Acta Agriculturae Scandinavica, Section A — Animal Science

ISSN: 0906-4702 (Print) 1651-1972 (Online) Journal homepage: https://www.tandfonline.com/loi/saga20

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To cite this article: T. A. Skjerve, L. Grøva, L. K. Sørheim, M. Slagboom, S. Eriksson, M. Kargo & A. Wallenbeck (2018) Norwegian dairy farmers' preferences for breeding goal traits and associations with herd and farm characteristics, Acta Agriculturae Scandinavica, Section A — Animal Science, 68:3, 117-123, DOI: 10.1080/09064702.2019.1627406

To link to this article: https://doi.org/10.1080/09064702.2019.1627406

Published online: 17 Jun 2019.

ACTA AGRICULTURAE SCANDINAVICA, SECTION A — ANIMAL SCIENCE
2018, VOL. 68, NO. 3, 117–123
https://doi.org/10.1080/09064702.2019.1627406

Norwegian dairy farmers' preferences for breeding goal traits and associations with herd and farm characteristics

T. A. Skjerve[a], L. Grøva[b], L. K. Sørheim[c], M. Slagboom[d], S. Eriksson[a], M. Kargo[d] and A. Wallenbeck[a,e]

[a]Department of Animal Breeding and Genetics, Swedish University of Agricultural Sciences, Uppsala, Sweden; [b]Division of Forest and Forest Resources, Norwegian Institute of Bioeconomy Research, Tingvoll, Norway; [c]Norwegian Centre for Organic Agriculture, Tingvoll, Norway; [d]Department of Molecular Biology and Genetics, Center for Quantitative Genetics and Genomics, Aarhus University, Tjele, Denmark; [e]Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Uppsala, Sweden

ABSTRACT

The aims of this study were to investigate variation and clustering in breeding goal trait preferences among Norwegian dairy farmers and to identify factors with a systematic influence on their preferences. An internet-based questionnaire was sent out to dairy farmers connected to the Norwegian co-operative breeding organization Geno ($N = 8222$), of which 10.8% answered ($N = 888$). Of the 15 suggested traits fertility had the highest overall ranking, while parasite resistance and methane emission had the lowest. Four distinct preference clusters were identified by the means of cluster analysis, of which two had a high preference for milk production. Differences in terms of farm and herd characteristics between clusters suggests a mixture of systematic and intrinsic effects on breeding goal trait priorities. This study shows that Norwegian dairy farmers' preferences for breeding goal traits fall into four distinct clusters, both affected by herd and farm characteristics along with intrinsic values.

ARTICLE HISTORY
Received 21 March 2019
Accepted 29 May 2019

KEYWORDS
Cluster analysis; dairy cattle production; preference study

Introduction

Dairy cattle breeding in the past concentrated on highly heritable production and conformation traits, leading to deterioration in functional traits such as health and fertility. To counteract these negative effects, the profile of breeding goals globally has now been broadened to include functional traits with lower heritability (reviewed by Miglior et al., 2017), a strategy that the Nordic countries were early to apply (Philipsson & Lindhé, 2003). Today, production traits generally receive 25–50% of the total emphasis in breeding goals worldwide (Ducrocq & Wiggans, 2015). Economic benefits of genetic change are a common basis for definition of breeding goals. A less common strategy is to study farmers' preferences, which can be evaluated by means of choice modelling experiments (Nielsen et al., 2014). Knowledge of farmers' preferences can be useful when establishing breeding programmes, official policies, and strategies for conserving animal genetic resources in the form of local breeds (Kosgey et al., 2006; Ouma et al., 2007; Zander & Drucker, 2008). While this approach has not been widely adopted in commercial breeding, some studies have examined dairy farmers' breeding goal trait preferences (Ahlman et al., 2014; Martin-Collado et al., 2015; Slagboom et al., 2016b). In Australia, the findings have been used to develop new breeding indices (Byrne et al., 2016), while a Danish study modelled the outcome of implementing specific breeding goals for organic production (Slagboom et al., 2018). Previous studies of Swedish and Danish dairy farmers' preferences for breeding goal traits have revealed significant differences between farmers, based on systematic differences between farm types (Ahlman et al., 2014; Slagboom et al., 2016a, 2016b). Similar differences are likely to exist between Norwegian dairy farmers.

The aims of this study were to investigate variation and clustering in breeding goal trait preferences among Norwegian dairy farmers and to identify factors with a systematic influence on their preferences.

Material and methods

Questionnaire on farmers' preferences

An internet-based questionnaire on dairy farmers' preferences and perceptions of breeding goal traits were sent out to all dairy producers connected to the

CONTACT A. Wallenbeck anna.wallenbeck@slu.se

Norwegian co-operative breeding organization Geno ($N = 8222$). The questionnaire was developed in 2012 for Swedish dairy farmers (Ahlman et al., 2014) and was translated to Norwegian for this study. A full description of the questionnaire can be found in Ahlman et al. (2014). The questionnaire listed 15 breeding goal traits, chosen to represent production traits, functional traits, and traits of possible future importance (Table 1). This study uses data from two of the five steps in the questionnaire: Step 2, where respondents were asked to rank the 15 given traits from 1 to 15 (Figure 1), and step 5, where respondents were asked to answer detailed questions about their herd, herd management, and themselves.

Table 1. Breeding goal traits included in the questionnaire and their definition.

Trait	Description
Beef production	Increased average daily gain
Calving difficulties	More cows with normal calving (percent of herd)
Carcass classification	Better classification (the EUROP scale converted to a numerical scale, 1 (*P*−) to 15 (E+)) where 15 is best
Leg and hoof health	More cows without feet and leg problems (percent of herd)
Disease resistance	More cows that do not need to be treated for diseases, except mastitis (percent of herd)
Feed conversion	More milk (kg ECM) produced per MJ ME in feed
Fertility	More cows become pregnant at first insemination (percent of herd)
Lactation curve	A flatter curve, i.e. higher ratio between milk produced in late lactation (day 280) and early lactation (day 60)
Longevity[a]	Longer period between first calving and culling (months)
Mastitis resistance	More cows that do not need treatment for mastitis (percent of herd)
Methane production[a]	More milk (kg ECM) per gram methane that the cows produce
Milk production	Higher milk production as kg ECM per 305-day lactation
Parasite resistance[a]	More cows without gastrointestinal parasite infections (percent of herd)
Roughage intake	Increased ability to eat roughage (kg DM/day)
Temperament	Calmer cows (scale from 1 (nervous/aggressive) to 9 (calm/friendly))

[a]Not included in Norwegian breeding goals.

Statistical analysis

Differences in overall ranking and cluster ranking of traits were analysed with Friedman's rank test and Neyemi's post hoc test in the rStudio package PMCMR (Pholert, 2014). Friedman's test was used due to non-normal distribution of the data. For data reduction, principal factor analysis based on polychoric correlation was carried out using PROC FACTOR in SAS 9.4 (SAS Institute Inc. 2013). Polychoric correlation is a measure of product-moment correlations between underlying normal variables (Drasgow, 2006), and was used to account for dependency and lack of equidistance in the ranking data (van der Eijk & Rose, 2015). Factors for further analyses were retained based on elbow breaks in scree plots and examination of eigenvalues. These factors were subjected to Ward's hierarchical cluster analysis, carried out in RStudio with the package hclust (R Core Team, 2017). Number of clusters was decided by examining change in dendrogram height and identifying the point at which further division would no longer decrease dendrogram height substantially. A Kruskall-Wallis test and Dunn's post hoc test were used to test for differences in trait ranking and differences in continuous variables between clusters, using r-package FSA (Ogle, 2014) and dunn.test (Dinno, 2017). Fisher's exact test was applied for categorical characteristic variables, using RStudio fisher.test, package stats (R Core Team, 2017).

Results

The response rate in the survey was 10.8% ($N = 888$), of which 38 of respondents with certified organic herds and 850 respondents with conventional herds. The dominant main breed (>50% of cows in the herd) was Norwegian Red (NRF), which comprised 95% of respondents' herds. Respondents with Holstein as the main breed

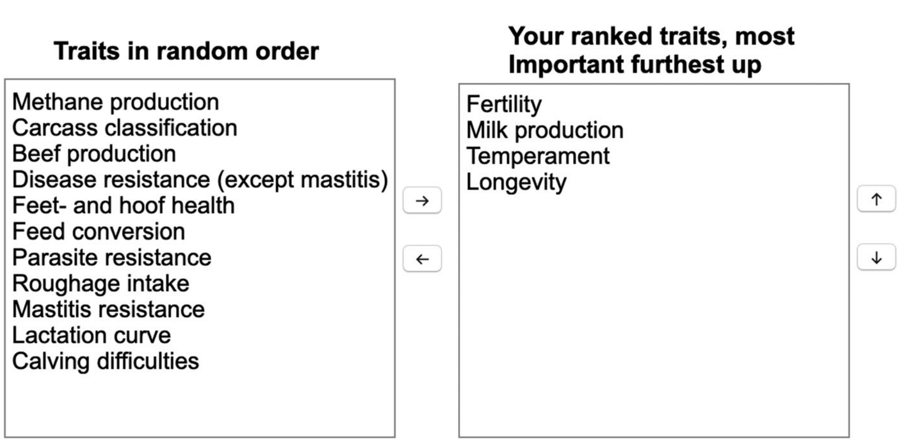

Figure 1. Illustration of the questionnaire ranking task.

constituted only 2%. In a few herds Jersey or Blacksided Trønder- and Nordland cattle (STN) were as the main breed, and these were pooled with 'other breeds' in further analysis (3%). The most common herd size was within the categories 15–24 and 24–49 cows (300 and 308 herds, respectively). Herds falling into size categories with more than 75 cows (108 herds) were pooled in further analysis. The mean age of respondents was 49.6 years and most respondents (94.2%) owned the herd to which their responses referred. The majority of the herds (76.6%) had an average milk production of between 6500 and 9499 kg ECM milk per year. Only 2.1% of herds had an average milk production below 5500 kg ECM per year, and only 4% of the herds produced more than 10,499 kg ECM per year. In the majority of the herds (56.1%), the number of inseminations per female was below 1.55, while in only 0.6% of the herds it was above 1.89. Means of continuous farm characteristics reported by the respondents are presented in Table 2.

Overall, fertility was the highest ranked trait among all respondents, followed by milk production, temperament, and longevity. Parasite resistance and methane production were ranked lowest (Figure 2). Four clusters of respondents were retained from the cluster analysis (Table 3). These were assigned names according to differences in ranking of traits between and within clusters. Milk production was ranked highest among respondents in two milk clusters 'Milk production and health' (MH) and 'Milk production, meat production, and functionality' (MMF). Fertility was top ranked among respondents in a 'Fertility and efficiency' cluster (FE), whereas mastitis resistance was given the highest ranking in a 'Robustness and Health' (RH) cluster. Health traits were ranked higher in the RH and MH clusters than in the FE and MMF clusters. In the FE cluster, leg and hoof health and temperament were highly emphasized. Beef production and carcass quality were ranked higher among MMF respondents than among the respondents in the other clusters (Table 3).

In Table 4 continuous farm and farmer characteristics for each cluster are presented. Respondents in the MH cluster had the highest mean percentage of cows treated for mastitis. The lowest mean percentages for the traits roughage in diet, number of weeks on pasture during the grazing season, and number of hours per day on pasture were found among respondents in the MMF cluster (Table 4). Table 5 presents categorical farm and farmer characteristics for each cluster. The FE and RH clusters had higher proportions of respondents with herd size <15, more herds kept in tie stalls, and more certified organic herds than the MH and MMF clusters. There was a higher proportion of herds in lower energy-corrected milk (ECM) production categories (<4999 and 5500–6499 kg ECM per year) and of farmers considering ending production in the FE and RH clusters than in the milk production clusters. The FE and RH clusters differed from the milk production clusters for similar characteristics and in similar direction, but the differences were more pronounced for the RH cluster. In addition, compared with all other clusters, the RH cluster had a higher proportion of respondents with herd size between 15 and 24 cows and with mainly other breeds in their herds, and a lower proportion of respondents using only artificial insemination (AI) on their herd (Table 5).

Table 2. Continuous farm characteristics for Norwegian respondents to the questionnaire (N, mean ± standard deviation (std), min and max value).

Variable	N	Mean ± std	Min	Max
Proportion of cows in the herd treated for mastitis (%)	798	6.0 ± 7.26	0	70
Proportion of cows in the herd treaded for other diseases (%)	760	4.9 ± 6.77	0	70
Roughage ratio in feed ration (%)	612	66.2 ± 10.64	31	100
Average hours per day on pasture during grazing period	818	14.7 ± 7.35	0	24
Average length of grazing period (weeks)	840	13.9 ± 5.11	0	52

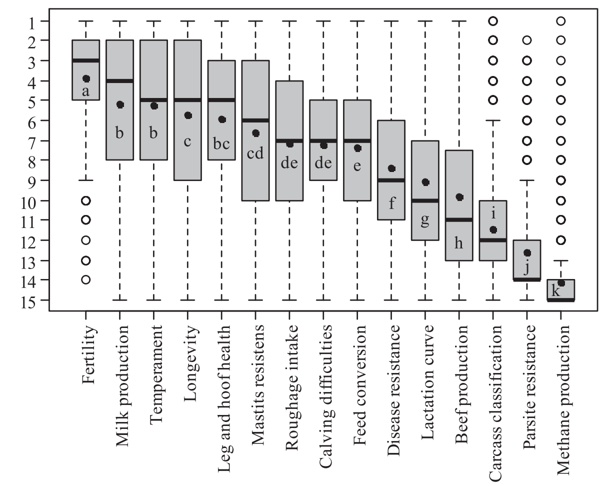

Figure 2. Overall ranking of breeding goal traits by the respondents. Means are represented by black dots. Different letters indicate pairwise differences between traits ($p < 0.05$).

Discussion

This study investigated Norwegian dairy farmers' preference for breeding goal traits. In the overall ranking, fertility was clearly the highest ranked trait, while parasite resistance and methane emissions were given the lowest overall ranking by respondents. Fertility issues are highly influential for the profitability of milk production and were the most common reason for culling

Table 3. Cluster trait ranking, median (interquartile range), in the respondent clusters Milk production, meat production and functionality' (MMF), 'Fertility and efficiency' (FE), 'Robustness and health' (RH), and 'Milk production and health' (MH).

	MMF N = 292	FE N = 327	RH N = 97	MH N = 173
Beef production	9 (6–12)[a]	11 (9–13)[b]	12 (10–13)[c]	10 (7–12)[d]
Calving difficulties	7 (6–9)[a]	6 (4–9)[b]	7 (5–9)[b]	8 (6–11)[c]
Carcass classification	12 (9–13)[a]	13 (11–14)[bc]	13 (11–14)[c]	12 (10–13)[ab]
Disease resistance	10 (8–12)[a]	9 (6–11)[b]	5 (3–8)[c]	8 (4–10)[d]
Fertility	4 (2–5)[a]	3 (2–5)[b]	4 (2–7)[a]	4 (2–6)[a]
Feed conversion	7(5–9)	8(5–10)	8(5–11)	7(4–10)
Lactation curve	9 (6–12)[a]	10 (7–12)[b]	11 (8–13)[c]	9 (6–12)[a]
Leg and hoof health	7 (4–9)[a]	4 (3–7)[b]	5 (4–7)[bc]	6 (4–8)[c]
Longevity	7 (4–10)[a]	5 (2–8)[b]	4 (1–7)[bc]	3 (1–6)[c]
Mastitis resistance	8 (5–11)[a]	7 (3–10)[b]	4 (2–7)[c]	4 (3–7)[c]
Methane production	15 (15–15)[a]	15 (14–15)[a]	15 (13–15)[b]	15 (14–15)ab
Milk production	1 (1–2)[a]	7 (5–9)[b]	11 (10–14)[c]	3 (1–5)[d]
Parasite resistance	14 (13–14)[a]	13 (12–14)[b]	8 (6–11)[c]	14 (13–14)a
Roughage intake	7 (4–9)[a]	7 (5–10)[ab]	8 (5–10)[b]	7 (4–10)[a]
Temperament	4 (2–6)[a]	3 (1–5)[b]	4 (2–8)[a]	10 (8–11)[c]

Between-cluster significance ($p < 0.05$) indicated with different superscript letters in the same row.

of dairy cows in Norway in 2017 (Østerås, 2017). Thus it could be argued that the highest ranking trait was also the trait farmers related most closely to profitability. The low overall ranking of the novel traits parasite resistance and methane emissions may have several explanations, including the fact that these traits were new to the responding farmers. Moreover, parasite resistance could be considered less important by the farmers due to the success of existing management routines to keep the parasite pressure low, with e.g. only 0.002 parasitic infections per 100 cow-years recorded in Norway in 2017 (Østerås, 2017). The low priority given to methane emissions can likely be explained by lack of an economic incentive, a perception that climate change is unlikely to have a negative effect on Norwegian farm production, an attitude that other sectors are more important, and general consensus that Norwegian agriculture already is quite environmentally friendly (Storstad & Bjørkhaug, 2003; Brita Aasprang, 2013; Brobakk, 2017; Bjerke, 2018). It is possible that a questionnaire sent out today would show a different result as the efforts on this area has increased since the time of the questionnaire. In 2016, in the wake of a working group report from the Norwegian Ministry of Agriculture, several of the industry organizations came together to establish the initiative Klimasmart Landbruk. The initiative was established with the purpose of reducing the carbon footprint of Norwegian agriculture and receives funding both from the industry and the Norwegian government (Klimasmart Landbruk SA, 2017). As a part of this Geno is currently exploring how to include methane emission in the NRF breeding goal (GENO SA, 2018). The focus created by these efforts, not only on the environmental importance, but also on the strategic importance, may have moved attitudes among farmers from where they were at the time this questionnaire was carried out.

In two of the four clusters created based on how respondents ranked breeding goal traits, respondents gave a high ranking to milk production. In contrast, in the other two clusters respondents gave a medium to low ranking to milk production. The finding that respondents in the milk production clusters (MMF and MH) had a lower proportion of certified organic herds contradicts findings in Denmark (Slagboom et al., 2016b), where respondents with certified organic herds were more frequently found in production trait-focused clusters. This difference in cluster identity between organic dairy farmers in Norway and in Denmark may be due to differences in markets and the structure of dairy production between the two countries. For example, farm size, number of farms, and organic market share are higher in Denmark than in Norway (Solemdal & Friis Pedersen, 2014). Additionally, milk quotas are still in place in Norway, which might make an increase in milk

Table 4. Continuous characteristics of farms and farmers (p-value, means ± standard deviations (std)) in the respondent clusters Milk production, meat production and functionality' (MMF), 'Fertility and efficiency' (FE), 'Robustness and health' (RH), and 'Milk production and health' (MH).

	p-value	MMF	FE	RH	MH
Percentage of cows treated for mastitis	0.026	5.5 ± 6.31[a]	6.0 ± 7.91[a]	5.0 ± 6.08[a]	7.1 ± 7.90[b]
Proportion of roughage in feed	<0.001	63.6 ± 11.13[a]	67.7 ± 10.47[b]	68.5 ± 9.82[b]	66 ± 10[b]
Weeks on pasture	0.002	13.3 ± 4.72[a]	14.5 ± 5.64[bc]	15.2 ± 4.42[b]	13.4 ± 4.8[ac]
Hours per day on pasture	0.001	14.5 ± 7.67[a*]	15.2 ± 7.09[b]	16.5 ± 7.04[b]	12.9 ± 7.1[a*]

Significant differences ($p < 0.05$) between clusters are indicated with different superscript letters.

Table 5. Differences in categorical characteristics of farms and farmers between the respondent clusters 'Milk production, meat production and functionality' (MMF), 'Fertility and efficiency' (FE), 'Robustness and Health' (RH), and 'Milk production and Health' (MH) (Fisher's exact test *p*-values and percentage of respondents).

			MMF	FE	RH	MH
Characteristic	Alternative	*p*-value	% of respondents in cluster			
System	Conventional*	0.004	97.6	94.2	90.6	98.3
	Organic*	0.004	2.4	5.8	9.4	1.7
Housing	Tie stall*	0.006	44.9	53.3	60.0	42.1
	Free stall with robot*	0.001	42.1	29.9	22.1	37.4
	Free stall with parlor	ns.	23.7	15.3	17.9	19.9
	Other housing	ns.	0.4	1.6	–	0.6
Herd size	<15*	< 0.001	12.8	18.5	16.7	3.5
	15–24*	0.020	29.7	34.9	46.9	35.5
	25–49†	0.098	36.2	34.6	26.0	41.3
	50–74*	0.009	16.2	9.6	8.3	18.0
	75–99	ns.	3.8	1.5	2.1	1.2
	100–149	ns.	1.4	0.6	–	0.6
	150+	ns.	–	0.3	–	–
Future of farm	Continue and develop*	0.002	64.8	53.1	54.0	42.1
	Continue in present form	ns.	28.9	37.4	32.2	37.4
	Considering ending production*	0.020	5.1	7.9	11.5	0.6
	In the process of ending production	ns.	1.1	1.6	2.3	19.9
Milk production level (kg ECM)	<4499*	0.008	–	0.6	3.1	–
	4500–5499	ns.	1.1	1.3	4.2	1.2
	5500–6499*	< 0.001	3.9	8.5	18.8	4.7
	6500–7499	ns.	21.8	23.2	24.0	18.7
	7500–8499	ns.	31.7	31.3	30.2	34.5
	8500–9499*	0.033	26.1	23.2	11.5	22.8
	9500–10,499	ns.	11.6	8.2	6.3	12.3
	10,500–1149	ns.	3.5	3.4	2.1	0.6
	11,500+	ns.	0.4	0.3	–	5.3
Main breed	Holstein	ns.	3.2	2.2	2.1	2.3
	Norwegian Red	ns.	95.7	94.9	90.4	94.8
	Other breed*	0.010	1.1	2.9	7.5	2.9
Use of artificial insemination	Only AI*	0.002	83.2	82.5	71.4	88.8
	AI and natural mating*	0.011	16.8	17.5	28.6	2.9

Between-cluster significance ($p < 0.05$) is indicated with *.

production volume less desirable. Finally, it is possible that adherence to organic principles may contribute more strongly to cluster identity in a ranking task where the final ranking is known (this study) than in a study where pairwise comparisons of comparable scenarios with the same unit outcome were used (the study by Slagboom et al., 2016b).

In previous studies, ranking by farmers of breeding goal traits has been suggested to be based on improving problematic traits and the production system (Slagboom et al., 2016a, 2016b), or to be completely dependent on farmers' intrinsic values (Martin-Collado et al., 2015). In the present study, there were indications that a combination of the two may have influenced the respondents. On comparing overall rankings, fertility was also the highest preferred trait in the study in Denmark (Slagboom et al., 2016b). Fertility seems to be recognized on national level as an important trait, even when ranking of other traits divides farmers' preference into clusters. This is supported by the relatively high ranking given to fertility within clusters in this study.

While a divergence between farmers prioritizing milk production and farmers prioritizing other traits was found in this study, recommendations regarding future breeding goals should be made with some caution for various reasons. First, the respondents were not presented with the actual genetic change resulting from the ranking, and thus it is important to keep in mind that a lower ranking of a trait is not the same as accepting a deterioration. Second, the traits were set by the researchers, which may have led to omission of traits viewed as important by farmers. Third, under existing breeding practices, semen from higher-yielding Nordic Red Cattle and Holstein bulls kept in Sweden, Denmark, and Finland is imported and used in Norway, and thus the different preferences of individual farmers might already be accommodated commercially.

The low response rate is in line with response rates reported by Wallenbeck et al. (2016) and Ahlman et al. (2014), who developed the questionnaire used in this study. There are likely to be many reasons for the low response rate, e.g. the large number of questionnaires recently sent out by e-mail to farmers may have led to some fatigue for this kind of research and the present questionnaire was rather time-consuming (estimated 15–45 min to finish). However, even with the low response rate, almost 11% of Norwegian dairy producers participated and, after further exploration, it was found that the dataset was in good agreement with average values for Norwegian dairy production. Furthermore, the aim and design of the advanced internet-based questionnaire used here was to obtain qualitative, rather than quantitative, results (Wallenbeck et al., 2016). Taking the high information load in the answers into account and the fact that the questionnaire was qualitative rather than quantitative, the response rate (10.8%) and number of responses ($N = 892$) can be considered satisfactory. The farmers willing to devote time to the questionnaire probably had a strong interest in breeding.

Conclusion

This study shows that Norwegian dairy farmers' preferences for breeding goal traits fall into different clusters, where preference for milk production is a major differentiating factor. While certain systematic effects seem to affect cluster identity, intrinsic values also seem to apply. This indicates a need for dairy cattle breeding in Norway to aim at both increased milk production levels and improvement of functional traits. However, firm recommendations cannot be made based on the data obtained in this study, due to the complexity in interpreting this type of ranking task and to confounding effects of existing breeding practices.

Acknowledgements

The authors gratefully acknowledge Eco-AB for funding translation of the questionnaire and for contributions to travel in connection with the Nordic cooperation. The authors are also grateful to Geno for input on the questionnaire and their interest in the study, and to all respondents for taking the time to complete the questionnaire.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

S. Eriksson http://orcid.org/0000-0003-3357-5065

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