with counterparts in the western United States.

Perhaps one challenge facing all of agriculture in the Northeast is the disparity between crop and livestock production relative to the rest of the United States ([Eshleman and Clancy, 2015](#)). Compared with the rest of the United States, the Northeast has a greater proportion of farmland that is wooded and a lesser proportion of farmland that is pasture. In addition, Northeast farms generate a greater proportion of total ag sales from livestock (56.6%) than crops (43.4%) compared with the rest of the United States (46.2% and 53.8%, from livestock and crops, respectively; [Eshleman and Clancy, 2015](#)). This is likely, in part, due to the greater number of smaller farms in the Northeast, forcing diversification. While larger farms routinely show reduced costs of production ([MacDonald et al., 2020](#)), land available for agriculture is reduced in the Northeast and the average farm size is only 59.9 ha compared to the 175.6 ha average across the United States. Despite the disparities with the rest of the United States, milk and dairy are responsible for 26% of the total agricultural value in the Northeast ([Eshleman and Clancy, 2015](#)). Therefore, a large part of the Northeast survey was to determine the impact of beef × dairy breeding decisions on economics of the operation.

Of the respondents using beef semen, 88.2% declared making an additional profit due to incorporating beef semen in their breeding decisions. Unlike the profitability reported by [Pereira et al. \(2022\)](#), where Angus cross progeny profitability was more variable than other breeds, profitability of beef × dairy crosses, within the Northeast survey respondents, was less dependent on breed. In fact, reported profitability was variable and, thus, it was difficult to ascertain the primary driver of profit. While a profit of more than \$100 per calf sold was reported by the majority of respondents that kept beef × dairy calves for sale at slaughter, only 40 of the 405 respondents to this question, or less than 10% of the population, kept calves until slaughter. Because most respondents reported an early sale of calves, research is needed to determine if the profit margin realized at the dairy supports the rearing of these beef × dairy cross-bred calves throughout the supply chain.

Key drivers of profitability in fed cattle across the United States are feed efficiency and costs of feed inputs. When finished on grass, purebred Hereford steers were more efficient, fattened in 27 months, than Hereford × Friesian steers took 29 months to achieve a similar degree of fatness, while purebred Friesians required 35 months ([Muir et al., 2000](#)). These results indicate that the pure beef breed, Herefords, was more

efficient in converting feed to finish or fattening. However, this study was conducted in a forage-finishing system and the majority of cattle in the United States are finished on grain-based diets because grain-finishing systems have long been reported to improve feed conversion relative to fiber or forage-based systems. [Basiel and Felix \(2022\)](#) summarized finishing systems for beef × dairy crosses and concluded that while beef × dairy cattle often gained more body weight, spent fewer days on feed, and were more feed efficient than dairy cattle finished on forage, they were less feed efficient than native beef cattle breeds. However, these authors reported the older nature of many of the studies they reviewed, and efficiency of finishing systems may warrant revisiting these results.

Perhaps more interesting were the preweaning dietary trends with 31.4% of calves fed hay preweaning. While hay is known to increase rumination ([Poier et al., 2022](#)), when fed to pre-weaned dairy calves, it reduces growth and feed intake ([Engelking et al., 2020](#)). Therefore, the value of including hay in pre-weaned dairy calf diets has become controversial ([Xiao et al., 2020](#)). These controversies have long been debated in dairy calves but have not been evaluated for crossbred beef × dairy calves to be raised for beef. Increased growth and feed intake would likely have more of an impact on calves reared in beef production systems due to the impact on production efficiency. Therefore, research regarding preweaning management is needed.

Less controversial than forage is the supply of colostrum. Interestingly, only 59.4% of respondents reported feeding colostrum to beef × dairy crossbreds. It is recognized that feeding colostrum is essential, not just for early calf health, but for the performance of calves throughout their lifetime ([Hammon et al., 2020](#)). Therefore, the fact that less than 60% of respondents provide colostrum to beef × dairy calves is concerning overall health in calves from birth to slaughter. Historically, calves that would not be retained as heifers were viewed as byproducts to the dairy industry. With 64.1% of survey respondents reporting the sale of calves at less than 1 week of age, this view may be continuing in the Northeast, restricting the use of colostrum. However, the benefits of feeding colostrum can be expected to enhance health of calves raised for beef and not just for milk cows. Therefore, extension educators in the Northeast may need to target programmatic efforts around colostrum management and feeding for dairy farmers selling beef × dairy crossbred cattle for beef.

Using beef semen to breed dairy cows is likely here to stay. However, profitability throughout the supply chain, not just at the dairies where survey efforts have focused, but through finishing systems and packing plants, must be realized for the production of beef × dairy calves to succeed. With the variety of management practices currently employed by dairy farms around the U.S., beef × dairy feeder calf performance and finishing may be unpredictable. It will be important for future publications and educational efforts to focus on management strategies to enhance the production of beef × dairy calves and ensure their profitability through the beef production systems if the current premiums for the dairy are to continue.

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Literature cited

- Andersson, J., and B. Lindhé. 1973. Optimum use of beef semen in a dual-purpose or dairy breed. *Acta Agric. Scand.* 23:102–108. doi:[10.1080/00015127309436230](https://doi.org/10.1080/00015127309436230).
- Basiel, B. L., and T. L. Felix. 2022. Board invited review: crossbreeding beef × dairy cattle for the modern beef production system. *Trans. Anim. Sci.* 6:txac025. doi:[10.1093/tas/txac025](https://doi.org/10.1093/tas/txac025).
- Berry, D. P. 2021. Invited review: beef-on-dairy—the generation of crossbred beef × dairy cattle. *J. Dairy Sci.* 104:3789–3819. doi:[10.3168/jds.2020-19519](https://doi.org/10.3168/jds.2020-19519).
- Berry, D. P., P. R. Amer, R. D. Evans, T. Byrne, A. R. Cromie, and F. Hely. 2019. A breeding index to rank beef bulls for use on dairy females to maximize profit. *J. Dairy Sci.* 102:10056–10072. doi:[10.3168/jds.2019-16912](https://doi.org/10.3168/jds.2019-16912).
- Bittante, G., R. Negrini, M. Bergamaschi, A. Cecchinato, and H. Toledo-Alvarado. 2020. Short communication: pure-breeding with sexed semen and crossbreeding with semen from double-musled sires to improve beef production from dairy herds: Weight and value of calves. *J. Dairy Sci.* 103:5258–5262. doi:[10.3168/jds.2019-18011](https://doi.org/10.3168/jds.2019-18011).
- Dal Zotto, R., M. Penasa, M. De Marchi, M. Cassandro, N. López-Villalobos, and G. Bittante. 2009. Use of crossbreeding with beef bulls in dairy herds: Effect on age, body weight, price, and market value of calves sold at livestock auctions. *J. Anim. Sci.* 87:3053–3059. doi:[10.2527/jas.2008-1620](https://doi.org/10.2527/jas.2008-1620).
- Engelking, L. E., T. Matsuba, K. Inouchi, T. Sugino, and M. Oba. 2020. Effects of feeding hay and calf starter as a mixture or as separate components to Holstein calves on intake, growth, and blood metabolite and hormone concentrations. *J. Dairy Sci.* 103:4423–4434. doi:[10.3168/jds.2019-17676](https://doi.org/10.3168/jds.2019-17676).
- Eshleman, J., and K. Clancy. 2015. The Northeast food system: context for innovative research. Penn State College of Agriculture. [accessed January 3, 2023]. <https://agsci.psu.edu/research/food-security/about/project-narratives/the-northeast-food-system-context-for-innovative-research>.
- Ettema, J. F., J. R. Thomasen, L. Hjortø, M. Kargo, S. Østergaard, and A. C. Sørensen. 2017. Economic opportunities for using sexed semen and semen of beef bulls in dairy herds. *J. Dairy Sci.* 100:4161–4171. doi:[10.3168/jds.2016-11333](https://doi.org/10.3168/jds.2016-11333).
- Hammon, H. M., W. Liermann, D. Frieten, and C. Koch. 2020. Review: importance of colostrum supply and milk feeding intensity on gastrointestinal and systemic development in calves. *Animal* 14:s133–s143. doi:[10.1017/S1751731119003148](https://doi.org/10.1017/S1751731119003148).
- MacDonald, J., J. Law, and R. Mosheim. 2020. Consolidation in U.S. Dairy Farming, ERR-274. [accessed December 15, 2022]. <https://www.ers.usda.gov/webdocs/publications/98901/err-274.pdf>
- Muir, P. D., G. J. Wallace, P. M. Dobbie, and M. D. Bown. 2000. A comparison of animal performance and carcass and meat quality characteristics in Hereford, Hereford × Friesian, and Friesian steers grazed together at pasture. *New Zeal. J. Agric. Res.* 43:193–205. doi:[10.1080/00288233.2000.9513421](https://doi.org/10.1080/00288233.2000.9513421).
- NAAB. 2022. Semen Sales Report. 2021–2020– [accessed March 17, 2023]. <https://www.naab-css.org/semen-sales>
- NASS. 2010. Milk Cow Inventory—All States. 2010– [accessed December 15, 2022]. https://www.nass.usda.gov/Data_and_Statistics/Pre-Defined_Queries/index.php

- Pereira, J. M. V., D. Bruno, M. I. Marcondes, and F. C. Ferreira. 2022. Use of beef semen on dairy farms: a cross-sectional study on attitudes of farmer toward breeding strategies. *Front. Anim. Sci.* 2:1–10. doi:[10.3389/fanim.2021.785253](https://doi.org/10.3389/fanim.2021.785253).
- Poier, G., G. Terler, F. Klevenhusen, S. Sharma, and Q. Zebeli. 2022. Replacing concentrates with a high-quality hay in the starter feed of dairy calves: II. Effects on the development of chewing and gut fermentation, and selected systemic health variables. *J. Dairy Sci.* 105:3113–3128. doi:[10.3168/jds.2021-21346](https://doi.org/10.3168/jds.2021-21346).
- Xiao, J., G. M. Alugongo, J. Li, Y. Wang, S. Li, and Z. Cao. 2020. Review: how forage feeding early in life influences the growth rate, ruminal environment, and the establishment of feeding behavior in pre-weaned calves. *Animals* 10:188. doi:[10.3390/ani10020188](https://doi.org/10.3390/ani10020188).