Comparison between dual-purpose and specialized dairy cattle in pasture-based systems:

change in body condition, locomotion score and cleanliness from summer to winter season

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Abstract:

This study is an exploratory research comparing the changes of body condition score, locomotion score and cleanliness score between pasture and indoor season in purebred Dutch Friesian, 75% Dutch Friesian, 50% Dutch Friesian, Holstein Bakels and Brown Swiss dairy cattle. The dual-purpose cows were expected to cope better with a change in season and harsher environmental conditions compared to specialized dairy cows. Therefore it was expected that the body condition of the dual-purpose cows would be closer to the optimum or even higher and would barely change over season. The specialized dairy cows were expected to cope less well on pastures and during a change of season, with a body condition under the optimum, higher prevalence of lameness and more dirt on the skin, compared to the dual-purpose breeds. Twenty-seven Holstein Bakels cows represented the specialized dairy breed in this study. The dual-purpose cows were represented by fifteen Brown Swiss cows and fifty-two purebred and crossbred Dutch Friesian cows. The Holstein Bakels and Brown Swiss cows were kept at a Polish bio-dynamic farm with an open barn housing concept and a low concentrate feed diet. The purebred and crossbred Dutch Friesian cows were housed at one organic and one conventional farm at different locations in the Netherlands. Body condition score was the highest (just above optimal) for the Dutch Friesian cattle compared to all other breeds and the Holstein Bakels and Brown Swiss breed scored the lowest (under the optimal score). A negative correlation between body condition and locomotion score, as well as a positive correlation between body condition and hygiene score was found. This shows that skinny individuals are more prone to lameness, but not necessarily dirtier. Severely fat individuals show less incidences of lameness, however they are more often covered with dirt. Milk yield was the highest for 50% Dutch Friesian, followed by 75% Dutch Friesian and Dutch Friesian, probably due to the amount of Holstein Friesian genes. The Holstein Bakels and Brown Swiss breed underperformed for milk yield. This shows that the dual-purpose breed Dutch Friesian can cope better with harsher environmental conditions of pasture based systems than more specialised dairy breeds like the Holstein Bakels. Furthermore, the Brown Swiss breed could be considered more as a specialized dairy breed than a dual purpose breed. Change over season might be more dependent on housing, feed quality and quantity and management than genotype.

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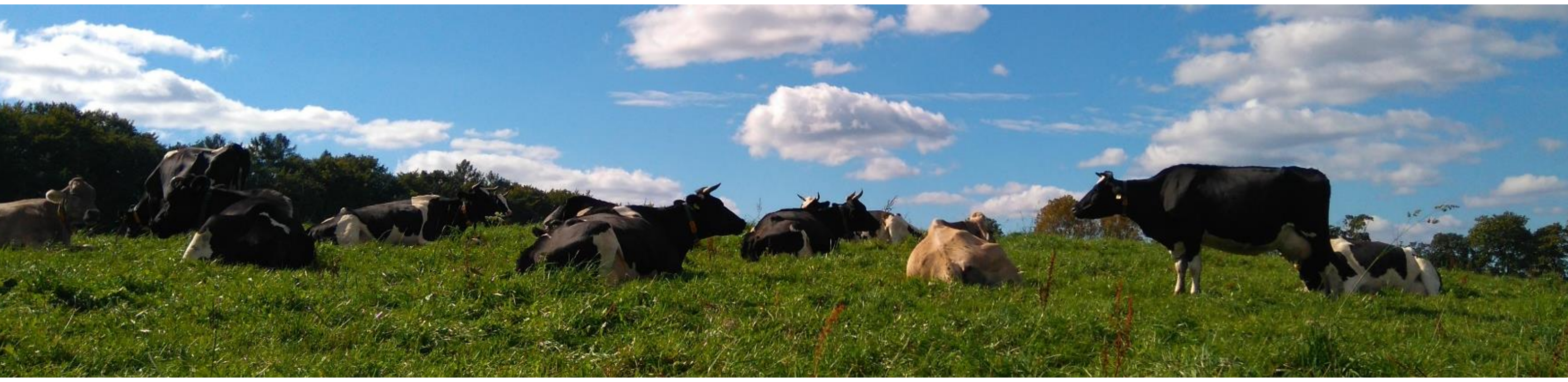

Introduction:

The use of dual purpose (meat and milk) cattle breeds is as old as the domestication of the cow itself (3000 years B.C.)(Howard, 1961). In harsh weather conditions and extensive farming systems it is important that the cow can survive on the amount of nutrition it can find in the field. The amount of energy that is necessary for milk production and body maintenance has to be in balance. Not only the cow, but also the farmer in the old days would have a benefit from the cow if it produced enough milk to support his family and would still have a good meat quality and quantity when slaughtered. It was not until after World War II that farms in Europe grew rapidly in size and started to specialize and intensify with dairy cattle and milk production (Theunissen, 2012). Breeding was focused on high milk yield and other traits, as longevity and resilience were compromised for this choice (Oltenacu and Broom, 2010). To reach the high production demands and the optimal milk production of these new dairy breeds, quality of housing and management had to be accommodating. Therefore the system is adapted to maintaining high milk yield with a lot of external inputs (concentrates, artificial fertilizer). In organic production, however, local environmental and ecological factors are more important and change towards a higher production yield is not the main aim. It is the challenge to make a functioning system with the land that belongs to the farm without the import of concentrates or medicine. Therefore the cattle used in organic farming should fit within and be able to cope with the existing system at each farm. From this point of view the use of local cattle breeds, that are often dual-purpose breeds, is interesting, since these breeds are already adapted to the local climate and feed quality as it is in the region (Baars and Nauta, 2001).

In the Netherlands, local breeds (e.g. Dutch Friesian, Groninger Whitehead and Maas-, Rijn- and Ijssel cattle (MRY)) got outcompeted by the Holstein Friesian cattle. Although the Dutch local breeds are the foundation of the Holstein Friesian cattle, it was the high selection for milk yield by American farmers that created this new breed. Nowadays 95% of the intensive herds in Europe consist of Holstein Friesian cattle. About 83% of the European dairy production systems are intensive farming systems (Arendonk and Liinamo,2003). These intensive farming systems can be recognised by their "high input : high output" characteristics. Stocking density is usually higher, they use more artificial fertiliser on the field, feed composition is based on large amounts of maize silage, concentrates and other additives, calving is all year round and cows stay inside the barn more days of the year compared to more extensive farming systems. All these characteristics are aimed at a high milk yield (Arendonk and Liinamo, 2003).

When high milk yield cow breeds are placed in low-input systems (summer mountain pasture) they are not able to cope with the situation (Horn et al., 2013). This is noticeable through a lower milk production and worse recovery from a negative energy balance after calving. In a research of Horn et al. (2013), comparing a high Austrian Brown Swiss breed and a Holstein Friesian strain selected for longevity on summer mountain pastures with different concentrate levels, he found that the Austrian Brown Swiss produce on average 1000 kg less milk per lactation when compared to housing in an intensive farming system. When fed a lower amount of concentrates while in the summer pasture the average milk performance dropped by another 720 kg per lactation. The Holstein Friesian cows selected for longevity in comparison only lost 450 kg per lactation when fed with less concentrates in the same system. Zendri et al. (2016) found similar results when he compared specialized breeds Holstein Friesian and Brown Swiss to dual purpose and local breeds on summer pastures. The negative energy balance produced a very steep drop in milk production for the specialized breeds. Even though the Holstein Friesian breed started out with a higher milk production at the start of the summer, at the end of the summer milk production was comparable to the local and dual-purpose breeds. So for organic production systems these specialized breeds, like Holstein Friesian and Austrian Brown Swiss, are not the best choice. When high yield dairy breeds cannot show their full potential, the benefit of using these breeds disappears. Other traits that might outlast the suboptimal situation, like longevity and durability of production, are not present in these breeds. This is due to the breeding goal focussed only on high milk production. The breeding goal of dual purpose and local breeds often contain traits that improve reproduction, health and durability. These breeds selected for feed efficiency, fertility and health are more adaptive to harsher conditions (Hiemstra et al., 2010). Therefore they are expected to be more suitable for pasture based farming systems.

2-ORG-COWS is an international research project concerned with the adaptation of breeds towards the organic dairy farm. The question addressed in the project is whether and how current dairy cattle breeding goals can be reformulated, or locally adapted breeds can be utilized to make the dairy cattle fit into the existing organic system. Functionality, robustness and longevity are key traits to be aimed for. Through the use of dual purpose breeds and selection on these key traits it is expected that production can increase while making use of local produced feed and grazing under harsh conditions. To increase functionality for the farmer and the use of local feeds the aim is to breed for a cow that has advantages in a pasture based system (harsh environmental conditions in term of climate and feed quality) compared to the specialized dairy breeds. As part of this comparison phenotypic health and welfare traits (body condition, locomotion and hygiene) are measured in this study.

Body condition score can be defined as a tactile or visual assessment of the subcutaneous fat and muscle components compared to non-fat components of the body. Body condition score and its change over time reflect the energy reserves (Roche et al., 2009). Spengler Neff (2011) conducted a thesis to find new health related traits. She found that there was a positive correlation between body condition score and the general health score of the cows ($r > 0.340$). For body condition score range she found a negative correlation to the general health score ($r = -0.323$). This implies that body condition score evaluation can be used as part for the welfare status of the cow, next to good housing, good feeding and the opportunity to show appropriate behaviour. In this study we use a scale from 1 to 5 for dual purpose cattle, where 1 stands for an emaciated cow and 5 is associated with obesity (Spengler Neff et al., 2015).

Even if a body condition score is of a different scale the optimal score is always somewhere in the middle. Having a body condition score that is too low (emaciated) or too high (obese) can cause many problems. Gillund et al. (2001) looked at the interaction of body condition score and the occurrence of ketosis. They found that a high body condition score (3.50 on a five-point score) at calving increased the probability to get ketosis 2.5 times compared to cows that had a body condition score of 3.25 or lower at calving. Hoedemaker et al. (2009) showed in their research with Holstein Friesian, that cows that are too thin at calving and during early lactation had a higher incidence of health and reproductive problems compared to cows with an optimal body condition score or higher at calving and during early lactation. Also cows with no body condition score loss antepartum encountered less health and reproductive problems than cows with a body condition score loss higher than 0.25 antepartum.

The second welfare trait looked at in this study is the locomotion score. The locomotion score is a scoring system based on the judgement of the gait of the cow. Lameness is regarded as a major welfare problem for dairy cows and is used as an early indicator for cow health problems (Von Keyserlingk et al., 2009). The severity of the lameness is what determines the score. In this study we used the system developed by Zinpro which makes use of a five point scale ranging from no impaired walking to severely lame. The posture while standing and the stride when walking are the main determinants of the score. Score point two implies a slightly abnormal gait. From score point three onwards the cow stands and walks with an arched back. From score point four onwards the cow actually favours certain legs and the term lame is used in this scoring system. Lameness can occur for several reasons. One of the main reasons for moderate lameness is the material used for and the cleanliness of the surface for walking, and bedding in the stable. Cook and Nordlund (2009) mention that moderately lame cows change their time budget behaviour when they are housed with hard mattress stalls compared to cows housed with sand as bedding. The cows with hard floor bedding almost halved their stall use sessions per day and reduced their lying time from twelve to ten hours a day. Cows also change their time budget when they are in the pasture. This however, does not lead to locomotion problems. In the research of Hernandez-Mendo et al. (2007) they found that a four week period in the pasture can improve locomotion. Next to the influence of floor and bedding material, some other factors influence lameness. One of these factors is the body condition score. Cows with a lower body condition score status have a higher incidence of lameness than cows with a higher body condition score. Cows with an antepartal loss of body condition score had a higher incidence of lameness than cows with no or low body condition score loss (Hoedemaker et al., 2009). The impairment on the locomotion of the cow might cause pain during standing, walking or when rising from a lying position. This might lead to a lower amount of feeding bouts, which might also influence the body condition score over a longer period of time.

A change from outdoor pasture to indoor barn brings along a big change in environment. The amount of free space will probably go down and walkways are no longer a free choice. Because of this restriction in space in the barn, encounters among cows are more frequent. This may lead to more psychological and physical stress when trying to avoid conflict. Another change is the hygiene of the environment when enclosed in a more confined space. Although most farms have regular cleaning of these floors through the use of manure scrapers or robots, it is still the same place as the cows have to walk through and stand on all day. The contact between the cow and the manure is more frequent than in the pasture. Wet, hard flooring (such as dirty slatted flooring) is more prone to incidents that cause lameness compared to dry and softer or more flexible flooring (such as rubber, sand, straw and the grassland of a pasture) (Hernandez-Mendo et al., 2007). Through the increased contact with manure and dirt the amount of exposure to bacteria also increases. Injuries of the hoof are therefore more prone to infection. The dirt and bacteria are also carried into the free stalls and come into contact with other body parts, for instance the udder. Hygiene scores are just a rough indicator for the amount of bacteria at the surface of the observed object. This is because even seemingly clean areas can contain plenty of harmful bacteria for certain infections (Cook, 2002). Research by Barlett et al. (1992) has also found a positive link between the amount of dirt on the udder and hind legs, the amount of bacteria present at the udder, and the prevalence of udder diseases such as coliform mastitis (Bartlett et al., 1992). In this study cleanliness scores for the upper hind leg and the udder were used as indicators for the hygiene of the cows and their surroundings. With an interest in increasing the health and yield of cows on extensive farms, we will look to compare the body condition, locomotion and hygiene of the cows considering the individual differences between the farms in this project.

The aim of this study is to compare body condition, locomotion and cleanliness of the cow between different dual purpose breeds and specialized dairy breeds, during the transition from pasture to indoor season in several European pasture based farming systems. It is expected that the dual-purpose cows will cope better in the pasture when exposed to local climate conditions and with lower feed quality, compared to specialized dairy breeds. Furthermore, it is expected that dual purpose cows are better able to cope with change from the pasture to the barn, than specialized dairy breeds. This information leads to the following hypotheses; the dual purpose breeds Dutch Friesian and Brown Swiss will have a better (median) body condition score, show less locomotion problems, and show less increase in the latter, both in the pasture and after change into the barn compared to a specialized dairy breed, such as the Holstein Bakels cattle. Furthermore; overall cleanliness will be better (lower) for all breeds during the pasture season compared to the indoor season.

Materials and methods:

For this study three farms were available for data collection. These farms were already participating in other trials from the overall “2-ORG-COWS” project and therefore were readily accessible. It concerns two Dutch dairy farms (Mts. Lozeman and Mts. Bosma) and one Polish dairy farm (Juchowo Farm). During the period of this study only grass related measurements were conducted at the two Dutch farms. At Juchowo farm there was an ongoing study regarding the activity measurements of the “SenSoor” system on grazing cattle. The measurements for this study were purely based on field observations of body condition, locomotion and cleanliness, the cows were not subjected to any invasive measurements during the process.

Participating farms

Mts. Lozeman is an organic Dutch dairy farm situated in Amersfoort (Gelderland) in the central part of The Netherlands. They have about 10 hectares available for grazing pasture and 9.5 hectares for the production of silage and fodder crops. On average they have about 50 cows that are in lactation. The largest part of the herd exists out of pure bred Dutch Friesian cattle. Some part, however, is mixed with British Friesian cattle to prevent a high degree of inbreeding within the herd. Milking was done once early in the morning and once in the evening. On average the cows got three kilograms of concentrates per day. The concentrates were provided through automatic feeding stations and during the milking process. The amount of concentrates given to a cow per day was regulated per cow. In the pasture season there was also a small amount of silage available. During the barn season a mixture of silage and beetroot were fed in addition to the concentrate feed.

Mts. Bosma is a conventional Dutch dairy farm situated in De Wilgen (Friesland) in the northern part of The Netherlands. They use approximately 40 hectares of grass for production of silage and as grazing pastures. On this farm they have Dutch Friesian, Holstein Friesian and several mixed animals of these breeds. On average they have 100 cows in lactation. In the pasture season the cows went outside for approximately 6 hours a day. Milking took place once in the morning and once in the evening. During the hours inside the cows got on average an additional three kilos of concentrates a day. The concentrates were provided through the use of automatic feeding stations and partially during the milking process. The amount of concentrates given to a cow per day was regulated per cow. In the barn season they got some extra concentrates, of which an extra kg soy, an extra kg German beet pulp and about four kg brewers’ grain. This was provided next to the daily supply of roughage of silage and maize.

Juchowo Farm is a Bio-dynamic Polish dairy farm situated in Juchowo (West Pomeranian) in the North-Western part of Poland. The whole farm includes 1900 hectares of ground. This modern company has on average 300 hundred cows in lactation. They use purebred Brown Swiss and Holstein Bakels cattle. Holstein Bakels is a strain of Holstein Friesian cows selected for robustness and durability of life. The cows are housed in 3 herds of approximately 100 cows per group. The groups are divided by days in lactation, therefore cows change groups at a regular basis. All cows have horns, only if a cow is aggressive the tip of the horns is removed. The cows got some additional concentrates immediately after the milking process, once in the morning and once in the evening. The first few weeks indoors the cows were fed fresh cut grass. When the fresh cut grass was no longer available hay, silage and beetroot became the main food source.

In total 94 animals were observed during the 4 month period in the fall season of the year 2016 (Table 1). The breed categories 100%, 75% and 50% Dutch Friesian, with 32, 15 and 5 cows respectively, were all from the Dutch farms. Mts. Bosma had a lower amount of observed cows compared to their amount of cows in lactation due to the fact that of all observations only a small group of cows were observed at every consecutive measurement moment. Only those nineteen cows were considered for comparison. The breed categories Holstein Bakels and Brown Swiss contained 27 and 15 cows respectively observed for four consecutive measurement moments in this study.

Table 1: Number of cows per breed category per farm.

	100% Dutch Friesian	75% Dutch Friesian	50% Dutch Friesian	Holstein Bakels	Brown Swiss
Mts. Lozeman	20	11	2		
Mts. Bosma	12	4	3		
Juchowo farm				27	15

Grazing management on the farms

In the months September and October the cows went outside during the day to graze. Mts. Lozeman would keep the cows in a separate field during the night. Mts. Bosma and Juchowo farm would keep the cows indoors during the night. In general the cows of Juchowo farm had to walk further to reach the pasture and had access to larger fields than the cows in The Netherlands. In November and December the cows were housed indoors.

Housing of cows in lactation

Mts Lozeman:

The barn for the lactating cows consists of two corridors mirrored to each other. Each corridor has a feeding fence on one side and free stalls on the other side. There are more spaces at the feeding fence and free stalls available than the amount of cattle housed in the barn. The space between a feeding cow at the fence and the free stalls behind it is still broad enough for other cows to pass by. The free stalls are deep and filled with dried horse manure mulch as bedding. The corridors are equipped with a manure scraper to rid the slatted floor of excess manure. For cow comfort there is an automated cow brush available. There are several large drinking troughs available and there are three individual concentrate feeding stations accessible for the cows.

Mts. Bosma:

The barn for the lactating cows has a rectangular shape. One of the long sides on this rectangle consists completely out of the feeding fence. There are slightly less feeding places at the fence than there are cows in the barn. The other long side of the rectangle consists mostly out of free stalls. In the middle part of the barn there are two islands of free stalls, one with a single row of free stalls and one with two rows of free stalls facing each other. The free stalls are flat concrete topped with a rubber mat (Figure 1). The corridors between feeding cows and free stalls are mostly broad enough to pass with two cows next to each other. The automated manure robot cleans the slatted floor in the corridors. For cow comfort there are two automated cow brushes available. There are three large drinking troughs available and four individual concentrate feeding stations accessible for the cows.

Juchowo farm:

Each group of approximately a hundred cows is housed in a similar barn. This barn consists out of two long rectangular parts next to each other. The first part is covered by a roof and contains the deep free stalls filled with a thick layer of straw (Figure 2). Both long sides of the barn are half open and one side is covered with a wind protection mesh. The corridor between the two rows of free stalls has a rubber floor and is cleaned by a manure scraper. In the passages from the first to the second part of the barn you can find several individual drinking spots and two large drinking troughs. There are also several mineral blocks and two cow brushes available for extra cow comfort. The second part of the barn is partially without a roof. This is a large open area with a rubber floor also cleaned by a manure scraper. The long side that is furthest away from the free stalls is covered by an overhanging roof above the feeding fence. There are a few more feeding places than there are cows per group.

A general sketch of the layout from all three farms can be found in Appendix 1. figure 15.

Figure 1: Example of the flat concrete free stalls topped with a rubber mat (it is white because of a thin layer of saw dust to absorb moisture) and a corridor with a slatted floor at Mts. Bosma

Figure 2: Example of the deep litter free stalls filled with straw and corridor with rubber coated floor at Juchowo farm.

Data collection

In this research three specific variables have been gathered directly related to the cow (e.g. body condition, locomotion and cleanliness). The measurement methods of these three variables are copied from the overall project of “2-ORG-COWS” on which this study is based. The skills to conduct the measurements are acquired from other project partners. During a five day visit to the project partners in Germany, the Research Farm Frankenhausen, belonging to the University of Kassel, was visited. At the farm the explanation was given for the conducting of the measurements. For the first few cows assessment was done together with the project partner. Later cows were assessed by everyone individually and scores were compared afterwards to come to method good inter-observer reliability. This provided the possibility for a correct comparison between the collected data of different countries and partners for future research questions of the overall project. The body condition score (BCS), the locomotion score (LS) and the hygiene or cleanliness score (HS) are always measured together at the same day of observation. All three scores were measured by the same person at every measurement. For the correct registration of cow-ID and to reduce searching time for missing cows an assistant was present at most measuring days.

Observation days per farm were preferably planned with one month in between measurements. Appointments were made with the farmers and due to practical reasons appointments could not always be made exactly one month between measurements. For Mts. Lozeman the observation dates were September 8th, October 6th, November 9th and December 6th 2016, with respectively 28, 34 and 27 days in between measurements. For Mts. Bosma the observation dates were September 16th, October 21th, November 21th and December 19th 2016, with respectively 35, 31 and 28 days in between measurements. For Juchowo farm observation dates were September 20th, October 12th, November 15th and December 13th 2016, with respectively 22, 34 and 28 days in between measurements. A schematic timeline of the observation dates can be seen in figure 3.

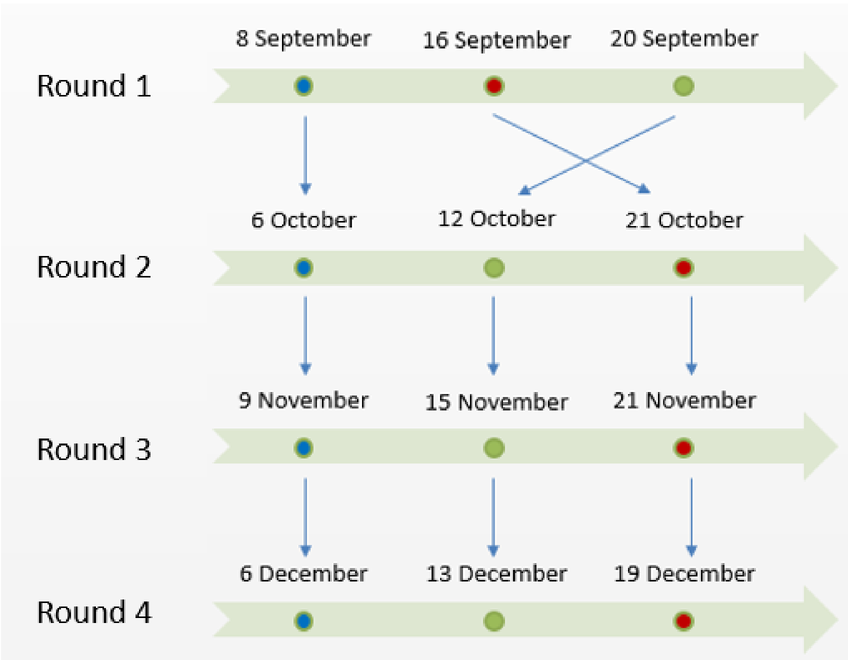

Figure 3: Schematic timeline of days of observation during farm visits. The three farms have a different coloured dot. Mts. Lozeman is orange, Mts. Bosma is blue and Juchowo farm is green. The date above or below the dot is the day of observation at the farm corresponding to the dot colour.

Body condition score was measured with the scale developed for dual purpose cattle by FiBL Research Institute of Organic Agriculture (Spengler Neff et al., 2015). The assessment is based on the visible subcutaneous fat of the cow, which is assessed by visual assessment and by feeling the cow’s body (Figure 4). Starting with the side view of the rear end of the cow and followed by a view from the back of the cow the amount of fat and muscle on and between the pin bone, the greater trochanter of the femur, the hook bone, the transverse processes of the spinal vertebrae, the sacral ligament and the tail head ligament are judged by means of drawings and descriptions on the score chart. The amount of subcutaneous fat is an indication for the cow’s energy reserves (Roche et al., 2009). To judge the condition of the cows in a similar manner all cows were judged inside the barn at the feeding fence. If for some practical reason it was not possible to retain a cow at the feeding fence, than this cow was judged when standing still on a flat surface. The body condition score is a 5 point scale ranging from < 2.00 to 5.00 with fourteen steps of 0.25 points. In this range 3.00 is the optimal score for the body condition. Scores below the 2.75 indicate that the cow is thinner than the optimal score (less than 2.00 would be emaciated). Scores above the 3.25 indicate that the cow is fatter than the optimal visual body condition score (more than 4.50 would be obese).

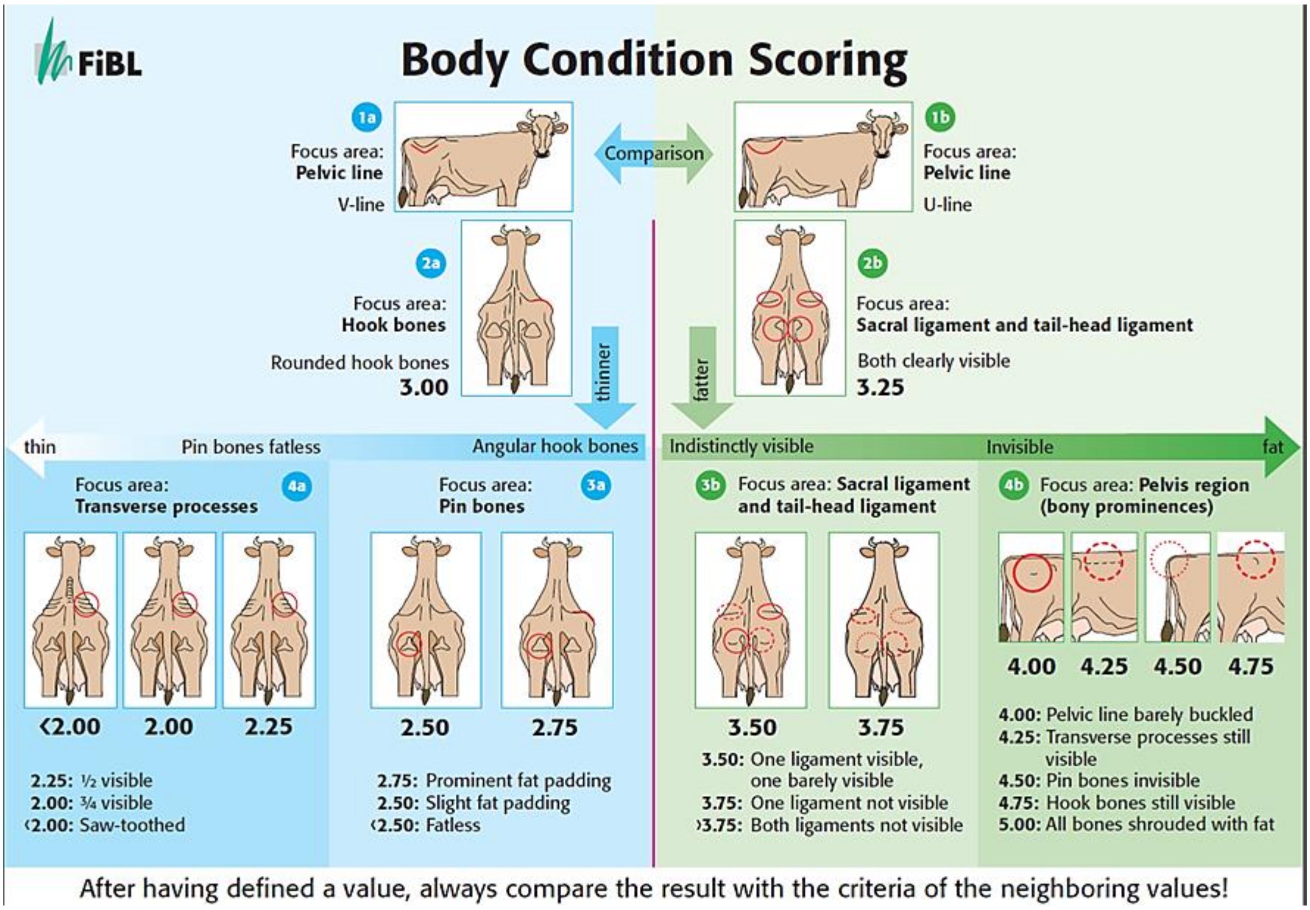

Figure 4: Score chart for body condition score developed by FiBL research institute of organic agriculture. The top part of the figure shows pictures of the optimum score conditions (3.00 and 3.25). The numbers mentioned with the pictures of the cows are the scores assigned to the body condition each picture represents. The blue arrow from the centre to the left of the figure shows reduction of visible subcutaneous body fat with the decrease of every score that can be assigned below the optimum score (<2.00 is emaciated). The green arrow from the centre of the figure to the right shows the increase of subcutaneous body fat with the increase of every score that can be assigned after the optimum score (>4.50 is obese). The bones or ligaments highlighted in each picture are mentioned beneath or next to each picture.

The locomotion score was measured with the score chart of the Dairy Lameness Assessment and prevention Program, from Zinpro, called The First Step®. This is a five point scale where a score of one indicates no lameness or impaired walking and a score of five indicates severe lameness. Locomotion scoring by means of this score chart is based on the observation of cows standing and walking (gait), with special emphasis on their back posture (the straightness or curve of the spine), both while standing still and while walking (Figure 5). To conduct locomotion measurements, the cows that were locked in the feeding fence for body condition and hygiene measurements were released one by one. After release the cow was ushered down a path with a flat surface and observed during its walk. The observation was successful if the cow could be observed for 15 meters without interruption at a normal walking pace.

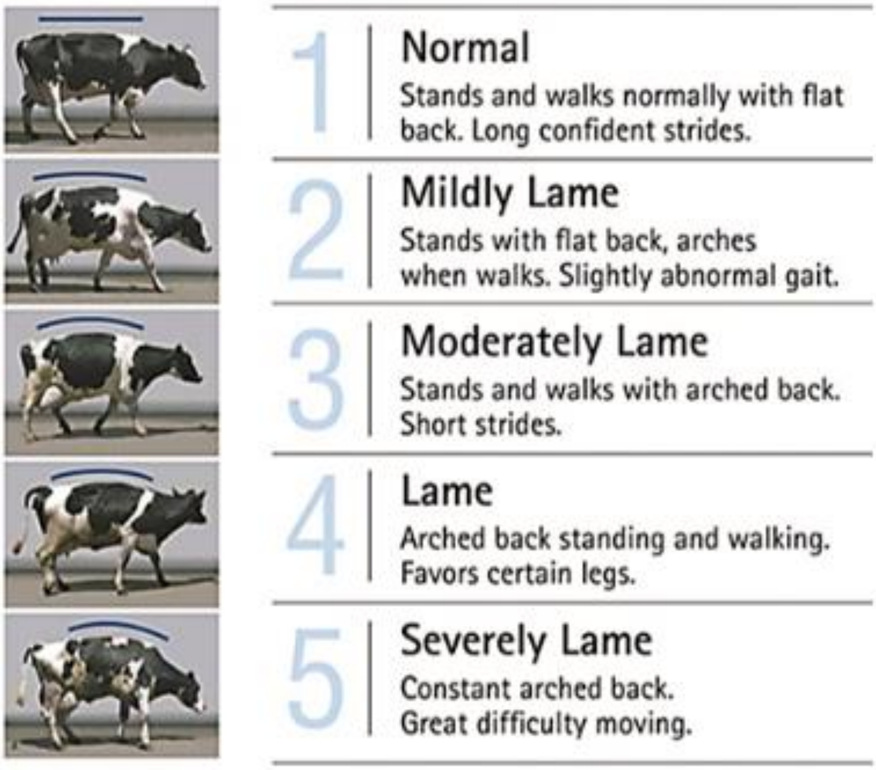

Figure 5: Score chart for locomotion score, developed by Zinpro. Score 1-5 represent the lameness increase from a normal to severely lame gait. Gait score is based on visual assessment of the cow in a standing position and while walking. Mainly the stride and the straitness or the arch of the back determine the score that will be assigned.

The cleanliness score was measured with the five point scale developed by Reneau et al. (2005). The score is assigned by the visual observation by the observer. In this study only the udder and hind leg portion were considered for observation. Udder includes fore and rear udders, and udder floor and teats. The hind leg portion includes the area around the tail head and the upper rear limb down to the hock point on both sides of the cow. On this five point scale a score of one indicates no presence of dirt and a score of five indicates that the whole surface is covered with dirt (Figure 6). The cleanliness score was observed immediately after the body condition score per cow, before the cow was released from the feeding fence.

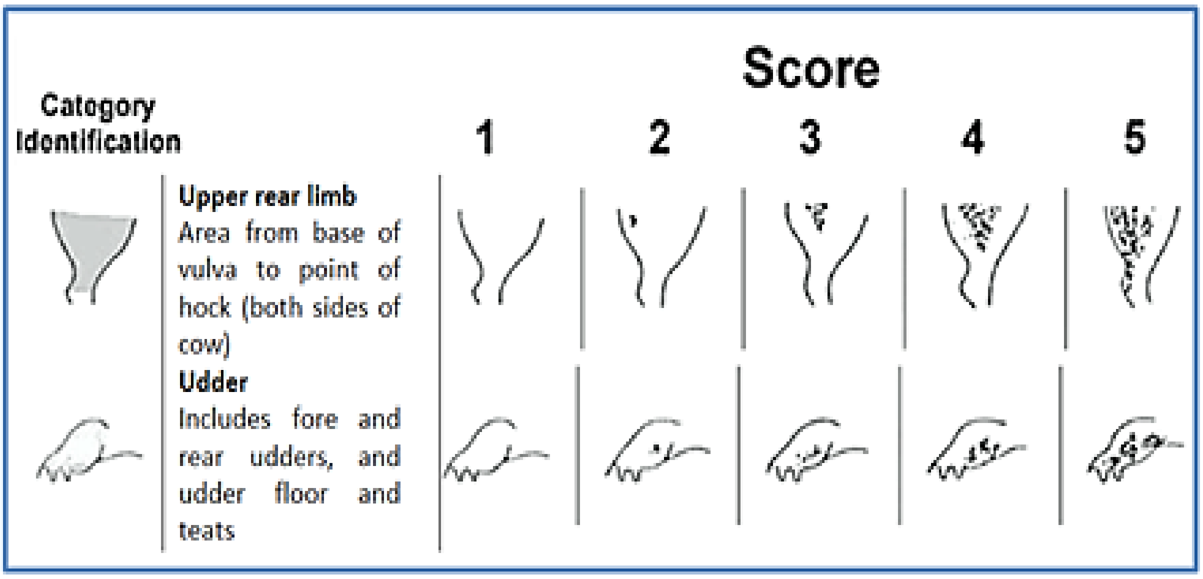

Figure 6: Score chart hygiene scores, developed by Reneau et al. (2005). On the left side of the figure the description of the observed areas is visible. From left to right the scores 1-5 represent the increase of dirt on the observed areas from no dirt present to completely covered with dirt.

Milk yield data

Milk samples were collected every month for every farm. Average milk yield per cow per day was calculated from the monthly information by the companies that take the milk samples. In this research we used average milk yield per cow per day, because this was available for all cows whereas the milk yield per sample moment was not complete for all cows. Average milk yield per cow per day and milk yield per sample moment had a strong positive correlation in this dataset ($r = 0.81$, $P = 0.00$).

Climate conditions

The measurements of climate conditions were gathered from national weather stations. The daily weather data for Utrecht (Mts. Lozeman) was collected from weather station The Bilt and for Friesland (Mts. Bosma) from the weather station in Leeuwarden. At these weather stations temperature, humidity, precipitation and wind speed information was available. Because the weather data was available per day it was possible to calculate the average weather conditions per observation period per farm. The Polish national weather data collection is less accurate than the Dutch data. This is probably due to the difference in population density and the number of weather stations per square kilometer. Juchowo farm, however, has its own daily measurement of barn temperature and humidity. Global precipitation data for Poland could be deducted from the national weather maps.

Statistical analyses

The data were analyzed using the software IBM SPSS statistics 23. The observations of the body condition, locomotion, hygiene score of the hind, hygiene score of the udder and milk yield data were included in a principle component analyses (PCA) to explore relationships between the measured variables in the data set. A principal component was considered of interest when the eigenvalue was larger than 1. Thereafter correlations between the measured traits in the research were considered in search of novel traits. This was done through a two tailed Pearson´s correlation test.

The collected data of milk yield, body condition and hygiene score of the hind were found to have a normal distribution and were tested through the use of mixed models. These models considered the cow ID as subject with round as the repeated measure. Breed (class 1: Purebred Dutch Friesian; class 2: 75% Dutch Friesian; class 3: 50% Dutch Friesian; class 4: Holstein Bakels; class 5: Brown Swiss), round (1-4), lactation number (1-7), days in lactation (0-99, 100-199, 200+ days) and locomotion score (1-5) were considered as fixed factors and farm was considered as a random factor. Locomotion score was left out of the model for milk yield. For hygiene score of the hind also the factor farm (1-3) was tested.

Comparison between the body condition score of the two Dutch farms was done by use of a mixed model. Dutch Friesian purebreds and 75% Dutch Friesian were analyzed separately. These models still considered the cow ID as subject with round as the repeated measure. Fixed factors were farm, round, days in lactation category and lactation number. The breed 50% Dutch Friesian was not tested seperately due to the low number of individuals in this group.

The collected data of locomotion score and hygiene score of the udder was not normally distributed due to the high skewness (≥ 1.743) and high kurtosis (≥ 3.104). These variables were tested through the use of a generalized linear mixed model per round with an ordinal scale. Fixed factors were farm, days in lactation, lactation number, breed, body condition score and hygiene score of the hind. When locomotion score was the dependent variable hygiene score of the udder was also added as fixed factor and when hygiene score of the udder was the dependent variable locomotion score was added as fixed factor to the model.

Results:

Through the means of a Principal component analyses two components were found with an eigenvalue above 1. Principal component 1 was associated with the hygiene score of the hind (HSH), the hygiene score of the udder (HSU) and the milk yield (MY) and explained 31.3% of the total variability. Principal component 2 was associated with the body condition (BCS) and the locomotion score (LS) in the opposite direction. Principal component 2 explained 24.2% of the total variability (Figure 7).

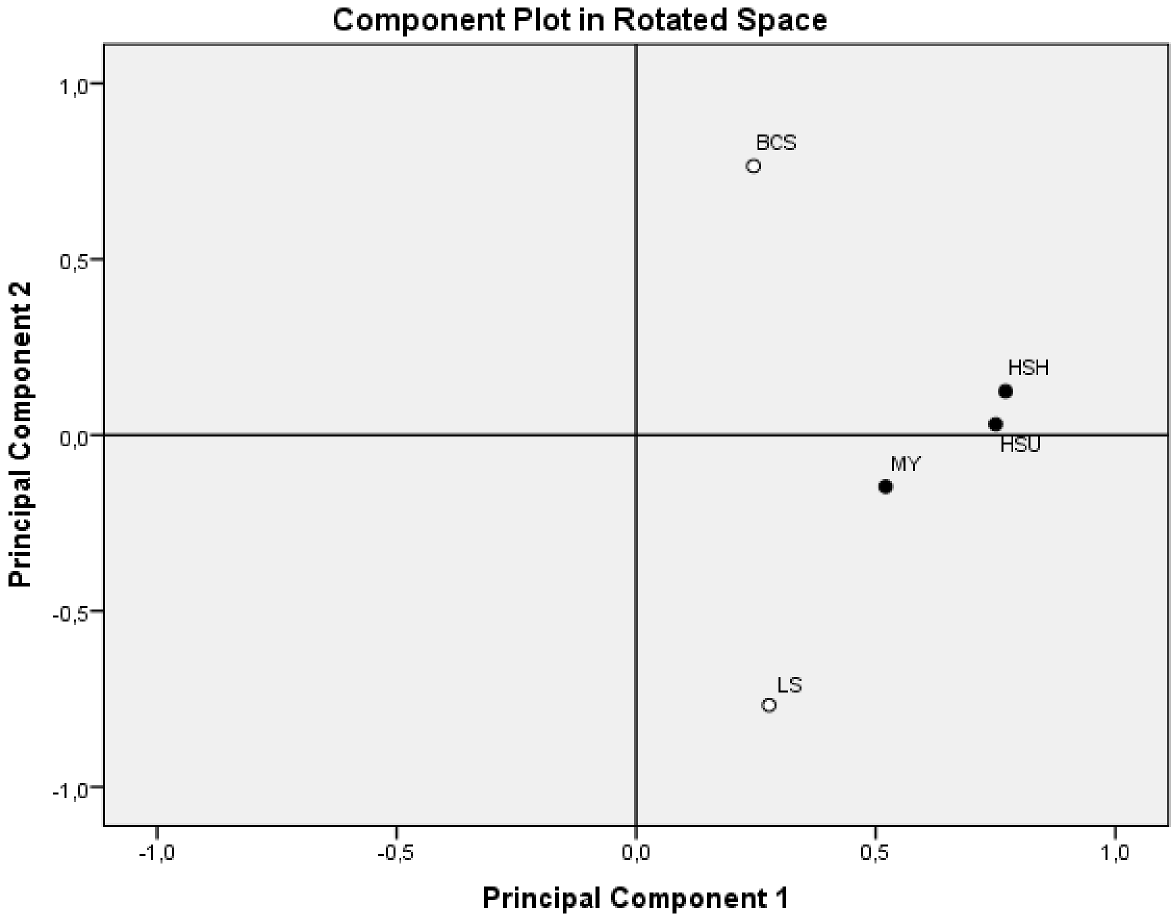

Figure 7: Principal component analyses of all measured variables (body condition score (BCS), locomotion score (LS), hygiene score of the hind leg (HSH), hygiene score of the udder (HSU) and average milk yield per day (MY)). Eigen value was set at 1.00. Principle component 1 mostly dependent on HSH, HSU and MY has dark markers. Principal component 2 mostly dependent on BCS and LS has white markers.

The association in the principal component analyses, can in this study also be shown with the Pearson‘s correlation test (Table 2). From this test a close correlation between both hygiene scores of the hindleg and udder is clear. Body condition score was found to be significantly negatively correlated to locomotion score and positively with hygiene score of the hind. Both hygiene scores and locomotion score were positively correlated with milk yield.

Table 2: Correlation calculations, corresponding P-values and number of measurements per trait, between all measured traits: body condition score (BCS), locomotion score (LS), hygiene score of the hind leg (HSH) and the udder (HSU) and milk yield (MY).

Correlations

		BCS	LS	HSH	HSU	MY
BCS	Pearson Correlation	1	-,184**	,157**	,080	,058
	Sig. (2-tailed)		,000	,002	,125	,266
	N	376	372	374	373	373
LS	Pearson Correlation	-,184**	1	,091	,096	,119*
	Sig. (2-tailed)	,000		,081	,065	,022
	N	372	372	371	370	369
HSH	Pearson Correlation	,157**	,091	1	,385**	,166**
	Sig. (2-tailed)	,002	,081		,000	,001
	N	374	371	374	373	371
HSU	Pearson Correlation	,080	,096	,385**	1	,154**
	Sig. (2-tailed)	,125	,065	,000		,003
	N	373	370	373	373	370
MY	Pearson Correlation	,058	,119*	,166**	,154**	1
	Sig. (2-tailed)	,266	,022	,001	,003	
	N	373	369	371	370	373

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Body condition score

Both the purebred Dutch Friesian and the 50% Dutch Friesian mixed cattle had a higher body condition score, around the optimum, than the Holstein Bakels ($P < 0.001$, $P = 0.001$ respectively) and Brown Swiss cattle ($P < 0.001$, P = 0,002) just below the optimum (Figure 8). (Table 3)

The average body condition score of round 2 was higher than the average body condition score in round 1, 3 and 4 ($P \leq 0.001$). The average body condition score of round 4 is lower than the average score in round 3 ($P = 0.014$) (Figure 8). The visible subcutaneous fat of the cows was highest in October and decreased continuously during the fall and winter months November and December. (Table 3)

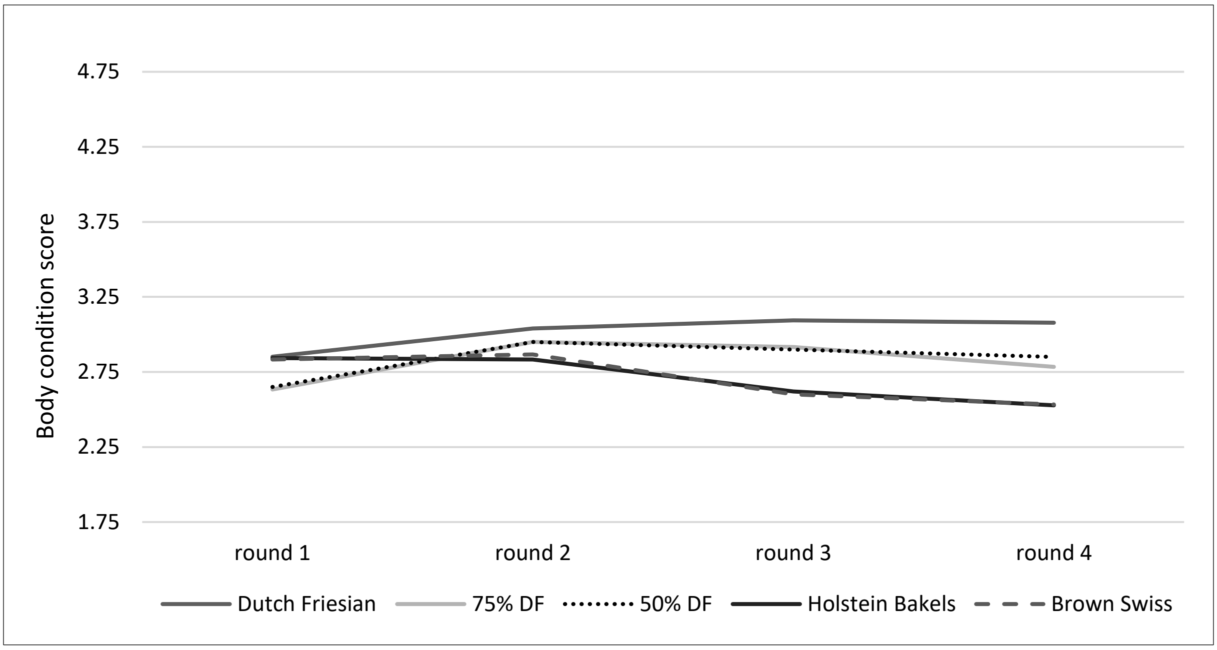

Figure 8: Body condition score (scale 1-5; skinny-fat) per observation round for the breed categories Dutch Friesian (DF), 75% mixed DF, 50% mixed DF, Holstein Bakels and Brown Swiss.

Cows in first lactation had a higher body condition score ($\mu = 2.94$), close to the optimum, than cows in fifth or seventh lactation which are thinner and under the optimum body condition score ($\mu = 2.62$ and $\mu = 2.14$, $P = 0.40$ and $P < 0.001$). Also cows in second, third, fourth and fifth lactation ($\mu = 2.88$, 2.85, 2.98 and 2.62) had a higher body condition score, closer to the optimum, than cows in seventh lactation, which are again thinner (lactation 1-4: $P \leq 0.001$, lactation 5: $P = 0.047$).

Cows with severe lameness have a lower body condition score ($\mu = 2.46$), thin and far under the optimum score, compared with cows with a normal, mildly-, moderately- and lame gait ($\mu \geq 2.68$, $P \leq 0.029$). This result is further supported by the correlation test where body condition score and locomotion score showed a negative correlation ($r = -0.184$) (Figure 9).

Table 3: Mean, standard error of the mean and number of cows per round (1-4) per breed (Dutch Friesian, 75% dutch Friesian, 50% Dutch Friesian, Holstein Bakels and Brown Swiss) for the variables body condition score (BCS), locomotion score (LS), hygiene score for hind leg (HSH) and udder (HSU), average milk yield (kg/day)(MY) and average temperature (◦C) (T avg.).

		100% Dutch Friesian		75% Dutch Friesian		50% Dutch Friesian		Holstein Bakels		Brown Swiss	
		n	μ (+/- sem)	n	μ (+/- sem)	n	μ (+/- sem)	n	μ (+/- sem)	n	μ (+/- sem)
BCS	round 1	32	2.85 (0.08)	15	2.63 (0.10)	5	2.65 (0.06)	27	2.84 (0.07)	15	2.83 (0.07)
	round 2	32	3.04 (0.09)	15	2.95 (0.10)	5	2.95 (0.09)	27	2.83 (0.06)	15	2.87 (0.07)
	round 3	32	3.09 (0.09)	15	2.92 (0.11)	5	2.90 (0.13)	27	2.62 (0.05)	15	2.60 (0.08)
	round 4	32	3.08 (0.08)	15	2.78 (0.13)	5	2.85 (0.13)	27	2.53 (0.05)	15	2.53 (0.08)
LS	round 1	30	1.73 (0.17)	13	1.92 (0.29)	5	1.00 (0.00)	27	1.15 (0.07)	15	1.20 (0.11)
	round 2	32	1.53 (0.18)	15	1.27 (0.15)	5	1.20 (0.20)	27	1.41 (0.11)	15	1.47 (0.22)
	round 3	32	1.58 (0.18)	15	2.07 (0.41)	5	1.20 (0.20)	27	1.15 (0.07)	15	1.00 (0.00)
	round 4	32	1.56 (0.17)	15	1.93 (0.38)	5	1.00 (0.00)	27	1.04 (0.04)	15	1.13 (0.09)
HSH	round 1	31	1.32 (0.10)	14	1.21 (0.11)	5	1.80 (0.37)	27	1.63 (0.14)	15	2.00 (0.14)
	round 2	32	1.38 (0.13)	15	1.40 (0.13)	5	1.20 (0.20)	27	1.89 (0.15)	15	2.13 (0.19)
	round 3	32	1.97 (0.18)	15	1.80 (0.22)	5	1.60 (0.24)	27	1.26 (0.10)	15	1.33 (0.13)
	round 4	32	1.94 (0.20)	15	1.87 (0.26)	5	1.80 (0.37)	27	1.26 (0.10)	15	1.27 (0.15)
HSU	round 1	31	1.06 (0.06)	14	1.21 (0.11)	5	1.20 (0.20)	27	1.19 (0.09)	15	1.27 (0.12)
	round 2	32	1.41 (0.10)	15	1.33 (0.13)	5	1.40 (0.24)	27	1.59 (0.11)	15	1.47 (0.13)
	round 3	32	1.69 (0.15)	15	1.20 (0.11)	5	1.20 (0.20)	27	1.22 (0.12)	15	1.13 (0.09)
	round 4	32	1.44 (0.12)	15	1.47 (0.17)	5	1.60 (0.40)	27	1.04 (0.04)	15	1.00 (0.00)
MY	round 1	30	21.90 (0.82)	15	24.98 (1.06)	5	29.50 (4.90)	27	21.45 (1.18)	15	23.38 (1.77)
	round 2	32	21.84 (0.92)	15	24.48 (0.85)	5	29.92 (4.94)	27	18.32 (1.26)	15	19.97 (1.64)
	round 3	32	20.67 (0.71)	15	23.61 (0.81)	5	28.12 (3.94)	27	14.64 (0.91)	15	16.68 (1.34)
	round 4	31	19.12 (0.73)	15	21.55 (0.82)	5	26.98 (4.07)	27	13.40 (0.86)	15	16.42 (1.35)
T avg.	round 1	32	18.33 (0.08)	15	18.23 (0.11)	5	18.53 (0.22)	27	18.75 (0.00)	15	18.75 (0.00)
	round 2	32	14.58 (0.32)	15	14.98 (0.44)	5	13.75 (0.91)	27	12.36 (0.00)	15	12.36 (0.00)
	round 3	32	7.81 (0.14)	15	7.98 (0.19)	5	7.46 (0.39)	27	6.18 (0.00)	15	6.18 (0.00)
	round 4	32	4.57 (0.03)	15	4.53 (0.04)	5	4.65 (0.09)	27	5.33 (0.00)	15	5.33 (0.00)

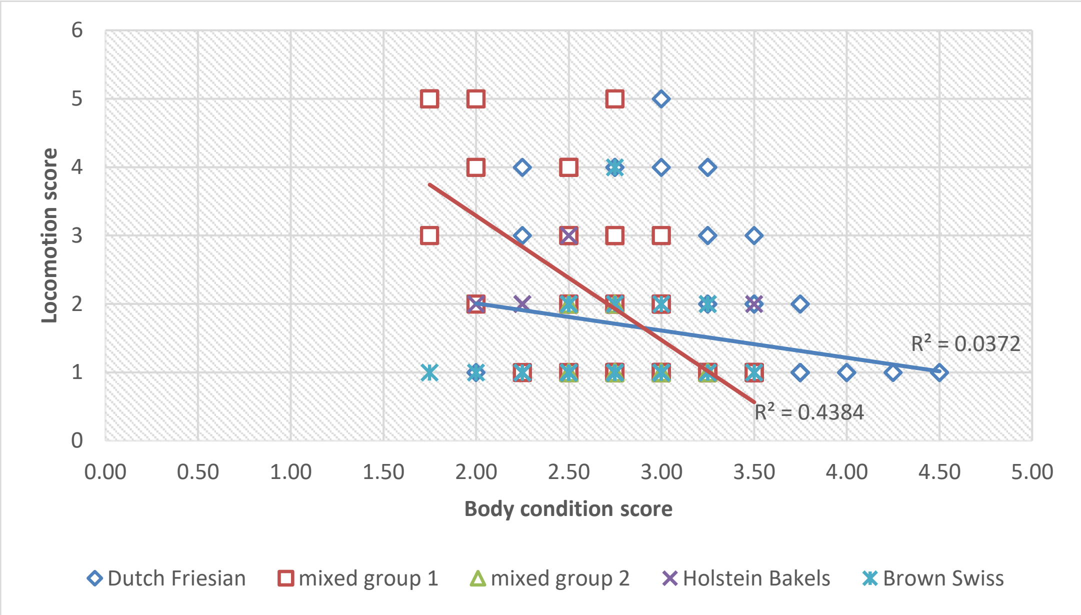

Figure 9: Correlation between body condition score (scale 1-5; skinny-fat) and locomotion score (scale 1-5; normal gait-lame) for Dutch Friesian, 75% Dutch Friesian (mixed group 1), 50% Dutch Friesian (mixed group 2), Holstein Bakels and Brown Swiss cattle.

When looking at body condition score of the purebred Dutch Friesian cattle (Table 4) only the average body condition score of round 1 (μ =3.03) is significantly lower than round 2, 3 and 4 (μ = 3.23, 3.27 and 3.26; P = 0.035, 0.016 and 0.025). This means that these cows had an optimal body condition score in September at the end of the summer and afterwards increased their body condition and weight slightly during fall and into December. Between farms the body condition score of Mts. Bosma (μ =3.46) is significantly higher than for Mts. Lozeman (μ = 2.93, P < 0.001). Furthermore, the body condition score of the cows who are over 200 days in lactation (μ = 3.48) is significantly higher than the BCS of cow groups who are less than 200 days in lactation (μ =3.09 and 3.02; P < 0.006). This means that cows on both farms increase weight and body condition after calving.

Table 4 Average body condition score (scale 1-5; skinny-fat) per round for the purebred breed Dutch Friesian for the farms Mts. Lozeman and Mts. Bosma.

	Mts. Lozeman	Mts. Bosma
	n = 20	n = 12
round 1	2.71	3.08
round 2	2.81	3.42
round 3	2.91	3.40
round 4	2.95	3.29

When looking at the 75% Dutch Friesian cattle (Table 5) only the average body condition score of round 1 (μ = 2.78) is significantly lower than round 2 and 3 (μ = 3.08 and 3.04; P = 0.010 and 0.013). These cows had on average a body condition score just below the average in September at the end of the summer. They gained weight and body condition in October and November up to an optimal body condition score. Between farms the average body condition score of Mts. Bosma (μ = 3.24) is again significantly higher (the cows are fatter) than the average body condition score of Mts. Lozeman (μ = 2.65, P = 0.003). Furthermore, the cows in third and fifth lactation (μ = 3.17 and 3.15) had a higher body condition score compared to the cows in seventh lactation (μ = 2.62, P < 0.008). There were no cows in fourth or sixt lactation in this breed category. Cows in second lactation also tended to have a higher BCS than cows in seventh lactation, but this was not significant (P = 0.079).

Table 5: Average body condition score (scale 1-5; skinny-fat) per round for the 75% Dutch Friesian group for the farms Mts. Lozeman and Mts. Bosma.

	Mts. Lozeman	Mts. Bosma
	n = 11	n = 4
round 1	2.55	2.88
round 2	2.82	3.31
round 3	2.75	3.38
round 4	2.61	3.25

Locomotion score

For locomotion score, there were only significant differences in round 1 and 3, although not significantly dependent on breed (Figure 10). In round 1 cows in seventh lactation scored higher for locomotion score than cows in first lactation (P = 0.13). In round 3 hygiene score of the udder was found as a positive significant effect on locomotion score (P = 0.023). Seventy-three cows showed a normal gait (score 1) in round three, ten cows were mildly lame, five cows were moderately lame, four cows were lame and two cows were severely lame. For hygiene score of the udder sixty-nine cows were completely clean (score 1) and score 2, 3 and 4 counted respectively eighteen, five and two cows.

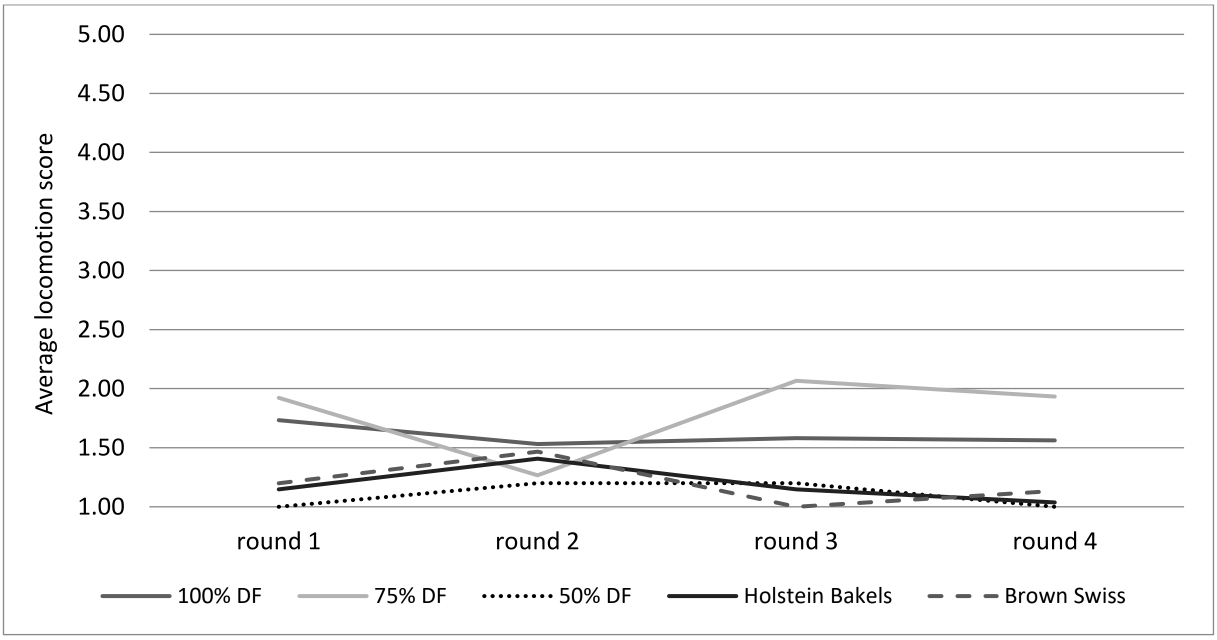

Figure 10: Average locomotion score (scale 1-5; normal gait-lame) per observation round for the breed categories Dutch Friesian (DF), 75% mixed DF, 50% mixed DF, Holstein Bakels and Brown Swiss.

Hygiene score of the hind leg

Cows that are in the first 100 days of lactation have more dirt on the surface of the hind leg (μ = 2.58) compared to cows that are in the category 100-199 days in lactation and the cows that are more than 200 days in lactation (μ =2.32 and 2.03; P = 0.019 and P ≤ 0.001). Cows in the category 100-199 days in lactation also have more dirt on the surface of the hind leg compared to cows in 200 or more days of lactation (P = 0.040).

In the Pearson's correlation test a low positive correlation was found bewteen hygiene score of the hind and body condition score (r = 0.157) (Figure 11). Very fat cows (BCS 4,50) had a very dirty surface of the hindleg (μ = 4.38) compared to cows with any other condition score (μ ≤ 2.43, P ≤ 0.002). The amount of dirt on the hindleg of cows with body condition score 4,50 (μ = 4.38) is higher than for cows of any other body condition score (μ ≤ 2.43, P ≤ 0.002). Furthermore very skinny cows (BCS 1,75 and 2,50) were cleaner (μ = 1.61 and 2.10) than cows with an optimum body condition score of 3,25 (μ = 2.43; P = 0.049 and 0.024).

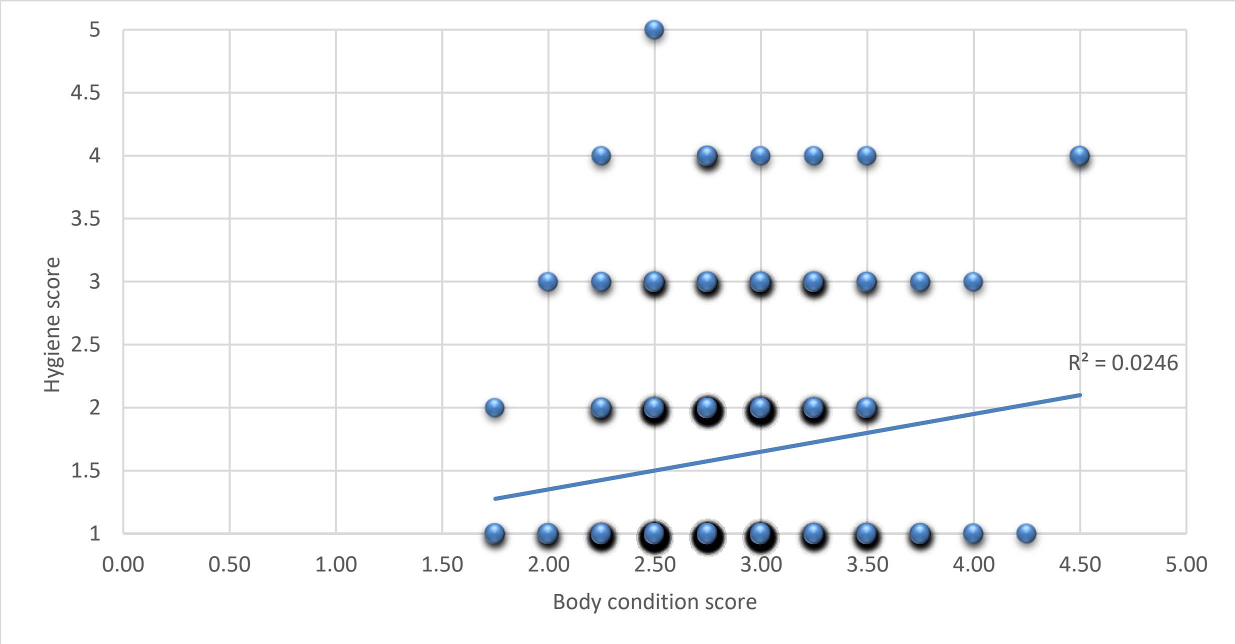

Figure 11: General correlation between body condition score (scale 1-5; skinny-fat) and hygiene score for the hind leg (scale 1-5; clean-dirty). Trend line (R^2 = 0.0246).

The hygiene score of the hind for cows that have a score of 1 or 2 for hygiene score of the udder (μ = 1.57 and 2.04) are cleaner than the hygiene hind leg score for cows that have a score of 3 (60% dirt cover) for udder hygiene score (μ = 2.86; P ≤ 0.001). Cows with udder hygiene score 1 (20% dirt cover) are also significantly cleaner than cows with udder hygiene score 2 (40% dirt cover)(P ≤0.001). Cows with udder hygiene score 4 (80% dirt cover) are intermediary (μ = 1.93). These finding are in agreement with the marginal positive correlation between hygiene score of the hind and the udder from the correlations test (r = 0.385).

Mts. Bosma (μ = 2.26) has more cows with a dirtier surface of the hind leg compared to Mts. Lozeman (μ =1.93, P = 0.02). Juchowo farm (μ = 2.10) tends to have more cows with a dirtier surface of the hind leg than Mts. Lozeman (P = 0.09), but is not different from Mts. Bosma (Figure 12).

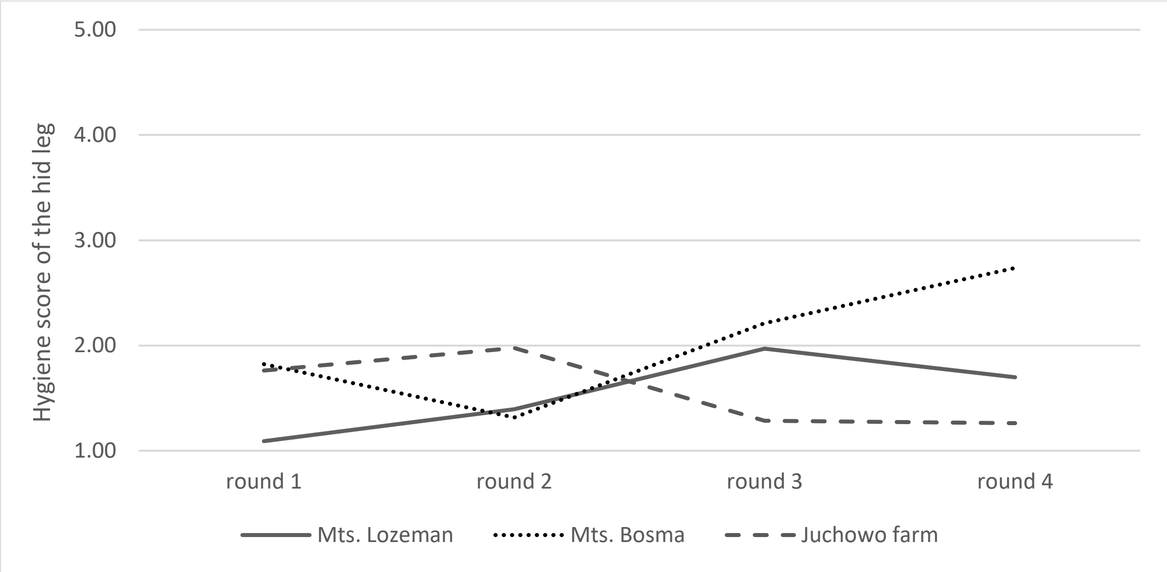

Figure 12: Average hygiene score of the hind leg (scale 1-5, clean-dirty) per observation round for the farms Mts. Lozeman, Mts. Bosma and Juchowo farm.

Hygiene score of the udder

In round 2 hygiene score of the hind shows significant influence on the hygiene score of the udder (P = 0.012). Cows with hind leg hygiene score 4 (80% dirt cover) are significantly dirtier in udder hygiene score outcome from cows with hind leg hygiene score of less than 60% dirt cover (P ≤ 0.006). In round 3 hygiene score of the hind is also of influence on udder hygiene (P = 0.001). The result of udder hygiene are significantly dirtier between cows with 80% dirt cover on the hind leg and cows with up to 20% dirt cover on the hind leg (P = 0.006). However, in round 4 there is only a trend towards differences in udder hygiene score between the different leg hygiene score groups (P = 0.072). This means that the two hygiene scores are less dependent of each other in December than during the fall months October and November.

Milk yield

The 50% Dutch Friesian cattle produced on average the most milk per day (μ = 28.52, P ≤ 0.014). The Purebred Dutch Friesian and the 75% Dutch Friesian cattle also produced on average more milk per day (μ = 21.69 and 23.44) than the remaining breeds (P = 0.000 and 0.014). There was no significant difference between the Purebred Dutch Friesian and the 75% Dutch Friesian cattle (P = 0.189). The Holstein Bakels and Brown Swiss cattle produced on average less milk per day (μ = 15.00 and 16.43) than the other breed categories (P ≤ 0.001). There was no significant difference between the Holstein Bakels and Brown Swiss cattle (P = 0.241). Figure 13 shows the interaction of milk yield and round per breed.

General milk yield was found significantly different between all rounds (P ≤ 0.001). In round 1 overall milk yield was the highest (μ = 23.60) and each round the overall milk yield declined a bit (μ round 2, 3 and 4 = 22.07, 19.84 and 18.54).

In general cows in their 4th lactation produced the most milk (μ = 25.54) especially compared to cows in 1st and 2nd lactation (μ = 18.17 and 20.99; $P \leq 0.005$). Furthermore cows in 1st and 2nd lactation both produce less milk than cows in 3rd lactation (μ = 23.19, $P \leq 0.001$ and 0.66) and cows in 1st lactation also produce less milk than cows in 5th lactation (μ = 21.78, P = 0.033).

When looked at days in lactation categories, cows that are over 200 days in lactation (μ = 18.03) produce less milk then cows that are less than 200 or even less than 100 days in lactation (μ = 21.80 and 23.23, P = 0.002 and ≤ 0.001).

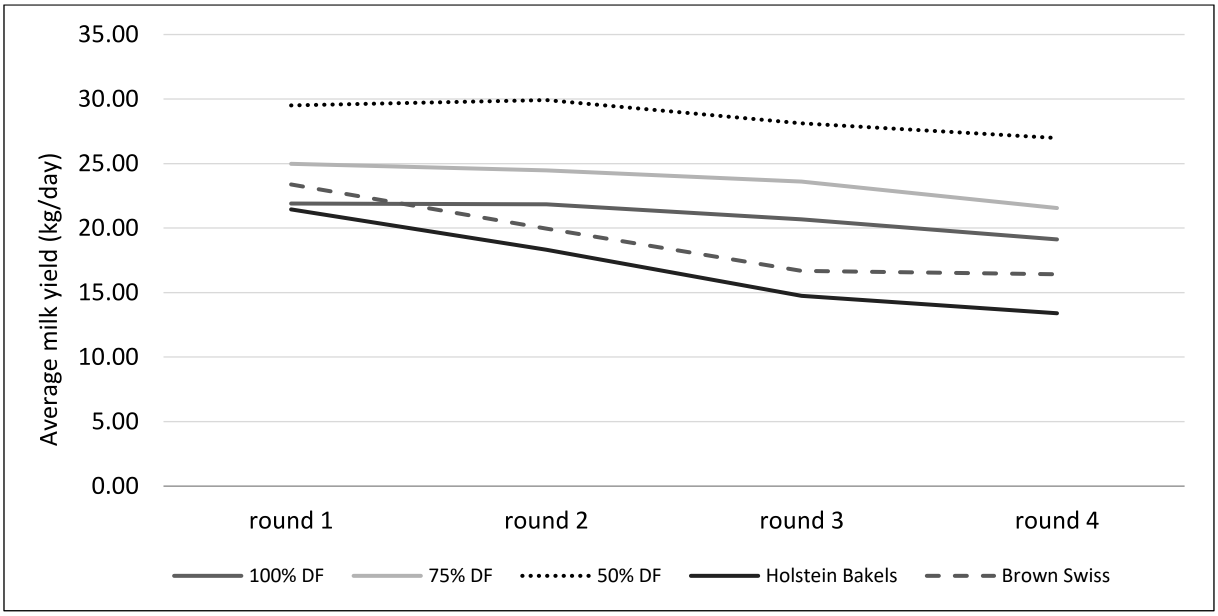

Figure 13: Average milk yield (kg/day) per observation round for the breed categories Dutch Friesian (DF), 75% mixed DF, 50% mixed DF, Holstein Bakels and Brown Swiss.

Discussion:

The aim of this study was to compare body condition, locomotion and cleanliness between dual-purpose breeds and specialized dairy breeds, during the transition from pasture to indoor season in several European pasture based farming systems. Most farming systems concerning specialized dairy breeds have been adjusted towards the high production of milk yield (e.g. high quality concentrate feeds and fodder, specialized housing systems and strict management factors). Dual-purpose breeds have, however, been selected for longevity, durability and robustness. These traits should be beneficial in a European pasture based farming system, because cows will be exposed to harsher climate conditions and lower quality feeds. Therefore the expectancy of this study was that the dual-purpose cows will cope better in the pasture when exposed to local climate conditions and on lower feed quality, compared to specialized dairy breeds. Furthermore, it is expected that dual-purpose cows are better able to cope with change from the pasture to the barn, than specialized dairy breeds. From these expectancies the following hypotheses for body condition, locomotion and cleanliness were made. The dual purpose breeds Dutch Friesian, either purebred or crossbred, and Brown Swiss would have a better (median) body condition score, show less locomotion problems and show less increase in the latter, both in the pasture and after change into the barn compared to a specialized dairy breed, such as the Holstein Bakels cattle. Furthermore; overall cleanliness would be better (lower score) for all breeds during the pasture season compared to the indoor season.

Body condition score

Body condition score showed quite some different curves over the four rounds per breed (Figure 8). The Dutch Friesian breed consistently scores higher than the other breeds and the difference increase into the winter season. The mixed breeds seem to profit from the long pasture season. Unfortunately it is not clear if the condition score was fluctuating more before round 1 or if the measurement at round 1 are the lowest point after a negative energy balance at the start of the summer. The decline from round 3 to 4 is only marginal. The larger decline of the 75% Dutch Friesian cattle compared to the 50% Dutch Friesian cattle does not match up to the findings of Buckley et al. (2003), which stated that it is the amount of Holstein Friesian genes that influences the condition score. This discrepancy might, however, be due to the fact that 11 out of 15 animals of this group are from the same farm. The bigger proportion of this group is from Mts. Lozeman and the other four animals are from Mts. Bosma. The reason for the lower body condition score might be due to the difference in feeding schedule during the barn season. Mts Lozeman feeds mainly roughage and 3 kg of concentrates a day. Mts. Bosma however feeds roughage with maize silage and on average 6 kg concentrates a day. This difference in diet used between the farms creates a big difference in body condition score per farm, so the unequal amount of individuals in the groups skews the general score to the lower body condition score in favour of Mts. Lozeman.

Interestingly the measurements of body condition score over rounds is almost opposite for the Holstein Bakels and Brown Swiss cattle compared to the Dutch Friesian cattle. There is almost no change between the two measurements in the pasture season. At the start of the barn season, however, there is a steep decline of almost 0.25 average body condition score for both the Holstein Bakels and the Brown Swiss cattle. This was followed by a further slow decline to the second measurement moment for the barn season. This might be because the balance between body maintenance and milk production cannot be achieved for these breeds, but it might also be due to the differences between the farms.

As these breeds are both from the same farm and at a different location than the two Dutch farms, the effect of climate is considered as a main effect when comparing them to the other breed categories (Appendix: figure 14). The average temperature curve, however, of Juchowo farm is not different from Mts. Bosma. A big difference between the two farms is the housing of the animals. In the Netherlands, the cows are kept in closed off barns with sufficient air flow, but protected from wind chill and precipitation. In Juchowo farm they choose a different concept with an open space between the covered feeding spots and free stalls (Appendix: figure 15). Because of the roofless part in the barn the cows are always exposed to all weather conditions, which is different from the Dutch system. This means that ultimately the weather conditions in Juchowo have a stronger effect than at Mts. Bosma. The amount of feed provided at the farms is also the lowest at Juchowo due to the lack of extra concentrate feed next to the roughage. Both are management factors that influence the body condition score.

It is of importance to notice that there is a significant difference in body condition score for the different months. When body condition is used for comparison this should be considered, since it might give a wrong outcome if body condition score is compared between different months or in two different seasons.

Furthermore, there is a negative correlation between locomotion score and body condition score. Hoedemaker et al. (2009) also found that the cows with a low body condition score have a higher incidence of lameness. An explanation for the fact that the skinny cows often experience locomotion problems might be due to the vicious cycle of having trouble reaching the feeding spots which results in low dry matter intake for these cows. The feeding spots that are easy to reach might already be taken up by healthy cows higher in the hierarchy. The low dry matter intake might also lead to increased disease risk and disease would then again lead to body condition score loss.

Locomotion score

Some farms put more attention into hoof care than others. A longer duration of pasture time has been found beneficial to the healthy state of the cows hoofs (Hernandez-Mendo et al., 2007). In the pasture season the cows of Mts. Lozeman have the longest access per day to the pasture, followed by Juchowo farm and Mts. Bosma respectively. In our study, however, it is not proven that the locomotion problems are higher when the cows are housed indoors all the time. Nor do the different breeds show that the dual purpose breeds would have less locomotion problems than the specialized dairy breed. It seems to be more farm dependent than breed dependent. Inside the barn, Juchowo farm offered the most hoof comfort, followed by Mts. Lozeman and Mts. Bosma. Juchowo farm had rubber mats to walk on, the rubber creates extra traction and a softer walking surface. Juchowo farm offered deep free stalls filled with loose straw so movement in the stall is more comfortable. When the bedding in the free stalls can be indented and pushed around when touched, then the hoof has more movement freedom and more soft contact surface. The increase in soft contact surface around the hoof provides more comfort and friction when a cows rises from the lying position to the standing position (Cook and Nordlund, 2009). This is especially beneficial for lame cows, because the lameness is not reinforced by difficult environmental conditions, as it would be with hard mats on concrete. Mts. Lozeman also offers soft free stall bedding with horse manure as bedding material so the hoof can move with more stability when moving in or out of the free stall. Mts. Bosma offers minimal hoof comfort by use of a manure robot on the hard slatted floors in combination with rubber mats in the free stalls.

Many of the cows scored normal or mildly lame for locomotion scores. The step from normal locomotion to mildly or moderately lame is quite small. The step to actually being lame is easier to visually score. Because of this the amount of moderately lame cows might be underestimated and the amount of mildly lame cows would be overestimated. Furthermore locomotion score can fluctuate over a shorter time period than BCS. Depending on the source of the lameness, either sickness, muscle pain, lesion or an ulcer, the time, intensity and occurrence of the lameness will differ. A regular observation for locomotion might therefore be useful. This could be achieved through automated measuring systems as described by Von Keyserlingk et al. (2009).

Hygiene scores

In general the hygiene score does get worse (higher) when the cows are moved from the pasture to the barn. This is however not the case for Juchowo farm. The difference might be caused by the lower stocking density and different free stall bedding in Juchowo. If the stocking density is higher there is more contact between the animals and the animals and the dirty environment. The time spent in dirty or wet alleyways increases and transfer of dirt to the free stalls is higher (Cook, 2002). Likely due to the large amount of animals closer to each other than at the other farms, the cows of Mts. Bosma had a worse score for upper hind leg cleanliness.

The significantly higher hygiene score of the hind that cows in the first hundred days of their lactation have implies that they are more soiled than cows that have been in lactation for a longer time. Cows that are in lactation for more than 200 days seem to be the cleanest animals. However, only 15 of all 373 measurements had a hygiene score of the hind were more than 40% of the surface of the hind leg was dirty (score 3 or higher). As is with the locomotion score rate of change between score 1 and 2 (no dirt present to slightly soiled) is easier judged and more frequent.

The close correlation between hygiene score of the hind and the udder makes that observations of dirt on the hind legs can be considered as indication for udder health. Udder health and amount of dirt on the udder are closely correlated (Schreiner and Ruegg, 2003). So the dirt can be seen as an early indicator for udder health problems.

The fact that hygiene score of the hind was lower for animals that have a low body condition score (figure 11) is in accordance with the negative correlation between body condition score and locomotion score (figure 9). Animals that suffer from locomotion problems decrease their lying time and therefore their body comes less into contact with dirty surfaces (Cook and Nordlund, 2009). Vice versa, the fatter cows with less locomotion problems spend more time lying down. These animals come into contact with a higher number of different free stalls and also more dirt and manure. Indirectly, the chance of getting a dirty udder also increases when cows lie down more.

Milk yield

For milk production (Figure 8) the difference between the best and the worst performing breed is quite big. It seems that the amount of Holstein Friesian genes here might show its influence, in an animal that can cope well with the environmental conditions, as the 50% crossbred Dutch Friesian has the highest yield. Followed by the 75% crossbred Dutch Friesian and the purebred Dutch Friesian. Unexpectedly both breeds that are more specialized for dairy than the Dutch Friesian breed have the lowest yield. The Holstein Bakels and Brown Swiss show a steep decline in milk production during the pasture season, which was also observed by Zendri et al. (2016). In their research the specialized breeds started out with a higher milk yield in the start of the pasture season than the dual-purpose and local breeds. Unfortunately our data set does not reach that far. At the end of the pasture season in October all cow breeds in the research of Zendri et al. (2016) produced the same amount of milk per day. This is different than the findings from this study. As the milk production still declines slowly at the end of the pasture season and even into the indoor season for the Holstein Bakels. The Brown Swiss cattle showed a slight increase in milk production during the indoor season. Indicating that the Brown Swiss cattle is able to regain some production yield when housed indoors compared to when housed in the pasture during the day. Because the Holstein Bakels and the Brown Swiss are from the same farm and receive the same feed diet it is not possible ascribe management or housing as the reason for the decline. The Brown Swiss cattle are after all doing slightly better under exactly the same conditions. This leads to the conclusion that the Holstein Bakels do in fact not cope well within the biodynamic farming system at Juchowo farm.

The Holstein Bakels cow, which is a Holstein Friesian strain selected for more durability and hardiness was expected to have the highest milk yield. In this study however, they are the cow with the lowest milk yield averaging over the whole four months. This might indicate that the Holstein Bakels, and therefore also other high production cows, are as we suspected, not suited for the extensive pasture system used at Juchowo farm. The low milk yield for this breed could partially be due to the difference of selection traits on this line of Holstein Friesian cattle. Also within some breeding lines of Brown Swiss cattle there is a high selection for milk yield, these cows are often referred to as Austrian Brown Swiss cattle. In this study the Brown Swiss cattle also seemed to have a hard time performing optimally under more difficult pasture held conditions. Zendri et al. (2016) found that the high performance Holstein Friesian and Brown Swiss did not cope well on the summer pastures in the North of Italy. Their milk production would decrease over the summer, in the end becoming equal to the yield of the Simmentaler, local Redena and Alpine grey breeds they were compared to. Horn et al (2013) found that the Brown Swiss cattle was not able to live up to its production potential in the Alpine pasture system independent of access to low or high concentrate levels. Therefore Brown Swiss cattle should perhaps be categorised as dairy cattle instead of dual-purpose cattle.

Considering former and future research

Most papers that do focus on dual-purpose cattle immediately go for quite extensive systems (Dillon et al., 2003; Gillund et al., 2001; Horn et al., 2013 and Zendri et al., 2016). Although maybe fitting for the organic sector, these systems are not applicable to, for instance, the Netherlands. Although the Dutch pastures have in general a very good feed quality and quantity, the Dutch farmers have lack of space. Organic dairy farms are mostly converted conventional farms. It would therefore be interesting to look at a large scale comparison of different dual-purpose breeds and specialized breeds in more intensive farming systems.

In a former Masters Thesis conducted by Kaptijn (2016, unpublished) a daily change of air humidity and other climate conditions seemed to have an influence on daily grazing activity. It would, therefore, be interesting to link the daily climate conditions, to the activity measurements done by SenSoor and link this to a two weekly body conditions score and locomotion score change.

In this study the opportunity to include accurate feed intake per cow was not possible. From the body condition score results, however, it seems feed supplementation might have a big influence. The comparison would be most interesting between breeds that are kept in the same kind of pasture based system and different concentrate diets. A high concentrate diet with low pasture access in this study led to a large number of obese cows at one farm. At the same time a low concentrate diet with large quantities of pasture available during the pasture season was not enough to support optimal production and body condition in high yielding cows.

The influence of the number of days in lactation on the BCS could be researched more in-depth. This study had too many differentiating factors between the farms and only a short period of time for field observation. When body condition score and especially the rate of change can be observed for a full lactation cycle for multiple cows direct conclusions can be made with regard to lactation stage. For organic farming this might be interesting with regards to “natural” spring calving and product enhancement.

Conclusion:

In this study body condition, locomotion, cleanliness and milk yield were compared between the dual-purpose breeds Dutch Friesian and Brown Swiss and the specialised dairy breed Holstein Bakels during the change from summer pasture to indoor barn season. The dual-purpose breeds were expected to cope better with the change of season compared to the specialized dairy breed. This would mean that the dual-purpose breeds would have an optimum body condition score, or even be a bit fatter than the optimum score and these breeds would be able to sustain this body condition score over a change of season. This compared to the specialized breed that would have a body condition score below the optimum during the pasture season and might even become skinnier when environmental conditions get worse during the indoor barn season. Furthermore the dual-purpose breeds were expected to have less prevalence of locomotion problems and to have a cleaner body surface, both during pasture as well as indoor season.

The Body condition score was indeed found to be the best for the dual purpose breed Dutch Friesian. This was the case for the purebred as well as the crossbred cows. Both the Holstein Friesian as the Brown Swiss cattle had a lower body condition score during the pasture season. Towards winter these breeds also encountered a steep decline, whereas some of the Dutch Friesian cows would increase their body condition. The body condition during the indoor season seems highly influenced by housing and diet management decisions. Also the locomotion score was more strongly influenced during the indoor season. During the pasture season there were no significant effects on locomotion and during the indoor season the locomotion score seemed to be more dependent on stocking density than on breed. The hygiene score, although not significant for a certain breed, did get worse when the cows went into the indoor season.

In this research a negative correlation has been found between body condition score and locomotion score together with a positive correlation between body condition and hygiene score of the hind. This is accordance to the other literature where the skinny cows are also the cows that show more lameness incidents. However due to their different time budget these skinny lame animals spent less time lying down and are therefore in less contact with dirty surfaces compared the fatter cows that spent more time lying down more times on a day.

The Influence of feed diet and housing conditions has a big impact on the performance of the cow. For the dual-purpose cattle breeds in this study the extra supplement of concentrates highly increases body condition score and milk yield. This might even lead to obesity in the cows, which can have detrimental effects. The more specialized dairy breeds Holstein Bakels and Brown Swiss seem to under-perform is the large pasture based system with open barn on a low concentrate feed diet. From this it can be concluded that dual-purpose breeds cope better in pasture based systems then more specialized dairy breeds. Therefore the dual-purpose breeds (like the Dutch Friesian cattle) are better suited for organic farming systems.

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Appendix:

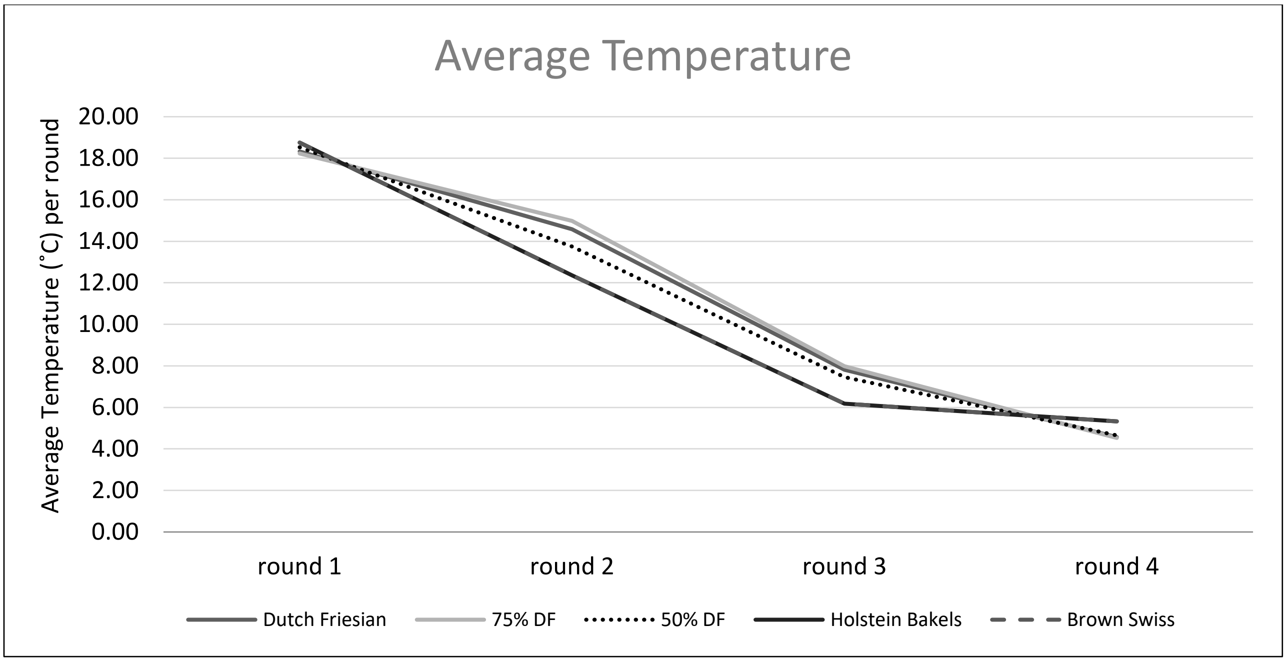

Figure 14: Average temperature (˚C) per observation round for the breed categories Dutch Friesian (DF), 75% mixed DF, 50% mixed DF, Holstein Bakels and Brown Swiss. The Brown Swiss and Holstein Bakels cattle have exactly the same line, because all these cows are from the same farm.

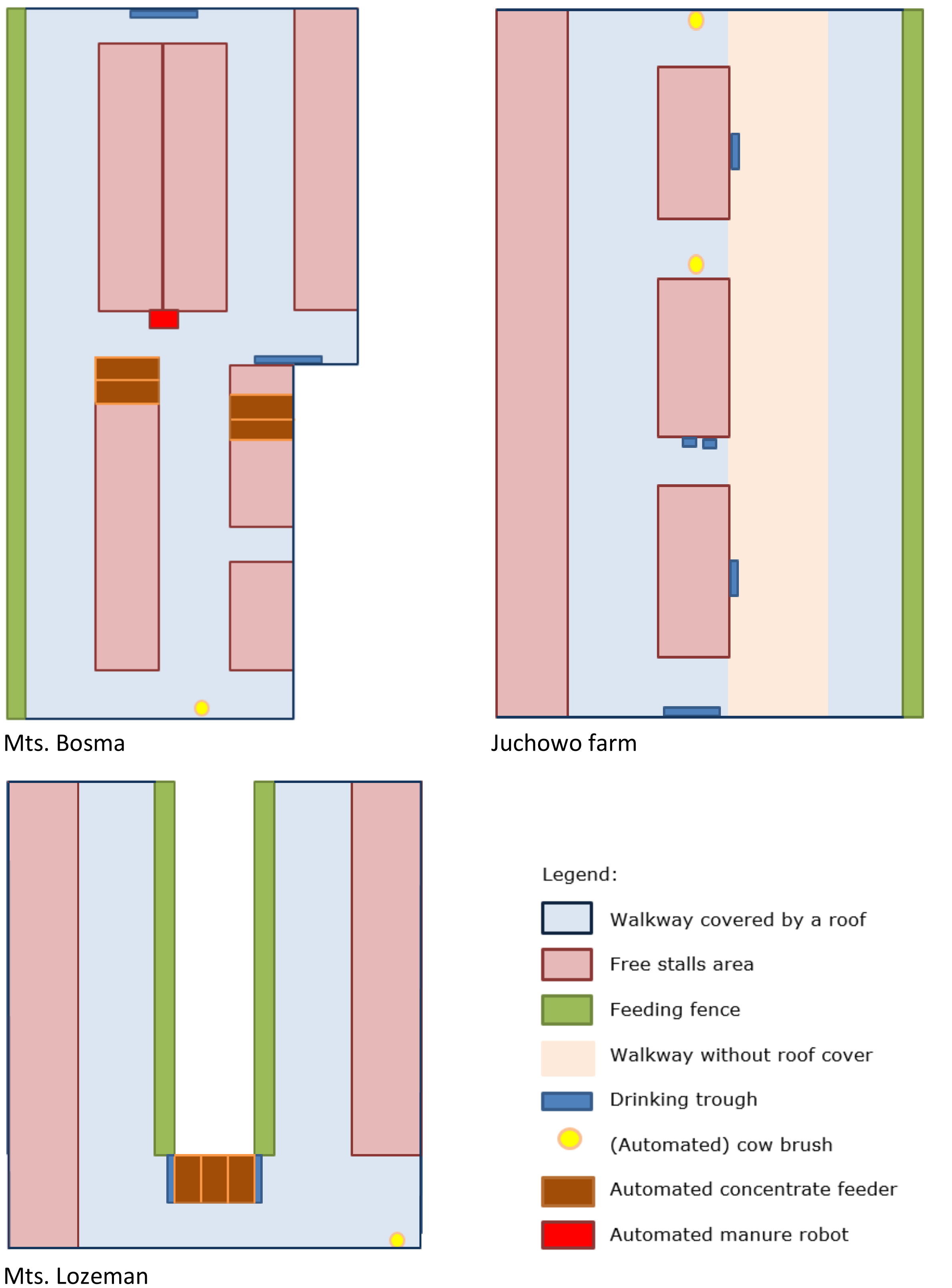

Figure 15: sketch of layout indoor housing cows in lactation per farm. Mts Bosma and Mts Lozeman have completely closed of barns, whereas Juchowo farm has an open roof concept and open side walls next to some of the free stalls.