Sveriges lantbruksuniversitet
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Preference for breeding goal traits among Swedish and Norwegian dairy farmers

– Associations between preference and herd characteristics

Svenska och norska mjölkbönders preferens för avelsmålsegenskaper

– Samband mellan preferens och besättningsprofil

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Abstract

The aim of this study was to investigate similarities and differences among Norwegian and Swedish dairy farmers' preference for breeding goal traits, and compare systematic effects within each country. The specific objectives were to analyse variation in ranking among farmers, and derivate relevant clusters using cluster analysis. Further objectives were to identify similarities and differences in farm and farmer characteristics between clusters, and compare these between the two countries.

Data of ranking of 15 traits, and information about the respondents and their herd, was collected in a questionnaire sent out to Swedish (2012) and Norwegian (2017) dairy farmers. Rankings were analysed using cluster analysis and Friedman test. The Swedish respondents ranked longevity highest, followed by a high-ranked group of four traits; fertility, milk production, mastitis resistance and leg and hoof health. A group of moderately ranked traits included calving difficulties, feed conversion, disease resistance, temperament, lactation curve and roughage intake, where calving difficulties was significantly higher ranked than lactation curve and roughage intake. Carcass classification, meat production and parasite resistance formed a low-ranked group, but methane production had the lowest ranking.

Norwegian respondents ranked fertility highest, followed by a high-ranked group of four traits; milk production, temperament, longevity and leg and hoof health, however ranking of leg and hoof health, mastitis resistance, roughage intake and calving difficulties was ranked higher than feed conversion and disease resistance in the group of moderately ranked traits. Meat production and carcass classification was the highest ranked of the low-ranked traits. As for the Swedish respondents, the Norwegian respondents also ranked methane production the lowest.

Three clusters were derived from the Swedish respondents' ranking of traits: "Milk production and Efficiency" (ME), "Robustness" and "Milk production and robustness" (MR). From the Norwegian questionnaire, four clusters were derived: "Milk production, meat production and functionality" (MMF), "Fertility and efficiency" (FE), "Robustness and Health" (RH) and "Milk production and health" (MH).

In both Sweden and Norway respondents in two of the clusters ranked milk production the highest, of which the cluster MR in Sweden and the cluster MMF in Norway were the larger. Respondents in these cluster had a higher ranking of temperament, while respondents in the Norwegian cluster MH and the Swedish cluster MR had a higher ranking of health traits. The two clusters with the largest number of respondents in both Sweden and Norway had either a high or a medium-high ranking of milk production. In Sweden the cluster ME, where respondents gave the highest rank to milk production, was the largest, followed by the Robustness cluster. In Norway the cluster FE, where respondents ranked milk production medium-high was the largest, followed by the MMF cluster. Some differences were found both for production-, herd- and farm-related characteristics of respondents between clusters, but many did not seem to affect cluster designation.

The results of this study suggest a broad variation in dairy farmer's preference for breeding goal traits in Norway and Sweden, affected both by the current status of the herd, production system and personal values. However, the reasoning behind farmers' ranking is unclear, and further studies on the gathered data is needed to get a fuller picture.

Sammanfattning

Syftet med denna studie var att undersöka likheter och olikheter mellan norska och svenska mjölkbönders preferenser för avelsmålsegenskaper, och att jämföra systematiska effekter inom länderna. De specifika målen var att analysera variation mellan böndernas ranking av 15 egenskaper, och baserad på detta ta fram relevanta kluster, och identifiera och jämföra skillnader mellan klustren i de två länderna.

Information om ranking av 15 avelsmålsegenskaper och om respondenten och besättningen blev insamlad genom en frågeundersökning utskickad till svenska (2012) och norska (2017) mjölkbönder. Analyser av ranking blev gjord med kluster analys och Friedman test.

Ranking av egenskaper var olika mellan de två länderna. De svenska respondenterna rankade hållbarhet högst, följd av med en grupp av hög-rankade egenskaper bestående av fertilitet, mjölkproduktion, mastittresistent och klöv- och benhälsa. Efter dessa följde en stor grupp av egenskaper rankad i mellanskiktet. Gruppen bestod av kalvningssvårigheter, foderomvandling, sjukdomsresistens, temperament, laktationskurva och grovfoderintag. Kalvningssvårigheter var signifikant högre rankad än laktationskurva och grovfoderintag. Köttproduktion, köttkvalité och parasitresistens utgjorde en lågrankad grupp. Metanproduktion hade den lägste ranking av alla 15 egenskaper. Norska respondenter rankade fertilitet högst, följd av en grupp med fyra hög-rankade egenskaper: mjölkproduktion, temperament, hållbarhet och klöv- och benhälsa. Klöv-och benhälsa, mastittresistent, grovfoderintag och kalvningssvårigheter var rankad högre än foderomvandling och sjukdomsresistens i en grupp av mellan-högt rankade egenskaper. Köttproduktion och köttkvalité var lägre rankad en de ovanstående, men högre rankad en parasitresistens och metanproduktion. Som de svenska respondenterna rankade också norska respondenter metanproduktion lägst.

Tre kluster togs fram från de svenska respondenternas ranking: ”Mjölkproduction och effektivitet” (ME), ”Hållbarhet” och ”Mjölkproduktion och hållbarhet” (MH). Från den norska undersökningen togs fyra kluster fram: ”Mjölkproduktion, köttproduktion och funktionalitet” (MKF), ”Fertilitet och effektivitet” (FE), ”Hållbarhet och hälsa” och ”Mjölkproduktion och hälsa”. Respondenterna i två av klustren i både Sverige och Norge rankade mjölkproduktion som den viktigaste egenskapen. De största av dessa var ME i Sverige och MKF i Norge, där respondenterna rankade temperament högre. De två mindre, MR i Sverige och MH i Norge, rankade hälsoegenskaper högre. Respondenterna i de två största klustren i båda länderna rankade mjölkproduktion antigen högt eller mellan-högt. ME-klustret var störst i Sverige, följd av Hållbarhet-klustret där respondenterna rankade mjölkproduktion mellan högt. I Norge var FE-klustret, i vilket respondenterna rangerade mjölkproduktion mellan-högt, följd av MKF-klustret. Några skillnad fanns mellan produktion, besättning och respondentkarakteristika, men många var lika mellan klustren.

Resultaten av denna studie tyder på en bred variation i mjölkbönders preferenser för avelsmålsegenskaper, påverkad både av den nuvarande situationen i besättningen, produktion och personliga värden. Dock är resonemanget bak ranking oklar, och vidare studier av den insamlade informationen behövs för att ge en klarare bild.

Contents

List of abbreviations

AI- Artificial insemination
ET – Embryo transfer
FE – Fertility and efficiency (Norwegian cluster)
MF – Milk production and efficiency (Swedish cluster)
MH – Milk production and health (Norwegian cluster)
MMF – Milk production, meat production and functionality (Norwegian cluster)
MR – Milk production and robustness (Swedish cluster)
NRF – Norwegian Red Cattle
PAF – Principal Axis Factor analysis
RH – Robustness and health (Norwegian cluster)
SH – Swedish Holstein
SKB – Swedish Polled
SLB – Swedish Lowland
SRB – Swedish Red Cattle
STN – Black-sided Trønder- and Nordland cattle

Introduction

In Sweden and Norway, ruminants are a vital part of the agricultural sector. Along with dairy and meat products, societal values such as employment and development in rural areas, as well as animal welfare and landscape maintenance have become more important. Norwegian and Swedish dairy farmers face relatively strict regulations and high production costs. For prices to meet the cost of production they are dependent on consumer's perception and willingness to pay more for domestic products. This is important as prices on domestic products are not able to compete with import from many of the major food producing countries, such as Germany and France (Prop. 2016/17:104; Meld. St. 11 (2016–2017)).

Dairy breeding in the Nordic countries has for a long time put larger emphasis on functional traits, starting many years before other parts of the developed world (Ducrocq and Wiggans, 2015). The Nordic red breeds are marketed with similar breed profiles, although focus on milk yield and meat production differs between the breeds involved in the Nordic cooperation (Sweden, Denmark and Finland) and the Norwegian (Norwegian Red Cattle) (see Table 1 and Table 2).

Breeding must fulfill the need of the farmers to stay relevant (Amer och Nielsen, 2007). Several studies have shown a large variation in preference for breeding goal traits among dairy farmers. In both developed and developing countries differences have been identified based on herd and farm characteristics, as well as variations which could not be explained by any particular factor investigated (e.g Bebe et al., 2003; Tano et al., 2003; Martin-Collado et al., 2015). Previous studies have identified such differences also in Denmark and Sweden (Ahlman et al., 2014; Slagboom et. al, 2016a; Slagboom et. al, 2016b). Swedish studies have been confined to differences between conventional and organic certified herds (Ahlman et al., 2014), and no thorough scientific studies on Norwegian dairy producers preference for breeding traits has been published.

Aim and objectives

The aim of this study was to investigate similarities and differences among Norwegian and Swedish dairy farmers' preference for breeding goal traits, and compare systematic effects within each country. The specific objectives were to:

- Analyze variation in ranking of breeding goal traits among dairy farmers in Norway and Sweden, and derivate relevant clusters of farmers within country.
- Identify differences in farm and farmer characteristics between farmer clusters.
- Compare differences and similarities between Norwegian and Swedish clusters.

Literature study

Breeding for dairy production

The first domestication of cattle started approximately 10 000 years ago, most likely due to need of traction power, but cattle steadily also turned into an important food source (Garric and Ruvinsky, 2015). Today, the world's cattle population mounts up to more than 1300 million individuals. In 2015, the total world production of cow milk was 600 million tons (Pilet, 2016), and for beef and veal more than 67 million tons in 2015 (OECD, 2017).

During the last century the pace of genetic improvement of cattle has increased as a results of the evolving knowledge of genetics, and the development of important reproduction techniques such as artificial insemination (AI) and embryo transfer (ET)(Garric and Ruvinsky, 2015).

Traits under consideration in dairy production

Up until 20 years ago, breeding goals for dairy cattle were in many countries focused on production and to some extent type traits with few exceptions. This one-sided approach led to a deterioration in traits related to robustness and survival (i.e. functional traits) due to unfavorable genetic correlations. When the effects of narrow-focused breeding became apparent one to two decades ago, broader and more sustainable breeding goals, such as the breeding goals that has been practiced in Scandinavia since the $70^{th,}$ were given more attention. Today, the proportion of breeding goal weight given to production traits is generally within the area of 25 to 50% of the total breeding goal (Ducrocq and Wiggans, 2015).

Functional traits is a collective term used for traits related to the animal's own potential of remaining productive and healthy. Although it may be difficult to directly quantify the economic value of such traits, and for some traits the monetary value in itself may not be of the highest importance, they still will affect the overall-farm bottom line. An example of such a trait is temperament which may not give a direct economic output. However, an animal that does not function well in the system may increase labour cost, and as such this trait may still be important in larger productions.

A general category partitioning of functional traits can be made into workability, calving, fertility, health and longevity traits. Heritabilities are low to moderate, with the exception of body size. They are as a general rule negatively correlated with production traits, and as such easily deteriorate if not included in the breeding goal. In some instances conformation traits are also included among functional traits (Ducrocq and Wiggans, 2015), but this is a matter of discussion (M Kargo 2017, pers.comm., 1 September).

Production traits are yield traits applying to different aspects of milk and meat production. Heritability estimates for milk yield, milk protein and milk fat usually are found in the range of 0.25 to 0.30 for 305d-lactation estimates, and up to 0.5 for estimates based on test-days. Heritabilities for lactation persistency, i.e. lactation curve, are generally found to be low (Ducrocq and Wiggans, 2015). Heritability for meat traits such as weight and different quality measurements vary from low to high, depending on the study and the trait under consideration. The heritability of meat production as defined in this study, average daily gain, has been estimated in the area of 0.30 (Berry et al., 2015).

Important reproductive and genetic technological developments affecting dairy breeding

To increase dissemination of superior genetic material and decrease the impact of problems with low fertility, a range of reproductive technologies have is applied to cattle breeding.

The first widely applied reproductive technology within dairy breeding was artificial insemination, and it still is the most common. The discovery in the 1940s of how to preserve the vitality of frozen sperm created the possibility for transportation of genetic material over larger distances, and formed the basis of the large-scale progeny testing seen in dairy breeding

(Gordon, 2005). Bull sperm is highly cryoresistant. In combination with the anatomy and physiology of sperm transportation in the cow's reproductive tract, the method has proven highly suitable for use within cattle reproduction (Saadi and Robert, 2015).

Embryo transfer (ET) first became popular within dairy cattle breeding in the 1970s, when non-surgical flushing was introduced to increase the breeding material of valuable exotic beef breed animals imported into the UK and North America. Gradually the technique started to be incorporated into dairy cattle breeding, in particular in Holstein. The technique makes it possible to produce more offspring from genetically superior animals, both for breeding on herd level and population level, and as such also increases efficiency of breeding (Gordon, 2005).

As knowledge about molecular genetics advanced, more loci and chromosomal regions affecting important trait within livestock production started to be identified identified. This led to investigations and use of marker- and gene-assisted selection in breeding. These tools were suggested to be of particular interest in cases of traits with low heritabilities where the measurement of phenotypes are difficult to obtain, for instance due to cost or time of onset. Different methods are available including direct markers which marks the causative gene, and linked markers which uses genetic linkage-disequilibrum (LD) or linkage-equilibrum (LE) with quantitative trait loci (QTL) to identify the genetically superior animals (Dekkers, 2004). However, this approach is limited by the fact that many of the traits important for dairy production are affected by a large number of loci, and testing can be expensive.

When the bovine genome was sequenced in 2009, it lead to the identification of a large number of single-nucleotide polymorphism (SNP) markers, and a decrease in cost of genotyping. This opened up for genomic selection where breeding values are based purely on genomic merit (Hayes et al., 2008). Breeding values have in the past been based on large scale progeny testing. This method is both time consuming and expensive, because you cannot accurately identify the bulls with the best genetic potential before records on their daughters' performance are available. Through genomic testing accurate prediction of animals can be made already at birth, and it is possible to test which of the progeny of high valued animals that have inherited the favourable genetic combination. This both serves to shorten generation intervals and reduce cost (Garrick and Fernando, 2015).

In 2015, Viking Genetics entered in a cooperation with Chinese and Danish universities and industry to establish a common reference population for Holstein (Viking Genetics, 2015). A similar cooperation was establish between Geno and Viking Genetics for the Red dairy cattle (RDC) and NRF in 2011 (Heringstad et al., 2013).

Breeding goals and breeding objectives

The purpose of breeding objectives

When making decisions on future genetic development, breeding objectives and information on the animals regarding specific traits are used to identify the best animals from an economic point of view. To predict the economic value (profit per change), selection index theory (Hazel, 1943) and best linear unbiased prediction (BLUP) (Henderson, 1975), an expanded version of the initial selection index calculations, can be used.

Traditionally, calculation of breeding indices have been focused on maximizing the animal's profitability in terms of economic in- and out-put. While some traits can easily be assigned economic values, such as milk and meat price, this is not the case for all, especially when it comes to functional traits. Along with challenges created by increased interest from the public for animal welfare and environmental impact, defining an individual as genetically superior based on profit functions alone may not be suitable. This can cause problems when trying to achieve accurate breeding values. The development of sustainable breeding goals where traits whose economic value is vaguer are attempts to account for this. It is achieved through assigning weights according to both market economic values (EV) and non-market values (NV). While EVs are based on traditional profit equations, NVs are based on improvements in animal welfare and social aspects calculated through simulations on economic outcome or genetic change (Nielsen et al., 2005).

The value of a breeding objective lies in the decision-making process it informs. To be useful for decisions on which animals to use as parents, the breeding objective it must give sufficient information to distinguish the animals based on selection criteria. To enable evaluation of the investments in breeding programs the breeding objective must give predictions of the genetic change that the breeding program can lead too. To fulfill this purpose the breeding objective must be as closely related to cost and income as possible (Goddard, 1998).

Methods and theories applied when defining breeding objectives had up until recently their origin in economic theory, farm modelling and animal breeding. A more recent development has been to apply methods from the social sciences (Nielsen, Amer and Byrne 2014), such as the investigation of Martin-Collado et al. (2015) investigation of farmer preference in Australia.

Methods from the social sciences: Including the stakeholders in the definition of breeding goals

Several studies and reviews have emphasized the necessity to include the stakeholders in the definition of breeding objectives (Groen et al., 1997; Ayalew et al., 2003; Kosgey et al., 2006; Nielsen and Amer, 2007; Nielsen et al., 2011, Nielsen et al., 2014). But who are the stakeholders? In a broader perspective, interest in breeding of production animals is not restricted to breeders alone. Animal production affects the society at large, both in terms of environmental impact and as an ethical issue. Therefore, consumers, citizens, NGO's and governmental authorities also becomes part of the list of people a breeding program needs to consider (Nielsen et al., 2011). Effectively however, the genetic changes is decided by the farmers, especially when it comes to dairy cattle, where AI bulls are recruited from the population. They become key stakeholders, as the decision of whether or not to accept the breeding objective lies with them (Dekkers and Gibson, 1998).

Dekkers and Gibson (1998) explains the intricate relationships between the developers (technical perspective) and the users (producer perspective) involved in the success of a breeding scheme. Information obtained by the breeding company and the producer takes on different characteristics. Although technically correct, a strategy based on theoretical calculations including concerns from all the mentioned stakeholders, can appear irrelevant where, for example, the cost of improving sustainability cannot be extracted from the market.

As the importance of the farmers' wishes for breeding goal traits have become more emphasized, studies on dairy farmers' preference for breeding traits have been conducted both in developing countries and, to a lesser extent, in industrialized countries (Nielsen et al., 2014). Studies on farmer's preference for breeding traits or attributes have been investigated by the means of choice modelling in the developing world for some time. It has been used both as a measure to inform the development of breeding programs or policies (Bebe et al., 2003; Tano et al., 2003; Kosgey et al., 2006; Ouma et al., 2007; Roessler et al., 2008; Dana et al., 2010; Gizaw et al., 2010; Duguma et al., 2011; Martin-Collado et al., 2015), and as a tool to identify the best tactics to preserve the animal genetic resources (AnGR) local farm animal breeds represent (Zander and Drucker, 2008, Scarpa et al., 2003a, Scarpa et al., 2003b, Ayalew et al., 2003).

In a study comparing preference for breeding traits between organic and conventional producers in Sweden, Ahlman et al., 2014 presented producers with an open-ended question where the respondents were asked to state which breeding traits they regarded as important to their herd. Behavior towards humans and other cows was the most commonly mentioned (71% of respondents), followed by feet and leg health (70%) and udder conformation (66%). A higher proportion of respondents with organic certified herds intuitively mentioned meat production, feed intake and feed conversion, general health and udder health, fertility and calving ability.

Afterwards the producers were asked to rank 15 given traits. A certain degree of re-ranking between the organic and conventional producers' preference were shown, but in general, the differences were small. When dividing rankings into groups of high ranked (1-5), medium ranked (6-10) and low ranked (11-14), the same ranking was found for both respondents with conventional and certified organic herds.

The producers were then asked to assign weights to their five most highly ranked traits, and were presented with the resulting genetic gain. Then production system was the herd characteristic that affected most of the traits. In that study, only the preference for carcass classification and parasite resistance were significantly different between producers with conventional and certified organic herds, with respondents with certified organic herds assigning higher desired genetic gain. Organic producers tended towards higher desired genetic gain for fewer occurrences of mastitis, fewer occurrences of other diseases and longevity. Conventional producers tended to prefer higher genetic gain in milk production.

Other characteristics were also found to have an effect. Desired genetic gain in temperament increased with age of the producer and when farm production level was under 8500 kg energy corrected milk (ECM) per/year. Interest in longevity, lactation curve and parasite resistance decreased with age, and desired genetic gain for methane production was higher for female respondents than for male respondents.

The authors concluded that although differences in preference for breeding traits exist between organic and conventional producers, these are already covered in the Nordic breeding goal. They argued that this might partly be due to the perceived importance of functional traits in Sweden, which has traditionally had a broad breeding goal. They also argued that the limited differences in production environment resulting from the strict Swedish animal welfare regulations decrease differences between conventional and organic farms.

In a Danish study from 2016, Slagboom et al. studied preferences of dairy farmers with Holstein, cattle using the online software 1000Minds for making pair-wise comparisons where one of the traits would be improved and the other would trait would remain at the same level, including a neutral alternative (“they are equal). A general questionnaire was linked to the pair-wise comparison study.

Among all farmers, cow fertility was the most preferred trait. Improvements of foot and leg disease, mastitis and milk production were also highly preferred, while calving difficulty was given the lowest rank. Organic producers gave higher ranks to calf mortality and milk production while conventional producers ranked calving difficulty, cow mortality and hoof leg disease higher.

Cluster analysis produced evidence for groupings of trait preference. Clusters were assigned names according to trait preference: “Health and fertility” (HF), “Production and Udder Health” (PU), “Survival” and “Fertility and Production” (FP). Organic farmers were more frequently found in the PU- and FP- clusters, while conventional farmers were more frequent in the Survival and the HF-cluster.

There was a difference between herd characteristics between clusters, where herds with higher cow mortality and somatic cell count (SCC) were more frequent in the Survival-cluster. Herds found in the HF-cluster had the highest prevalence of foot- and leg diseases and udder disease. Within the FP-cluster, herds with the lowest conception rate ranked fertility and heifer fertility highest. Herds in clusters with focus on production had the lowest production levels.

In a separate cluster analysis of farmers with conventional production, three clusters were identified. Two of the cluster were the same as found for the overall cluster analysis: Survival and FP. In the third, Health, disease traits were ranked high, but fertility was not particularly highly ranked. Herd characteristics also differed between clusters within the conventional cluster analysis in the case of the Survival cluster, which also for conventional farms had a higher frequency of herds with higher cow mortality. Three clusters were also identified in a separate analysis of respondents with certified organic herds’ preferences. Two of the clusters were similar to the overall-clusters PU and FP. The third cluster, Robustness, had high rankings of mortality and disease traits. No difference in herd characteristics were found between the clusters.

Slagboom et al. (2016) suggest that the higher frequency of farmers with certified organic herds in the production clusters and the higher mean ranking of milk production might be due to the higher price payed for organic milk, and that production level in general was lower in certified organic farms than in conventional.

The results from the Swedish and the Danish study showed two opposites: in the Swedish study, respondents with certified organic herds prioritized milk production lower than respondents with conventional production, whereas the opposite was found in the Danish study. Slagboom et al. (2016) suggested several reasons which might explain this. Firstly, the differences are to a great extent affected by time horizon, where the Danish study had a considerably shorter time horizon than the Swedish. Secondly the design of the questionnaires were different, where the Swedish study the entire final ranking was shown to the farmer. The Danish study used a revealed preference method, where rankings were calculated by the software based on pair-wise comparisons without showing the farmer the final resulting ranking. Also, different economic weights were used in the two studies.

Dairy production in Sweden and Norway

Norway

The development in Norwegian dairy farming and overall agricultural enterprises is towards fewer and larger farms. Although the number of farms has been reduced with 79% since 1959 to 2015, the area of cultivated land remains approximately unchanged with 9.8 million da, which constitutes about 3% of the total land area (SSB, 2016). In 2016, there were a total number of 8603 dairy farms in Norway, a decrease of approximately 43% compared to 2006. There was a decrease in all size categories, except 30 cows and up, which increased with about 10% (SSB, 2017).

Quotas regulate Norwegian milk production since the 1980s. The yearly production of milk reached a peak in the 80s, and from that point on, the production gradually decreased until reaching a stable level at approximately 1 500 million liters milk per year during the early 2000 (SSB, 2015).

Norwegian dairy breeds

Norwegian Red Cattle (Norsk Rødt Fe, NRF) is the dominant breed, constituting 93.3% of dairy cows registered in the national breeding recording scheme Kukontrollen. Norwegian Holstein comprised 4.1% of all registered cows, while the remaining 2.6% were of other breeds including Norwegian Jersey and Black-sided Trønder- and Nordland cattle (Sidet Trønder- og Nordlandsfe, STN) (Tine rådgivning, 2017).

The NRF breed is a synthetic breed, with a large degree of imported Ayrshire and Swedish Red as its foundation along with some native breeds. In the 1980s some Holstein-Friesan was also imported (Syrstad, 1995). In 2016, the average milk yield was 7785 kg milk with a fat percentage at 4.3% and protein percentage of 3.47% (Tine rådgivning, 2017). The Norwegian Holstein had a higer average milk yield at 9494 kg milk, a fat percentage at 4.3% fat and 3.47% protein. This is a slightly lower milk yield and slightly higher protein and fat content compared to its Swedish counterparts (VÄXA Sverige 2017: Tine rådgivning 2017).

A number of native dairy breeds were established towards the end of the 19th century. Six of these remain, of which Sidet Trønder- og Nordlandsfe (STN) has the largest population with 1016 breeding females registered in 2012. The breed is closely related to the Swedish breed Swedish Polled – Mountain Cattle and exchange of breeding material between the two has been frequent. The average weight is 450 kg. The average milk yield in 2016 was 4000 kg milk, with a fat content at 4.2% and protein content at 3.3% (Norsk genressurssenter, 2007; Tine rådgivning 2017).

Organization of breeding and breeding goals

Milk recordings in Norway started up in local dairies around the country. The national recording scheme Kukontrollen is today kept by the large dairy cooperation Tine (Syrstad, 1995).

Geno is both breeding association and breeding organization for the NRF-breed. NRF started breeding for functional traits in the 1970s, and the breeding goal is still of a broad-character dual-purpose breed (Geno, 2016). Decisions regarding the breeding goal is made by the board which consist of members from local associations and the breeding company, and a member-elected chairman, after hearings among local member associations. The current weighting of breeding goal traits is shown in Table 1.

Table 1. Weighting of NRF breeding goal traits, 2016. Source: Geno, 2016.

Trait	**Weight**
Milk	28
Udder health	18
Fertility	18
Udder exterior	18
Meat production	6
Other diseases	4
Claw health	4
Leg health	2
Temperament	1
Calving difficulties	0.5
Stillbirths	0.5

The overall goal for STN is to maintain the breed as a well-functioning dairy breed without inclusion of other breeds, the exception being the sister breed Swedish Polled – Mountain cattle. Exterior-wise, good udder and teat form along with breed-specific exterior is prioritized.

The breeding associations for Norwegian Holstein and Norwegian Jersey joined the Nordic cattle genetic evaluation in 2016 (Viking genetics press release, 2016), and as such follows the Nordic Total Merit.

Sweden

Swedish dairy farming has undergone the same development as the Norwegian, where farms get fewer and bigger. In 2016 there were 3872 dairy farms, almost half compared to ten years earlier when the number was 8500 (SJV, 2017). In 2016, the average dairy herd consisted of 81 cows, compared to 62 in 2010 (SJV, 2017).

In contrast to Norway, the use of land for agricultural production has decreased since the 1950. Between 1951 and 2005 this mounted to 26%. The decrease has been strongest in the North, where close to 45% has become out of use. In 2014, slightly more than 3 million ha of land was used for agriculture, approximately 6.7% of total land area. (SJV, 2014).

Sweden entered the European Union in 1994, and therefore also adopted the Common Agricultural Policies (CAP), the European Union's quota restrictions and the European common market, where Swedish farmers no longer were protected from competition of produce from other EU-countries. Sweden was granted a quota of 3.3 million tons, but the Swedish production have in later years been well below this limit (SJV, 2011). The production has steadily decreased since entering the EU, and in 2016 mounted to approximately 3.1 million tons (SJV, 2017). The so-called “milk-crisis” in 2014, caused by Russian blockade of milk import from EU and decreased milk powder export to China, hit the Swedish dairy sector particularly hard. This resulted in a strong further decrease of number of milk farms followed by a decrease in total milk production (LRF, 2014).

Swedish dairy breeds
In 2016, 36.6% of dairy cows registered in the Swedish national recording scheme were of the breed Swedish Red Cattle (Svensk Rödbrokig Boskap, SRB), 54.8% were Swedish Holstein (Svensk Holstein, SH) while the remaining were of other breeds, including Swedish Jersey (Svensk Jersey Boskap, SJB) and Swedish Polled Cattle (Svensk Kullig Boskap, SKB) (VÄXA Sverige, 2013).

SRB is one of the breeds in the Red Dairy Cattle-cooperation (RDC), along with Finnish Ayrshire and Danish Red Cattle. With its origin in imported Ayrshire, English Shorthorn and to some extent native breeds, a large degree of genetic exchange with other Nordic red breed has occurred, culminating in SRB joining the combined efforts of Nordisk Avelsvärdering in 2008 (SJV, 2010).The average milk yield for SRB was 9156 kg with an average fat content at 4.40% and protein content at 3.60 % in 2016 (VÄXA Sverige, 2017).

From the 1980s there was an extensive use of imported semen, especially from American Holstein, in the Swedish Holstein-Friesan population called Swedish Lowland (Svensk Låglandsboskap, SLB). In 2005, 90% of the genes in the population came from Holstein, and the breed has been renamed Swedish Holstein (SH) (Bett et al., 2013). The average milk yield for the SH was 10274 kg with an average fat content at 4.12% and protein content at 3.22 % in 2016 (VÄXA Sverige 2017).

SKB is the results of Swedish efforts in late 1800s to establish native breeds also in Sweden. Rather than one breed, SKB represents two breeds under the same breeding association: Swedish Polled Mountain cattle (Svensk Fjällras, SKB-Mountain breed) and Swedish Red Polled (Svensk Rödkulla, SKB-Red polled) (Gjeldstad, 1993). The average milk yield for the SKB was 5371 kg with an average fat content at 4.45% and protein content at 4.06 % in 2016 (VÄXA Sverige, 2017).

Organization of breeding and breeding goals
Milk recordings in Sweden started up towards the end of the 1800s. Svensk Mjölk, a cooperation between various dairy associations and Svensk Husdjurskötsel (SHS), which had until then kept recordings, was formed in 1996 (Rendel, 2003). In 2013 Svensk Mjölk was separated into VÄXA Sverige which handles breeding and advisory services, and the stakeholder organization Svensk Mjölk (Isaksson, 2013). VÄXA Sverige is the official breeding organization for all larger dairy breeds in Sweden and also keep the Swedish national recording scheme. They are also stakeholders in the breeding company VikingGenetics which handles breeding programs for RDC, SH and SJB.

The most common Nordic dairy breeds were joined with Denmark and Finland through the cooperation Nordic cattle genetic evaluation (Nordisk Avelsvärdering, NAV) in 2008. A common breeding goal, Nordic Total Merit (NTM), is kept for the Holstein population, for the Jersey population, and is kept for the red dairy breed population, RDC (SRB, Red Danish cattle and Finnish Ayrshire). Decisions on breeding goals are made through discussion in owner organizations, including breed associations, within each of the three countries. Subsequently decisions are presented to and coordinated by NAV (Carlén, 2017). Weighting of breeding goals for RDC, Holstein and Jersey can be found in Table 2.

Table 2. Weighting of breeding goal traits for RDC, Holstein and Jersey in the NTM. Source: NAV, 2017

Trait	RDC	Holstein	Jersey
Milk yield (index)	36	27.6	37
Growth (index)	0	2.2	0
Fertility	4.7	11.4	8.5
Calving (direct)	8.6	5.5	2.6
Calving (maternal)	4	6.3	2.6
Udder health	10.8	12.9	18.7
General health	4	4.1	1.7
Claw health	1.8	3	2.1
Frame (body size)	0	0	0
Legs	2.9	4.4	1.7
Udder	12.5	9.2	11
Milkability	3.2	3	4.3
Temperament	1.1	1.1	1.3
Longevity	2.5	4.1	3.4
Youngstock survival	7.9	5.2	5.1

Breeding goals for SKB are kept by the breed associations for the two breeds under the Swedish Polled-umbrella. The breeding goal for SKB-Mountain Cattle breed states that the breeding should aim towards keeping a robust and functional cow. Special attention is directed towards improvement of udder form and udder attachment, and maintaining protein content composition in the milk (high kappa-casein B, Beta-casein A2 and B, Beta-lactoglobulin B), which is considered to be favorable in this breed (Eklundh, 2016).The main breeding goal for SKB-Red Polled is to expand the population and to secure the important traits connected to meat- and dairy production (Rydström, 2015).

Methods and material

The data used in the project were obtained from one Swedish (carried out in 2012) and one Norwegian (carried out in 2017) questionnaire study on dairy farmers. The two data sets were analyzed separately. The original questionnaire in the Swedish study was designed in five steps. Each step was headlined by a question followed by a description of the question and the answering procedure. A full description of the questionnaire can be found in Ahlman et al., 2014. In this study, only data from the respondents ranking of traits in step 2 and questions about farm and farmer characteristics in step 5 were used in the analyses.

In step 2 of the questionnaire a list of 15 traits was given, and the respondent was asked to rank them in descending order of importance (1-15) (Figure 1). Description of the traits could be found in a drop-down menu below the ranking task. The full list is shown in Table 3. The same traits were used in both the Norwegian and the Swedish questionnaire, and both production and functional traits were included. The questionnaire also contained novel traits which were not currently part of Norwegian or Swedish breeding goals, but which could be relevant to include in future breeding. Step 2 was accompanied by instructional videos.

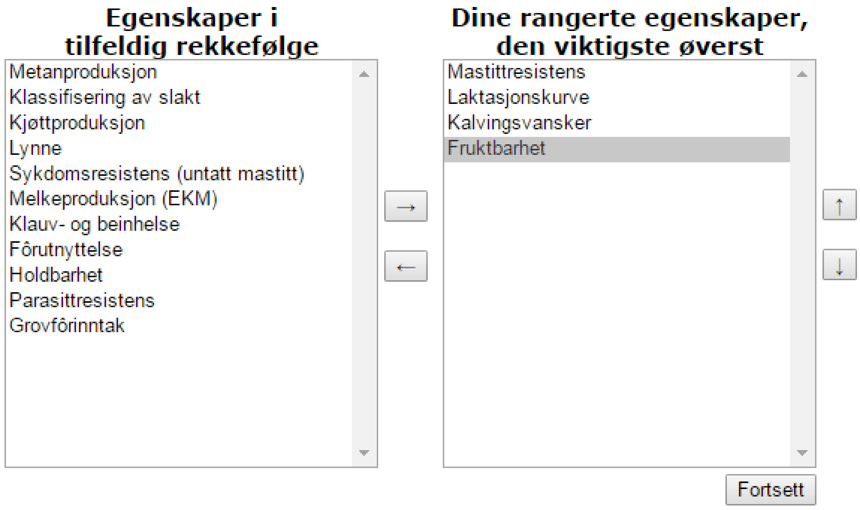

Figure 1. Ranking task.

Table 3. Traits included in the questionnaire and their definitions.

Trait	Description
Meat 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 the best
Leg and hoof health	More cows without feet and leg problems (percent of the herd)
Disease resistance	More cows that do not need to be treated for diseases, except mastitis (percent of the herd)
Feed conversion	More milk (kg ECM) produced per MJ ME in the feed
Fertility	More cows become pregnant at first insemination (percent of the herd)
Lactation curve	A flatter curve, i.e. the ratio between milk produced in late lactation (day 280) and early in lactation (day 60) is increased
Longevity[2]	Longer period between first calving and culling (months)
Mastitis resistance	More cows that do not need to be treated for mastitis (percent of the herd)
Methane production[1,2]	More milk (kg ECM) per gram methane that the cows produce
Milk production	Higher milk production kg energy corrected milk (ECM) per 305 days lactation
Parasite resistance[1,2]	More cows without gastrointestinal parasite infections (percent of the herd)
Roughage intake	Increased ability to eat roughage (kg DM/day)
Temperament	Calmer cows (scale from 1 (nervous/aggressive) to 9 (calm/friendly)

[1] Not included in Swedish breeding goals
[2] Not included in Norwegian breeding goals

In step 5, the respondents were asked a number of questions about the herd, herd management and about the respondents themselves. Questions asked can be found in Appendix 1 and 2.

Swedish data

The Swedish data set was obtained from a study performed in 2012 (Ahlman et al., 2014) (468 answers) at Sveriges Lantbruksuniversitet (SLU), where questionnaires were sent out to 1481 Swedish dairy producers by e-mail, at that time approximately ¼ of all Swedish producers. The e-mail addresses were obtained from the databases of the Swedish Dairy Association and Swedish organic certification organization KRAV. The e-mail contained information on the subject of the questionnaire, how it would be used, and who were responsible for the project including institution and name of researchers. Following the invitations, two reminders were sent with approximately two weeks in-between.

The questionnaire was open from the 23rd of February until the 30th of March. The respondents entered the questionnaire through a farm-specific link included in them e-mail. The questionnaire could be accessed through the link several times as long as the answers had not been submitted.

Norwegian data

The Norwegian data set was obtained from a survey performed in 2017 with a questionnaire developed using the Swedish questionnaire as a starting point. The text was translated in cooperation with researchers at NIBIO and NORSØK. Some adaptations were made to the questions about the farm/farmer, including additional alternatives to existing questions (Appendix X). E-mail addresses were obtained through the Norwegian breeding cooperative company Geno, and all milk producers connected to Geno were contacted. Following the invitations, 2 reminders where sent out with approximately two weeks in-between.

The questionnaire was open from the 23rd of February until the 22th of April. The respondents entered the questionnaire through a farm-specific link included in the e-mail. The questionnaire could be accessed through the link several times as long as the answers had not been submitted.

Statistical Analysis

Several different statistical analyses were performed, aiming to describe the data, test for differences in ranking of traits for overall data and within and between clusters, reduce noise created by forced ranking-format of ranking task, identify meaningful ranking clusters and test for farm and farmer characteristics between clusters.

Descriptive statistical analysis was performed using PROC FREQ and PROC MEANS in SAS 9.4 (SAS Institute, Inc, 2013).

A Friedman test was performed to assess overall effect and pairwise differences in overall ranking and within-cluster ranking. The Friedman test is a non-parametric test to detect significant differences between classes when data cannot be assumed to be independent or normally distributed (Friedman, 1937). A significant result ($p < 0.05$) of the Friedman test meant that there is at least one significant difference between rankings of traits. If results of the Friedman test was $p<0.05$, a Neyemi's post hoc test was performed to test for pair-wise differences between traits. Both tests were carried out using rStudio package PMCMR (Pohlert, 2015).

For data reduction a principal factor analysis (PAF) based on polychorric correlations was carried out in SAS 9.4 using PROC FACTOR and PROC CORR (SAS Institute, Inc, 2013).

Polychorric correlations were chosen to account for dependency and lack of equidistance in the ranking data (Van der Eijk and Rose, 2015). PAF was chosen to account for lack of equidistance, independency and normal distribution in the ranking data (Van der Eijk and Rose, 2015). Number of factors were decided through examination of scree plots with elbow break as criterion, and final communalities of eigenvalues.

Ward's hierarchical cluster analysis on eucledian distance based on factor scores were carried out in rStudio using package FactormineR (Husson et.al, 2017). Ward's hierarchical cluster analysis is a special case of the objective function approach. It merges clusters by considering all possible merges, and selecting the solution which gives the maximal value to the objective function of the chosen criterion, i.e. minimizing the increase of overall within-cluster sum of squares (Ward, 1963). Number of clusters were decided through examining reduction in dendrogram height which scales the Euclidian distance between observations in the eucledian space. Change in dendogram height was examined by plotting a graph of height change through the sequence of merging, and number of clusters retained was decided through identifying the point where partitioning of clusters would no longer reduce dendrogram height considerably.

A Kruskall-Wallis test was performed on rankings and continuous farm characteristics to test for significant differences between clusters. Kruskall-Wallis is a non-parametric test to test if samples originate from the same distribution, and is used when assumptions of one-way ANOVA of normal distribution and equal variance are violated (Kruskall-Wallis, 1952). If $p < 0.1$ a post hoc Dunn's test was performed to test for pairwise differences (Dunn, 1964). Kruskall-Wallis test was performed using r-package FSA (Ogle, 2017) and dunn.test (Dinno, 2017). Categorical variables were tested using a Fisher's exact test. The Fisher's exact test is based on contingency tables, and is used instead of the $\chi 2$ - test when number of observations in individual cells are small (Agresti, 1992).

Microsoft Excel 2013 (Windows Microsoft inc., 2013) was used for summarizing data tables. Microsoft Excel 2013 and rStudio were used for graphical illustrations.

Results

Description of data

Sweden

Of the invited farmers, 772 started the survey, but 304 dropped out before finishing, leaving the final number of respondents at 468 (response rate 32%). 346 of the final responses came from conventional producers, while the remaining 122 were from producers with organic production. Of the organic producers 107 were certified only according to KRAV's regulations, and 2 were certified only according to the EU organic regulations. Of the producers with organic production, 36 were certified according to multiple regulations, the most common being KRAV and Svenskt Sigil (N=26). 4 of the farms did not provide information on organic certification of which 2 were certified according to Svenskt Sigil. Of the conventional farms 134 were certified according to Svenskt Sigil, 3 according to multiple certifications, and 147 were not. Of the Swedish respondents 33% had Swedish Red as the main breed in the herd, 15% a combination of Swedish Holstein/Swedish red, 35% had Swedish Holstein and 17% had other breeds, including Swedish Jersey and Swedish Polled. Among farms with predominantly SRB, SH or a combination of the two, 29.9 % had with herd sizes above 100 year cows, while the corresponding number for farms keeping other breeds was 18.5%. Distribution of herd average milk production level and number of insemination per female animal can be seen in Figure 2.

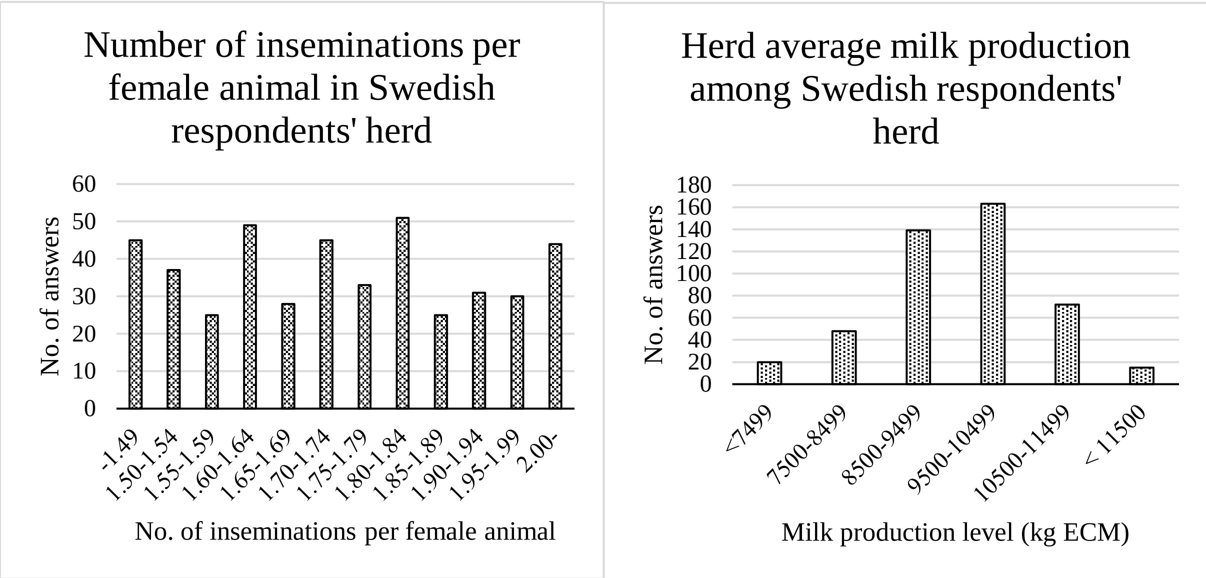

Figure 2. Number of inseminations and milk production level (kg ECM) among Swedish respondents.

In total 180 of the respondents had an automatic milking robot, 171 of the respondents had tie stalls and 105 of the respondents had milking parlor. Only four of the respondents used other systems. The distribution of respondents for different herd size and housing category is given in Figure 3.The majority of respondents (N=417) were owners of the farm. The distribution between female and male respondents was 178 and 285 respectively, and those were the only gender alternatives. The mean age of respondents was 47.

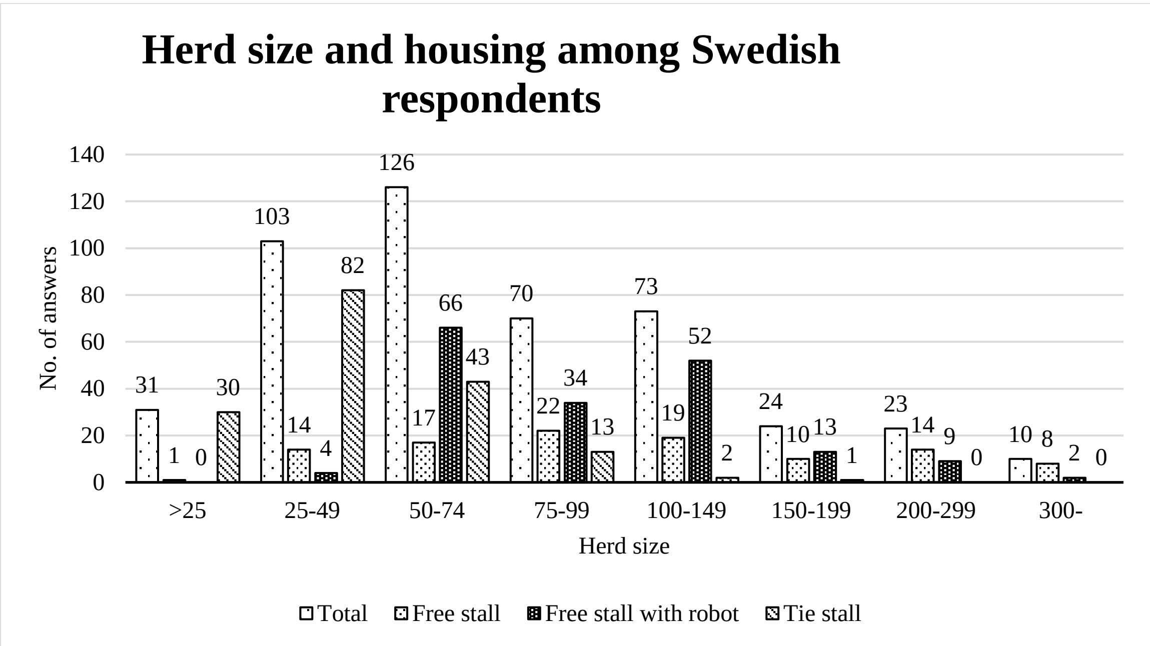

Figure 3. Distribution of housing system per herd size and group among Swedish respondents.

Table 4. . Continuous farm and farmer characteristics for Swedish data (N, mean ± standard deviation (std), min and max value).

Variable	N	Mean ± std	Min	Max
Proportion of herd treated for mastitis (%)	400	11.2± 9.09	0	85
Proportion of herd treaded for other diseases (%)	386	9.9 ± 9.30	0	60
Roughage ratio in feed ration (%)	382	58.1 ± 12.53	30	90
Pasture period (weeks)	453	17.6 ± 4.71	4	30
Average hours at pasture during pasture period	446	14.5 ± 6.41	2	24

Norway

Of the 8222 contacted producers, 892 (10.8%) answered the survey. Of these, three respondents were identified as suckle cow-herds (based criteria on breed, housing systems, raising of calves and milk production) and were therefore excluded from further analysis, leaving the total number of analyzed records at 888. Of these, 38 of the respondents had organically certified production, 850 conventional production. All of the 38 organic producers were certified according to the organic certification DEBIO, while one was also certified by the biodynamic certification Demeter. In total 862 of the respondents were certified according to the KSL-standard (Kvalitetssikring i Landbruket). Norwegian Red was the main breed in the herds of 95% of the respondents, Holstein in 2% of the herds and 3% kept mainly other breeds, including Jersey and STN. Distribution of average herd milk production level and number of insemination per female animal can be seen in Figure 4.

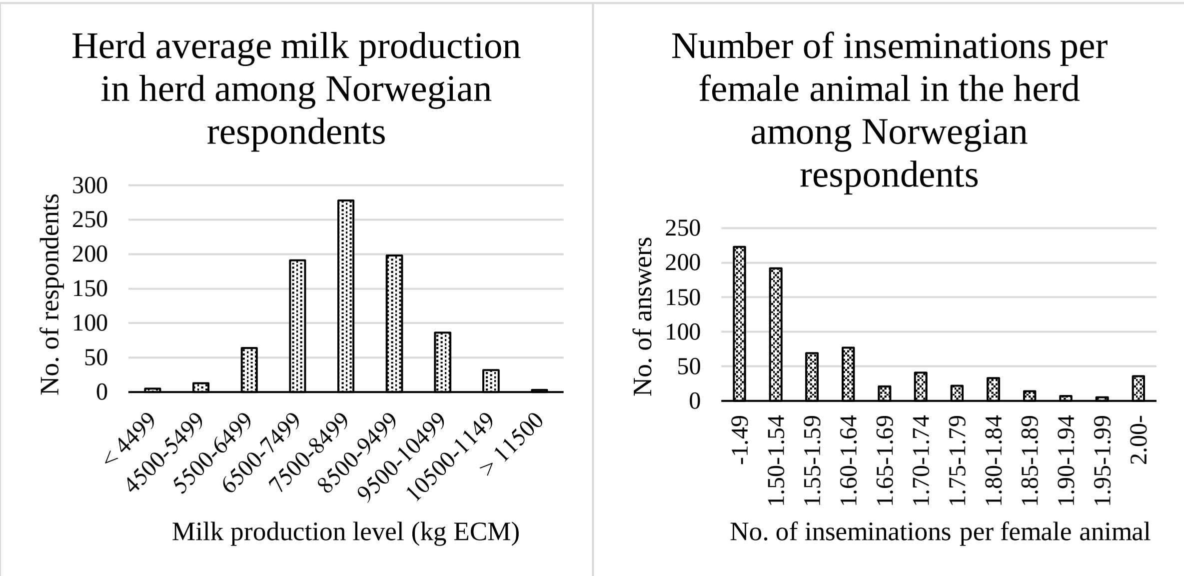

Figure 4. Number of inseminations and milk production level among Norwegian respondents.

In total 427 of the respondents had tie stalls, 302 of the respondents an automatic milking system and 136 of the respondents had milking parlour. Most herds had either 15-24 (N=300) of 25-49 (N=308) cows. The distribution of respondents between herd size and housing categories are given in Figure 5. The majority of the respondents (N=837) where owners of the farm. Of the respondents, 61 was in either in the process or ending production, or considering to end production. 135 were women, 748 were men and 2 were of other gender. The mean age of the respondents was 50.

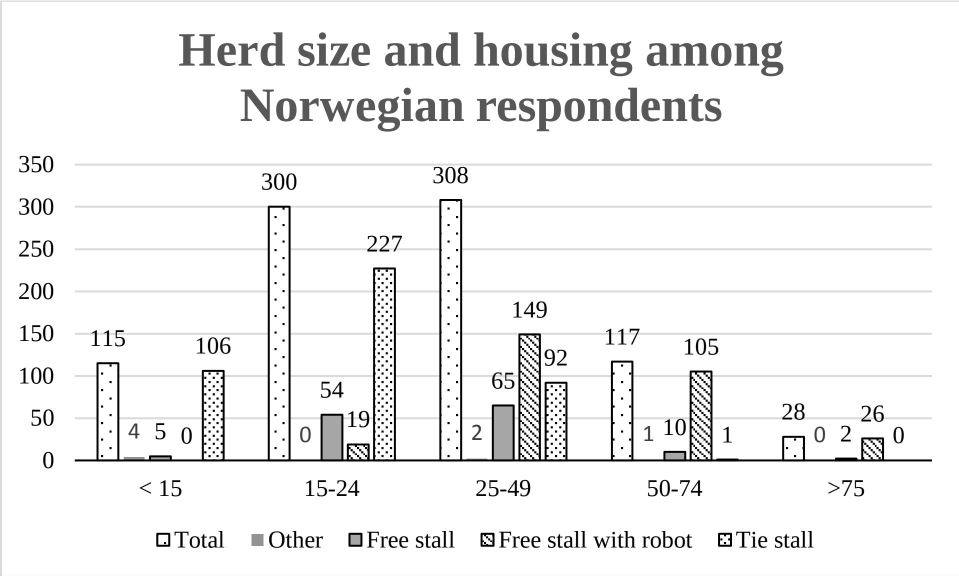

Figure 5. Distribution of housing system per herd size and group among Norwegian respondents.

Table 5. Continuous farm and farmer characteristics for Norwegian data (N, mean ± standard deviation (std), min and max value).

Variable	N	Mean ± std	Min	Max
Proportion of herd treated for mastitis (%)	798	6.0 ± 7.26	0	70
Proportion of 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 at pasture during pasture period	818	14.7 ± 7.35	0	24
Pasture period (weeks)	840	13.9 ± 5.11	0	52

Description of overall ranking data

A Friedman test was performed to test differences of ranking between traits within the Norwegian and the Swedish ranking data separately. Results are presented separately for each country in Figure 6 and Figure 7. Rankings are described in terms of high (1-5), medium (5-10), and low (11-15) if no other criterion is stated.

Sweden

The trait highest ranked by Swedish respondents was longevity, and the lowest ranked trait was methane production (Figure 6). Milk production, mastitis, fertility and feet- and claw health were lower ranked than longevity, but higher than all other traits. No significant differences were found between the meat traits and parasite resistance, but these traits were higher ranked than methane production.

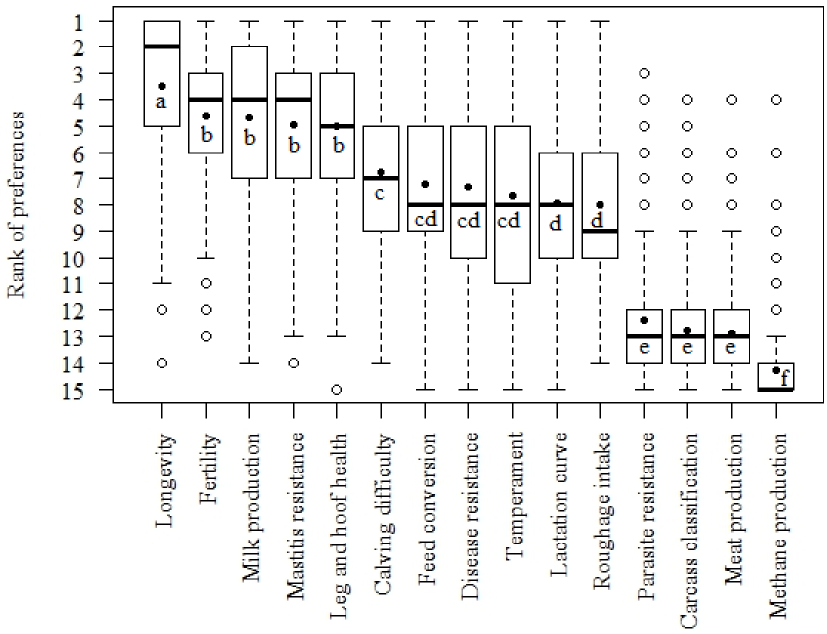

Figure 6. Ranking of traits among Swedish respondents. Letters represent ranking significance. Means are represented by black dots.

Norway

The trait highest ranked by Norwegian respondents were fertility, and the lowest ranked trait was methane production (Figure 7). Milk production, temperament, longevity and leg hoof and health followed, but difference in ranking among these traits were was not significant, and ranking of leg and hoof health was not significantly different from ranking of mastitis resistance. The ranking of low ranked traits (meat traits, parasite resistance and methane production) all differed significantly from each other with methane production being given the lowest preference and meat production the highest.

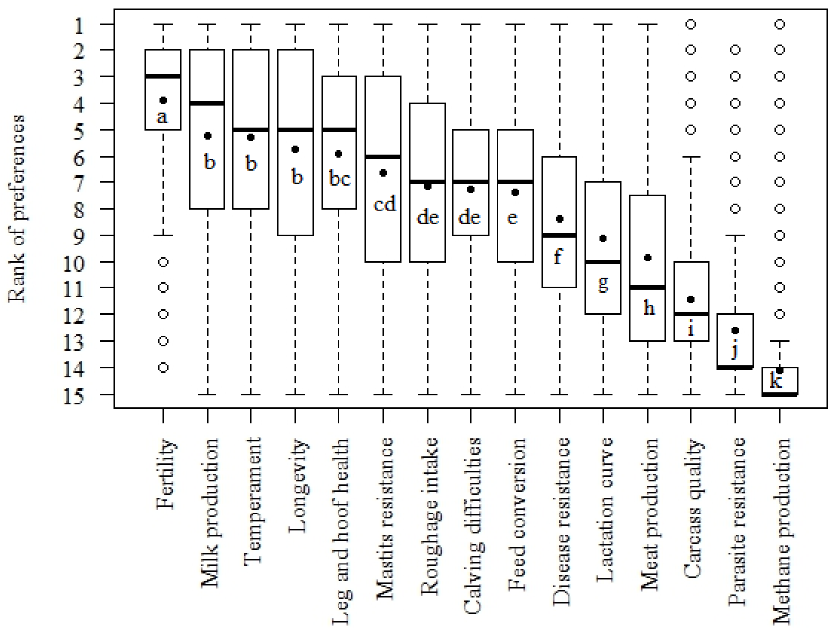

Figure 7. Ranking of traits in among Norwegian respondents.. Letters represent ranking significance. Means are represented by black dots.

Principal Axis Factor analysis

Principal Axis Factor analysis (PAF) using polychoric correlations was run for data reduction. Number of factors to be retained was chosen through examination of final communalities. Results are presented separately for each country in Figure 8 and Figure 9.

Swedish data set

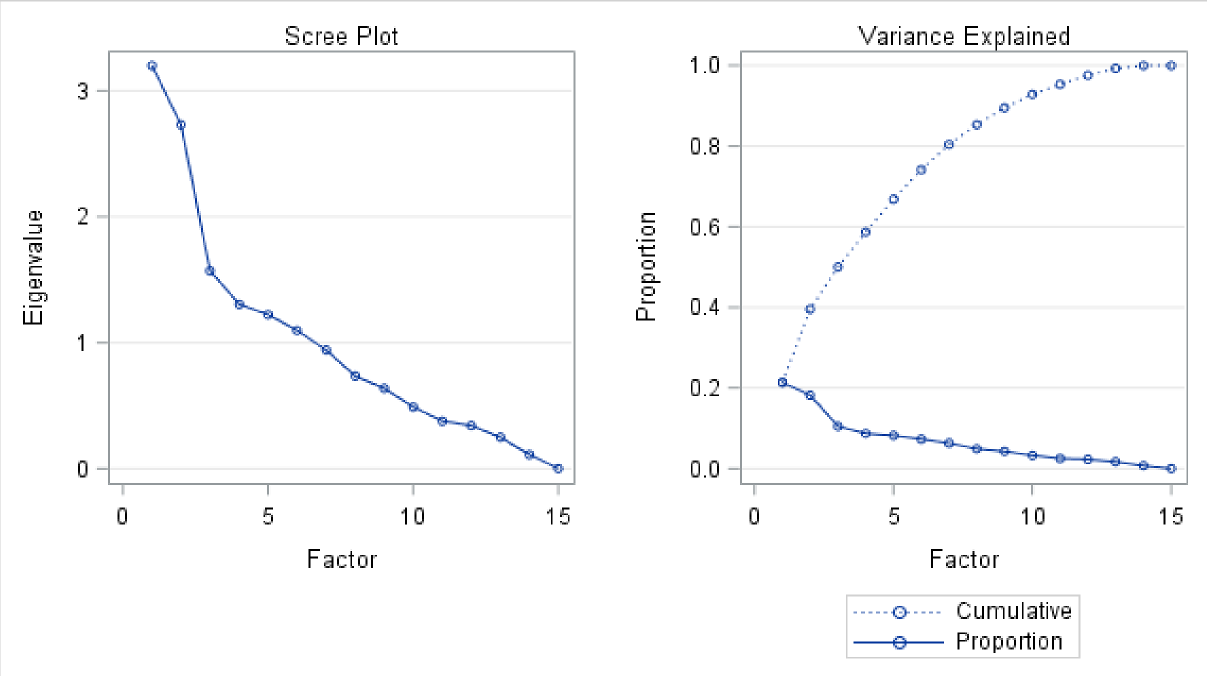

Figure 8. Scree plot of changes in final communalities following inclusion of factors for Swedish data.

Examining eigenvalues and the scree plot showed a weak elbow break at 5 factors (Figure 8). However, with so few factors only 0.66 of the final communality was explained. After 7 factors, eigenvalues dropped below 1. It was decided to retain 7 factors to mirror the final communalities of the Norwegian data.

Norwegian data set

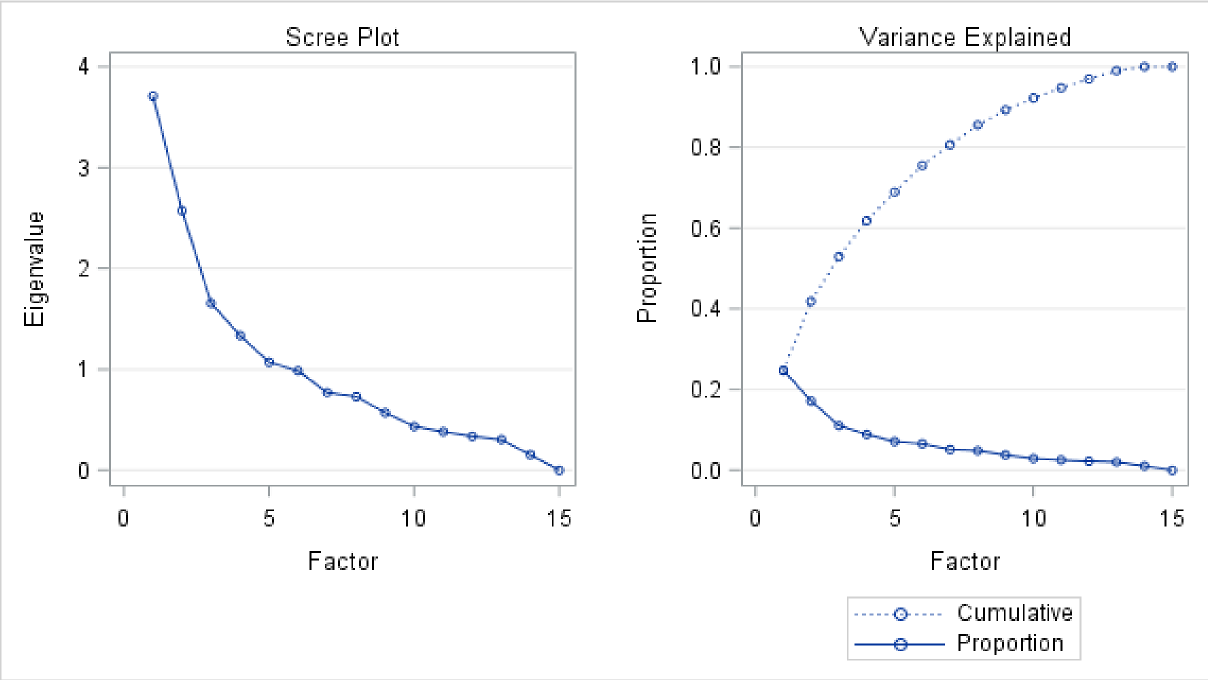

Figure 9. Scree plot of changes in final communalities following inclusion of factors for Norwegian data.

The scree plot shows a weak elbow break at about 7 factors (Figure 9). Examination of eigenvalues shows that inclusion of these account for 0.8064 of final communities, and it was decided to retain 7 factors for further analysis.

Cluster analysis

A Ward's hierarchical cluster analysis was performed to identify clusters of trait ranking for the Swedish and Norwegian ranking data. Number of clusters were decided through examining reduction in dendrogram height in the sequence of merging, identifying the point where merging would no longer reduce dendrogram height considerably. Dendrogram and change in dendrogram height is presented below, separately for each country (See Figure 10 and Figure 11 for Sweden; Figure 12 and Figure 13 for Norway. The cut-off point for the Norwegian data was considerably clearer than for the Swedish data. Three and four clusters were retained for the Swedish and the Norwegian data respectively.

Sweden
In the Swedish data, reduction in dendrogram height decreased notably after the third merging (Figure 10) and three clusters were retained (Figure 11).

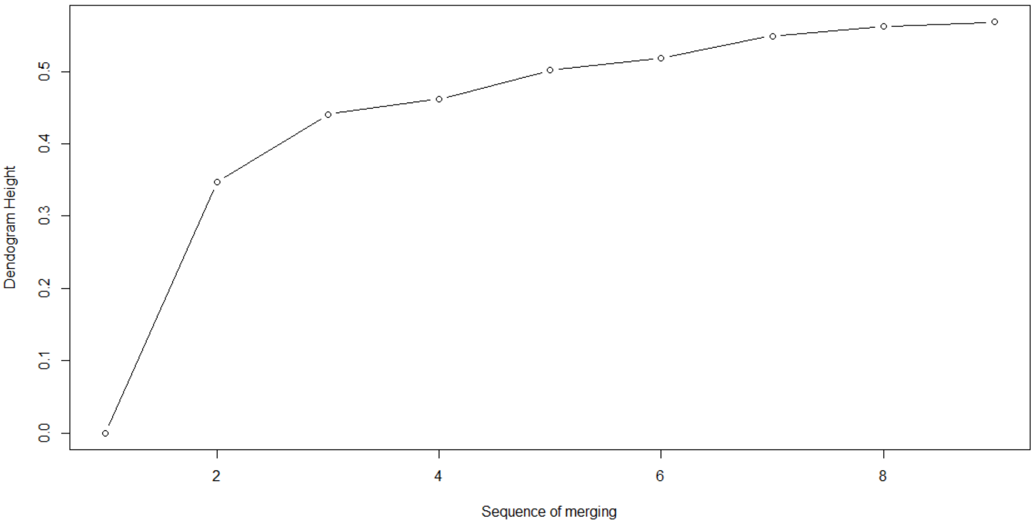

Figure 10.Changes in dendrogram height through sequence of merging in cluster analysis on 7 retained factors from the Swedish data.

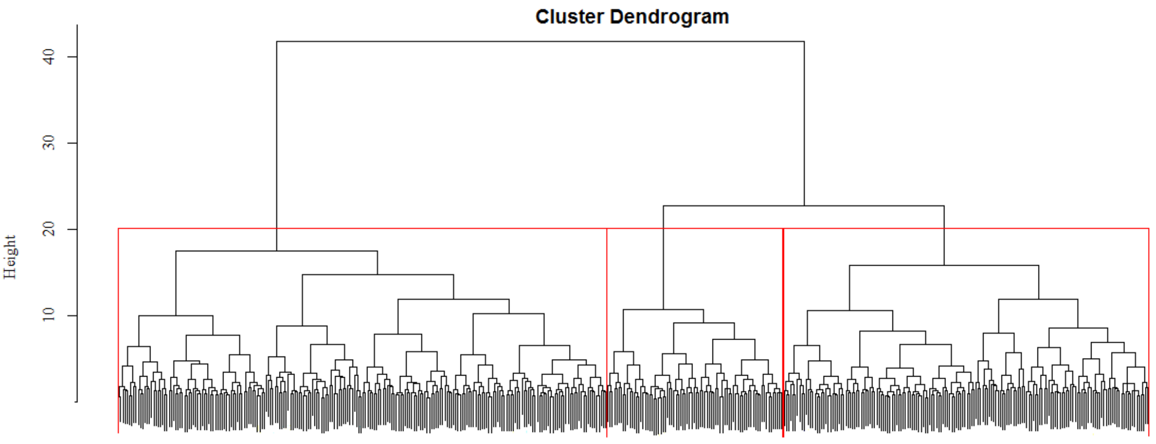

Figure 11. Dendrogram 3 cluster-solution for cluster analysis on 7 retained factors from the Swedish data.

Norway

In the Norwegian data, reduction in dendrogram height decreased notably after the fourth merging (Figure 12) and four clusters were retained (Figure 13).

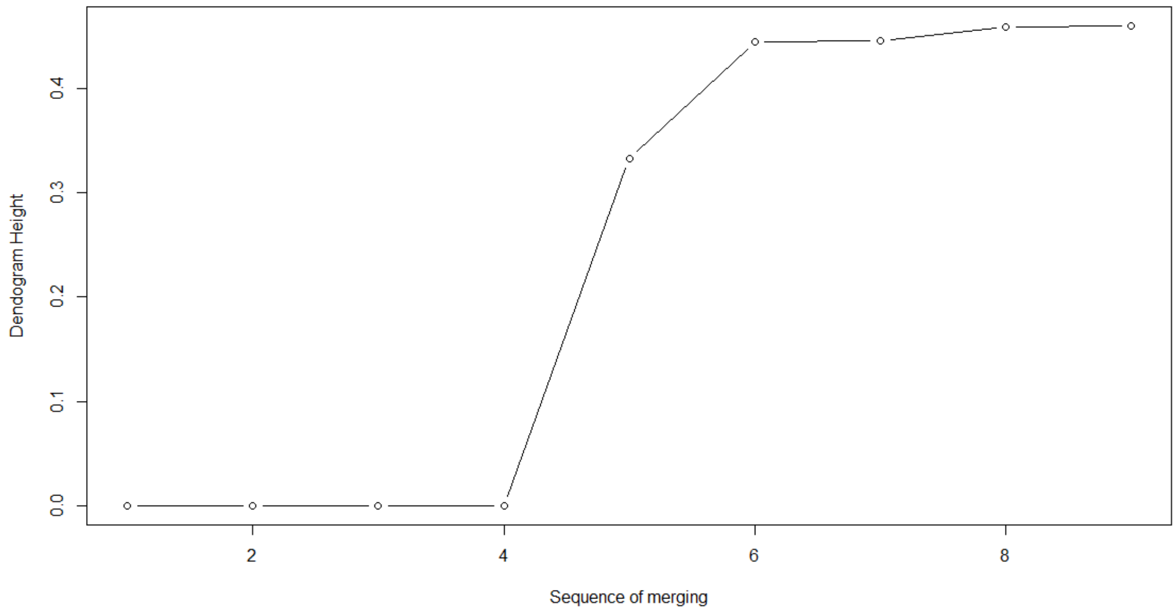

Figure 12. Changes in dendrogram height through sequence of merging in cluster analysis on 7 retained factors from the Swedish data.

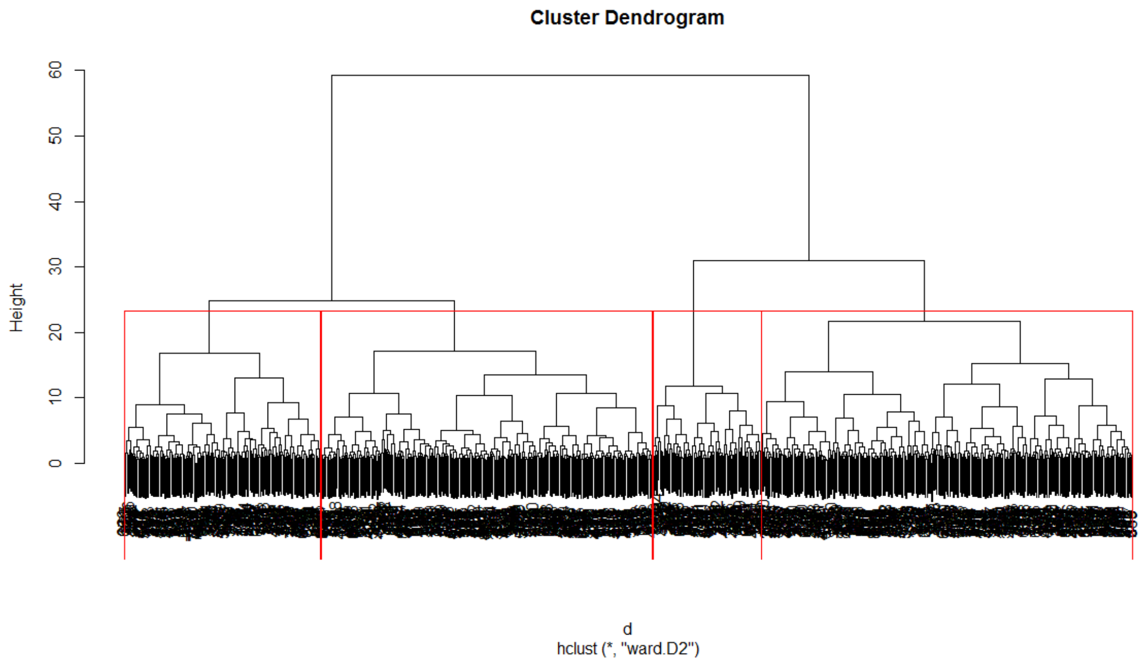

Figure 13. Dendrogram 4 cluster-solution for cluster analysis on 7 retained factors from the Norwegian data.

Cluster description

Sweden

Characterization of clusters

Three clusters of respondents were retained based on the trait rankings of the Swedish farmers. Significant difference in ranking between clusters was found for nine of the 15 traits. The highest ranked trait, longevity, was not significantly different between any of the clusters, thus highest ranked among respondents in all clusters. The low-ranked traits, meat production, carcass classification, parasite resistance and methane production were not significantly differently ranked between clusters. Cluster names based on cluster characteristics were assigned according to significance between clusters, ranking within cluster, and in a way that would facilitate differentiation in presentation of results and discussion. Between-cluster significance is presented in Table 6.

Table 6. Swedish between-cluster differences of trait ranking. Between-cluster significance is indicated with letters.

	Cluster 1 "Milk production and efficiency" (ME) N=222	Cluster 2 "Robustness" N=166	Cluster 3 "Milk production and robustness" (MR) N=80
Calving difficulties	a	b	c
Milk production	a	b	a
Feed conversion	a	b	c
Fertility	a	b	ab
Roughage intake	a	b	c
Lactation curve	a	b	b
Mastits resistance	a	b	b
Disease resistance	a	b	c
Temperament	a	b	c

Respondents in cluster 1 and 3 ranked milk production higher than respondents in cluster 2. Respondents in cluster 1 ranked feed conversion and roughage intake higher than all other clusters, while those in cluster 3 ranked calving difficulties and temperament higher than respondents in all other clusters, and mastitis resistance and disease resistance higher than respondents in cluster 1. Cluster 1 and cluster 3 were therefore assigned the names "Milk production and efficiency" (ME) and "Milk production and robustness" (MR) respectively.

Respondents in cluster 2 ranked disease resistance and mastitis resistance significantly higher than respondents in cluster 1 and 3. They also ranked calving difficulties, temperament and milk production significantly lower. The five most highly ranked traits were longevity, disease resistance, mastitis resistance and leg and hoof health, and this cluster was therefore named "Robustness".

Traits with significant differences in ranking between clusters

All clusters had a group of four highly ranked traits, significantly different from all other traits, but not from each other. Among the clusters, a total of six traits were found in such high-ranked groups: Calving difficulties, leg and hoof health, milk production, fertility, mastitis resistance and disease resistance. All of these showed significant ranking between clusters except for leg and hoof health.

Disease resistance and calving difficulties were significantly differently ranked between all clusters. Respondents in the MR cluster ranked calving difficulties higher than respondents in clusters ME and Robustness, while respondents in the Robustness cluster ranked disease resistance higher than respondents in the milk production clusters.

No significant differences were found between ranking of milk production between respondents in the milk production clusters, or between respondents in clusters Robustness and MR for fertility and mastitis resistance. While respondents in the ME cluster ranked fertility higher than respondents in the Robustness cluster did, those in the Robustness cluster ranked mastitis resistance higher than in respondents in the ME cluster (Figure 17).

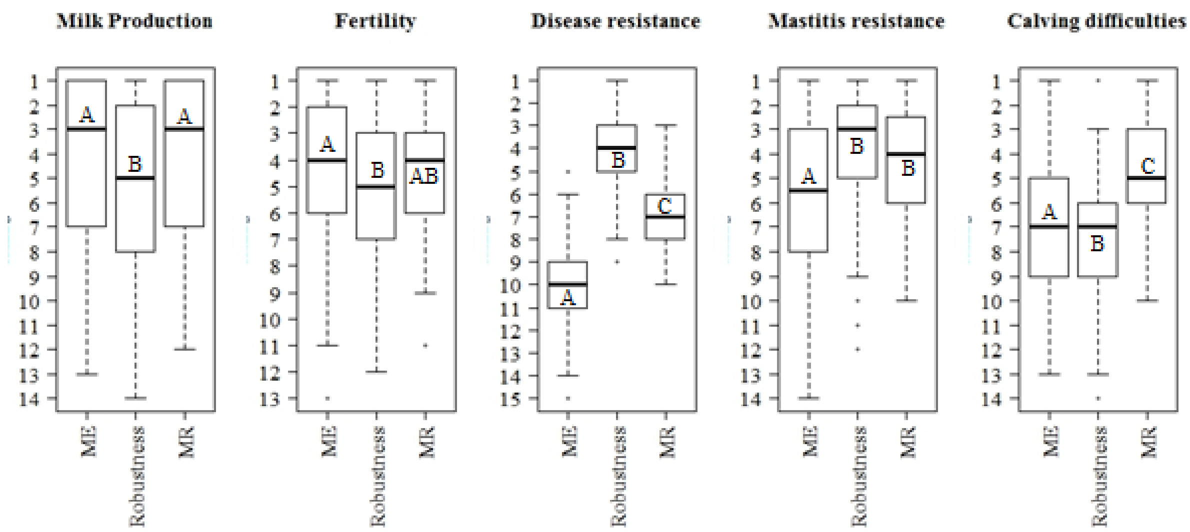

Figure 14. Difference in ranking of high ranked traits between the three Swedish clusters "Milk production and efficiency" (ME), "Robustness" and "Milk production and robustness" (MR). Significant differences are indicated with different capital letters.

A significant difference was found between respondents in all clusters for feed conversion and roughage, with the respondents in the ME cluster giving the highest preference to both. Respondents in the ME cluster also ranked lactation curve higher than those in both clusters Robustness and MR, and respondents in the MR cluster ranked temperament higher than both clusters Robustness and ME (Figure 14).

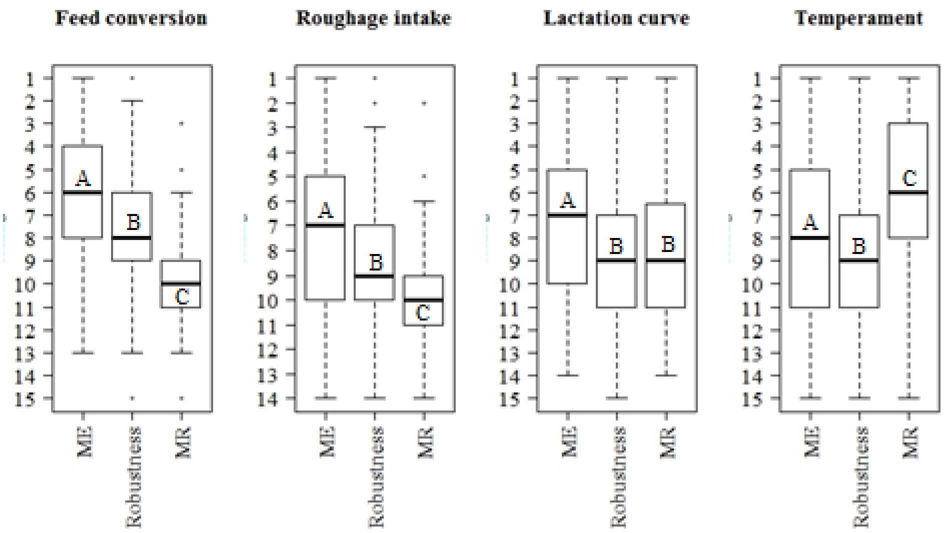

Figure 15. Difference in ranking between the Swedish clusters "Milk production and efficiency" (ME), "Robustness" and "Milk production and robustness" (MR) of mid-ranked traits. Significant differences are indicated with different letters.

Herd and famer characteristics

Basic descriptions of farms and farmer can be seen in 7 and 8. No significant differences were found between clusters for any of the analysed continuous variables.

Table 7. Continuous characteristics of farm and farmer (p-value, means ± standard deviations (std)) for the Swedish clusters "Milk production and efficiency" (ME), "Robustness" and "Milk production and robustness" (MR). Significant differences are indicated with letters, tendencies are indicated with asterix.

	p-value	**ME cluster**	**Robustness cluster**	**MR cluster**
Percentage of cows treated for mastitis	ns.	11.7 ± 10.04	10.9 ± 8.25	10.2 ± 8.07
Percentage of cows treated for other diseases	ns.	10.3 ±10.18	9.8 ± 8.67	8.8 ± 8.04
Proportion of roughage in feed	ns.	57.7 ±13.64	58.4 ± 11.28	58.9 ± 11.94
Weeks at pasture	ns.	17.6 ± 4.78	17.5 ±4.71	17.8 ± 4.54
Hours at pasture	ns.	13.9 ± 6.25	15.1 ±6.56	14.7 ± 6.49
Age of farmer	ns.	48.0 ± 10.39	46.0 ±10.48	48.2 ± 10.49

Significant differences or tendencies towards significant differences for categorical variables were only found for production system, tie stalls and herd sizes between 150 and 199. The highest proportion of respondents with organic production was found in the MR cluster, and MR cluster had the highest proportion of respondents with conventional production. The MR cluster also had the highest proportion of respondents with tie stall, the ME cluster the lowest. Herd sized between 150 and 199 significantly differed between clusters with the highest proportion found in the ME cluster. Swedish Red and Swedish Holstein was the most common breed in all clusters at approximately 30-40% within each cluster (Table 8).

Table 8. Swedish within-cluster categorical characteristics of farm and farmer (Fisher's exact test p-values and percentage of respondents) within Swedish clusters "Milk production and efficiency" (ME), Robustness and "Milk production and robustness" (MR). Between-cluster significance is indicated with asterix, between-clusters tendency is indicated with asterix in parenthesis.

Characteristic	**Alternative**	**p-value**	**% of respondents in cluster**		
			ME	Robustness	MR
System*	Conventional*	0.032	79.3	70.5	66.3
	Organic*	0.032	20.7	29.5	33.7
Housing(*)	Tie stall(*)	0.061	41.6	36.2	26.9
	Free stall with robot*	ns.	35.2	39.9	48.7
	Free stall with parlour	ns.	22.4	23.9	21.8
	Other housing	ns.	-	-	2.6
Herd size*	< 25	ns.	6.4	6.0	9.0
	25-49	ns.	24.1	23.5	15.4
	50-74	ns.	26.8	29.5	24.4
	75-99	ns.	14.1	13.3	21.8
	100-149	ns.	15.9	18.1	12.8
	150-199*	0.042	3.6	4.2	11.5
	200-299	ns.	5.9	3.6	5.1
	> 300	ns.	3.2	1.8	-
Framtid	Continue and develop	ns.	51.2	59.5	53.9
	Continue in present form	ns.	35.2	29.1	36.8
	Considering to end production	ns.	8.0	6.3	7.9
	In the process of ending production	ns.	5.6	5.1	1.3
Milk production level (kg ECM)	< 7499	ns.	2.3	6.6	5.3
	7500-8499	ns.	8.4	13.9	9.2
	8500-9499	ns.	29.3	31.3	31.6
	9500-10499	ns.	37.7	34.3	32.9
	10500-11499	ns.	18.6	11.4	17.1
	> 11500	ns.	3.7	2.4	3.9
Breed	Swedish Red	ns.	36.9	33.1	32.5
	Swedish Red/Swedish Holstein	ns.	16.2	14.4	13.7
	Swedish Holstein	ns.	34.2	32.5	32.5
	Other	ns.	12.6	19.8	21.2
Rearing of bull calves	Raising for slaughter	ns.	12.7	18.6	17.1
	Selling	ns.	76.7	68.3	72.4
	Selling and raising*	ns.	10.0	11.8	7.9
	Euthanize	ns.	0.5	1.2	2.6
Use of AI	Only AI	ns.	71.6	68.4	76.0
	AI and natural mating	ns.	28.4	31.5	24.0

Norway

Characterization of clusters

Four clusters of respondents were retained based on the trait rankings of the Norwegian farmers. Significant difference in ranking was found for 13 of the 15 traits. Ranking of feed conversion, a medium preferred trait, was not significantly different between respondents in any of the four clusters. Cluster names were assigned according to significance between clusters, ranking within clusters, and in a way which would facilitate differentiation in presentation of results and discussion (Table 9).

Table 9. Norwegian between-cluster difference of trait ranking. Between-cluster significance is indicated with letters.

	Cluster 1:	Cluster 2:	Cluster 3:	Cluster 4:
	Milk production, meat production and functionality (MMF) N=292	Fertility and efficiency (FE) N=327	Robustness and Health (RH) N=97	Milk production and health (MH) N=173
Calving difficulties	a	b	b	c
Leg and hoof health	a	b	bc	c
Milk production	a	b	c	d
Fertility	a	b	a	a
Roughage intake	a	ab	b	a
Lactation curve	a	b	c	a
Longevity	a	b	bc	c
Mastits resistance	a	b	c	c
Meat production	a	b	c	d
Carcass classification	a	bc	c	ab
Methane production	a	a	b	ab
Parasite resistance	a	b	c	a
Disease resistance	a	b	c	d
Temperament	a	b	a	c

Respondents in cluster 1 and 4 ranked milk production higher than those in cluster 2 and 3. Although respondents in cluster 1 ranked milk production significantly higher than in cluster 4, milk production was the highest ranked trait in both these clusters, they were therefore named milk production-clusters. Respondents in cluster 4 ranked mastitis resistance higher than in cluster 1 and 2, but not significantly higher than in cluster 3, and disease resistance significantly higher than in cluster 1. This group was therefore named "Milk production and health" (MH). Respondents in cluster 1 ranked temperament and calving difficulties significantly higher than cluster 4, and meat production significantly higher than all other clusters. Like all other clusters fertility and leg hoof health was also high ranked. This cluster was therefore assigned the name "Milk production, meat production and functionality" (MMF).

Respondents in cluster 3 ranked the output traits milk- and meat production significantly lower than in all other clusters, and carcass classification significantly lower than in cluster 1 and 4. Of the functionality traits only parasite resistance was low ranked, the cluster was therefore named "Robustness and health" (RH).

Respondents in cluster 2 had the highest ranking for fertility and temperament compared to all other clusters, and calving difficulties was significantly higher ranked than in cluster 1 and 4. Although significantly lower than both cluster 1 and 4, milk production and carcass classification was significantly higher ranked by respondents in this cluster than in cluster 3. Looking on within-cluster significance a mid-ranked group consisting of milk production, roughage intake and feed conversion could be identified with significance towards both high and low-ranked traits, but not against other medium ranked traits. The cluster was assigned the name “Fertility and efficiency" (FE).

Traits with significant differences

Respondents in MMF ranked all production traits higher or at the same level as in any of the three other clusters. Respondents in RH ranked all production traits lower than respondents in all other clusters did, but the difference FE for carcass classification was not significant. Milk production was the trait with the largest variation in ranking between clusters (Figure 16).

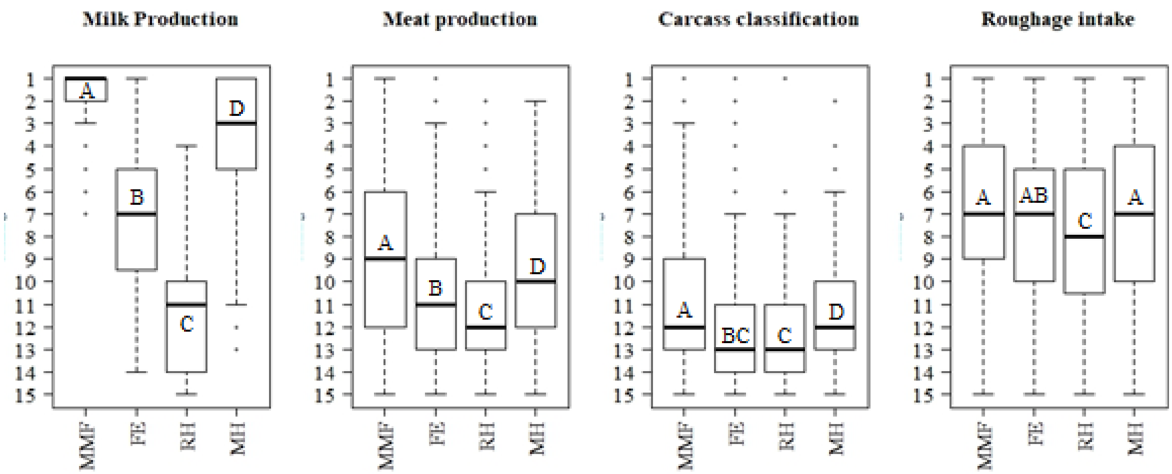

Figure 16. Difference in ranking between the Norwegian clusters “Milk production, meat production and functionality” (MMF), “Fertility and efficiency” (FE), “Robustness and health” (RH) and “Milk production and health” (MH) of production traits. Significant differences are indicated with different letters.

Respondents in the RH cluster ranked health traits significantly higher, or at the same level as respondents in other clusters. Longevity was ranked the highest by respondents in the MH cluster, but not significantly higher than respondents in RH cluster. The same was true for respondents in the FE cluster and ranking of leg and hoof health. Respondents in the MMF cluster ranked all health traits lower than respondents in other clusters (Figure 17).

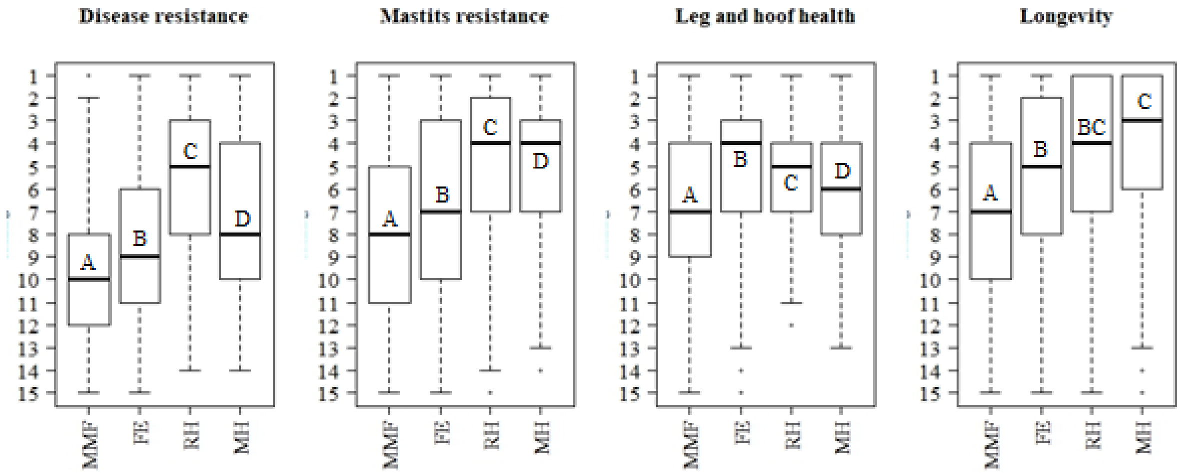

Figure 17. Difference in ranking between the Norwegian clusters "Milk production, meat production and functionality", "Fertility and efficiency", "Robustness and health" and "Milk production and health" of disease resistance, mastitis resistance, leg and hoof health and longevity. Significant differences are indicated with different letters.

Respondents in the FE cluster had the highest ranking of temperament and fertility, and had the highest ranking of calving difficulties, although this was not significant compared to the RH cluster. The MH cluster had the significantly lowest ranking of temperament, calving difficulties and lactation curve (Figure 18).

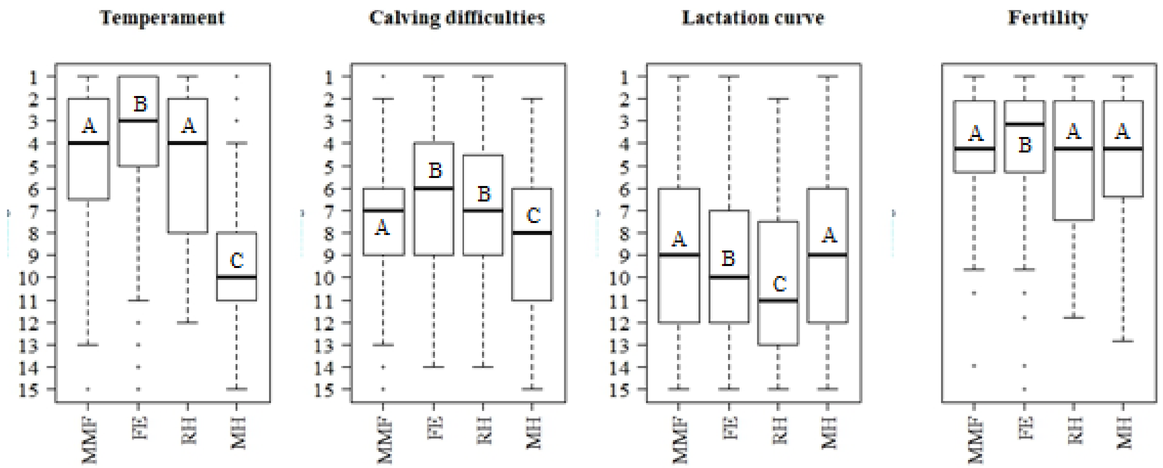

Figure 18. Difference in ranking between Norwegian clusters "Milk production, meat production and functionality" (MMF), "Fertility and efficiency" (FE), "Robustness and health" (RH) and "Milk production and health" (MH) of temperament, calving difficulties, lactation curve and fertility. Significant differences are indicated with different letters.

Methane production was in general low-ranked also within clusters. Respondents in cluster RH had a higher ranking of methane production compared to respondents in clusters MMF and FE, but not compared to the MH cluster. Respondents in the RH cluster higher ranked parasite resistance than in all other clusters (Figure 19).

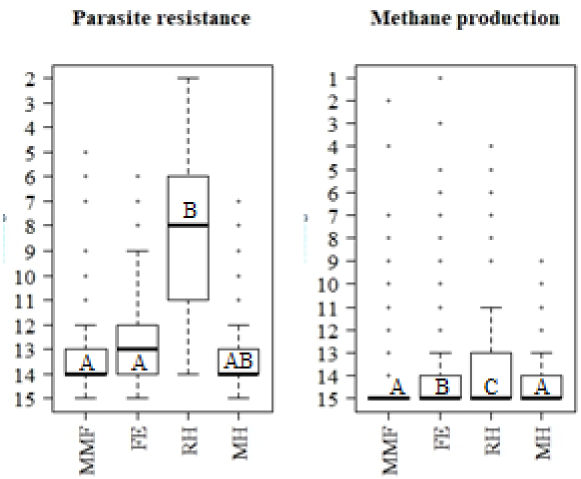

Figure 19. Difference in ranking between clusters "Milk production, meat production and functionality" (MMF), "Fertility and efficiency" (FE), "Robustness and health" (RH) and "Milk production and health" (MH) of novel traits. Significant differences are indicated with different letters.

Herd and farmer characteristics

Basic descriptions of farms and farmer can be seen in Table 10 and 11. In terms of continuous variables, difference in proportion of herd treated for mastitis and disease, along with percentage of roughage in feed and number of pasture weeks- and hours were found to be significant, or tended to be significant. Respondents in clusters MMF and FE had a lower proportion of cows treated for mastitis, and respondents in the RH cluster had a lower proportion than respondents in the MH cluster, but only the MH cluster was or tended to be significantly different from all other clusters. Proportion of herd treated for other diseases was higher in cluster 4, but this difference was not significant (Table 10).

Table 10. Continuous characteristics of farm and farmer (p-value, means ± standard deviation (std)) for the Norwegian clusters "Milk production, meat production and functionality" (MMF), "Fertility and efficiency" (FE), "Robustness and health" (RH) and "Milk production and robustness" (MH). Significant differences are indicated with letters, tendencies are indicated with asterix.

	p--value	**MMF cluster**	**FE cluster**	**RH cluster**	**MH cluster**
Lactation number	ns.	2.6 ± 0.88	2.6 ± 0.96	2.8 ± 1.04	2.7 ± 0.8
Percentage of cows treated for mastits	0.026	5.5 ± 6.31[*a]	6.0 ± 7.91*[a]	5.0 ± 6.08[a]	7.1 ± 7.90[b*]
Percentage of cows treated for other diseases	ns.	4.7 ± 7.22	4.8 ± 6.72	4.9 ± 5.61	5.4 ± 6.6
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 at pasture	0.002	13.3 ± 4.72[a]	14.5 ± 5.64[bc]	15.2 ± 4.42[b]	13.4 ± 4.8[c]
Hours at pasture	0.001	14.5 ± 7.67[b*]	15.2 ± 7.09[a]	16.5 ± 7.04[a]	12.9 ± 7.1[b*]
Age of farmer	ns.	50.1 ± 9.71	50.0 ± 9.56	47.9 ± 11.45	49.2 ± 9.65

The cluster with the highest percentage of respondents with certified organic production was the RH (9.4%), while the lowest percentage was found for the milk production clusters in the area of 2%. The RH cluster also had the highest percentages of respondents with tie stalls, herd sizes < 25 and had the largest proportions of farmers considering ending the dairy production on the farm. The largest proportion of respondents with free stalls with robots and free stalls with parlour was found in the MMF cluster. For respondents in clusters MMF, FE and MH herd sized between 25 and 49 was the most common. The MMF cluster had a higher percentage of farmers that planned to continue and develop production (64.8%), while clusters FE and MH had the highest percentage of farmers planning to continue production in its present form (Table 11).

Table 11. Categorical characteristics of farm and farmer (Percentage of respondents and Fisher's exact test p-value) within Norwegian clusters. Between-cluster significance (p < 0.05) is indicated with asterix, between-clusters tendency (p<0.1) is indicated with asterix in parenthesis.

Characteristic	**Alternative**	**p-value**	**% of respondents in cluster**			
			1	2	3	4
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 parlour	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
Sex	Female	ns.	13.8	17.12	18.75	12.20
	Male	ns.	86.2	82.57	81.25	87.20
	Other	ns.	0.31	-	-	0.58
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
	9500-10499	ns.	11.6	8.2	6.3	12.3
	10500-1149	ns.	3.5	3.4	2.1	0.6
	11500+	ns.	0.4	0.3	-	5.3
Breed	Holstein	ns.	3.2	2.2	2.1	2.3
	NRF	ns.	95.7	94.9	90.4	94.8
	Other breed*	0.010	1.1	2.9	7.5	2.9
Raising of bull calves*	Raising for slaughter*	0.012	49.3	40.3	35.4	50.9
	Selling	ns.	40.7	45.5	44.8	34.7
	Selling and raising(*)	0.082	10.0	14.5	19.8	14.5
Use of AI*	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

Discussion

Herd traits and representativeness of respondents

The low response rate to the Swedish questionnaire has previously been discussed by Ahlman et al., 2014. The complicated and extensive nature of the questionnaire probably had an effect on the respondents. It is assumed that the once finishing the questionnaire were the once with the stronger interest for dairy breeding, and as such the data has been considered relevant. The same argument can be made for the Norwegian questionnaire.

In the present study 26% of the Swedish respondents had certified organic production. Looking at the total for the entire country in the year of the survey (2012), the proportion of herds certified as organic in 2012, were 12% (SJV, 2015). Thus organic farmers were over-represented among Swedish respondents, most likely due to the method of distribution of the questionnaire. The questionnaire was sent out to all dairy farmers with herds certified as organic, while only part of the producers with conventional production were invited. Of the 888 dairy producer that responded to the Norwegian survey, only these 4.3% with organically certified herds. This was within the same range as in the country at large, where 3.7% of Norwegian dairy cows were in certified organic production in 2015 (Norwegian Agriculture Agency, 2016).

In 2012, 40.5% of the cows with information in the Swedish national milk recording scheme Kokontrollen were Swedish red (SRB), 51.8% were Swedish Holstein (SH) and 7.7% were of other breeds including Swedish polled (SKB) and Swedish Jersey (SJB) (VÄXA, 2013). This might suggest an overrepresentation of other breeds among the Swedish respondents in the present study, as 17% of the respondents kept mainly other breeds, and the proportion in the Swedish dairy cow population of these breeds is much lower. However, when examining herd sizes from respondents keeping either predominantly SRB, SH or a combinations of SRB and SH versus herd sizes of farms keeping other breeds, farms with SRB, SH or a combination of SRB and SH had a higher proportion of farms with herd sizes above 100 year cows. It is therefore possible that the unbalance between breeds might be a result of recording methods as the number of cows of each breed is not the same as number of herds with a certain breed. However, smaller herd sizes were underrepresented, with respondents with herd sizes below 50 constituting approximately 7%, whereas 47% of herds in the national recording scheme and 50% of farms registered by the national office of statistics (SJV, 2013) were of these sizes.

Data from the Norwegian national milk recording scheme Kukontrollen showed that 93.3% of cows registered were NRF, 4.1% were Holstein and 2.5% were of other breeds, including Jersey and STN (Tine rådgivning, 2017). This is quite similar to the breed distribution among the Norwegian respondents, where 95% of respondents in the data set had NRF, and 2% Holstein.

The Swedish mean herd proportion of cows treated for mastitis was 11.2%, and the mean herd proportion of cows treated for other reasons was 9.9%. This is slightly lower than the overall population average recorded in national recording scheme for production year 2012, where the same numbers were 14.3% and 13.6%. The Norwegian mean herd proportions for cows treated for mastitis (6%) and other diseases (4.9%) were lower than the Swedish. On country basis, 10% of all cows were treated for mastitis and 12% for other diseases in 2016

(Helsekortordningen for Storfe, 2017). It is important to note that the recording in the questionnaire was based on herd average, and as such the numbers reported in the country at large, which is based on individual cows, cannot be compared directly.

A consideration when using national recording schemes, is the accuracy of reporting. In a study from 2009, Mörk compared data from field studies on Swedish farms recorded by farmers and by veterinarians, with data for the same farms found in the Swedish national recording scheme for five common diseases. The findings from this study showed that numbers in the national recording schemes were considerably lower, and that the degree of coverage was affected by both demographic and herd specific characteristics. As numbers reported in this study were most probably found in health reports from the advisory services, it is possible that it does not give an entirely accurate picture of the health status in the herd.

There was an overrepresentation of larger herd sizes among Swedish respondents. About 70.5% of farms among the Swedish respondents had herd sizes below 100 year cows, while it was 80.6% in 2012 on country basis registered in Kokontrollen (VÄXA Sverige, 2013), and 19% according to the Swedish Board of Agriculture (SJV) (SJV, 2013). The clearest difference was found for the herd size category 25-49, which constituted 22% of the respondents. This is lower than on a country basis, where it in 2012 was 34% registered in Kokontrollen (VÄXA Sverige, 2013), and 32.9% according to SJV (SJV, 2013). Farms with tie stalls were also underrepresented among the Swedish respondents with 36.5% of the respondents specifying that they had tie stall, while the number on country basis was 41% according to the Swedish national recording scheme (VÄXA Sverige, 2013). Since tie stalls are more common in smaller herd sizes, the unbalance of these two is linked.

The proportion of tie stalls among Norwegian respondents in the present study was 49.1%, which is about 16% lower than the actual numbers for producers with tie stalls in the Norwegian national recording scheme Kukontrollen (Tine rådgivning, 2017). Herds with less than 15 cows were also underrepresented at 13.2%, while 25.8% of the herds registered in the national recording scheme is within this size category (Tine rådgivning, 2017), and 23.4% in the country at large according to the Norwegian office of statistics (SSB, 2017). As found among Swedish respondents, these two are most likely intertwined. The numbers found in the Norwegian milk recording scheme are not directly comparable to numbers in the questionnaire, since recorded herd size intervals are not the same. However, among Norwegian respondents 34.6% falls in the category 25-49, and 41.5% of recorded herds were of a size between 20 and 49. Herd sizes from 50 and up constituted 13.6 % among Norwegian respondents, while looking at herds recorded in the national recording scheme 10.6 % of farms had herd sizes above 50. Along with the lower proportion of herd sizes below 15 cows, it can be assumed that herd sizes among respondent are somewhat larger than at country level (Tine Rådgivning, 2017).

Among Swedish respondents approximately 69% had average herd production level between 8500 and 10499 kg ECM. This corresponds well to the national averages where the most common breeds, SRB and SH had an average milk production of 9246 kg ECM and 9845 kg ECM respectively in 2012 (VÄXA Sverige, 2013). Among Norwegian producers, approximately 77% had an average herd production level between 6500 and 9499. This might be a slightly low, considering the average production of the NRF (8241 kg ECM) and Holstein (9941 kg ECM), which are the two dominant breeds (Tine rådgivning, 2017).

The low response rate to the questionnaires prompts the need to look into the data material more closely. Where considerable deviations from the real population exist, it is necessary to recognize them and keep these in mind in further analysis. For instance, the high proportion of certified organic herds among Swedish respondents may be important when considering number of respondents in each cluster, as it is possible that the relative sizes of the clusters would change. However, when excluding respondents with certified organic herds, no change of which cluster had the highest and the lowest number of respondents occurred.

Ranking of traits in Norway and Sweden

Looking at statistics from the year of the questionnaire in Sweden in 2012 and in Norway in 2016, the Swedish dairy farms had a higher average number of inseminations per cow (1.9 vs. 1.7), and a higher percentage of culling due to reduced fertility (23.6% vs. 21.2%) (VÄXA Sverige, 2013; Tine rådgivning, 2017). A larger proportion of Swedish respondents also had a higher number of inseminations per female animal. Among the Norwegian respondent approximately 30% had below 1.50 inseminations per female animal, among Swedish respondent this was only true for 10%. The average for the whole population was 1.9 in Sweden and 1.7 in Norway according to the national recording scheme (VÄXA, 2013; Tine, 2017). It could therefore be expected to find that fertility would be ranked higher by Swedish than by Norwegian respondents. However, the Norwegian respondents ranked fertility as a breeding goal trait the highest of all traits, while Swedish respondents ranked it at a medium-high level, giving the highest rank to longevity. Fertility was the most common reason for culling in Sweden in 2012 and in Norway in 2016, and since longevity is a composite trait, a possible explanation could be that the Swedish farmers regarded reduction of culling in general more important than a reduction in fertility-related culling specifically.

The higher ranking of temperament by the Norwegian respondents compared to the Swedish could partly be explained by the fact that 3% of culling in Norway in 2016 was due to unsuitable temperament, while it was at 1% in Sweden in the year of the questionnaire (Tine rådgivning, 2017; VÄXA, 2013). Although the difference is not large, it may be an indication that temperament is perceived as a larger problem among Norwegian respondents. Mastitis and disease resistance was ranked higher by Swedish respondents than Norwegian. As discussed previously, both on a country basis and among the respondents, the Norwegian had lower prevalence of mastitis and disease in general, so this was expected.

Ranking of meat production and carcass classification was different between the two countries. While there was no significant difference in ranking of carcass classification, meat production and parasite resistance in the Swedish respondents ranking, meat production and carcass classification were ranked higher than parasite production by Norwegian respondents. One possible explanation may be the quota-system in place for milk delivery in Norway. Traditionally, dairy farms have been based on a combination of milk and meat production, which still is the situation today (Eldby and Fjellhammar, 2014). Swedish dairy production is regulated by EU-quota, but in later years Swedish milk production has been well below this limit. As such, it no longer affects the amount of milk a farm can sell to the dairies. However, the Norwegian milk production is still under quota regulation, and so if producers wish to increase delivery of milk, they will first have to buy quota. As such, higher meat production and better carcass classification can be a way to increase income without having to embark on further investment.

Although it can be interesting to compare ranking between countries, it is important to keep in mind the interpretation. Understanding respondents' motivation for ranking is in itself a challenge, but it is also necessary to consider confusing factors introduced by countrywide differences.

Cluster descriptions

In the cluster analysis, two clusters with respondents giving a strong preference to milk production was found in both Norway and Sweden. The milk production clusters differed in which functional traits were ranked highest, where the clusters with highest emphasis on health had the fewest number of respondents (MR and in Sweden, MH in Norway). The two milk production clusters with the largest number of respondents (ME in Sweden and MMF in Norway) both had the highest emphasis on temperament of the significantly differently ranked traits. Similarly, Slagboom et al. (2016) found that the production clusters found in a survey on Danish dairy farmer's preference could be differentiated by ranking of categories of functional traits. Martin-Collado et al. (2015) only found one production-based cluster in their study of Australian dairy farmers' preference.

A lower proportion of respondents with certified organic production was found in the Norwegian milk production clusters compared to the clusters FE and RH clusters, where milk production was ranked medium-high and low. These results are contradictory of results found in Slagboom et al. (2016) where Danish production clusters had a higher percentage of farmers with herds certified as organic. They suggested that along with the lower production found in organic herds, the higher milk price was an incentive to farmers to produce more. Opposite of this, Ahlman et al. (2014) found that farmers with organically certified herds had a lower preference for milk production when comparing average ranking, and a general linear model (GLM) analysis of weighting. The authors explained this with the higher milk price opening up for prioritizing other traits, which could also be relevant in this study.

In Sweden, the MR-cluster had the highest proportion of respondents with certified organic herds, which is in agreement with Slagboom et al. (2016). This was somewhat surprising, as the Swedish data used in this study was the same as the data used in Ahlman et al. (2014), where respondents with certified organic herds on average ranked milk production lower than respondents with conventional production, and a GLM analysis of trait weighting showed a similar tendency. However, respondents ranking milk production lower than rank 5 could not see genetic change in milk production and it is uncertain if the weighting of traits would be the same if this was shown. The analysis used in the two studies are also quite different. Ahlman et al. (2014) used a GLM analysis which is focuses on a group. A cluster analysis, as used in this study, is focused on the individual observation. In the raw data, the percentage of respondents with certified organic herds giving milk production the absolute highest preference were the same as for the percentage of farmers with conventional herds (approximately 22%, results not presented in this report), and as such it seems reasonable that a large proportion will fall within a milk production cluster. A final consideration is that the difference in proportion of respondents with organically certified herds was quite small, only about 3%.

The Norwegian cluster “Robustness and health” was the most different from the other Norwegian clusters when it comes to characteristics, with a higher percentage of producer with herds certified as organic (9.4%), higher percentage of herds with less than 25 cows and tie stalls, and a higher percentage of with farmers considering to end the milk production on the farm (11.5%). The ranking of traits by the respondents in this cluster also deviated the most from respondents’ ranking in the other cluster, with a very low ranking of production traits.

In this study, clusters with respondents with a lower preference for milk production also had a higher proportion of respondents with lower milk production level. There were no significant differences in percentage of herd treated for mastitis, or percentage of herd treated for other diseases between respondents in the Swedish clusters, but between respondents in the Norwegian clusters, respondents in "Milk production and Health” had a higher percentage of herd treated for mastitis. Differences were also found for other characteristics such as raising of bull calves and future plans. In Slagboom et al. (2016) respondents tended to be found in clusters with emphasis on improving problematic traits in their herds, suggesting that production-related herd characteristics were important to breeding goal trait preference. Martin-Collado et al. (2015) found no such connections, and concluded that the breeding goal trait preference was intrinsic to the farmer. As such, this study suggest a combination of the two. However, it is important to note that Martin-Collado et al. (2015) and Slagboom et al. (2016) used a pair-wise comparison study in which farmers were asked to compare changes in two traits, and chose which of the two they preferred. Alternatives in the two studies were also formulated differently, where Slagboom et al. (2016) presented scenario alternatives (e.g. higher milk yield and same mastitis prevalence in herd, or same milk yield and lower mastitis prevalence in herd) and Martin-Collado et al. (2015) presented optional alternatives (either higher milk yield or lower mastitis prevalence). In this study, no consequence for other traits were shown in the ranking task, and the final ranking was known to the farmer.

Statistical Analysis

Since the method used in the questionnaire was a forced choice ranking task, the nature of ranking had to be taken into consideration when deciding on statistical analysis to be used. In the case of this study, a principal factor analysis (PAF) was done using polychorric correlations. Polychorric correlations is the recommended method when correlations are used in analysis of ranking data. It compares each pair of trait ranking and combines it into an overall correlation sum, and as such does not rely on equidistance. Using factor analysis is done to reduce the presence of noise introduced by ranking between more or less equally important options. In the case of this study, a PAF was used, as it makes few assumptions on the underlying data set (Costello and Osborne, 2005).

In general, this way of analyzing data necessitates decision making based on the researcher’s understanding of the data rather than absolute rules which can be followed. While precautions were taken to minimize the risks decision affecting the overall result of such methods, it should be noted that the use of factor analysis in the case of ranking data is a matter of discussion (see e.g. Beavers et al., 2013; Baglin, 2014; Van der Eijk and Rose, 2015).

Suggestions

Caution should be taken when making recommendations based on this study. Reasoning behind ranking may vary, and a low-ranking of a certain trait does not necessarily mean that the respondent would accept a deterioration in the current level. To investigate the reasoning behind ranking, and understand the farmers' willingness to accept undesirable genetic changes in other traits, other parts of the data could be studied e.g. weighting simulation in step 3 (Ahlman et al., 2014).

Another consideration is that the traits included were chosen by the researchers, and it is likely that some traits considered important by farmers are missing. When studying answers from step 1 of the Swedish questionnaire, where farmers were asked to name traits without any guidance, Ahlman et al. (2014) found that traits mentioned was included in later steps. However, no such investigation has been done on the Norwegian data, and feedback from respondents suggests that certain traits they find important were not included (e.g. udder conformation).

However, from the results of this study, it is reasonable to assume that milk production has a strong influence on breeding choices. SRB and Holstein have a higher milk yield than NRF, and promoting the exchange and use of these breeds, both in cross breeding as well as pure-breeds, may be beneficial to accommodate the preference of some individual farmers. Considering the difference in preference for milk production may be important when setting future breeding goals, since the NRF's emphasis on milk production has increased in later years.

This study focused on overall-preference independent of breed. However, exploring preferences between respondent with the same main breed, as done by Slagboom et al. (2017), could also be of interest. The size of the data set is in this case a limiting factor, especially in Sweden where a more even distribution of breeds and a smaller sample size makes number of respondents keeping each breed rather small. In the Norwegian data set however, 95% of respondents kept NRF as their main breed, and the data set had a considerably higher amount of observations. This open ups for further investigation using only data on the NRF breed to explore the agreement on breeding goal traits within-breed in Norway.

Conclusion

Clusters of variation in ranking of 15 breeding goal traits were defined using data from a questionnaire sent out to Norwegian and Swedish dairy farmers. When defining clusters, milk production was an important differentiating factor, where the two clusters with the highest number of respondents in each country had either a high or a medium-high ranking. In Norway, the largest cluster was "Fertility and efficiency" with a medium-high ranking of milk production. In Sweden the largest cluster was "Milk production and efficiency" where respondents prioritized milk production as the most important trait.

Some differences were found both for production-, herd- and farm-related characteristics of respondents between clusters, but many did not seem to affect cluster designation. This implies that preference for breeding goal traits among Swedish and Norwegian respondents to some extent is based both on personal values and on herd- and production-related criteria.

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Appendices

Questions from Step 5 of the questionnaire

Appendix 1. Questions included in both questionnaires.

<table>
<tr><th></th><th colspan="2">English</th><th colspan="2">Swedish</th><th colspan="2">Norwegian</th></tr>
<tr><td rowspan="2">1</td><td colspan="2">State the number of year cows in the herd during the previous year (kontrollår):</td><td colspan="2">Ange antalet årskor i besättningen under det föregående kontrollåret:</td><td colspan="2">Angi antall årskyr i besetningen i 2013:</td></tr>
<tr><td></td><td>Do not know/unsure</td><td>- 1-24
- 25-49
- 50-99
- 100-149
- 150-199
- 200-299
- 300-</td><td>Vet ej/ingen uppfattning</td><td>- 1-24
- 25-49
- 50-99
- 100-149
- 150-199
- 200-299
- 300-</td><td>Vet ikke/ingen formening</td></tr>
<tr><td rowspan="3">2</td><td colspan="2">Which is the most common breed in the herd?</td><td colspan="2">Vilken är den vanligaste rasen i besättningen?</td><td colspan="2">Hvilken rase er mest vanlig i besetningen?</td></tr>
<tr><td>Swedish breeds</td><td>Norwegian breeds</td><td colspan="2" rowspan="2">- SLB
- SRB
- SJB
- SKB
- Halften SLB/SRB
- Annan ras</td><td colspan="2" rowspan="2">- NRF
- Holstein
- Jersey
- STN
- Annen</td></tr>
<tr><td>- Swedish Holstein (SLB)
- Swedish Red (SRB)
- Swedish Jersey (SJB)</td><td>- Norwegian Red (NRF)
- Holstein
- Jersey
- Sida Trønder- og Nordlandsfe (STN)</td></tr>
</table>

<table>
<tr><td></td><td>- Swedish Culled (SKB)
- Other</td><td>- Other</td><td></td><td></td></tr>
<tr><td rowspan="2">3</td><td colspan="2">Production level during the previous year:</td><td>Produktionsnivå under det föregående kontrollåret (kg ECM):</td><td>Produktionsnivå under det föregående kontrollåret (kg ECM):</td></tr>
<tr><td colspan="2"></td><td>- < 7499
- 7500-8499
- 8500-9499
- 9500-10499
- 10500-11499
- > 11500</td><td>- < 4499
- 4500-5499
- 5500-6499
- 6500-7499
- 7500-8499
- 8500-9499
- 9500-10499
- 10500-11499
- > 11500</td></tr>
<tr><td>4</td><td colspan="2">Calving interval during the previous year:</td><td>Kalvningsintervall under det föregående kontrollåret (månader):</td><td>Kalvingsintervall (måneder) i 2013:</td></tr>
<tr><td>5</td><td colspan="2">Number of inseminations per female animal during the previous year:</td><td>Antal insemineringar per hondjur under det föregående kontrollåret:</td><td>Antall insemineringer per dyr i 2013:</td></tr>
<tr><td>6</td><td colspan="2">Proportion of cows treated for mastitis during the previous year (%):</td><td>Andel kor behandlade för mastit under det föregående kontrollåret (%):</td><td>Andel kyr som ble behandlet for mastitt i 2013 (%):</td></tr>
<tr><td>7</td><td colspan="2">Proportion of cows treated for other diseases during the previous year (%):</td><td>Andel kor behandlade för övriga sjukdomar under det föregående kontrollåret (%):</td><td>Andel kyr som ble behandlet for øvrige sykdommer i 2013 (%):</td></tr>
<tr><td rowspan="3">8</td><td colspan="2">What do you do with the bull calves?</td><td>Hur gör ni med tjurkalvarna?</td><td>Hva gjør dere med oksekalvene?</td></tr>
<tr><td>Swedish</td><td>Norwegian</td><td rowspan="2">- Säljer dem
- Föder upp dem till slakt
- Föder upp en del av dem till slakt och säljer de övriga
- Avlivar direkt</td><td rowspan="2">- Selger dem
- Fôrer dem til slakt
- Fôrer noen av de til slakt og selger resten</td></tr>
<tr><td>- Sell them
- Raise for slaughter
- Raise some for slaughter</td><td>- Sell them
- Raise for slaughter
- Raise some for slaughter</td></tr>
</table>

	and sell the rest - Euthanize | and sell the rest		
9	Which housing system is used?	Vilket inhysningssystem används? Ange det system som majoriteten av mjölkkorna finns i.	Hvilken type fjøs har du?
	- Tied stall - Free stall with milking parlor or carrousel - Free stall with robot	- Uppbundet - Lösdrift med mjölkgrop eller karusell - Lösdrift med robot	- Båsfjøs - Løsdrift med melkegrav eller karusell - Løsdrift med robot
10	Average proportion of roughage in the feed ration %:	Genomsnittlig andel grovfoder i foderstaten (%):	Gjennomsnittlig andel grovfôr i fôrrasjonen (%):
11	Duration of pasture period (weeks):	Betesperiodens längd (veckor):	Lengde på beitesesongen (uker):
12	Time at pasture per 24 hrs during the pasture period?	Tid på bete per dygn under betesperioden (timmar):	Tid på beite per døgn i beitesesongen (timer):
13	Do you take part in the recruitment of heifers in the herd?	Är du delaktig i rekryteringen av kvigor i besättningen?	Er du med å bestemme rekruteringen av kviger i besetningen?
	- Always - Often - Sometimes - Never	- Alltid - Ofta - Ibland - Aldrig	- Alltid - Ofte - I blant - Aldri
14	Do you take part in the choice of bulls?	Är du delaktig i valet av tjurar?	Er du med å bestemme valg av okser?
	- Always - Often - Sometimes - Never	- Alltid - Ofta - Ibland - Aldrig	- Alltid - Ofte - I blant - Aldri
15	Is insemination always used in the herd?	Används alltid semin i besättningen?	Benyttes alltid inseminering?
	- Yes, only insemination is used | - Do not know/unsure	- Ja, bara semin används | - Vet ej/ingen uppfattning	- Ja vi bruker kun inseminering | - Vet ikke/ingen formening

	- No, we have some natural mating	- Nej, naturliga betäckningar förekommer	- Nei, vi har noe naturlig bedekning
16	Which of the following statements is the most accurate with your future plans with milk production?	Vilket av nedanstående påståenden tycker du passar bäst in på dina framtidsplaner med mjölkproduktionen?	Hvilken av påstandene synes du passer best inn i din fremtidsplan med melkeproduksjon?
	- Continue and develope - Continue in present form - Considering to end production - In the process of ending production	- Fortsätta och vidareutveckla - Fortsätta i nuvarande form - Överväger att avbryta - Håller på att avsluta	- Fortsette og videreutvikle - Fortsette i nåværende form - Vurderer å legge ned - Holder på å legge ned
17	Which of the following advisory services are regularly used in the herd? More alternatives can be chosen.	Vilken/vilka typer av rådgivning anlitas regelbundet i besättningen? Flera alternativ kan kryssas i.	Hvilken/hvilke typer rådgivning bruker du regelmessig i besetningen? Flere alternativ kan avkrysses:
	- Production advisors - Veterinary advisors - Breeding advisors - Other animal-related advisors - No animal-related advisors - Do not know	- Produktionsrådgivning - Veterinärrådgivning (t.ex. via Svenska Djurhälsovården) - Avelsrådgivning - Annan djurrelaterad rådgivning - Ingen djurrelaterad rådgivning anlitas - Vet ej	- Produksjonsrådgivning - Veterinærrådgivning - Avlsrådgivning - Annen dyrerelatert rådgivning - Ingen dyrerelatert rådgivning benyttes - Vet ikke/ingen formening
18	Is the milk production certified according to any of the following regulations?	Är mjölkproduktionen certifierad enligt något/några av följande regelverk? Flera alternativ kan kryssas i.	Er melkeproduksjonen sertifisert ifølge noen eller flere av følgende regelverk? Flere alternativ kan avkrysses:
		- Svenskt Sigill - KRAV - EU:s regelverk för ekologisk produktion - Annat regelverk - Besättningen är inte certifierad enligt något regelverk	- Debio - Demeter - Annen - Besetningen er ikke sertifisert i følge noe regelverk

19	What is your role at the farm? You can choose more than one alternative.		Vilken roll har du på gården? Du kan markera flera alternativ.	Hvilken rolle har du på gården? Du kan markere flere alternativ:
	- Owner/tenant - Manager - Animal keeper - Other		- Ägare/arrendator - Driftsledare - Djurskötare - Annan	- Eier/forpakter - Driftsleder - Røkter - Annet
20	When are you born?		När är du född?	Når er du født?
21	Are you…?		Är du...?	Er du..?
	Swedish	Norwegian	- Kvinna - Man	- Kvinne - Mann - Annet
	- Female - Male	- Female - Male - Other		

Appendix 2. Additional questions Norwegian questionnaire.

Category additional question	**English**	**Norwegian**
Production	What is the average number of lactation in the herd?	Hva er gjennomsnittlig laktasjonsnummer i besetningen?
Pasture	Do you feed additional roughage in the pasture period?	Fôrer du grovfôr i tillegg i beitesesongen?
	- Always - Sometimes - Never	- Alltid - Noen ganger - Aldri
Reproduction	Which proportion of the herd is naturally serviced?	Hvor stor andel av besetningen pares naturlig (%)?