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Culling from the actors' perspectives—Decision-making criteria for culling in Québec dairy herds enrolled in a veterinary preventive medicine program

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ABSTRACT

The series of events leading to the decision to cull a cow is complex, involving both individual-level and herd-level factors. While the decision is guided by financial returns, it is also influenced by social and psychological factors. Research studies on the motivational and behavioural aspects of farmers' decision utility are sparse, and nonexistent regarding culling expectations and its decision process. Our goal was to identify shared criteria on culling decisions held by dairy producers and farm advisers, with the help of the Q-methodology.

Forty-one dairy producers and 42 advisers (17 veterinarians, 13 feed mill advisers, and 12 dairy herd improvement (DHI) advisers) undertook a Q-sort with 40 statements that represented a range of views about cow and herd health, production performance, management issues, and material factors that might impact their culling decision-making process. The sorts were analysed by-person using factor analysis and oblimin rotation.

A single view on culling could be identified among dairy producers that can be extended to dairy farm advisers, who showed two variations of the same well-structured, uni-dimensional decision-making process. Udder health, milk production performance, and milk quota management were the key criteria for the culling decision. Farm management parameters (debts, amortization, employees, milking parlour capacity, herd size) did not play any role in the decision process. Three key differences were, however, identified between producers and the two types of advisers. One group of advisers followed the recommendations from mathematical models, where pregnancy is a major determinant of a cow's value. They assessed the cow in a more abstract way than did the other participants, still taking into account udder health and milk production, but adding economic considerations, like the availability of financial incentives and an evaluation of the post-partum health of the cow. Dairy producers were also more concerned about producing healthy and safe milk, which might reflect a different value given to dairy farming than by advisers. Very different degrees of importance were given to animal welfare by the three groups, which could represent different views on the attributed relationships between dairy farmers and their animals.

Our findings suggest that dairy producers and their advisers hold a general common view regarding culling decision-making. However there are significant differences between producers and advisers, and among advisers. Understanding and managing these differences is important for assisting the change management processes required to increase farm profitability, and call for further investigation.

1. Introduction

The process leading to the decision to cull a cow is complex, involving both individual-level (milk production level, stage of lactation, reproductive status, age, genetic value, health problems) and herd-level factors (herd short and long-term dynamics, production needs, availability of replacement animals, price of milk and culled cows, milk quota; Dohoo and Dijkhuizen, 1993). The cost associated with animal replacement is substantial, second in importance only to feeding costs and labour. As such, the decision to cull a cow is a farm management decision for the dairy producer to better reach his goals. While minimizing the total losses (the sum of the production loss and disease

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control expenditures) is recognized to be the most profitable approach (McInerney et al., 1992), dairy producers have flexibility regarding the timing of their decisions and have to deal with certain constraints (e.g., regulations, quotas, etc.; Wallace and Moss, 2002). Bigras-Poulin et al. (1985) already demonstrated that a farmer's socio-psychological characteristics were more important to farm performance than herd-level variables describing production, health, and fertility. These results were later confirmed by other studies (Willock et al., 1999; Bergevoet et al., 2004). Farmers' decisions are certainly guided by financial returns, but are also influenced by social and psychological factors (Beaudeau et al., 1996; Edwards-Jones, 2006). Their behavioural choices are constrained and facilitated by their social context. Holding a complex set of core values makes some choices more appealing than others even if they might not be as financially rewarding (Garforth, 2010).

To help them make decisions on their farm operations, dairy producers can have access to several resources, including veterinarians, consultants, industry representatives, and Dairy Herd Improvement (DHI) personnel (Jordan and Fourdraine, 1993; Jensen et al., 2009). Over the years, veterinary practitioners have seen their role and responsibilities moving from diagnosing and treating clinical diseases on individual animals, to an integrated approach to disease prevention and herd health improvement, leading to a rise in herd productivity (LeBlanc et al., 2006; Mee, 2007). By doing so, they had to acquire skills in nutrition, cow/calf housing, data analysis, fertility management, milk quality, economics, and farm guidance. Their role evolved from mostly clinical, task-oriented, service providers to one of advice-oriented consultants (LeBlanc et al., 2006). Following this change in role, they had to engage with other specialists already present on the farms, like nutritionists, lenders, milk processors, extension educators, etc. Advisory teams including all these players could even be built to support farmers in the implementation of 'best practice' farm management (Chase et al., 2006; Noordhuizen et al., 2007).

In classic economic theory, it is assumed that people make decisions based on the expected changes in their 'well being', referred to as 'utility', searching for a maximum utility level (Edwards-Jones, 2006). Likewise, agricultural economic models assume that farmers maximize utility and, as utility is hard to measure, profit is used as a surrogate for utility (Wallace and Moss, 2002). However, profit maximization is only one of many motivations determining decision-making behaviour. For any given choice, people have to use some implicit decision rules based on their goals and motivations. These decision rules do not have to translate the 'maximization of something', or even to maximize anything at all (Wallace and Moss, 2002; Edwards-Jones, 2006). Even if researchers can model this maximization post hoc, people might not have psychologically followed that process (Ahuvia, 2008). Based on criteria that have varying degrees of explicitness, the decision maker will prefer one course of action over others. We can define decision utility as the utility that determines our choices (Kahneman and Thaler, 2006; Robson and Samuelson, 2011). Decision utility is what people maximize when making choices (Robbins, 1935; Samuelson, 1938). Making a decision involves freedom of choice, even if these choices could be constrained. And the choices made reveal preferences, i.e. subjective judgments about (1) the relative importance of the collected facts, (2) personal values, (3) the requirements for implementing the course of action, and (4) the relative significance of these judgments (Stephenson, 1973).

A prevailing behavioural aspect of decision making is loss aversion or *status quo* bias (Samuelson and Zeckhauser, 1988). When making a decision about gains, individuals are risk averse, whereas they are risk loving when they have to make a decision about losses (Kahneman and Tversky, 1979), i.e. losses from a reference state are valued far more negatively than the positive value obtained from gains, and less risky, but lower, gains are preferred to higher, uncertain, gains. Farmers in general (Bocquého et al., 2014), and dairy farmers specifically (Huijps et al., 2010), have been demonstrated to follow this loss aversion behaviour. However, one group of people has been shown not to adhere to this behaviour, manifesting a less loss-averse set of actions. Advisers are recognized to more heavily weight the advantages of a decision than its disadvantages (Polman, 2012; Lu and Xie, 2014).

Producers and advisers can rely on decision support systems (DSS) to enhance their culling decision process. These DSS estimate a cow's economic value based on mathematical models (De Vries, 2006; Cabrera, 2010; Kalantari et al., 2010). However, these models can become very large and complex (Demeter et al., 2011). Due to these complexities, few of them have found a practical application in daily decision-making by milk producers or even been translated into a user-friendly decision support system (Smith et al., 1993; Groenendaal et al., 2004). In all of these models, the importance of pregnancy is critical for the determination of a cow's value, and hence the decision to keep or replace the cow (De Vries, 2006; Kalantari et al., 2010; Nielsen et al., 2010; Cabrera, 2012).

While the choices made by dairy producers are likely rational, they are also bounded by personal values and the limits of human cognition, potentially falling back on the use of short cuts and rules of thumb. The culling decision is therefore complex, context related, exists within constraints, and is possibly influenced by individual differences. These differences and the rationales behind the decision are important for understanding the choices made and for facilitating communication between actors at the farm. Research studies on the motivational and behavioural aspects of farmers' decision utility are sparse, and non-existent regarding culling expectations and the culling decision process. Therefore, in the current study, we have sought to identify shared criteria for the culling decision, held by dairy producers and farm advisers, using the Q methodology.

2. Materials and methods

2.1. Overview of the Q methodology

The Q methodology was first described by Stephenson (1935a,b), combining quantitative research techniques and analysis with qualitative approaches to pattern interpretation (Brown, 1980; Watts and Stenner, 2012; McKeown and Thomas, 2013). The Q methodology provides a means to identify the various preferences of each decision maker and their relative influence on the decision, revealing the decision structure of each individual (Durning and Brown, 2006). It allows researchers to identify groups of participants with similar viewpoints, by determining different patterns of thought rather than their numerical distribution among a larger population. The focus is not on the estimation of the proportions of participants (here, the dairy producers and the advisers) holding a specific view on a topic, but to identify qualitative categories of views shared by these groups of participants. This methodology has been effectively applied to various areas of research, including many issues of human health, like clinical decision making (Wong et al., 2004) or educational programs (Wallenburg et al., 2010), and sometimes encountered in veterinary medicine or animal health studies (de Graaf, 2005, 2007; Kristensen and Enevoldsen, 2008; Kristensen and Jakobsen, 2011).

In a Q methodology study, the participants rank a set of statements, the 'Q-set', sorting them according to a subjective dimension, such as 'agreement/disagreement' or 'most like me/least like me'. The sorting is referred to as the 'Q-sort'. By sorting these items, the participants reveal their viewpoints on the issue under study, i.e. the vantage point from which they understand and order the items. The Q-sorts of the different individuals are subject to correlation analysis. Clusters of correlations are then contrasted by factor analysis, revealing distinguishable viewpoints.

2.2. Q-set design

A 'Q-set' of statements of criteria used when evaluating a cow to be culled was developed for the participants to rank. A comprehensive list was first drafted, as far as was possible, of the criteria dairy producers and farm advisers could possibly take into account when they have to decide to cull a cow or not. For this, a review of both the scientific and non-scientific literature was carried out, as well as a scan of the technical and annual reports of the major North American DHI organizations and dairy producers' associations. Three researchers refined the initial sample of approximately 100 items to a Q-set made of 40 statements, by removing duplicates, double-barrelled propositions, and ambiguous statements, merging similar ones, etc. The Q-set was pilot tested by one dairy producer for clarity of instructions and statements, as well as any missing ones. The final Q-set is given in Table 1. All instructions and statements were written in French. While the producers received first-person account statements, the advisers got them as third-person. The statements were randomly allocated a number between 1 and 40 and printed onto cards.

2.3. Participants

One pack of materials (containing the Q-set, instructions, and response grid) was given to 60 dairy producers under the preventive medicine program of the ambulatory clinic, Faculté de médecine vétérinaire (FMV), Université de Montréal, QC, Canada, visited between February 1, 2014 and April 30, 2014. If a producer declined to participate, his pack was given to another one. The pack was retrieved on the following preventive medicine visit, and the producer was rewarded with a $25 gift card if the material was completed.

Veterinary practitioners doing preventive veterinary medicine were recruited at a continuing education course held at the FMV on January 2014 as well as through VETBOVIN-L,[1] a Québec, francophone web discussion list for bovine practitioners. Thirteen veterinarians from Québec responded to our call, to which we added five veterinarians from the FMV ambulatory clinic.

Twelve advisers from Québec DHI were volunteers for the study. Dairy production advisers from three Québec feed mills were asked to participate. Two feed mills provided 8 advisers each, and 6 came from the third one.

2.4. Administration of the Q-sort

All participants received the same guidance on the completion of the card sorting exercise. Dairy producers were asked the following question: 'Which among the following are the most and least influential criteria to decide to cull a cow in your herd?'. Advisers received the same question but asked as third-person ('in a herd'). Participants were asked to read carefully the 40 items and arrange them into three piles according to their judgment about the criteria they use when deciding to cull a cow: 'influential', 'neutral' and 'not influential'. Next, they were asked to sort them into a grid (Fig. 1), the response matrix, ranging from −4 (not influential) through 0 (neutral) to +4 (very influential). Hence the two most influential items were placed under +4, followed by the three next influential with items in +3, and so on, until a quasi-normal distribution was produced. The cards were attached onto the matrix with Velcro tape, and collected at the next preventive medicine visit. Statements in each Q sort were coded according to their position in the response matrix, i.e. from −4 to +4.

2.5. Statistical analyses

The Q-sorts from the dairy producers on the one hand and farm advisers (veterinarians, DHI and feed mill advisers) on the other were analysed separately. The rationale for analysing the two groups, producers and advisers, separately was to be able to comprehend the views of both groups in their own right (Watts and Stenner, 2012), which would not be allowed by mixing them together. Secondly the administration of the Q-sort was not exactly the same in the two groups, as one group, the producers, was asked about their own herd and cows, i.e. in the first person, and the second, the advisers, was asked about herd and animals they don't own, i.e. in the third person. This also leads to the third reason. As their decision making behaviour regarding loss aversion potentially gives these two groups different vantage points on the understanding of the questions, involvement in the decision process, and feedback on the decision outcome, mixing them together would have confused the interpretation of the results.

A correlation matrix was created, displaying how each participant's unique 40-statement rank-ordered Q-sort correlated with each of the other participants' unique 40-statement arrangement. Using the correlation matrix as raw data, groupings of Q-sorts in which participants placed statements in significantly similar fashions were determined. Each grouping of Q-sorts (i.e. a grouping of participants) represented a factor (a particular point of view). For each sample of participants

Table 1
Q-set statements and idealized (weighted and normalized) Q-sorts (in original units, from −4 to +4) within dairy producers (one factor) and farm advisers' perspectives (2 factors) on culling. Participants received instructions and statements in French. Producers received first-person account statements; advisers got them as third-person.

Id	Statement	Producers	F1 advisers	F2 advisers
1	I have to consider amortizing materials, buildings, mechanics	−4	−4	−4
2	Season of the year	−1	2	−2
3	I need room for replacement heifers	−1	1	−1
4	I think about herd/cow health first before cow longevity	0	−1	1
5	If pregnant	1	4	2
6	I have replacement heifers available	−1	0	0
7	I have to produce healthy and safe milk	2	−2	2
8	Cow's somatic cell count	4	4	4
9	Her annual production	2	2	1
10	Her lactational stage	1	2	1
11	If she ever had difficulties calving	0	0	−1
12	Her body condition score	−1	−1	−1
13	Her daily production	2	2	2
14	Heifer price	−2	−1	−2
15	If she had diseases after calving (e.g. RP, metritis, MF)[a]	0	2	0
16	Milk price	−2	−3	−2
17	I had warnings for bulktank somatic cell count	3	3	4
18	Debts	−3	−2	−3
19	Herd genetics	−1	−2	−1
20	Her number of artificial inseminations	2	3	1
21	Herd size	−2	−3	−3
22	Her conformation	1	0	0
23	Her projected production for the current lactation	1	1	1
24	Cow welfare	0	−2	2
25	I know which ones have chronic mastitis in the herd	4	1	3
26	Her gestational stage	0	1	−1
27	There's a market for my heifers	−3	−1	−2
28	Number of employees on the farm	−4	−4	−4
29	I can always buy cows in the market	−2	−1	−3
30	She ever had clinical mastitis	3	1	2
31	I'm over- or under-milk production	2	3	3
32	Her age	−1	0	−1
33	Withdrawal period for milk or meat	0	−1	3
34	Milking parlour capacity	−3	−3	−2
35	Ease of milking	1	1	0
36	Culling rate	−2	−2	−1
37	Her udder conformation	1	0	1
38	Culled cow price	−1	0	0
39	She's got abnormal milk	3	1	1
40	Cow genetics	1	−1	0

[a] RP = retained placenta; MF = milk fever.

[1] http://www.dsahr.ca/liens/VetBovin.aspx

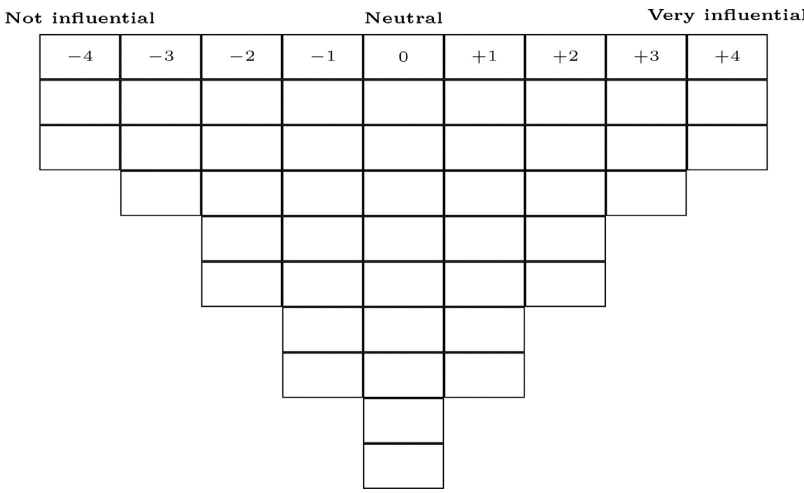

Fig. 1. Q sort response grid.

(dairy producers, farm advisers), the factorability of the matrix was evaluated using Bartlett's Test of Sphericity (Bartlett, 1950). Then factor extractions were made by an exploratory factor analysis using the minimum residual (Harman and Jones, 1966). The number of factors to be extracted was investigated by a parallel analysis (Horn, 1965), employing the Very Simple Structure (VSS) criterion (Revelle and Rocklin, 1979), Velicer's Minimum Average Partial (MAP) test (Velicer, 1976), and the broken-stick distribution (Frontier, 1976). The factor structure was simplified using oblimin rotation (Harman, 1976). Significant factors were then extracted by applying the rule from Brown (1980). Factor loadings, i.e. the correlations between each Q-sort and each factor, were obtained from the factor extraction. The loading expresses the extent to which each Q-sort is associated with each factor extracted. Brown (1980) suggests that a significant factor loading at the 0.01 level is calculated using the equation $2.58 \times (1/\sqrt{\text{no. of statements}})$. Here, this value was $2.58 \times (1/\sqrt{40}) = 0.408$. For reliability, a factor is kept if it is the composite of at least three Q-sorts. Those Q-sorts significantly loading on the same factor share a similar sorting pattern. They are known as *exemplar sorts* in that they best exemplify the viewpoint represented by the factor.

The exemplar sorts are then merged to form a single ideal-typical Q-sort for each factor, called a *factor array*. The *factor array* is the normalized weighted average statement score of respondents that define that factor. The weight (w) is based on the respondent's factor loading (f) and is calculated as $w = f/(1 - f^2)$. The weighted average statement score is then normalized (with a mean of 0.00 and SD = 1.00) to remove the effect of differences in the number of defining respondents per factor, thereby making the statements' factor scores comparable across factors. Then tentative factor labels were chosen as simple, short reminders of the composite viewpoint of the whole factor, reflecting the makeup of the factor.

The comparison between the two groups, dairy producers and advisers, was made post hoc. A second-order factor analysis was performed using the factors identified in the two groups of dairy producers and farm advisers. Our goal was to check whether the decision-making process of the participants were group-specific or based entirely or partially on a general core of shared principles. The composite *factor arrays* from the two original Q-sort analyses were factor analysed again, following the same method as above, and new factors identified.

All statistics were computed with R version 3.3.2 (Core Team, 2015), `psych package` (Revelle, 2015)—parallel analysis with `paran` package (Dinno, 2012).

2.6. Ethics

Ethical approval for the study was obtained from Université de Montréal Ethics Committee (CERES; 14-016-CERES-D).

3. Results

A total of 41 producers and 43 advisers participated in the study. One feed mill adviser had missing statements in his Q-sort and was excluded from the factor analysis. The dairy producers had either secondary school/professional or college/technical education (44% and 51%, respectively; one had a university degree). The characteristics of the participating farms are summarized in Table 2. The median number of animals in lactation was 48 (lower and upper quartiles: 39 and 58, respectively). The farms got their revenue mainly from dairy, but not exclusively (median proportion of revenue from dairy: 75%; lower and

Table 2
Characteristics of the 41 participating farms (*N* is the number of non-missing values. Numbers after percents are frequencies).

	N	
Farm size (acres)	41	
< 100		5%
100–199		29%
200–299		15%
> 299		49%
Do not know		2%
Feed	41	
Total mixed ration (TMR)		61%
Conventional, manual		10%
Conventional, robot		22%
TMR and Conventional, robot		5%
TMR and Other		2%
Stall type	41	
Free-stall		12%
Tie-stall		88%
Production (kg)	41	
7000–8999		17%
9000–10999		73%
≥11000		10%
Cull rate (actual, %)	40	
< 20		12%
20–24		12%
25–29		15%
30–34		30%
35–39		18%
≥40		2%
Do not know		10%
Number of employees	40	
0		22%
0.5		2%
1		42%
2		28%
4		5%

Table 3
Rotated factor loadings of the participating dairy producers on the selected factors.

Q-Sort	F1	F2	h^2
1	0.62**	−0.19	0.42
2	0.7**	−0.17	0.52
3	0.72**	−0.12	0.53
4	0.73**	0.01	0.54
5	0.82**	−0.03	0.66
6	0.56**	−0.06	0.31
7	0.59**	−0.16	0.37
8	0.7**	0	0.49
9	0.73**	0	0.53
10	0.47**	0.28	0.31
11	0.55*	0.51*	0.57
12	0.72**	−0.12	0.53
13	0.56**	0.04	0.32
14	0.58**	0.22	0.39
15	0.43**	0.03	0.18
16	0.73**	0.33	0.65
17	0.74**	0.15	0.58
18	0.55**	0.28	0.38
19	0.47*	−0.68*	0.67
20	0.57*	−0.52*	0.59
21	0.52**	−0.4	0.42
22	0.75**	−0.27	0.62
23	0.71**	−0.17	0.53
24	0.39	0.44**	0.35
25	0.5**	0.23	0.3
26	0.47*	0.47*	0.45
27	0.66**	0.03	0.43
28	0.43*	0.57*	0.53
29	0.57**	0.06	0.33
30	0.48**	−0.02	0.23
31	0.75**	−0.03	0.57
32	0.76**	−0.28	0.65
33	0.73**	0.2	0.58
34	0.84**	−0.1	0.7
35	0.72**	0.17	0.55
36	0.79**	0	0.63
37	0.6**	0.18	0.39
38	0.81**	0.18	0.69
39	0.43**	0.06	0.19
40	0.48**	0.29	0.32
41	0.77**	−0.04	0.59
Eigenvalues	16.7	2.8	
Variance (%)	40.8	6.9	

Significant loadings ($p < 0.01$) are shown with one star. Defining sorts (sorts which are significant on only one factor) are identified by two stars. h^2 is the sum of squares of factor loadings by rows, eigenvalues are sum of square factor loadings by columns.

Table 4
Rotated factor loadings of the participating farm advisers on the selected factors.

Q-Sort	F1	F2	h^2
1	0.85**	−0.11	0.63
2	0.88**	−0.12	0.68
3	0.89**	−0.27	0.61
4	0.83**	−0.04	0.66
5	0.85**	0.01	0.73
6	0.84**	0.07	0.78
7	0.6**	0.29	0.63
8	0.52**	0.08	0.32
9	0.78**	0.06	0.66
10	0.42*	0.46*	0.6
11	0.26	0.54**	0.5
12	0.13	0.69**	0.58
13	0.22	0.63**	0.59
14	0.59**	0.33	0.65
15	−0.02	0.85**	0.69
16	0.59**	0.31	0.63
17	0.34	0.57**	0.65
18	0.33	0.58**	0.64
19	0.6**	0.09	0.42
20	0.52*	0.44*	0.7
21	0.53**	0.29	0.52
22	0.21	0.65**	0.61
23	0.48**	0.35	0.53
24	0.12	0.8**	0.75
25	0.57**	0.12	0.41
26	0.56*	0.4*	0.71
27	0.67**	0.32	0.76
28	−0.13	0.7**	0.41
29	0.31	0.31	0.29
30	0.08	0.61**	0.44
31	0.47**	0.21	0.36
32	0.36	0.49**	0.55
33	−0.43*	0.87*	0.55
34	0.55**	0.31	0.58
35	0.35	0.27	0.3
36	0.44**	0.32	0.44
37	0.46**	0.27	0.41
38	0.13	0.71**	0.61
39	0.34	0.37	0.38
40	0.26	0.42**	0.36
41	0.4*	0.02	0.17
42	0.85**	−0.06	0.68
Eigenvalues	11.7	8.1	
Variance (%)	27.9	19.2	

Significant loadings ($p < 0.01$) are shown with one star. Defining sorts (sorts which are significant on only one factor) are identified by two stars. h^2 is the sum of squares of factor loadings by rows, eigenvalues are sum of square factor loadings by columns.

upper quartiles: 65% and 90%, respectively). The sample of feed mill advisers was fairly well-educated (i.e. 64% had a university degree) and more experienced (i.e. median of 12 years) than the DHI advisers (education evenly spread between college/technical and university; median experience of 9 years). Most of the participating veterinarians (59%) spent at least 50% of their monthly working time in preventive medicine for dairy cattle.

After examination of the statistical characteristics of the factors, a two factor solution emerged both for the analysis of the dairy producers and for that of the advisers. The second factor for the dairy producers was defined by less than three non-confounded Q-sorts (i.e., one) and was therefore not retained for the interpretation. The factor loadings for the dairy producers and the advisers are shown in Tables 3 and 4 respectively.

In the three subsections which follow, each factor is presented, using factor scores and distinguishing statements. In describing the factors, the first number within parentheses refers to the statement number, and the second number indicates its ranking.

3.1. Dairy producers' views I (F1)—udder health focus

The single retained factor for dairy producers had an eigenvalue of 16.7 and explained 40.8% of the study variance. Thirty-five of the 41 producers were significantly associated with this factor.

Dairy producers evaluated first and foremost the udder health of the cow and herd, through the cow's somatic cell count (SCC; #8: +4), by knowing which cows in the herd have chronic mastitis (#25: +4), warnings received for bulktank SCC (#17: +3), the presence of abnormal milk (#39: +3), and if the cow ever had clinical mastitis (#30: +3). They are also engaged in having to produce healthy, safe milk (#7: +2). Then they look at production parameters: the cow's annual and daily production (#9: +2; #13: +2) and if the herd is over- or under-producing relative to quota (#31: +2). Difficulties getting the cow pregnant are also considered, according to the number of artificial insemination (AI) services she received (#20: +2). Other reproduction parameters were not very much taken into account (being pregnant—#5: +1; gestational stage—#26: 0). Farm parameters are not included in the decision process to cull a cow: number of employees on the farm (#28: −4), amortization of materials, buildings, mechanics

(#1: −4), milking parlour capacity (#34: −3), farm debts (#18: −3), herd size (#21: −2). The culling rate is also a piece of information having very little weight in the decision-making process (#36: −2). Heifers (needing room for them—#3: −1; their availability—#6: −1) are also attributed a low influence in the decision, but could be considered modulators of the decision, as are genetics (cow—#40: +1; herd—#19: −1) and health problems after calving (#15: 0).

3.2. Advisers' views I (F1)—economic focus

The advisers' factor representing an economic focus had an eigenvalue of 11.7 and explained 27.9% of the study variance. Twenty-one advisers were significantly associated with this factor, of which 8 were veterinarians (47% of the 17 vets), 8 were from a feed mill (62% of the feed mill advisers), and 5 from the DHI (42%). Sixty percent of the DHI and 62% of the feed mill advisers with this factor had received a university degree. The median experience of feed mill advisers was 27 years, while it was only 7 years for DHI advisers. The majority (63%) of the veterinarians associated with this factor spent less than 50% of their time doing preventive medicine.

Like the dairy producer profile, farm economics were not taken into account, as seen from the low score given to the amortization of materials, buildings, mechanics (#1: −4), the number of employees on the farm (#28: −4), herd size (#21: −3), milking parlour capacity (#34: −3), and farm debts (#18: −2). They also use the same key decision points: cow's SCC (#8: +4), cow's daily production (#13: +2), warnings for bulktank SCC (#17: +3), and being under- or over-production (#31: +3). But they give a greater importance to the reproduction parameters, i.e. the pregnancy status of the cow (#5: +4), the number of AI services received (#20: +3), and the cow's gestational stage (#26: +1). They modulate their decision according to the season of the year (#2: +2), whether room is needed in the barn for the coming heifers (#3: +1), and whether the cow had diseases after calving (#15: +2). In contrast, they give less importance than the other profiles to cow welfare (#24: −2), having to produce a healthy, secure milk (#7: −2), and the withdrawal period for milk or meat (#33: −1). They are also less likely to adjust their decision according to knowing which cows in the herd have chronic mastitis (#25: +1). They declare further that they give more thought to herd/cow health than to cow longevity in their decision making (#4: −1).

3.3. Advisers' views II (F2)—animal welfare focus

The factor representing an animal welfare focus had an eigenvalue of 8.1 and explained 19.2% of the study variance. Thirteen advisers were significantly associated with this factor (29% [5] of the veterinarians, 23% [3] of the feed mill advisers, and 42% [5] of the DHI advisers). The majority of the DHI and feed mill advisers associated with this factor had received a college/technical education (60% and 67% respectively). All veterinarians in this profile spent more than 50% of their time doing preventive medicine.

This profile uses the same key points as the other two regarding udder health and milk production. But they give more importance to cow welfare (#24: +2), the withdrawal period for milk/meat (#33: +3), and (vs. the other adviser profile) having to produce a healthy, secure milk (#7: +2). They also give more importance to knowing which cows in the herd have chronic mastitis (#25: +3). They do not pay attention to the season of the year (#2: −2), reproduction (pregnancy status—#5: +2; number of AI services—#20: +1; gestational stage—#26: −1), the presence of diseases after calving (#15: 0), or having the possibility of buying cows in the market (#29: −3).

3.4. Second-order factor analysis

A second-order factor analysis was used to determine the common shared subjective dimensions, if any could be found, in the variety of perceptions. This second-order factor analysis began with the three views identified above as variates and ended with a highly correlated single-factor solution (an explained variance of 78.4%). Each original view had an estimated composite reliability (h^2, or communality) greater than 50% (98%, 58%, and 81%, respectively, for dairy producers, advisers' first factor, and the advisers' second factor).

4. Discussion

Q-methodology studies are exploratory, qualitative investigations relying on small, non-randomized samples of participants (i.e. typically 25–40 respondents) conducting a large number of 'tests' (i.e. ranking 30–50 statements). As a consequence, the results of a Q study can only be generalized to the subject area from which the statements were sampled, but not—as in survey research—to the population (Brown, 1980; Watts and Stenner, 2012). Generalizations can be drawn about the nature of the opinions and shared perspectives that exist on a given topic; while the frequency of people and their characteristics associated with each viewpoint cannot be inferred (Thomas and Baas, 1992; Van Exel and de Graaf, 2005). The interest of the Q-methodology is in uncovering opinion clusters. These clusters can later be investigated with classical survey methods regarding their prevalence among the general population. Therefore, the results from this study are directly applicable to the particular participants, settings, and contexts, but inferences to the general population or other groups are to be made with care.

Our main finding is that there is one well-structured, uni-dimensional decision-making process across groups. The single view identified among the dairy producers can be extended to the dairy farm advisers, who showed two variations on the same framework. The output of the dairy enterprise is of prime importance in the decision process. Milk quality, udder health, planned production and quantity of milk produced are carefully considered before making the decision. On the other hand, farm economics, i.e. debts, number of employees, amortization of materials, buildings, and mechanics, milking parlour capacity, or herd size, do not play a role in the decision to cull a cow. Elements requiring a mix of data collection and analysis, with the interpretation of the results to the wider business, are thus not included in the decision, even though they can mediate farm profitability through its efficiency and productivity.

This decision framework is similar to risk factors or reported disposal codes for culling. Failure to conceive, mastitis, SCC, low milk yield, and age or parity are the major reported reasons why cows leave the herd (Beaudeau et al., 1995; Bascom and Young, 1998; Rajala-Schultz and Gröhn, 1999b). While the most important risk factor for culling is reproduction status (Beaudeau et al., 1995; Seegers et al., 1998; Rajala-Schultz and Gröhn, 1999a; Pinedo et al., 2014), it was put forward only by 'Economic Focus' advisers. All statements related to reproduction were ranked higher by 'Economic Focus' advisers than in the other two factors, with pregnancy status and number of inseminations being determinant in their decision. Reproduction status is not the most influential parameter taken into account by producers (and 'Animal Welfare Focus' advisers), but is the culling reason they most often report. It can be assumed that the reliability of the reported culling reasons is questionable, as they are subjective (Stewart et al., 1977), and recall bias might be present. Even if udder health and cow's production are the top influential parameters, the number of inseminations is close. The beginning of lactation is at high risk for mastitis and milk production losses resulting from it (Rajala-Schultz et al., 1999; Dürr et al., 2008; Hagnestam-Nielsen et al., 2009). Failure to conceive will come into play a few months later into lactation, may trigger the culling decision, and be the reason reported. But there is a set of factors which lead to that decision, of which reproduction is a secondary element according to producers. But that element might hold the balance of the decision.

Three key differences were identified between producers and the two types of advisers. 'Economic Focus' advisers were named as such because this profile, or factor, follows the recommendations from mathematical models, where pregnancy is a major determinant of the cow's value (De Vries, 2006; Kalantari et al., 2010; Nielsen et al., 2010; Cabrera, 2012). These advisers appear to judge the cow in a more abstract way than do the other participants. While still considering udder health and milk production, they complement their evaluation by including additional economic considerations, like the season of the year, i.e. the availability of financial incentives, and post-partum diseases. The province of Québec (Canada) has a system of premiums for milk produced between August and November, i.e. extra quota production days allowed to the producers. Therefore there is an interest in keeping cows a little longer, bringing in heifers, or buying cows for that period. They also pay more attention to post-partum diseases which can reveal potential problems with the management of the transition period, leading to decreased profitability (LeBlanc, 2010). If they consider udder health just as much as the other groups, they use surrogates to assess udder health. Somatic cell counts and bulk tank SCC are an efficient way to monitor herd udder health (Schukken et al., 2003); quantifying the clinical and chronic mastitis status of the cow or herd by other means appeared in the present data to be an afterthought. Moreover, they take into account the flow of incoming heifers into the herd, not considered by the 'Animal Welfare Focus' advisers or the producers. They tend to have a global approach to the herd and its economic performance.

Dairy cattle are a reservoir for several zoonotic agents, like *Campylobacter*, *E. coli* O157:H7, *Listeria*, *Coxiella*, and *Salmonella* (Tauxe, 1997). Crohn's and variant Creutzfeld–Jacob diseases in humans could potentially be associated with Johne's disease and bovine spongiform encephalopathy in cows, respectively (Barria et al., 2014; Waddell et al., 2015). And there are growing concerns about the development of antimicrobial resistance in humans due to antibiotic use in livestock (Woolhouse et al., 2015); or the environmental impact of modern agriculture practices (Sørensen et al., 2006; Food Forum, Food et al., 2014). Consumers expect healthy, safe, and sustainable dairy products. This concern is reflected in the decision process of the dairy producers and 'Animal Welfare Focus' advisers. It was also recognized by Young et al. (2010), who found Canadian dairy producers were inclined towards food safety and generally knowledgeable about certain, but not all, infectious agents. While the importance of producing safe, more sustainable food has gained more prominence during the last decade, the preoccupation of farmers for producing healthy and safe products is not new. As shown by Burgess et al. (2000), farmers see themselves as food processors. Therefore it should not be a surprise to see the importance they give to the quality of their production, reflecting the value placed on their role in society (Burton, 2004). If the 'Animal Welfare Focus' advisers follow producers on this matter, 'Economic Focus' advisers are the opposite. This may reflect the departure of one group of advisers from the social value given to dairy farming as an enterprise, often family-driven. 'Economic Focus' advisers have a more 'cold-blooded' view of the dairy enterprise, focusing on the economic aspect of the decision.

Each group also gave a different weight to animal welfare. Our results agree with other studies, where the perception of animal welfare varies across groups of people (Vanhonacker et al., 2008). Producers gave a neutral influence to animal welfare (and milk/meat withdrawal), which could be viewed as contradictory with the importance they give to producing a healthy/safe milk. The relationship producers have with animals is a professional one, where they care about animal welfare but the cows are instrumental to the production of milk (Dockès and Kling-Eveillard, 2006). The cow's purpose is to produce. Producers are always affected by health disorders of their animals (Dockès and Kling-Eveillard, 2006). But they want the best for them with the objective of ensuring their productivity (McInerney, 2004; Hansson and Lagerkvist, 2015). As such, procuring the good health of the animals (by checking udder health, producing healthy milk) is how to provide animal welfare, resulting in a neutral position of animal welfare in their decision ranking. Dockès and Kling-Eveillard (2006) have shown that if producers see their animals as production tools, advisers are more likely to see them as production tools *and* sentient beings, resulting in three profiles of advisers: (1) animal welfare defines the quality of the relationship between animals and farmers, (2) animal welfare is a production means among others, and (3) animal welfare is part of professional ethics. This division among advisers about animal welfare is found in their decision making process. 'Economic Focus' advisers put forward the animal seen through its production function, with the key economic parameter, reproduction, put first and animal welfare well behind. On the other hand, 'Animal Welfare Focus' advisers might combine the obligation of animals to produce (through the decision parameters related to production, udder health) and the right of the animals to be well treated.

5. Conclusion

Our findings suggest that dairy producers and their advisers hold a general common view regarding culling decision-making. Udder health and individual production performances characterized each profile, whereas a subgroup of advisers uses recommendations from economic models in which reproduction status is central for farm profitability. Underlying this general framework are significant differences between producers and advisers, and among the advisers. These differences can impede collaboration between the actors intervening at the farm. Understanding and managing these differences is important to assist the change management processes required to increase farm profitability. Views held by dairy producers and their advisers can influence the success of this relationship both positively and negatively. Understanding the differences in views is critical to managing change processes both in initiating and sustaining collaborations, and deserves further research. A challenge for the future will be the generation of rules of thumb and models that both reflect the complexity of the business and allow the dairy producers an ability to make decisions based on wider criteria that include an economic focus.

Conflict of interest

None.

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