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Exploring farmers' attitudes and determinants of dairy calf welfare in an expanding dairy sector

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ABSTRACT

The 2015 European Union milk quota abolition initiated considerable expansion in the dairy sector in many European Union countries, most significantly in Ireland. However, this major production increase also had wider societal implications, such as negative environmental and animal welfare consequences. In this article, we used survey data of 441 Irish dairy farmers to assess farmers' attitudes toward the welfare of farmed animals and dairy calves, as well as the reputation of the Irish dairy sector. We also explored how expansion, breeding, calf management, and farmer characteristics relate to calf welfare outcomes (i.e., calf mortality, calf export, and premature culling). In relation to attitudes, farmers expressed a general concern toward animal welfare, while views toward dairy calves and industry reputation were mixed. We used Ward's linkage hierarchical cluster analysis to group farmers based on their attitudes. The cluster analysis revealed 3 distinct groups relating to high, medium, and low animal welfare concern. Herd expansion was negatively associated with being in a higher animal welfare concern cluster, whereas beef trait–focused breeding was positively associated with it. In relation to dairy calf welfare outcomes, our econometric analyses based on multiple regression and binary choice models revealed that expansion was positively associated with calf mortality, whereas improved breeding and calf management factors had a negative association. In addition, being in the high animal welfare concern cluster was negatively associated with calf mortality. Furthermore, breeding decisions were significantly associated with whether calves were exported, and being in the high animal welfare concern cluster was negatively associated with the probability that calves were sent for live export. Finally, farmers' breeding and calf management decisions were associated with premature culling of calves. Overall, this article revealed strategies worth promoting to improve dairy calf welfare, such as beef trait–focused breeding leading to greater dairy-beef integration.

Key words: calf welfare, farmer attitudes, calf mortality, calf management, dairy breeding

INTRODUCTION

The European Union milk quota abolition in 2015 initiated significant restructuring within the European Union dairy sector. Regions with a comparative advantage such as the ability to produce milk cheaply from grazed grass saw some of the largest increases. The Irish dairy industry, for example, took advantage of its spring calving pasture-based system to increase production of low-cost milk by more than 50% over the last decade (2008/2009–2019/2020), resulting in an increase in the national herd by more than one-third (CSO, 2020).

Changes associated with dairy production expansion in Ireland included, among other things, increased breeding focus on better milk production characteristics (Kelly et al., 2020). This resulted in the production of male calves with poor beef characteristics and therefore low economic value. In combination with the higher number of surplus male calves produced in general, this led to an increase in live exports of unweaned dairy calves to the European continent for veal production. A higher number of surplus male calves has also meant that more calves are culled shortly after birth or disposed of by animal by-product collection services (DAFM, 2019).

Live export and premature culling of unweaned calves imply a series of stressors namely transportation, food withdrawal, and movement through markets (Pardon et al., 2014; Haskell, 2020). In addition, there are also other concerns for the welfare of male calves in dairy herds (Thomas and Jordaan, 2013). This includes differential feeding, as well as suboptimal housing and management provisions for male compared with female

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calves (Renaud et al., 2018; Boulton et al., 2020). Specifically, male calves, which represent the majority of surplus calves, are less likely to receive adequate good quality colostrum relative to female calves, thus increasing their risk of morbidity and mortality (Renaud et al., 2017; Shivley et al., 2019). As such, animal welfare and ethical concerns in relation to male dairy calves are not unique to Ireland.

In general, perinatal mortality during the first 48 h of life is greater in male than female dairy calves (Cuttance and Laven, 2019). For Great Britain, Hyde et al. (2020) reported higher mortality in male dairy calves for the first 3 mo of life compared with female dairy calves, as well as beef calves of both sexes. In a study in France, Raboisson et al. (2013) described higher mortality during the first month of life in male compared with female calves with a mortality odds ratio of 1.20. In Ireland, Ring et al. (2018) showed higher risks of calf mortality in herds with Jersey genetics, as well as generally higher odds of male dairy calves' deaths compared with females. In general, Irish calf mortality rates are comparable with any significant dairy production country worldwide. For example, Mee (2020) reported percentage dairy calf mortality for 13 countries and Ireland ranks seventh with 6.3% calf mortality.

In relation to attitudes, previous studies revealed a link between farmers' attitudes about farm management and animal welfare provision and their farming decisions (Kielland et al., 2010; Kauppinen et al., 2010; Jääskeläinen et al., 2014). Kielland et al. (2010), for example, when assessing Norwegian dairy farmers' attitudes, showed that indicators of negative beliefs were associated with a higher prevalence of skin lesions. In addition, a recent semi-systematic review by Balzani and Hanlon (2020) identified 11 internal and 15 external factors, which influenced farmers' perspectives on animal welfare. For example, costs, herd size, and communication were the top 3 external factors.

Overall, the significant dairy herd expansion represents a major challenge to dairy calf welfare outcomes, mainly due to the increased number of surplus calves that need to be marketed, but also due to a stronger focus on higher milk yield in breeding. Therefore, the overall aim of this study was to assess how changes in the dairy sector associated with expansion (resulting in more surplus calves), as well as farmers' attitudes, influenced calf welfare outcomes. This overall aim was addressed by the following specific objectives: (1) to explore farmers' attitudes in relation to animal and dairy calf welfare, as well as industry reputation; (2) to categorize farmers into animal welfare concern groups and to explore determinants of high and low animal welfare concern; (3) to determine associations between dairy expansion, breeding, and other management strategies with the following calf welfare outcomes: calf mortality, calf export, and premature culling.

MATERIALS AND METHODS

Study Design, Setting, and Participants

The data used in this article are from an online survey of Irish dairy farmers conducted at the beginning of 2020. Data collection took place over a 6-wk period between January and March 2020. We used 2 means to distribute the survey: first, the survey was circulated via a link sent directly to dairy farmers through their Teagasc dairy advisor. Teagasc is the Irish Agriculture and Food Development Authority that provides agricultural extension, education, and research. All dairy advisors were asked to send a reminder approximately 10 d after sending the initial link. Second, an online link was published in Agriland, a popular Irish farming publication. To be eligible to participate in the survey, participants had to be dairy farmers in the Republic of Ireland and at least 18 yr old. In addition, participation in the survey was incentivized with a gift voucher.

The survey design followed a process of initial design, refinement, and online piloting. In relation to the initial design, the survey items were derived based on a literature review, meetings of the authors, discussions with experts, and reviewing existing surveys or questions (i.e., Norwood and Lusk, 2011). Once a complete questionnaire was designed, we consulted expert opinions to refine the survey. This included several one-to-one meetings with peers, dairy specialists, scientists, dairy advisors, and farmers. These meetings took between 1 and 2 h each, and several changes to the survey resulted from every meeting. The suggested changes were implemented before discussing the survey with another expert. Once we had a refined survey, the online piloting phase commenced. With support from dairy advisors, a link was sent to 29 dairy farmers to complete the survey. The survey included the following sections: (1) farm characteristics, breeding choices (i.e., breed composition of the dairy herd, breed of sires used, and so on) and marketing of calves; (2) contingent valuation in relation to policies on animal welfare; (3) attitudinal questions about animal and dairy calf welfare, as well as industry reputation; (4) questions relating to social values and information use; (5) calf housing (i.e., questions on calf facilities and details on how calves are fed); and a final section (6) relating to socio-economic characteristics, such as age, level of education and agricultural training, farm labor (full-time, part-time, and seasonal), and agricultural extension participation. In relation to this study, there were no changes to the survey after the pilot phase. The changes made to the survey were related to the sections on contingent valuation, and social value and information use, whereas this article focuses only on sections 1, 3, 5, and 6 of the survey. All relevant sections of the survey are provided in the supplemental material (https://dx.doi.org/10.17632/gxcptgc798.2, Osawe et al., 2021).

Description of Variables

In relation to outcome variables, in line with evidence from the literature, we used calf mortality (self-reported percentage of calves that died on the farm in 2019) as an indicator of calf welfare (Ortiz-Pelaez et al., 2008; Sandgren et al., 2009; Kelly et al., 2013). In addition, given the previously described situation and implications of dairy expansion on calf market outlets, we used 2 other outcome variables: whether farmers sold any calves for live export (calf export) and whether calves were culled prematurely (premature culling). The latter included both slaughter at an abattoir and disposal of calves by an animal by-product collection service. Calf export and premature culling were used as welfare outcomes in this context as the major dairy expansion in Ireland increased pressure on calf markets. This raised concern for the welfare of unweaned calves because the marketing channels used are associated with a series of stressors such as transportation, food withdrawal, and movement through markets (Pardon et al., 2014; Haskell, 2020). A description and summary statistics of the calf welfare outcome measures are reported in Table 1.

We used several categories in relation to variables explaining calf welfare. Since we were interested in the association between dairy expansion and calf welfare, we included a set of variables in relation to expansion. These included herd size, herd expansion since milk quota abolition, stocking rate, and dairy herd stockperson ratio, shown in Table 2. Stocking rate was calculated as herd size divided by the size of the farm in hectares (cows per hectare), whereas stockperson (per animal) ratio was calculated as the total number of workers divided by dairy herd size (this was multiplied by 100 to provide a measure per 100 dairy cows). The total number of workers on the farm was based on full-time equivalent (**FTE**) hours and included the total of all persons working on the farm such as the farm holder, family, and hired labor computed as full-time (1 FTE), part-time (0.5 FTE), and seasonal (0.25 FTE). The corresponding questions are in section 1 and 6 of the survey in the supplemental material (https://dx.doi.org/10.17632/gxcptgc798.2, Osawe et al., 2021).

The literature also identified several breeding strategies that can be used to improve herd performance and reduce the number of surplus dairy calves (e.g., De Vries et al., 2008; Holden and Butler, 2018; Johnson et al., 2018). Therefore, our survey captured information on dairy cow breeds, sires of the current calf crop, whether or not the farmer used sexed semen and if farmers considered the Dairy Beef Index (**DBI**) in their breeding decisions. The aim of the DBI is to increase the amount of high-quality beef cattle bred from the dairy herd by including specific beef traits in the breeding index calculation. All corresponding questions are in section 1 of the survey.

In line with the literature, we also considered variables that relate to calf management (Renaud et al., 2017; Holden and Butler, 2018; Boulton et al., 2020). Here, our survey assessed calf feeding strategies (automatic vs. manual and frequency of feeding), as well as calf housing facilities. These questions are in section 5 of the survey. Finally, we asked several questions relating to farmer characteristics such as age, level of education and extension participation, which are in section 6 of the survey.

Furthermore, the survey explored attitudes based on 6 statements to assess farmers' opinions about dairy calves, general animal welfare, and the reputation of the Irish dairy industry. Our current understanding of animal welfare is that it is a state within the animal itself that reflects the integrated outcome of all the mental experiences the animal has at a given point in time (Green and Mellor, 2011; Mellor and Beausoleil, 2015). For this study, animal welfare is defined as an animal's capacity to avoid suffering and sustain fitness, where fitness considers the future prospect of the animal (e.g., longevity; Webster, 2011). In addition, calf welfare is determined by management and resource-based inputs, which are influenced by breed purpose. In Ireland, there

Table 1. Definition of calf welfare outcomes and associated descriptive statistics

Calf welfare outcomes	Definition	n[1]	Mean/n (%)	SD
Calf mortality	% of calves that died in 2019 [What was your calf mortality rate (%) in 2019?]	429	3.61	2.42
Calf export	= 1 if the farmer sold any calves for live export, 0 otherwise	441	133 (30.16)	
Premature culling	= 1 if the farmer sold any calves to the abattoir or had any calves collected by animal by-product collection service, 0 otherwise	441	84 (19.05)	

[1]n = number of responses from the survey.

are 3 main outcomes for calf production determined by the breed of the sire (dairy vs. beef): dairy calf to beef production, live export for veal production, and culling. The threats to calf welfare vary with production outcome described by Balzani et al. (2021). In addition, societal concerns arise for live exports and culling of young calves (Kevany and Busby, 2020) and therefore pose a reputation risk to the dairy industry in Ireland. The above influenced the selection of our attitudinal statements.

Specifically, in relation to our attitudinal statements, statement 1 and 2 represent Irish dairy farmers' attitudes toward dairy calves and their willingness to reduce unwanted (surplus) male calves, which is important in the context of calf markets and thus the welfare of dairy calves. Statement 3 examines Irish dairy farmers' concern about the reputation of the industry regarding dairy-bred calves. Statements 4 and 5 were used by Norwood and Lusk (2011) to assess animal welfare concerns of US consumers. Statement 6 was suggested by a dairy scientist in a personal conversation with the view of assessing how farmers feel about the welfare of their calves. The assumption and link to animal welfare of this statement is that farmers who believe they treat their calves well will be happy to describe their calf care to consumers. Therefore, the majority of these statements were deemed to directly or indirectly address attitudes toward animal and dairy calf welfare and we thus refer to the attitudinal statements as relating to animal welfare and industry concern.

Farmers were asked to indicate their level of agreement with each of the 6 statements on a 5-point Likert scale that ranged from strongly disagree (1) to strongly agree (5). Table 3 and section 3 of the survey in the

Table 2. Descriptive statistics of responses of dairy farmers to questions relating to dairy expansion, breeding and calf management strategies, and farmer characteristics

Variable	Definition	n[1]	Mean/n (%)	SD
Expansion (section 1 and 5 of the survey)				
Herd size	Number of dairy cows	441	132.36	95.18
Stocking rate	Dairy cows per hectare (cows/ha)	437	1.79	1.25
Herd expansion	% of herd size increase since 2015	441	25.97	21.96
Stockperson ratio	Stockperson to 100 dairy cow ratio	439	1.74	1.27
Breeding (section 1 of the survey)				
Friesian cows	% of herd Friesian cows	441	79.09	31.17
Jersey Friesian (JF) cross cows	% of herd JF cross	441	14.92	27.31
Sexed semen	= 1 if farmers used any sexed semen in 2019, 0 otherwise	441	82 (18.59)	
DBI[2]	= 1 if farmer used DBI, 0 otherwise	441	178 (40.36)	
Friesian	% of calf crop born sired by Friesian	441	53.39	27.56
JF cross	% of calf crop born sired by JF cross	441	7.40	20.31
Jersey	% of calf crop born sired by Jersey	441	3.27	9.92
Beef breed	% of calf crop born sired by any beef breed	441	31.44	26.61
Other breeds	% of calf crop born sired by other breeds (i.e., Fleckvieh, Montbéliarde)	441	4.50	16.02
Dairy only	= 1 if farmer used dairy breeds only, 0 otherwise	441	106 (24.04)	
Calf management (section 5 of the survey)				
Calf feeding	= 1 if farmer uses automatic feeder; = 2 if calves fed twice a day; = 3 if calves fed twice then once; = 4 if calves fed once a day only	401	2.17	0.67
Calf space	% of calves that can be housed on the farm	380	380 (82.03)	
Calf housing	= 1 if farmer invested in calf housing or already has adequate housing, 0 otherwise	441	265 (60.09)	
Farmer characteristics (section 6 of the survey)				
Age	Age category (= 1 if 18–25 yr; = 2 if 26–35 yr; = 3 if 36–45 yr; = 4 if 46–55 yr; = 5 if 56+ yr)	399	3.18	1.17
Education	= 1 if third level or higher, 0 otherwise	441	230 (52.15)	
Agricultural training	= 1 if third-level agricultural training, 0 otherwise	441	114 (25.85)	
Sex	= 1 if the farmer is a male, 0 otherwise	396	370 (93.43)	
Extension	= 1 if the farmer is member of a dairy discussion group, 0 otherwise	441	291 (65.99)	
South	= 1 if the farm is located in the south, 0 otherwise	388	279 (71.91)	
East and midlands	= 1 if the farm is located in the east and midlands, 0 otherwise	388	71 (18.30)	
Northwest	= 1 if the farm is located in the northwest, 0 otherwise	388	38 (9.79)	

[1]n = number of responses from the survey.

[2]DBI = Dairy Beef Index.

supplemental material provide a complete set of statements.

Data

Overall, we received 450 responses representing about 2.5% of the population of about 18,000 Irish dairy farmers. After data cleaning, the final sample consisted of 441 dairy farmers. However, not all farmers completed the entire survey as some farmers exited the survey early. Therefore, we explored the relationship between observed variables and missing values for the calf welfare outcome analyses using chi-squared test for missing completely at random and covariate-dependent missingness (Little, 1988). The observed *P*-value (0.978) from the test was not statistically significant and missing values were deemed random. Thus, each analysis was performed with the maximum number of completed responses available, ranging from 365 to 441.

It is also worth mentioning that our sample differs from the average Irish farm. Our sample farms, for example, had on average 132 cows and farmed 80 ha in 2019. In contrast, the national average dairy herd size in 2018 was 79 dairy cows with a total farm area of 61 ha (Dillon et al., 2019). Furthermore, the farmers in our sample were, on average, between 36 and 45 yr of age with more than 50% possessing a third-level degree or higher. The national average age of a dairy farm holder in 2018 was 53 yr (Dillon et al., 2019). In addition, participation in dairy discussion groups with 66% is higher in our sample compared with the national average of 43% in 2018 (Dillon et al., 2019). Therefore, survey respondents were from larger farms managed by younger farmers, indicating possible self-selection of more progressive farmers into our sample, which may limit the representativeness of our findings. Nevertheless, in relation to regional distribution, our sample is representative of national figures. Specifically, 72% of our sample farms were located in the south, 18% in the east and midlands, and 10% were located in the northwest of the country. This is similar to the national geographic distribution of dairy farms, where 72% of all dairy farms are located in the south region (Dillon et al., 2019).

Statistical Methods

Data analysis followed several steps consisting of cluster analysis and econometric analyses, described in detail below. Sensitivity analyses for the econometric models were also conducted.

First, we performed Ward's linkage hierarchical cluster analysis (Ward, 1963) using stata (version 16.1, 2019, StataCorp LLC) on the 6 attitudinal statements (shown in Table 3). Ward's linkage hierarchical clustering is suitable for ordinal data. Before conducting the cluster analysis, the scales of 2 negatively worded statements were reversed to ensure conformity in the analysis (e.g., the scoring of the statement "the feelings of animals are not important" was reversed). We computed a dissimilarity matrix based on the absolute value distance measure. Furthermore, a dendrogram was produced that showed a graphical classification of unique groupings in the data, which was used to assess the validity and accuracy of the cluster analysis. In addition, to evaluate the accuracy and performance of the cluster procedure, the Bayesian (posterior) probability of group membership (Fisher, 1936) assuming equal priors (group prior probabilities) of being in any of the clusters was computed using the *k*th-nearest-neighbor discriminant analysis algorithm based on the attitudinal statements. This procedure has the advantage that it not only assesses the performance of the cluster classification but also maximizes the number of correct classifications (Andrew et al., 2015). Finally, a Kruskal-Wallis test of equality of population and one-way ANOVA were used to examine differences in the clusters.

Table 3. Description of attitudinal statements and distribution of responses of dairy farmers by clusters[1,2]

Statement	High animal welfare concern, mean (SD)	Medium animal welfare concern, mean (SD)	Low animal welfare concern, mean (SD)
Male dairy calves are an unwanted by-product of dairy production.	4.38 (0.71)	1.99 (0.74)	3.21 (1.25)
Dairy farmers are responsible to produce animals for the beef sector.	3.06 (1.34)	3.11 (1.20)	2.79 (1.17)
The reputation of Irish dairy farming in relation to calves is of increasing concern.	3.93 (1.32)	4.31 (0.73)	3.53 (1.30)
The feelings of animals are not important.	1.08 (0.27)	1.18 (0.38)	3.18 (1.17)
Farm animals should be guaranteed a happy and content life.	4.83 (0.53)	4.63 (0.88)	3.91 (1.37)
I would be willing to explain to a consumer what I do with my dairy calves.	4.78 (0.52)	4.40 (0.85)	4.11 (1.27)
Observation (n)	149	135	157

[1]The original questionnaire included 7 statements, but we removed one because it proved not to be internally consistent.

[2]Each statement were based on a 5-point Likert scale that ranged from strongly disagree (1) to strongly agree (5).

Next, we used a multinomial logit regression model to explore factors related to the probability of farms being in one of the animal welfare concern clusters, revealed by the previously described cluster analysis. The multinomial logit model is an extension of a binary logistic regression model and allows for more than 2 categories for the outcome variable. Thus, the outcome variable y can take on values $j = 1, 2, \ldots J$, with J being a positive integer, representing the number of animal welfare concern groups (i.e., identified clusters); X denotes explanatory variables such as dairy expansion, calf breeding, calf management, and socio-economic variables, and β are parameters estimated by maximum likelihood. In the multinomial logit model, interest lies in how changes in the X variables affect the outcome probabilities, as follows (Wooldridge, 2010):

$$P\left(y = j \mid X\right) = \frac{\exp\left(X\beta_j\right)}{1 + \sum_{j=1}^{J} \exp\left(X\beta_j\right)}, j = 1, \ldots, J, \qquad [1]$$

since the outcome probabilities must sum to unity, $P(y = 0|X)$ is determined once the probabilities for $j = 1, \ldots, J$ are estimated (Wooldridge, 2010). Thus, equation [1] can be rewritten as

$$P\left(y = j - 1 \mid X\right) = \frac{1}{1 + \sum_{j=1}^{J} \exp\left(X\beta_j\right)}. \qquad [2]$$

A likelihood-ratio chi-squared test was used to assess whether the different categories can be combined in our model. The null hypothesis in the test is that the groups are the same and should be treated as such in the model. This is important because treating the groups as different when they are the same would bias the result and inferences. The result of the likelihood-ratio test ($\chi^2 = 70.38$, $P < 0.01$) confirmed that the 3 farmer groups cannot be combined, thereby justifying treating the 3 groups separately in our model.

Next, we used both a linear model (estimated by an ordinary least squares estimator) and a probit regression model to explain calf welfare outcomes using the previously explained outcome variables: calf mortality, calf export, and premature culling.

For the linear model, calf mortality was the outcome variable of interest. A linear model is a continuous outcome model that estimates the relationship between explanatory variables and an outcome measure. For each observation, i, the model predicts the value of the observed dependent variable, y (calf mortality) from a sum of k explanatory variables X, with a coefficient β, and an unobserved, normally distributed error term ε (Wooldridge, 2010). For this study, the model takes the form

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 C + \varepsilon, \quad [3]$$

where X_1 represents variables related to expansion, X_2 represents breeding variables, X_3 accounts for variables related to calf management, X_4 are farm characteristics, whereas C is a dummy variable controlling for the animal welfare concern clusters.

For the probit models, calf export and premature culling were the outcome variables of interest. A probit model is a binary outcome model that predicts the probability of occurrence of an event. In this study, it is the probability that farmers send calves for export (calf export) and the probability that calves were culled prematurely (premature culling). Therefore, in the probit models, the outcome of interest (dependent variable) y takes only 2 values: a value of 1 if the event occurs (i.e., calves were sent for live export or culled prematurely) and 0 if it does not (i.e., no calves are exported/culled prematurely).

Taking the probability as a function of a vector of explanatory variables X, and a vector of unknown parameters β, we can write a general binary choice model as follows (Wooldridge, 2010):

$$P\left(y = 1 \mid X\right) = F\left(\beta' X\right) \equiv p\left(X\right), \qquad [4]$$

where X represents the same explanatory variables used in the previously described linear model, see equation [3]. Here, our interest lies in estimating the effect of X on the response probabilities $P(y = 1|X)$ and this simplifies to

$$y = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{if } y^* \le 0 \end{cases},$$

where y^* is the unobserved response variable, then $P(y = 1) = P(y^* > 0) = P(\mu > -\beta' X)$, as per Wooldridge (2010). In this framework, μ was assumed to be normally distributed with mean 0 and variance 1; thus, the probability distribution function is bounded between 0 and 1. As parameter estimates in this model cannot be directly interpreted, marginal effects are reported. The marginal effects represent the partial effects of each explanatory variables on the observed outcome variable (Wooldridge, 2010).

As a robustness check and to detect any problems of multicollinearity, we computed variance inflation factors. Variance inflation factor determines the strength of the correlations between the explanatory variables by measuring the extent to which the variance of an estimated regression coefficient increased because of collinearity (Zuur et al., 2010). Variance inflation factor values of 5 and above often signal high multicollinearity (Zuur et al., 2010).

RESULTS AND DISCUSSION

Descriptive Statistics

Descriptive statistics of our sample data are provided in Table 2.

Calf mortality was 3.6% on our sample farms in 2019. Of all farms surveyed, 30% sell calves for live export (on average 12% of calves were sold for export). Also, 19% of all farms conduct some premature culling (5% of calves were culled prematurely).

Almost 84% of farmers indicated that they increased their herd size after milk quota abolition in 2015, which is comparable to national figures (Dillon et al., 2019). The average increase was 41 dairy cows. Exploring this in more detail revealed that farmers in the top 25% in terms of herd size increased their herds by just over 53%, which is an average of 100 cows.

Adjustment of breeding strategies is one of the most important aspects that can significantly affect dairy cow and calf welfare due to its influence on reproductive efficiency, milk output, and the quality of calves bred (Johnson et al., 2018). In relation to breeding, almost 80% of dairy cows in our sample were Friesian, whereas almost 15% were Jersey Friesian cross breeds. Furthermore, 19% of sample farmers used sexed semen, but only 40% of those used sexed semen on all heifers. Only one farmer indicated that sexed semen was used for all heifers and all dairy cows. The remaining farmers used sexed semen only on selected dairy cows, heifers, or both. Furthermore, 40% of farmers considered the DBI in their breeding decisions. The main reasons for using the DBI were easy calving, short gestation, and high carcass weight. Finally, a Friesian bull was used for just over 53% of the calf crop born in 2019. Jersey and Jersey Friesian cross sires were used for about 10% of cows, whereas just under one-third of the calf crop was sired by any beef breed.

In relation to calf management, the majority of farmers fed calves manually (85%). Sixty-nine percent of the manually fed calves were fed twice a day, and the remainder were fed once a day or first twice, then once a day. One drawback of our data is that it does not include any information on the age of calves at different feeding regimens. Once a day feeding from birth is not recommended (FAWAC, 2020) because it may result in underfeeding, which poses major concerns for calf health and welfare (Devant and Marti, 2020).

Furthermore, on average more than 82% of calves born could be housed on the farm and more than 60% of farmers had either invested in calf housing or already had adequate housing facilities (i.e., they could house 100% of the calves born on the farm).

In relation to farmer characteristics, 52% of our sample farmers had a third-level degree or higher, and 66% were part of a dairy discussion group.

Attitudes to Animal Welfare and Industry Reputation

Farmers' responses to the statements relating to attitudes to animal and dairy calf welfare, as well as dairy industry reputation, are shown in Figure 1. Almost half of the sample farmers (48.8%) either strongly or somewhat disagreed with the statement that "male dairy calves are an unwanted by-product of dairy production." In contrast, just over 38% of farmers somewhat or strongly agreed with this statement. A similar pattern was evident with the statement "dairy farmers are responsible to produce animals for the beef sector" and 40% of farmers either somewhat or strongly agreed, whereas 37% either strongly or somewhat disagreed. This suggests that farmers' opinions were quite divided in relation to statements that were indirectly related to dairy calf welfare. In contrast, almost three-quarters (74%) of farmers agreed that the reputation of the Irish dairy industry is of increasing concern compared with almost 15% who either somewhat or strongly disagreed. In addition, just over 86% of farmers either somewhat or strongly agreed with the statement "farm animals should be guaranteed a happy and content life."

Overall, the results revealed that farmers in our study had a positive attitude toward general animal welfare but had more widely dispersed opinions when specific animal welfare questions were posed such as those related to dairy calf welfare. Farmer characteristics such as personality, empathy, and knowledge, and external factors such as costs or herd size likely influenced these opinions (Balzani and Hanlon, 2020). Moreover, previous studies on the associations of farmers' attitudes in relation to farm management and animal welfare provisions showed similar findings amplifying the fact that farmers' decisions are influenced by their attitudes (Kielland et al., 2010; Kauppinen et al., 2010; Jääskeläinen et al., 2014).

However, whereas our study shows that farmers have a positive attitude toward animal welfare, it is noteworthy to acknowledge potential self-selection bias toward more animal welfare-minded farmers in our study.

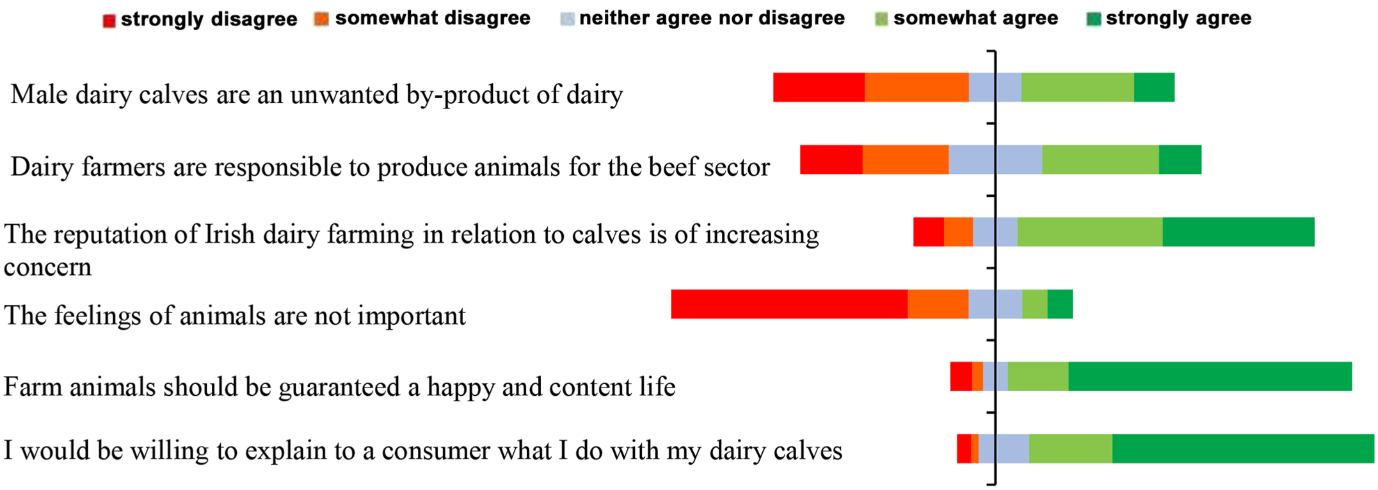

Figure 1. Farmers' responses to animal welfare attitudinal questions based on a 5-point Likert scale that ranged from strongly disagree (1) to strongly agree (5).

Animal Welfare Clusters

The cluster analysis revealed 3 distinct groups of dairy farmers based on their attitudes toward animal and dairy calf welfare, and dairy industry reputation. Despite the fact that one attitudinal statement refers to industry reputation, for brevity, we refer to the clusters as high or low animal welfare concern clusters. The predicted Bayesian (posterior) probability of the discriminate analysis showed that cluster group 1 was highest at 0.35 followed by group 2 and group 3 (0.33 and 0.32, respectively). The distribution of farmers showed that, generally, farmers in group 1 tended to have a more positive attitude toward animal welfare compared with farmers in groups 2 and 3, as shown in Table 3. For example, compared with groups 2 and 3, most farmers in group 1 disagreed strongly (1.08 ± 0.27) that the feelings of animals are not important and agreed strongly (4.83 ± 0.53) that farm animals should be guaranteed a happy and content life. Thus, combining the results from the Bayesian probability of group membership of the discriminate analysis and these results, the groups are labeled as high animal welfare (group 1), medium animal welfare (group 2), and low animal welfare (group 3) concern groups or clusters.

The main descriptive statistics for each cluster are in Table 4. The numbers reveal that farmers in the 3 groups were significantly different in 2 of the 3 calf welfare outcome variables. For example, the reported calf mortality rates differed significantly across each of the animal welfare clusters. As expected, calf mortality, with 3.8%, was highest among the low animal welfare concern group. In addition, the extent to which calves were culled prematurely was significantly higher among the low animal welfare concern group when compared with the medium and high animal welfare concern groups.

Furthermore, the groups were significantly different with respect to herd size, herd expansion after milk quota abolition, stocking rate, stockperson to animal ratio, breeding composition of the herd, and farmer characteristics, such as age and farm location. For example, in relation to farmer characteristics, a significant number of farmers in the low animal welfare cluster were older and farms were more concentrated in the south compared with the other 2 clusters.

Multinomial Logit Analysis of Determinants of Animal Welfare Concern Clusters

The results (coefficient estimates) of the multinomial logit analysis are in Table 5. Group 3 (low animal welfare concern cluster) is the base category in our model.

Our empirical findings indicate that herd size, the percentage increase in the herd after milk quota abolition, DBI, age, and level of agricultural training were significantly correlated with cluster membership (i.e., whether farmers in our sample were in high, medium, or low animal welfare concern groups). In addition, we found significant regional differences in relation to cluster membership. In other words, farm location was significantly associated with the probability of being in a particular animal welfare concern cluster.

A larger herd size was significantly associated with the likelihood of farmers being in the medium animal welfare concern cluster compared with the low animal welfare concern cluster. Dairy herd expansion was negatively associated with being in the high and medium animal welfare concern clusters compared with the low animal welfare concern cluster. In contrast, DBI usage was positively associated with high and medium animal welfare concern cluster membership compared with being in the low animal welfare concern cluster. The DBI use suggests that these farmers were attempting to reduce the number of low-value calves born on their farm. Berry et al. (2019) highlighted the importance of DBI usage not only in the context of animal welfare improvement but also as a means for improving economic gains in dairy farming. Furthermore, compared with farmers above 55 yr of age, younger farmers (≤35 yr) were significantly more likely to be in the high and medium animal welfare concern clusters compared with being in the low animal welfare concern cluster. However, we did not find any significant differences in relation to cluster membership of farmers above 35 yr and farmers in the 55-plus age category. Interestingly, the level of education was not a statistically significant determinant of cluster membership, whereas agricultural training was negatively associated with being in a higher animal welfare concern cluster. This may suggest that animal welfare is not a major topic in agricultural training courses in Ireland. Finally, farmers located in the east/midlands and northwest regions were more likely to be in the high animal welfare concern group (compared with farmers in the south region). This is consistent with the fact that the majority of dairy expansion happened in the south region. In addition, this could point to the so-called "cowshed culture" where regional differences reflect a geographical culture toward dairying (Burton et al., 2012). Thus, as dairy farms expanded, the drive to be more competitive may predominate animal welfare concerns for farmers in the dairy intensive regions, such as those in the south region.

Determinants of Calf Welfare Outcomes

As the last step of our analysis, we explored the determinants of calf welfare outcomes. Results are re-

Table 4. Characteristics of the animal welfare concern clusters based on the indicators of calf welfare outcome, dairy expansion, breeding and calf management, and farmer characteristics

Characteristic	High animal welfare concern (n = 149)	Medium animal welfare concern (n = 135)	Low animal welfare concern (n = 157)	Difference test[1] (χ^2)
Calf welfare indicator				
Calf mortality	3.35	3.66	3.81	10.70***
Calf export	0.25	0.30	0.36	1.60
Premature culling	0.17	0.13	0.26	8.91**
Expansion				
Herd size	137.38	121.99	136.52	8.54**
Herd expansion	26.98	23.92	26.77	21.25***
Stocking rate	1.67	1.77	1.70	6.08*
Stockperson ratio (per 100 cows)	1.71	1.87	1.66	15.47***
Breeding				
Friesian breed	81.47	78.52	77.33	2.13
Jersey Friesian breed	14.58	14.08	15.97	0.12
Sexed semen	0.18	0.18	0.20	0.22
DBI[2]	0.46	0.39	0.37	1.93
% calf crop born by				
Friesian	49.55	54.47	56.11	2.24
Jersey Friesian	8.09	7.19	6.92	5.03*
Jersey	3.25	2.39	4.06	17.75***
Beef	35.32	30.70	28.40	0.39
Dairy	0.18	0.25	0.29	4.04
Calf management				
Calf feeding	2.15	2.16	2.20	0.31
Calf space	82.44	83.16	80.68	1.12
Calf housing	0.73	0.72	0.71	0.14
Farmer characteristic				
Age	3.13	3.01	3.36	5.99*
Education	0.55	0.49	0.52	2.78
Agricultural training	0.25	0.22	0.31	2.77
Extension	0.69	0.61	0.68	1.66
South	0.71	0.65	0.78	7.35**
East and midlands	0.21	0.21	0.14	0.89
Northwest	0.08	0.15	0.08	0.61

[1]Statistics are from univariate analysis. One-way ANOVA (Bartlett's χ^2 test) for continuous variables and a Kruskal-Wallis test for binary or ordinal variables.

[2]DBI = Dairy Beef Index.

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

ported in Table 6. Model 1 is based on results from a linear model used to explain calf mortality, whereas the other models (model 2 and 3) are results from the probit models that assessed the probability of farmers' calf marketing choices (i.e., calf export and premature culling). The results of the probit models are reported as marginal effects. A mean variance inflation factor of 1.86 (linear model) and 1.90 (probit models) suggests that multicollinearity is not a concern in the analyses.

Determinants of Calf Mortality

In relation to our calf mortality model, the empirical results suggest that of the herd expansion variables, herd size and stocking rate were significantly associated with calf mortality. More specifically, our findings indicate that calf mortality increased with larger herd size, albeit at a small rate. For example, our model predicted that an increase of 10 dairy cows was associated with a 0.03% increase in calf mortality. Gulliksen et al. (2009) also found that calf mortality rates across all age groups increased with larger herd size on Norwegian dairy farms. In terms of stocking density, a higher stocking rate was negatively related to calf mortality. For example, a 1-unit increase in stocking rate was associated with a 0.5% decline in calf mortality. Although this may seem counterintuitive, stocking rate could be a proxy for efficient farm management, resulting in a reduced risk of calf mortality. Interestingly, stockperson ratio was not significantly associated with calf mortality, suggesting that labor shortages did not play an important role.

In relation to breeding variables, selective breeding was positively associated with calf mortality. For example, farmers that used dairy breeds only (e.g., Friesian, Jersey Friesian, and Jersey breeds only) were predicted to have a 0.78% higher calf mortality compared with farmers that used dairy and beef breeds. However, for a 1-unit increase in the percentage of beef breed used, calf mortality was predicted to increase by 0.01%. These findings suggest that using dairy breeds only may exacerbate calf mortality due to previously outlined reasons such as differential management and feeding strategies between male and female calves (Renaud et al., 2017;

Table 5. Multinomial logit model result of the determinants of the probability of being in the high or medium animal welfare concern cluster in relation to the low animal welfare cluster[1]

Variable	High animal welfare concern cluster	Medium animal welfare concern cluster
Expansion		
Herd size	0.00 (<0.01)	0.01 (<0.01)**
Herd expansion	−0.01 (0.01)*	−0.02 (0.01)**
Stocking rate	0.67 (0.30)**	0.18 (0.27)
Stockperson ratio (per 100 cows)	0.28 (0.24)	0.12 (0.18)
Breeding		
Sexed semen	−0.14 (0.43)	0.05 (0.37)
Dairy Beef Index	0.67 (0.33)**	0.67 (0.31)**
% calf crop born by		
Dairy breed	−0.59 (0.48)	−0.637 (0.447)
Beef breed	−0.01 (0.01)	0.00 (0.01)
Calf management		
Calf feeding (base = automatic)		
Twice a day	0.58 (0.47)	0.60 (0.44)
Twice then once	0.38 (0.52)	0.18 (0.50)
Once a day only	−0.64 (1.22)	−0.34 (0.94)
Calf space	0.01 (0.01)	0.01 (0.01)
Calf housing	0.23 (0.41)	−0.00 (0.34)
Farmer characteristic		
Age category (yr)		
18–25	1.97 (0.75)***	0.58 (0.75)
26–35	2.02 (0.68)***	1.80 (0.63)***
36–45	0.19 (0.50)	0.11 (0.50)
46–55	0.25 (0.48)	−0.28 (0.47)
Education	−0.42 (0.34)	0.18 (0.33)
Agricultural training	−1.62 (0.49)***	−1.18 (0.40)***
Extension	−0.27 (0.36)	−0.18 (0.35)
Northwest	1.23 (0.58)**	0.54 (0.54)
East and midlands	0.84 (0.41)**	0.69 (0.38)*
Observations	329	329

[1]Coefficient estimates; robust standard errors in parentheses. Figures are estimates from a multivariate (multinomial logit regression) analysis. Base outcome = low animal welfare cluster.

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Boulton et al., 2020). However, calves from beef sires tend to be larger, which increases the risk of calving difficulties and can potentially exacerbate calf mortality (Berry et al., 2019).

In relation to calf management, calf space and calf housing were significantly negatively associated with calf mortality. For example, for each additional percentage of calves that could be housed on the farm at any one time, calf mortality was predicted to decline by 0.1%. In addition, investments in calf facilities or adequate facilities were associated with a 0.78% lower rate of calf mortality. This suggests that housing facilities played an important role in reducing the risk of calf mortality. However, this is in contrast to Boulton et al. (2020) who did not find a significant association between variables related to on-farm management and calf mortality in New Zealand. However, their study was based on a small sample size.

Finally, the calf mortality model also revealed that being in the high animal welfare concern cluster was significantly associated with a lower calf mortality rate when compared with the low animal welfare concern cluster. Overall, the findings from this model suggest that breeding decisions, as well as adequate calf facilities, were significantly associated with calf mortality.

Determinants of Calf Exports

Model 2 in Table 6 explored determinants of calf exports. As previously explained, the dependent variable is a binary outcome that equals 1 if the farmer sold any calves for live export and 0 otherwise. The marginal

Table 6. Results of the linear and probit regression models of the determinants of the 3 measures of calf welfare outcome[1]

Variable	Model 1 (calf mortality)	Model 2 (calf export)	Model 3 (premature culling)
Expansion			
Herd size	0.003*	0.001*	0.001***
	(0.002)	(0.001)	(0.001)
Herd expansion	−0.007	−0.003**	0.002***
	(0.005)	(0.001)	(0.001)
Stocking rate	−0.489**	0.054	−0.007
	(0.225)	(0.041)	(0.026)
Stockperson ratio	−0.175	−0.017	0.001
	(0.129)	(0.023)	(0.019)
Breeding			
Dairy Beef Index	0.027	−0.038	−0.064*
	(0.243)	(0.046)	(0.035)
Sexed semen	0.235	0.140***	0.074*
	(0.290)	(0.054)	(0.040)
% calf crop born by			
Dairy breed	0.785**	−0.126*	0.133***
	(0.385)	(0.068)	(0.049)
Beef breed	0.010*	−0.003***	0.001
	(0.006)	(0.001)	(0.001)
Calf management			
Calf feeding (base = automatic)			
Twice daily	0.052	0.007	0.015
	(0.365)	(0.068)	(0.045)
Twice then once	−0.145	0.057	0.182***
	(0.399)	(0.078)	(0.060)
Once a day only	−0.473	−0.070	0.210
	(0.663)	(0.141)	(0.156)
Calf space	−0.014*	−0.001	−0.002***
	(0.008)	(0.001)	(0.001)
Calf housing	−0.734**	0.005	−0.033
	(0.314)	(0.056)	(0.038)
Farmer cluster			
Medium animal welfare	−0.056	−0.062	−0.042
	(0.324)	(0.059)	(0.041)
High animal welfare	−0.521*	−0.121**	−0.024
	(0.269)	(0.055)	(0.040)
Other controls	Yes	Yes	Yes
Observations	365	375	375

[1]We tested for regional differences but found no significant association across all the 3 calf welfare outcomes. Robust standard errors are shown in parentheses. Other controls include farmer characteristics.

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

effects of the probit model suggest that in relation to expansion variables, herd size and herd expansion were significantly associated with the probability of exporting calves; however, the absolute values of the coefficients are small. For example, an increase of 10 dairy cows increased the probability that farmers would export calves by 0.01%. In addition, the probability that farmers would export calves decreased with increased herd expansion. For instance, a 10% increase in herd expansion after milk quota abolition was associated with a 0.03% reduction in the probability that farmers would export calves. This may suggest that farmers already had markets in place when deciding to expand.

In relation to breeding variables, the use of sexed semen and breed composition of the herd were significantly associated with the probability of calf exports. More specifically, the use of sexed semen was linked to a 0.14% increase in the probability of calf exports. The positive association of sexed semen use with the probability to sell calves for export is somehow surprising. When explored in more detail, however, farmers who used sexed semen appeared to favor Jersey breeds. As Jersey-bred calves are hard to market, calf exports may be the only option. In addition, sexed semen is more expensive than conventional AI; therefore, farmers may try to recover costs through calf exports.

The probability that farmers exported calves was associated with a 0.13% reduction for a 1 percentage point increase in the use of dairy breeds only. A similar association, albeit with a lower absolute value (0.003), was observed when farmers included beef breeds in their breeding decision. This suggests that an increase in the percentage of beef breeds used reduced the probability that farmers export calves. This may be due to better economic value for beef bred calves in local markets or farmers may have the possibility to rear calves themselves. This is in line with Berry et al. (2019) who argue that employing effective breeding strategies through the selection of appropriate beef bulls can improve economic gains on Irish dairy farms.

In addition, our results revealed that calf management variables (calf feeding, calf space, and calf housing) did not seem to play a significant role in the decision to export calves. Irrespective of calf feeding practices, calf space, and housing, farmers may still decide to export calves. In addition, current regulations in Ireland stipulate that farmers cannot move calves off the farm before 14 d of age.

Finally, the calf export model showed that the probability of selling calves for live export was significantly lower for farmers in the high animal welfare concern cluster compared with those in the low animal welfare concern cluster. This suggests that farmers' attitudes play a role in the decision to export dairy calves. Overall, the findings from the calf export model suggest that calf export is mainly associated with breeding and dairy expansion related variables.

Determinants of Premature Culling of Calves

Model 3 in Table 6 focused on the determinants of premature culling of calves. The findings suggest that expansion variables, such as larger herd size and expansion, were positively associated with the probability that calves were culled prematurely. More specifically, the results of the marginal effects suggest that an increase of 10 dairy cows was associated with an increase of 0.01% in the probability that calves were culled prematurely. In addition, a 10% increase in herd expansion after milk quota abolition was associated with a 0.02% increase in the probability that calves were culled prematurely. This suggests that expansion in Irish dairying may have significantly exacerbated the number of calves that were culled prematurely, thus amplifying the need to develop a new policy strategy that can support the industry in terms of how to effectively manage surplus calves.

In relation to breeding variables, our results indicated that using the DBI was significantly associated with a lower probability that calves were culled prematurely. Specifically, the probability that calves were culled prematurely reduced by 0.06% if farmers considered the DBI in their breeding decision. In contrast, using sexed semen was positively associated with the probability that calves were culled prematurely. This positive association seems somehow counterintuitive. In this context, it is important to remember that the variable on the use of sexed semen did not include any information on how widely sexed semen was used in the herd. More detailed exploration of the data revealed that of the farmers who used sexed semen, 59% used sexed semen on dairy cows, whereas only 39% used it on heifers. However, for reproductive effectiveness, it is recommended to use sexed semen primarily on heifers because they are, on average, genetically superior, have greater fertility, and achieve better replacement value (Hohenboken, 1999; Garner and Seidel, 2003; Weigel, 2004; Diers et al., 2020). Thus, increasing the use of sexed semen in heifers may better support the goal of reducing the number of low-value male dairy calves. Finally, in relation to breeding, farmers that used dairy breeds only were predicted to have a 0.13% higher probability of having calves culled prematurely compared with farmers that combined dairy breeds with some beef breeds.

In relation to calf feeding management, our model predicted that manually feeding calves (e.g., when they are fed twice and then once a day) was positively associated with the probability that calves were culled prematurely compared with when automatic feeders were used. However, a note of caution is required when interpreting this finding as feeding practices change depending on the age of the calf, which was not addressed in this study. In this context, time and labor are external factors that influence farmers' views and decisions on animal welfare (Balzani and Hanlon, 2020). Thus, the additional workload of manual feeding, especially when there are labor shortages within the industry, may expedite the early removal of calves from the farm. In contrast, for each additional percentage of calves that could be housed on the farm at any one time, the probability that calves were culled prematurely decreased by 0.002%. These results further strengthen the finding that improved calf management decisions and housing practices can reduce the number of calves that are culled prematurely. Interestingly, we did not find significant differences between our animal welfare concern clusters in relation to the probability of premature culling.

Overall, the findings from model 3 suggest that herd size and herd expansion in the post-milk quota abolition era potentially exacerbated the number of calves culled prematurely on Irish dairy farms. However, better breeding decisions (i.e., the use of DBI) or increased space for housing calves appeared to circumvent the problem.

CONCLUSIONS

This article explored how dairy expansion, breeding, and calf management decisions, as well as farmers' attitudes, relate to calf welfare outcomes (i.e., calf mortality, calf export, and premature culling). Our findings revealed that farmers had a positive attitude toward the welfare of farmed animals, but had more dispersed opinions about dairy calf welfare. In addition, we found that breeding decisions and calf facilities were significantly associated with calf mortality, whereas herd expansion and breeding were significantly correlated with calf export and premature culling. Furthermore, calf housing was significantly negatively associated with calf mortality. In this context, investments in calf housing facilities could be one option to improve the welfare of dairy calves, as adequate housing also reduces pressure to move calves from the farm shortly after birth. Possible solutions to reduce premature culling or live exports would be a domestic veal industry or fostering greater dairy-beef farm integration. For example, supporting a greater focus on beef traits in the breeding of surplus calves will help reduce the problem, supported by our findings. The latter point in particular needs some farm adjustments and convincing farmers of its merit by involving them and other stakeholders in the development process.

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