

Case Report “Farm A”

1. Description of the case herd

1.1. Presentation of the farmer and the development history of the farm

John D. (not his real name), a 51-year-old farmer, operates Farm A, a family-owned dairy farm in Denmark. Under John D.’s management, the farm has grown significantly from its beginning of 23 hectares with 50 cows and over 100 heifers. Approximately 1.5 years after purchasing the farm, he relocated cows from his wife’s family farm to streamline operations.

In 2007, the farm expanded with the acquisition of a 90-hectare property housing 100 cows. While the cows were sold due to his father-in-law’s health issues, the family retained the land, benefiting from low-interest rates to ensure financial stability. In 2020, John D. constructed a modern cowshed for 340 cows, enhancing housing conditions and operational efficiency. Despite financial pressure from high loan interest rates, recent profits driven by higher milk prices and stable feed costs have bolstered the farm’s success.

Farm A now spans 220 hectares and houses 400 yearcows, including 300 Danish Holstein and 100 Danish Red Holstein. Known for high productivity, these breeds reflect John D.’s focus on maximizing milk yield and herd health. The farm employs six full-time workers who support daily operations, ensuring smooth workflows and high standards of animal welfare.

Family involvement remains a key feature. While John D.’s wife works outside the farm, his daughters may continue the family legacy, and his son-in-law assists during busy periods. Looking ahead, John D. plans to adopt advanced technologies to enhance efficiency and sustain financial resilience, ensuring the farm remains a leader in dairy production. Farm A exemplifies perseverance, innovation, and a commitment to excellence in modern farming.

1.2. Type and scale of production

Farm A is mainly focused on dairy production, for which reason they are cooperating with a neighbor, who cultivates the fields. Thereby, Farm A can focus on dairy production, as they don’t have the equipment or the interest of cultivation. The cultivated crops include grass and maize, used for silage, and grains, also used in the rations. Concentrate feed as rapeseed and soybeans are bought. The plan is to rent the fields to the neighboring farm, and buy the harvested crops, instead of the current situation. Thereby, the neighbor has better possibilities in their crop rotation, and John D. can focus 100% on dairy production. The farm consists of both old and new barns, as seen in Figure 1, and different stables house calves, heifers, dairy-, sick-, and dry cows. The housing system of the different groups is described in chapter 3.

With 14.455 kg ECM produced per cow in the past 12 months, the yield is 20% higher than the average, and 13% higher than the highest 25% conventional dairy farms in Denmark, which makes the farm highly productive. The replacement rate of cows is lower than the average, and they have more older cows, compared to other farms. However, they did experience problems with the older cows before, as they suddenly got sick and died. The somatic cell count was around 200 in September 2024, an average for all cows, where especially the older cows contributed to a high SCC. So, generally, the farm is highly productive, and it is very clear that the main focus and interest of the farmer is the cows, which are reflected in the key production figures, further explained in detail in chapter 4.

1.3. Farm personnel allocation and total labour force

At Farm A high level scheduling is not prioritized. However, they do have a system on the computer to keep track of what is done, and a whiteboard is used for smaller orientations.

As listed in Table 1 they have a roughly scheduled workflow around the farm regarding the primary daily tasks. They milk three times a day and calves are likewise fed three times a day. For the weekly workflow they for example also have fixed days for drying off cows (Monday), doing pregnancy tests (Wednesday), and having the veterinary visit (every other Thursday).

Table 1. Work list of daily, weekly and ongoing tasks at the farm.

Daily

Morning: Feeding cows; feeding calves; milking

Noon: Feeding calves; milking

Afternoon: Feeding calves; milking

Weekly

Monday: Dry cows off; Calving area: Move heifers; Calving area: Move cows; Clean water troughs

Tuesday: calves for sale

Wednesday: Heat/Pregnancy test of heifers; Heat/Pregnancy test of cows

Thursday: Clean water tanks; Veterinary visit (every second week)

Friday: section move

Monthly (on Thursdays)

Hooftrimming of heifers and cows (once a month)

Identifying cows for slaughter/culling

Insemination (whenever needed)

The work is divided between John D. himself and his seven paid employees: Two of the workers are from Eastern Europe, a man and a woman, who take care of milking. The rest of the staff are Danish, consisting of three men and two women. One woman is taking care of the calves and the other woman is herd manager in charge of the calves. One of the men moves the cows, supplies straw and cleans out the stables. The two other men are doing work around the farm and help with milking the cows when needed. One employee is working part-time and the rest are full-time employees. His daughters also help out during weekends and whenever it is needed, however they are not employed and do not get paid. All the workers are relatively young with two of the employees in their 40's, three in their 20's and two are students. Once they occupied Polish employees, however John D. finds it best to have international workers with the same nationality so now he only employs Ukrainian workers. Both Ukrainians have a veterinary education from Ukraine. The rest of the staff are either trained farmers or students under training.

1.4. Advisors and herd health agreements

Advisement regarding health is carried out with the help of a veterinarian and a hoof trimmer at varying frequencies. In feeding, the farmer receives monthly advice from management tools like Landbo Nord and Vi-loMix. In reproduction, inseminations are performed 50% by an inseminator and 50% by the farmer himself, while breeding is managed using tools like AI total and Viking, with the farmer's involvement. In the economic area, advice is provided by both an economic advisor and the farmer himself.

2. The goals of the farmer

2.1. The attributes and goals of the farmer

Attributes can also be defined as values and the motivation for work and goals. They say why someone wants to do things the way he does them. To determine his attributes was difficult for the farmer. He could not think of any by himself but used the ones we provided. After choosing them, we asked him to rank the attributes from most important to least important. This is how it came out:

1. Animal welfare
2. Working conditions
3. Product quality
4. Environment
5. Professional prestige
6. Spare time

These are his explanations and definitions of the single attributes:

Animal welfare is the overall well-being and health of his cows. When he looks at the eyes, ears and skin of a cow and they are not ok, this makes him sad. He states: "If we don't take good care of the animals, they won't work good for us." But he mentions the struggle between knowing what the animals want and the things that are possible to give them in a commercial farm. What he wants to provide for the cows is an environment where the cows must only worry about eating, sleeping and ruminating. Therefore, it is important for him to bring the cows to milking fast and provide new feed as soon as they come back. But still there is no stress while milking: The cows are separated in groups by body size so that smaller cows don't feel under pressure when standing next to a bigger cow while milking and the cows can slowly walk in the milking parlour by themselves without shouting of the milker. The farmer wants to have a clear conscience about how he treats his animals and that people from outside can also see that the cows are treated well. And at the end animal welfare of course gives money. Short, animal welfare is about the good productivity and health of his cows.

Working conditions are not further specified, except for the fact that it provides money, when workflows become more efficient. When people work more efficiently, less workers are needed, and the outcome becomes bigger. The product quality increases, and the product becomes more valuable.

Product quality was also not further specified, except for giving money. E.g. in milk a farmer gets paid for the ingredients - protein and fat - and not only for the amount of milk in kg. Calves are also a product of a dairy farm. Well-grown and healthy calves give more money when sold.

Environment was not further specified. But it could mean that he doesn't want his farm to be a threat for the environment. This would include clean management of manure, e.g. storage places with concrete floor and drainage, so that the nutrients don't spoil the soil.

Professional prestige is the way others see the farm. They want to present the farm in a good way by treating their animals well, having good numbers and results compared to other farms and they want to get accepted from their neighbors even when they e.g. lose mud on the street. This they want to achieve by generally not disturbing them but greeting when meeting in the street.

Spare time is the time the farmer has free and available for his family. It is not a big effort by the farmer to increase his spare time, but he is glad about every spare time he has. He feels that it is ok at the moment as the family is able to make holidays (also depending on the money) and the number of weekends the farmer has off was increasing in the last years.

To make a general goal more concrete, it should follow the "SMART"-model. This makes the goal, and the tasks related to its achievement more tangible for everybody involved in it.

The goals the farmer has set for the next year are as following and ranked in the same way:

1. Reducing the death rate in the cows by 4 % within one year (Sept. 2025)
2. Reducing the age of first calving from 24 to 23 months of age within one year (Sept. 2025)
3. Reducing the carbon footprint to below 1 CO₂e per litre milk in one year (Sept. 2025) from the present value of 1,06 as required from the dairy company.

The ways these goals are planned to be achieved are:

- 1 Use of minerals e.g. for faster claw growth to prevent thin claws due to rough concrete floors. Additionally, sodium carbonate is already used to reduce the occurrence of suddenly dying cows in the mid of lactation, which is a problem the farm is confronted with without knowing the reason.
- 2 Start earlier with detecting heat and therefore inseminate earlier by moving the collars from pregnant heifers to young heifers already at the age of 13 months. In September 2024 the moving happens still in month 14 but the process of moving it forward is already started.
- 3 E.g. not using more water and electricity than necessary. This goal is by far the most difficult one to achieve, according to the farmer. But he assumes that the carbon will reduce automatically by getting a longer lactation period through achieving goal 1 and 2. Additionally SEGES will implement “methane catcher”-boxes over the beds and feeding places to reduce methane emissions.

Money is not an attribute or goal of the farmer as it is nothing he wants to have for his prestige or to buy a new car or tractor even if it is not needed. The reason money is important to him is to run the farm and to have a protection in case of an emergency. He wants his farm to be “in balance”. He wants it to be better, not bigger (at the moment). Examples on how to get better are the development strategies mentioned in Chapter 2.2.

2.2. The development strategy for the coming 3-5 years

Various strategies are used to achieve developments within the herd. The developments include improving the animals within the herd through selective breeding, implementing strategies that directly impact the existing animals, enhancing housing conditions and equipment, among other approaches.

Breeding strategy

The breeding strategy at the farm focus on improving udder health by primarily focus on improvement of the back udder, lactation persistency, low mastitis susceptibility and increase milk yield. Improving lactation persistency is a part of the farmers strategy to lower the herd's carbon emissions. By extending the lactation period, fewer heifers are needed, reducing feed consumption for growth and increasing the proportion used for milk production, thereby contributing to lower emissions. Increasing milk yield was also a part of the breeding strategy in the herd. This trait is primarily related to production. This may contribute to higher profit and the farms further investments and resilience. Apart from focusing on udder health, the breeding strategy in the herd also focused conformation of the legs. This trait was chosen as a focus to improve animal health and welfare in the future generations and contribute to a reduced re-placement rate in the milking cows in the herd, which further may contribute to a decrease in carbon emission. Therefore, it may contribute to the production and economy in the herd.

This strategy aligns with his attributes about a good animal welfare, good working conditions, quality products and the environment.

Housing of dry cows and sick animals

One of the plans for development at the farm is to construct single pens and reconstruct the area for sick- and dry cows. Currently, there are no single pens in the herd to house sick animals or calving cows in. The construction of individual pens on the farm is driven by multiple factors. One of these factors being to ensure compliance with legal requirements.

Currently, sick cows are housed with cows close to calving in a smaller group on soft bedding. However, the farm seeks to improve animal health and welfare by minimizing competition at the feed table, reducing stress mainly for the sick cows, and lowering the risk of infections to dry cows and newborn calves. This is expected to cause a reduction in time used for treating animals, length of the cow being sick, calves which gets an increased risk of dying or negatively affect their growth and production afterwards, and a decrease in the fresh cow's following production in the lactation.

The plans for development of this area in the herd is still in process. The farm wants to construct some temporary single pens to meet the requirements and reach some of the benefits related to animal health and welfare as mentioned above, within a short period. This will be until a more permanent solution is constructed.

Currently, the dry cows are divided into two groups depending on time from calving. These divisions are to be maintained also after the expansion, because it is found to be a solution which makes it able to differentiate the feed rations between the two groups. This strategy aligns well with his attributes due to its expected positive effect on animal welfare and working conditions.

Same floor at the heifers as in the cow barn.

The heifers are housed in the shed formerly used for the milking cows. For bedding in the shed sand is being used, and the floor is slatted floor.

The barn was not build to handle sand as bedding material. This causes problems with the manure managing system and the associated pump. This problem leads to a higher frequency of replacing parts of the system, and thereby increases the costs for maintaining the system and a high amount of man hours are used on maintaining the system. It is a plan on the farm to change the floor to solid floor with a scraper system. At the same time the manure managing system should be changes to a system able to handle the sand. This development should decrease maintenance cost on the system and reduce man hours used on maintenance, which is assumed to affect production. This investment is expected to be made at earliest in five years. This improvement should be able to improve working conditions and animal welfare.

Solar panels

The farmer had already begun to investigate the possibilities for having solar panels placed the roof on some of the building. The farmer wants to be more self-sufficiency in energy over time, because he believes that this will contribute to decreasing the farm's carbon emission. This could contribute to a decreasing the carbon dioxide tax which the farmer has to pay the government. The investment is found to be favorable in the long term, to provide the farm a reduce in cost for electricity. This development on the farm will not be affecting the animal health and welfare directly. However, by reducing the costs on the farm an increased profit may be made. When having a larger sum of money available at the farm, developments in the farm, such as expansion

of dry cows and sick animals' area, or other health and welfare improving initiatives may be reached earlier than planned.

Focus on mastitis

An increased focus on mastitis is desired to be reached in the herd during the next couple of years. The increased focus should mainly be reached by investing in technology, which can detect mastitis more efficient than the subjective assessment conducted by the milkers, during the daily milking of the cows and the performance evaluation carried out once a month. The technology which the farm was going to invest in has not been decided yet. The investment was not considered to be one of the technologies which is already on the market but was considered to be one of the technologies which are still under development. Therefore, the horizon for the investment is unknown.

3. Housing system

3.1. Milking cows

The milking cows are divided into 4 groups. The first group are the newly calved cows, called "*new mothers*", who are housed together with heifers close to calving and sick cows. As soon as they have calved in the neighbour box (dry cows), they get moved there. For description see chapter 3.6 Sick cows.

After a few days with the "*new mothers*", cows get moved to the group for cows early in lactation, called "*fresh cows*", who are housed in the old barn (from 2001) in the back right corner. This barn has slatted floor, the feed bunk is internal, and the long sides are open with the opportunity to close curtains. In the fresh cows-group there are 40 cows. They have 40 sand-beds in two rows with a lying space of 190 cm length, 120 cm width, and 110 cm height. For the Holstein cows they are a bit small. The farm has 7 Jersey cows who always stay in this group because of the small beds. The group has two drinkers. The first one is 360 cm long, 50 cm wide and 70 cm high. The water is 20 cm deep. The second drinker is 150 cm long and 55 cm wide. There is one cow brush. The feed fence is a self-catching feed fence with 42 places. The distances between feed fence and beds and beds and beds are 3.60 m and 2.15 m respectively. The whole section is 26.1 m long and 11 m wide.

After their time at the fresh cows, Holstein cows go to one of two milking cow groups. One group is for the first lactation cows and the body size-wise smallest of the older cows, and the other group is for all the cows from second parity onwards and the cows with large body size. They differentiate them to give different feed to the parity-cows and to reduce stressful situations for small cows standing next to big cows. These two groups are housed in the new barn from 2020 (Figure 5) with roughened concrete floor and a slurry scraper on each side of the internal feed bunk. The sides are totally open with the possibility to close curtains. The barn has a size of 86 m length and 36.5 m width. The feed bunk is 4 m wide, so that ca. 14 m remain per section. The lying space in the beds is 180 cm long (160 cm at the top), 125 cm wide and 135 cm high. The beds start 28 cm above the floor and are filled with sand. They are arranged in three rows. The walking space between beds is 3 m wide and the distance between feed fence and beds is 4 m.

The first parity and small cows are housed on the whole left side. There are 168 cows in this group. The behind part (19.3 m) of their section is used as a separation while milking. It has 25 self-catching feed fence places and 38 beds. There is one drinker of 405 cm length and 91 cm height. However, the water surface available is only 365 x 49 cm and the water depth is 15.5 cm. The drinker is placed in a passage of 4.24 m width and 10 cm height. The remaining part of their section has 130 beds. There are three brushes and three more drinkers each in one passage. The feed fence contains here only a neck tube. When milking is over, the separation is opened again for the cows of this group. Then they have a total of 168 beds over the whole 86 m length of the barn.

The cows from second parity onwards and the tall cows live on the right side of the barn and share this side with the dry cows. The interior is the same as for the young cows. The section of the cows from second parity onwards is approximately 65 m long and has a neck tube as feed fence. They have 137 beds in three rows and 3 drinkers of which one is shared with the dry cows. The drinkers are each in one passage. There are 3 cow brushes also in the passages. There are 135 cows in this group.

In the old barn, where the early lactation cows are housed, especially the beds are too small. But also the overall design of where beds are placed and how big the alleys and passages are, could be improved. For the new barn, the overall space per cow, feeding and drinking space are too small.

3.2. Dry cows

The transition cows are housed in two groups with one containing the cows ranging from newly dried off to two weeks before calving, and a group containing the cows less than two weeks pre-calving. The dry cows are divided into these two groups due to limited space in the straw bedding. The requirements referred to in the following are found in "Bekendtgørelse om dyrevelfærdsmæssige mindstekrav til hold af kvæg, BEK nr 1743 af 30/11/2020.

The group longer than two weeks from calving is housed in a separate section in the barn with lactating cows. This section contains 33 cubicles with sand as bedding. On the day of counting, 32 cows were housed in the section, which meets the requirements. The section includes two alleys for passage, and two alleys along the feed bunk with a scraper for cleaning. All of them being concrete floor. The length of the feed bunk was 19,3 m, and contained 25 eating spaces, which does meet the requirement if all the cows in the section are categorized as not close to calving. The size of the cubicles is the same as for the lactating cows. The section has in total 6 m drinking trough, which meets the requirement saying that there should be max. 10 cows per meter drinking through (§82, stk 3).

The group containing the dry cows less than two weeks pre-calving are housed in a barn next to the section of sick cows, and fresh cows closest post calving. The section has a deep bedding area containing straw, and this area had a size of 195 m² and housed by the day of counting 12 animals. The area was well-bedded and flexible, which meets the requirements with the floor being dry and soft material (§86 stk5). It also meets the requirements for size being min. 8 m² per cow (§88). The section also contains an area with concrete floor by the feed bunk. This area has a size of 48.5 m². The section has an outside feed bunk with a length of 12.13 m total, with 12 eating spaces plus some open feed space. This meets the requirements that says a shared area for pre-calving cows should have at least one eating space per cow (§79, stk 4). The section does not have the possibility to milk with machine in the calving area, which is required. The section does not contain any single pens. The requirements are that if a herd contains more than 100 cattle, there shall be 4 spaces for calving pr 100 cattle with half of these being single pens. In the section were two drinking cups. According to the requirements there should be max 6 cows per drinking cup (§82, stk 2) so this meets the requirements.

3.3. Heifers

In the old barn of the farm, heifers and fresh cows are housed as shown in Figure 8. Heifers are separated into five groups according to age body size, and are moved from one pen to another following the direction the purple arrow shows in Figure 8 (excluding the fresh cows pen). Thus, the first pen contains the younger heifers, and the last pen contains the pregnant heifers.

On the same side as the milking parlor, there are three heifer pens, sizing 13.3 m wide and 56.4 m long in total. Each section contains a brush and a 3.40 m long, 0.50 m wide and 0.95 m high drinking bunk. The smaller heifers are housed in a section containing 39 cubicles (1.85 m long, 0.73 m wide and 0.93 m high) with sand as bedding and a 3.56 m wide passage alley. On the day of counting, 39 cows were housed in the section, which

meets the requirements, but this section is also totally filled. The next group of heifers is composed of 32 animals with 54 cubicles (1.85 m long, 0.80 m wide and 1 m high). The heifers pen closest to the milking parlor contains 70 cows and 80 cubicles (1.85 m long, 0.80 m wide and 1.10 m high).

On the other side, the barn contains two heifer pens and the fresh cows pen, sizing 11.3 m wide and 64.4 m long in total. The sand beds are the same size for the three pens (1.90 m long, 1.20 m wide and 1.10 m high). The first heifer pen contains 37 animals, 37 sand beds, a brush and a 1.40 m long, 0.50 m wide and 0.95 m high drinking bunk. Lastly, the pregnant heifer pen contains 19 cows, 19 cubicles, a 3.56 m wide passage alley and a 1.60 m long, 0.35 m wide and 0.90 m high drinking bunk. Note that the pregnant heifers pen does not have a brush.

As described in chapter 17 (sections 106 and 109) of the Decree on minimum animal welfare requirements for keeping cattle, the length and width of cubicles, as well as the width of the cross passage meet with the requirements.

3.4. Calves

On the farm, calves are housed in pairs within pens equipped with huts, separated by gender and age, with pairs designated for males and others for females of similar ages. Calves are housing in pairs, as the farm are a part of a heart-agreement. This arrangement ensures efficient management and fosters a suitable environment for their growth. The minimum area of the hut varies by the calf's weight, requiring 1.70 m² for calves under 60 kg and 2.00 m² for those over 60 kg (Housing Design for Cattle, 2001). On this farm, the hut area is slightly larger at 1.99 m², providing ample space for resting. Additionally, the exercise fold exceeds regulatory standards, with the farm offering 1.82 m² compared to the recommended minimum of 1.20 m². This ensures that calves have sufficient space for movement and exercise, contributing to both physical development and behavioral expression.

Temperature regulation is also a key consideration. While cattle generally tolerate temperature fluctuations between -20°C and +30°C, Denmark's climate rarely exceeds these limits. To address seasonal variations, the farm uses brightly colored huts to prevent excessive heat during the summer and adjustable ventilation vents to maintain airflow. In colder months, blankets are provided for calves, helping them cope with damp and cold conditions, which is essential for maintaining their overall health and comfort.

The partitions between pens are equipped with strip railings that allow visual and auditory contact among calves. This design supports their natural social interactions while preventing full physical contact, reducing the risk of injuries or disease transmission. Research indicates that such setups promote mental well-being and help calves adapt better to group housing later in life.

The farm's management practices also emphasize hygiene. Regular cleaning and disinfection of the pens, along with weekly replacement of bedding, help maintain a clean and dry environment. This reduces the risk of respiratory and gastrointestinal diseases, which are common concerns in calf rearing. Overall, the farm's infrastructure and management reflect a commitment to meeting and exceeding welfare standards, ensuring that the calves have a safe, healthy, and enriching environment to grow.

Each calf pen is provided with straw bedding approximately 37-45 cm thick, offering a soft and supportive surface for calves to lie down comfortably. This bedding promotes natural resting behavior, as calves instinctively prefer softer surfaces over hard or slippery ones. Additionally, the thick layer of straw provides insulation, helping calves maintain their body temperature, especially during colder months. The farm ensures hygiene by adding fresh bedding weekly, which not only enhances comfort but also reduces the accumulation of pathogens, minimizing the risk of respiratory and gastrointestinal diseases. Proper bedding maintenance is crucial for preventing infections such as navel ill or foot rot, which are common in damp and unclean environments.

Milk and water are provided in a teat bucket or a calf bowl mounted outside the front gate, with hay supplied in a hay rack. The bucket and bowl are removable, allowing for regular cleaning to maintain hygiene. On this farm, water is typically offered in the teat bucket immediately after milk feedings, ensuring calves have access to fresh water more than twice daily. While this practice meets hydration needs, teat buckets are not the most recommended option due to challenges in maintaining consistent cleanliness. Instead, using a dedicated water bowl is suggested for better hygiene and ease of access.

Additionally, the farm may need to adjust the hanging height of the teat bucket. With the high bedding level, the bucket occasionally hangs too low, making it difficult for calves to drink comfortably. Such adjustments would not only improve feeding efficiency but also support better animal welfare, as calves can maintain a more natural posture while drinking. These considerations reflect the farm's ongoing efforts to optimize feeding practices and calf well-being.

After eight weeks, calves are transitioned to group housing, where they have access to resting areas that meet their developmental needs. This shift is essential for fostering social behaviors and reducing stress, as calves begin interacting with peers in a shared space. The joint pens used on this farm adhere to the recommended space requirements for each young stock, providing sufficient room for exercise and maintaining individual distance.

The pen area is designed to support movement and minimize competition among animals, while the resting area features comfortable bedding that encourages natural lying behavior and ensures proper rest. This bedding is regularly maintained to ensure cleanliness and reduce the risk of disease. The farm's approach reflects a focus on both physical and psychological well-being, as group housing allows calves to develop social bonds while maintaining hygiene and comfort. Additionally, the infrastructure ensures that each calf has ample space to thrive during this critical developmental phase, balancing welfare and efficiency in housing management.

3.5. Sick pens

Currently, sick cows are housed with cows close to calving in a smaller group. It does not meet the requirements that must be possible to keep sick and injured dairy cows and young animals separate from other cattle (§ 32). However, the farm seeks to improve animal health and welfare by minimizing competition at the feed table, which helps to lower stress levels, especially for sick cows, and minimizes the risk of infections for dry cows and newborn calves. All together there are nine animals in this box. They live on straw, The section has soft bedding area containing straw which is fulfilling the requirements of bedding materials (§ 30), which is cleaned out ones every month. New straw is provided every second day. The feeding area has concrete floor and doesn't have a cleaning measure. Therefore, the cows must walk on dirty, wet floor. This does not meet the requirement that, Floors in the aisle areas in stables must be non-slip and be constructed, designed and maintained so that the dairy cows can walk naturally and are not injured (§ 61). The barn is shared with the dry cows close to calving. The length differs: The wall at the feed bunk (concrete part) is 16,7 m long and contains 8,25 m of self-catching feed fence (12 places) and a short piece of wall and a gate. The feed fence is tilted forwards to the feed bunk and this is fulfill the requirement that, the floor behind the feeding table must be arranged so that the cows are ensured a natural eating position and be level (§ 63). The concrete part is 4 m deep. The straw part therefore is 11,55 m deep, and it is 12,45 m wide which is not meet the requirement that, on farms with dairy cattle, single nursing pens must have an area of at least 10^{m²} for small breeds and 12^{m²} for large breeds (§ 35). The barn has openings on every side. The back wall is made from half-high concrete. Above this it is open for probably former curtains broke out. The front side is closed above the feed fence with corrugated sheet metal. The sides are half open half closed with corrugated sheet metal. To prevent cows from escaping through the side, a broken wooden beam was replaced with an unused drinker, in which, unfortunately, some very dirty water was accumulated. This group has three small drinkers that has a size of 23 x 55 cm. This section has one cow brush at the corner which meet the requirement that, cows must have access to at least one rotating cow brush in the herd (§ 64).

Production and animal health key figures

This chapter focuses on key figures from the production system, including quantitative measures of milk production, durability, reproductive performance and general health. Data is drawn from the Danish data cattle database, DMS. The purpose of key figures from the production system is to provide the farmer with relevant information, expressing the production. The farmer can use the information to benchmark with relevant comparison groups, and search for improvements. The benefits of them can be health, welfare, economics, technical efficiency. Three properties of key figures are relevant: correctness, validity and precision (Kristensen et al., 2010).

4.1. Production key figures

Farm A differs from other farms in their production figures by generally having a high milk yield throughout the cows' life and low replacement rates. A key figure describing the productivity in the herd is the yearly milk production, which at Farm A is above the Danish average (12065 kg ECM per cow per year), and even above the highest 25% of the comparison group. With a yield of 14499 kg ECM (13918 kg ECM delivered to dairy), it is thereby a very productive farm. A minor increase in milk production happened during the last year, compared to the previous year. The fat content of the milk is ~4% and the protein content is ~3.4%, which is fine. Between cows, older cows are more efficient and have higher milk production than younger cows, which is similar to other farms. The lactation curve for all age groups of cows peaked in the late lactation (>84 days after calving), but the first and second lactating cows were far from the farms' goal (kg ECM). Therefore, either the goal could be changed, or more focus could be on these groups. Generally, for all groups, the peak was approximately 181 days from calving, which was later than the comparison group. On the other hand, the yield is higher than the average, which is seen throughout their whole life, indicating that there is a focus on the older cows, that must perform too. When comparing the first lactating cows with the third lactating or older cows, they follow their production well. For both first lactating cows and older cows, the variation between cows is low (10.2% and 10.9%, respectively), which is good, but high for the second lactating cows (16.6%).

Compared to other farms, the replacement rate of the cows is lower. The replacement rate is 29.1%, and cows are therefore kept in the herd for a longer time, while they are still highly productive. A high productivity is seen throughout their whole life, which is good. Farm A differs from other farms regarding the mortality, that in both the last and previous 12 months have been higher (7.7% and 7.6%, respectively) than the comparison group. In the fifth lactation, the survival rate of cows was 8% lower than the average, but follows the average or are higher than the average in younger cow groups. For meat production, cows are in general slaughtered after 301 days, and thereby approximately 10 months after calving. Thereby, the farm utilizes the cows as much as possible before slaughter, and a lactation period is not wasted because of slaughter.

The reproduction efficiency is 0.27 for cows and 0.37 for first parity cows. This is fine, but could possibly be a little higher, and improvement could be made by catching the heat in time, and in that way, the pregnancy rate could be increased. The age of heifers at calving is 24.2 months, a little lower than the average. However, the farm wants to lower this, which easily can be done by adding sense hub monitors to younger livestock. Additionally, for the heifers, there is an average dissemination of 1.5 months between expected calvings, which is high and indicates that the time of insemination differs between heifers. Figure 13 shows the average age and the dissemination in the calving age of heifers, and the age ranges from 22-30 months. Again, catching the heat in time could decrease the dissemination in age between heifers. Generally, the farm could pay more attention to the younger livestock groups, as this age is very important for the future cow generations.

4.2. Health key figures

Key figures can also be used to determine the health status of the herd. Health can be displayed through different measures such as mammary diseases, metabolic diseases, reproductive issues and hoof- and limb problems. The following chapter will describe a few selected key figures regarding each of these areas.

Cows

Over the past 12 months the three most common diseases in the herd were mange, mastitis and ketosis (261 animals were diagnosed with mange, 51 cows had mastitis and 50 with ketosis). Third lactating cows and older are the ones who are most at risk. Of course, these numbers do not consider the number of cows in each lactation. For the third lactating and older cows the most common disease is mastitis. In 2023 a total of 16% of all the cows were diagnosed with new cases of mastitis, where a majority of these were third lactation and older.

For prevention measure when drying off they use teat sealer, in some cases combined with antibiotics. For the newly infected a large majority of the cows were only treated with teat sealer, whereas the chronic and cured were often treated with both. Fig. 15 shows the distribution of healthy, newly infected, chronic and recovered cows in the past two years (nov. 2022 - nov. 2024: this interval was chosen to get more data). It is noteworthy that more cows get infected than recover, and 52 cows during this period were registered to have chronic mastitis. Looking only at the past year (nov. 2023 – nov. 2024), the relation between newly infected and recovered is more equal with a few more cured than infected. This could be explained by an increase in the use of antibiotics. But a more efficient prevention method could still be highly beneficial – this will be further described in chapter '6. Biosecurity'.

Metabolic diseases

In 2023, 92 cows were diagnosed with metabolic diseases in total. Out of these 39 were incidences of ketosis, 21 were calving fever and 21 were displaced abomasum. Figure 16 illustrates the distribution of disease registrations over the days after calving. The figure shows or identifies a risk period being on day one after parturition, where a vast majority of the incidences of metabolic diseases occur.

Hoof- and limb problems

In 2023, 37 cows had a hoof or limb problem. 14 of the cows were diagnosed out of which 13 were skin related hoof disorders and just one was a limb disorder. Figure 17 shows a spiderweb diagram of the different disease areas. This shows that digital dermatitis is the far most common hoof disease occurring in this herd.

Other diseases

Under 'other diseases' 286 animals were diagnosed where 276 of these suffered from skin related diseases. This very high number could possibly partly be explained by a current out-break of ringworm in the older heifers.

Young animals

In young animals, the most common disease is cryptosporidiosis, coccidiosis, pneumonia and enteritis. The distribution is illustrated on figure 18, aside from cryptosporidiosis which is for some reason not included in these numbers. Over the past 12 months 164 cases were registered. 151 young heifers were diagnosed with pneumonia and the majority were between 15-60 days of age.

Deaths

Another key figure of health status is deaths. For calves (aged 0-2 months) the death percentage in this herd is 9.2%. For comparison the 25% best herds have a deathrate of 3.2% and the 25% worst are 6.2%. The main issues lie with the primiparous cows which calves have a deathrate of 13.7%. The survival rate for heifers at first calving is 87.4% with an average calving age of 24.2 months. For the cows this herd also has a relatively high death percent. Over the past 3 months the percentage of dead cows was 11.9% and over the past 12 months it was 7.7%. This indicates there currently must be some problem in the herd causing the death rate to increase so rapidly.

5. Management systems and management tools

5.1. Feeding management

Feed management is defined as all inputs ensuring that a cow is eating the expected amount and quality of feed it is supposed to. It tries to make sure that the formulated ration, the ration in the mixer wagon, the ration on the feed bunk and the ate and digested ration are all as calculated. There are many factors that are involved in feed management: First, there is the quality of the feed, with which the ration is planned. Then there is the precision of the weighing when filled in the mixer wagon, how homogeneous the feed gets mixed and how much structure damage happens by (over-) mixing. The next factor is whether the cows can sort the feed because it is either badly mixed or too dry. Then the cows prefer to first eat the more delicious concentrate feed and therefore get an unbalanced nutrient intake as well as probably too less fibre what can damage the rumen. As a result, not all cows are going to eat the same ration, when some cows already took away one component. At the end, the cow-feed space-ratio also has an impact on how well every cow can eat the planned ration. At Farm A the cows get a TMR (total mixed ration) that contains roughage and concentrate feed. They are fed ad libitum. There is no supplementary concentrate feeding for single cows, but cows are grouped according to their lactation status and every group gets a different ration that fits the animal's needs.

In Denmark a feeding management index tool is used, developed by Knowledge Centre for Agriculture (Bligaard, 2007). It is based on a questionnaire and gives guidelines describing good and poor management. It detects both strong and weak areas and finds not only the big obvious problems but also problems that consist of several minor problems. To illustrate the results, the program gives out diagrams. There are six focus areas:

1. Forage and supplementary feeds: Quality and storage
 - Silo surface (clean cutting edge)
 - Clean and dry concrete area in front of silo
 - Mold, heat, etc.
2. Feeding techniques: feeding the expected amount every day
Stick to the plan! -> putting more or less of one component changes the whole ration nutrient wise
3. Feed bunk management and water: Uniform feed ration and no sorting
 - Plenty, clean and fresh water
 - Penn State Particle Separator
4. Cow comfort: Hygiene
 - a. Clean cows (thin faeces can be influenced by the feed)
 - b. Hock lesions
5. Transition cows: Strategic decisions and practical arrangements
 - Is the drying off planned?
 - How is grouping?
 - Are plans followed?

Forage and supplementary feeds:

The silos make a good all in all appearance. Figures 19 and 20 give an overview over the forage silos. They are closed well and airtight with foil, tires and stone bags. Behind the silos grass and some small bushes are growing, and I found some dog excrement. The concrete floors in the silos were a bit dirty from soil and little feed leftovers. The grass silos had most spilled feed. Other than that, they were clean but especially from the closed silos lots of liquid run out assembling together with rainwater in puddles and flowing over the everyday working ways. From there, it can easily be carried over the whole farm by wheels and shoes. These are of course mainly biosecurity and environmental issues, but some are caused by the feed handling. This is the reason, why they are mentioned here as well. In the following every silo is described shortly:

Maize silo: When approaching the silo, three sparrows flew away from the open part of the silo. Ca. 2 m are uncovered. The silage at the top right side had a very bad acidic smell and there was reheating ca. 20 cm below the surface. There was no reheating in the middle on the top. The cutting edge was a bit messy but still ok. On the floor were still some leftovers in two heaps. On one of them I could find some spots of mold, but it wasn't visible where it originated from. The shaft length is nice; some pieces of timothy leaves were still quite long. The seeds are cracked well. The front part of the silo is used to store some straw and hay. It is not protected from rain there.

Grass silo 1: This silo has a rather messy cutting edge, and a big heap was laying in front. It was uncovered 80-140 cm. There were some small stones from the stone bags on the top left of the silo. This probably wasn't noticed by the people uncovering. Directly under the surface there was a little mold in some areas and on the top right corner there was a mold nest. I couldn't find reheating there but, on Figure 22 there was some steam visible. So perhaps there was reheating.

Grass silo 2: The silo was 2-2.85 m uncovered. The colour is lighter than in grass silo 1 and it seemed to be dryer. At a small area there was some mold below the surface (Figure 23). The cutting edge is also quite messy, and some rest lay on the floor.

Concentrate silos: At the farm, two different concentrates are used: Soybean meal and a pelleted concentrate. They are stored openly in a barn and separated by a concrete wall. On the soybean meal sat two doves and one bird faeces could be spot. In both concentrates little contamination with other feeds were found. It was mainly straw.

There are also milk replacer, calf feed and minerals used, such as feed salt, sodium carbonate and calcium carbonate. They are stored next to the concentrate silos under the roof. There were no open bags, and the big bags were closed so that no bird or other animal can go inside.

Penn State Particle Separator

The Penn State Particle Separator contains of 4 boxes with different sized sieves in the bottom (Figure 24). The sizes are 19, 8 and 1.18 mm from the top to the bottom. The last box doesn't have a sieve. The separator is used to find out about the particle size distribution in the feed: Is there enough fibre inside and can the concentrate feed be separated out by the cows? In this case, the system was used to examine the sorting possibilities. Therefore, a feed sample of around 500 g is placed evenly on top of the Penn State Particle Separator, which then is shaken according to a specific pattern. At the end the feed on every section is weighed. These are the results from the different feeds at the farm:

The recommended distribution of particle size according to Penn State Extension for milking cows is 2-8% in the upper sieve (>19 mm), 30-50% in the middle sieve (8-19 mm), 30-50% in the lower sieve (1.18-8 mm) and <20% in the bottom pan (Pen State Extension, 2022). These recommendations are barely met what can be good and bad at the same time. More big particles mean a higher fibre content good for the rumen health but at the expense of a high energy level. In heifers and dry cows, a lower energy level is required, so there the tall particles are many. Few small particles can mean that there is only little use of concentrate feed meaning there might not be a high energy level in the feed. In this farm's case the reason for a so small fraction below 1.18

mm might be the good wetness of the feed. Most of the small particles stick to the bigger ones so that they can't be sorted out by the cows.

The Penn State Particle Separator can also be used to determine the uniformity of the mixing. Therefore, two samples from the same feed and taken at the same time are tested and compared, one from the beginning and one from the end of the feed bunk. They should have the same structure and distribution on the different sieves. Likewise, it can also be tested how robust the feed is against selection. Therefore, two samples from the same feed and from the same place are taken with some hours difference. When the second sample has less small particles, it can be concluded that the cows sorted them out and ate them first.

Cow comfort:

This topic wasn't particularly examined but what attracted attention was the thin faeces in the milking cows. Considering the results of the Penn State Particle Separator, the cause might not lay in the amount of big fibrous particles although this might be the first impression. The cows already have way more of them than recommended.

Transition cows: Strategic decisions and practical arrangements

Dry cows are housed in two different groups: Far off and close to calving. The close up feed-ing contains additional X-Zelit to the normal dry cow ration. X-Zelit lowers the amount of calcium the cow can take up from the feed. Without the calcium from the feed, the calcium concentration in the blood sinks and the body must mobilise calcium from the bones. It is important that cows start training mobilising calcium from the bones before they calve, because they need it afterwards. As soon as the milk production starts, the cow needs a very high amount of calcium that can't be satisfied by the feed alone. A cow whose body isn't used to mobilise calcium from the bones, will take it from the muscles and is very likely to fall sick from milk fever. Figure 25 summarises the results of the Index for feeding management.

5.2. Reproduction and replacement management

The farm is interested in breeding, so there might be a bigger focus on the selection of semen at this farm, compared to other farms. Heifers are inseminated with sexed semen to make their first calving easier, as heifer calves are smaller than bull calves, and heifers are less developed and smaller than older cows. If insemination is not successful after a couple of tries, general semen is chosen, and if not successful after multiple times, the heifer is sent for slaughter. Older cows are often inseminated with beef semen. Collars, to measure activity and heat, are attached to heifers at a minimum of 14 months of age, but the farm wants to lower this age as one of their goals. For the cows, the farm uses a medicament to induce heat after treatment of cysts or if heat is undetectable. In the last 12 months, 100 cows out of 400 cows have been treated to induce heat, 79 have been inseminated within a month after treatment, but only 22 of those were positively pregnant. Improvements can be made in this area, as a positive pregnancy rate of 22% is low. Problems with reproduction could be due to the high productivity, negative energy balance and hormonal imbalances. Research show that the onset of lactation is associated with changes in the hormone balance, negatively affecting the reproduction, possible delaying the cycle (Walsh et al., 2011).

Regarding replacement management, the timing where new 1st lactating cows are introduced to the herd after having their first calf, replacement should happen if the number of yearcows should remain stable. Different tasks occur in replacement management. First, cows for replacement need to be chosen, which is done based on different criteria. Secondly, the reason for culling is often based on the same criteria, but the time of culling is essential. A cow can e.g. be non-pregnant, but still have a high yield, and the time of culling could then be when the costs exceed the income from the cow. However, the cow could potentially milk in this state of life for a long period. Cows sent for slaughter could potentially be a few months pregnant, as this is legal. However,

the farmer would avoid this if possible. Heifers are often culled due to non-pregnancy after several tries of insemination, and the time of slaughter here is essential for economics, as heifers don't have another function, and empty days are expensive in feed sources.

The management cycle consists of different parts. As an example, a goal could be to increase the pregnancy percentage of heifers by 5% within 3 months (53% → 58%), thereby increasing the reproductive efficiency. For planning, the farmer must analyze the present situation and collect the current pregnancy percentage. The plan depends on the situation, but it could be to optimize the feeding, so heifers are in the correct shape for insemination. Implementation is done when the feed has changed. After three months and during the period, the farmer can check to see if the plan goes in the right direction. After three months, data from the database are analyzed, and if the goal is achieved, the plan works. If not, another plan could be made, e.g. buying new collars.

5.3. Tools currently applied in production and health management

Management tools assist the farmer in the herd management. Tools provide the farmer with data that can be used as an information source to gain knowledge and work as a decision support system. Different management tools can be applied in dairy cow production systems to monitor different aspects and improve production regarding productivity, health, reproduction, and health.

6. Biosecurity

6.1. Internal biosecurity

Farm A Farm has established biosecurity practices to ensure the well-being of its livestock, specifically targeting areas like calf, heifer, and lactating cow management. These practices focus on grouping, hygiene, feeding protocols, and housing conditions to mitigate disease risks effectively.

6.1.1. Calves

The calves on the farm are managed with a focus on optimal grouping and hygiene to minimize health risks and promote well-being. Calves are housed in pairs based on gender and age, creating a controlled environment that supports social interaction while reducing the likelihood of disease transmission (Figure 27). Younger calves are housed two per pen, while older calves are grouped in fives. This system ensures that calves at similar developmental stages are housed together, which reduces competition and facilitates easier management. Feeding follows a structured order, starting with younger animals in the morning and then moving to older animals. In the afternoon, feeding occurs after milking the lactating cows. This carefully planned sequence minimizes cross-contact between animals of different ages, reducing the potential spread of pathogens.

Hygiene is a critical component of calf management. Before feeding, workers change into clean clothes and shoes to avoid bringing contaminants into the feeding area. Gloves are replaced after handling sick cows to prevent cross-contamination. Feeding equipment, such as teat buckets, is cleaned daily using hot water, soap and brush, with a weekly deep cleaning using soap for thorough sanitation. This practice ensures that milk and water provided to the calves remain safe and free from harmful bacteria.

The farm also implements an all-in, all-out system for calf pens, which involves thorough cleaning and disinfection of each pen before introducing new calves. This practice reduces the risk of pathogen build-up and provides a healthier environment for incoming animals. Bedding is replaced weekly, ensuring that calves have a clean, dry, and comfortable resting area. Combined, these measures reflect the farm's commitment to maintaining high standards of health, hygiene, and animal welfare.

6.1.2. Lactating Cows

For the lactating cows, cleanliness and a strict milking routine are emphasized to ensure optimal milk quality and herd health. The cubicles where the cows rest are cleaned three times daily, specifically during cow collection for milking. This frequent cleaning helps to maintain a hygienic and comfortable resting environment, reducing the risk of udder infections caused by dirty bedding. Additionally, water troughs are cleaned twice a week, with soap being used once weekly for deeper sanitation. This routine ensures that cows always have access to clean, safe drinking water, which is crucial for their hydration and overall health.

The milking order follows a carefully designed protocol, starting with fresh cows and sick cows, followed by young or first-lactating cows, and finally, older cows. This sequence minimizes the potential spread of diseases, as younger and fresh cows, being more susceptible to infections, are milked earlier. The protocol ensures that any pathogens from older cows are less likely to affect the more vulnerable members of the herd. This systematic approach reflects the farm's commitment to minimizing disease transmission during milking.

The milking procedure itself is thorough and hygienic. It begins with stripping out milk from five cows, cleaning their teats with foam, and attaching the milking machine. After milking, a teat dip is applied to protect the udder from bacterial contamination. To prevent cross-contamination between cows, each milker wears gloves and uses a separate cloth for each cow. This meticulous routine underscores the farm's dedication to maintaining both animal health and milk safety, ensuring high standards are met consistently.

6.1.3. Heifers

Heifers on the farm are primarily managed with a focus on cleaning and feeding, although there are areas that could benefit from improvement. One significant health challenge is the presence of ringworm, which remains untreated and poses a risk to the overall health of the animals. This issue highlights the need for further health interventions, such as implementing a vaccination program or adopting more rigorous biosecurity measures to prevent the spread of skin diseases. Addressing this would improve not only animal welfare but also productivity.

The cleaning routine for heifers involves adding sand to the pens as needed to enhance bedding comfort and absorb moisture. However, old material is not removed regularly, which could lead to hygiene concerns over time. Cubicles are also not cleaned as frequently as desired, potentially impacting cleanliness and health. Slatted floors are utilized to facilitate drainage and improve the overall sanitation of the housing environment. Water troughs in the heifer pens are cleaned twice weekly using a brush, with a focus on maintaining sanitary drinking conditions and reducing the risk of waterborne diseases.

In terms of feeding, the farm practices efficient resource use by providing leftover fresh cow rations to the youngest heifers. This ensures they receive high-quality nutrition, which is vital for their growth and development. However, consistent monitoring is necessary to confirm that the feed remains fresh and suitable for consumption. Improving oversight in this area would further enhance the health and growth of the heifers, ensuring their nutritional needs are met effectively.

6.1.4. Dry and Sick Cows

The dry and sick cows on the farm are grouped in separate areas to minimize cross-contamination and maintain overall herd health. Dry cows are housed either in a dairy barn or in a straw-bedded area two weeks before calving, ensuring they have a comfortable environment as they prepare for parturition. A separate group is designated for new mothers, sick cows, and heifers one week before calving. However, housing sick cows and dry cows in the same area poses significant risks, as it may lead to the transmission of diseases. This concern is especially critical for newborn calves, which are highly susceptible to contracting infections shortly after birth. To mitigate these risks, implementing stricter separation protocols for sick cows could improve disease control.

Straw bedding in these areas is fully replaced once a month, with fresh straw added every other day. This routine helps maintain a clean and dry environment, reducing the risk of respiratory and skin infections, which

are common in damp or unhygienic conditions. Regular bedding management not only improves animal comfort but also supports their overall health during this vulnerable period.

Newborn calves are moved into individual boxes within 12-24 hours of birth. This early separation reduces the likelihood of disease transmission from the mother and allows for closer monitoring of each calf. It also ensures proper colostrum intake, which is vital for building immunity and supporting early development. These measures reflect the farm's commitment to balancing health, hygiene, and animal welfare.

6.1.5. General Biosecurity Measures

In general, all staff members are required to change their clothes and boots upon arrival at the farm to prevent the introduction of external pathogens. When moving across different sections of the farm, such as from slatted floors to feed bunk areas, workers clean their boots to prevent cross-contamination between areas. However, washing facilities for boots are currently unavailable in the heifer and dry cow barns, which could pose a biosecurity risk.

The farm also utilizes different tools in each section for practical reasons rather than biosecurity. Deep bedding is used, with straw stored close to calves but away from feed to reduce contamination. Straw from sick cows is directly sent to manure facilities on the farm, reducing the risk of spreading pathogens through waste material.

6.2. External biosecurity

6.2.1. Cattle movement

The farmer currently does not buy any cows or heifers; it has been 7 years since the last purchase of two Jerseys. For outside trucks, the farmer ensures they are kept as far as possible from the barn. Small calves are transported in a small box, and the people who pick them up have no contact with the other animals. When large animals are sold, they are placed in a wagon and brought to the roadside, where they are then loaded onto the truck. The farm handles the transportation of animals to the slaughterhouse, and wagons are thoroughly cleaned afterwards, before re-entering the farm. This same protocol applies in feed transportation: the outside re-mains outside the farm, as far as possible from the animals, and farm staff is responsible for bringing the feed inside.

It is also important to note that the farmer attends numerous farm shows. Although testing and control measures are in place in these events, the animals are housed for about one week with animals from other farms and share milk machines with one another.

6.2.2. Boundary control and disinfestation

The farm has no physical boundaries or fences. To deter birds, they use "BirdAlert", which works by emitting sound and according to the farmer, works very well and solved a significant problem they had with birds last year. The alert makes sounds which scares the birds, and keeps them away. To control rats, a pest control company sets traps and poison once a month. Rats are not a major problem throughout the year, but more may appear during winter (Figure 29a). The tall vegetation around the buildings can provide hiding spots for rats or mice.

Regarding cats and dogs, while the farmer's dog does not go far from the barn, cats cannot be controlled within a 2-kilometer area around the farm, so they have access to all areas.

A spilled area of milk discharged was found (Figure 30), which, along with the grains from the feed storage, can be a potential attraction for animals like mice, rats and cats.

6.2.3. Visitors

The farmer is not very strict with farm visitors, as having visitors is important for the farm. He hopes that visitors act responsibly and have not visited other farms beforehand. Routine visitors, such as technicians and

veterinarians, must change their boots and wear suits when visiting the farm. During guided tours and daily work, they try to keep boots and clothing clean when moving from the cows to the calves.

6.2.4. Feed and water

When it comes to feed delivery, no quality tests are conducted. In terms of water quality, regulations in Denmark include specific standards for drinking water for livestock, similar to those for human consumption.

6.2.5. Location and environment

The nearest farm is the farmer's father in law small farm, which houses 20 heifers. There are 7 kilometers to nearest slaughterhouse, where the farmer's wife works. She works in the office, so contamination does not pose a problem. Additionally, she is not very involved in the herd and does not help in the stable.

Regarding the disposal and storage of dead cows, there is a storage beside the barn. This is not the best place, because the route for the feed truck crosses this. It is also notable that there is a lack of a manure heap with proper drainage or discharge, which causes areas of standing nutrient-rich wastewater.

7. Animal welfare

7.0. Introduction: Animal welfare

Animal welfare refers to the physical and mental well-being of animals and is a key consideration in their care and management. However, it is not easily defined. Welfare assessments have often used the "Five Freedoms" framework, which provides a comprehensive perspective on the needs of animals. By evaluating these freedoms, farmers as well as politicians, professionals and consumers can identify and mitigate welfare concerns. This ensuring that animals experience a 'good' life, as well as ensuring an understanding for exactly what is animal welfare. Fraser (2008) proposed three perspectives of viewing animal welfare (Basic health and functioning, Affective States and Natural Living). He suggested that depending on background and education different people might define animal welfare differently. This is also why a clear definition and understanding of animal welfare is needed for a proper discussion.

John D. defines and views animal welfare from Fraser's Basic health and functioning perspective. According to John D. animal welfare is obtained if the animals are healthy and high producing.

In the present report four different animal welfare assessments were made to assess animal welfare through both a health and affective states perspective:

1. Lameness score
2. Body condition score
3. Social interactions
4. Use of brush

Lameness score was assessed by observing a total of 79 cows walking past the observer at a moderate pace. The cows were chosen by assessing every third cow. The cows were walking from the milking parlor and back to the stable in a straight line. The observed cows were picked by convenience sampling. As a starting point every third cow was observed, however at certain times several cows left the milking parlor at once and at these times observation was not possible. The cows were scored from 0-3 according to their lameness, which will be further described later.

Body condition score was assessed by the same approach as the lameness score. The 79 observed cows were also picked by every third cow walking by. As a starting point every third cow was observed, however at certain times several cows left the milking parlor at once and at these times observation was not possible. Body condition scoring is also further described later.

Social interactions were assessed through observations of two different groups of animals: Pregnant heifers (19 animals) and young heifers (39 animals). Each group was observed during a 30-minute time period. Two observers each monitored one side of the pen observed pen and registered every interaction occurring on their given side. Interactions were divided into four different groups and the observations were carried out first 30 minutes on pregnant heifers and then 30 minutes on young heifers.

Use of brush was also registered on two different groups of animals: Young heifers (39 animals) and old heifers (37 animals). The observations were carried out at 2x 30-minute intervals resulting in 60 minutes in total for each group. One observer monitored each group. Observations were registered each time an animal came into physical contact with the brush for more than 3 seconds, i.e. intentional contact and not just walking by. Each animal was registered by ear-tag or specific characteristics to be able to differentiate between the animals engaging interaction with the brush. Along with this the amount of time for which the animal used the brush was also registered. These observations made it possible to register number of different animals visiting the brush, number of visits in total, amount of time per visit in average and amount of time the brush was used in total among all animals.

The two main differences between the two groups observed was primarily age and health status: The young heifers were approximately 6 months of age and were visibly infected with ringworm. The old heifers were approximately 20 months of age and had no visible skin infections or disease.

These four different animal assessments will be further described in the following two sub-chapters.

7.1. Biological and mental animal welfare

7.1.1. Body condition score:

When analyzing body score condition (BCS) at the farm for all lactating cows variations in this were detected. It was determined that a 69.7% of the cows were found to have an optimal BCS (determined to be 3,25). A notable amount of the lactating cows were detected to have BCS a bit below (10.5%) or above (19,7%) optimal, with a minor pro-portion of the cows detected to have a BCS further from optimal (<3 or >3.75). The results from the BCS assessment in appendix 3. These variation may be due to several factors, which results in reduced welfare. Cows determined to have a low BCS, may be affected by a disease, or lameness which causes less time at the feed bunk as the cow will try to reduce pain by avoiding to put weight on it, and thereby a reduced feed intake and an increased risk of hunger. Other factors might be if a cow is placed low in the hierarchy, which increases the risk of lower feed intake, or a lower nutrient intake if the cows are able to separate the feed (Hartung & Rehage, u.å.). According to the Penn state separator test, the recommendations of particle size are barely met, which indicates that the cows can separate the feed ration.

Cows with an optimal BCS (around 3.25) are generally in a state of balance where their energy reserves support essential functions such as milk production, movement, and immune response. This optimal condition allows cows to feel content and comfortable, free from the distress associated with hunger or physical discomfort. Such cows are more likely to engage in natural behaviors, such as grooming, socializing, and resting, which are indicators of positive welfare and a good emotional state.

However, when cows fall below the optimal BCS, their emotional state can shift negatively, reflecting their struggles. Cows with a low BCS may experience persistent hunger due to insufficient nutrient intake, which leads to feelings of frustration and discomfort. Hunger is not merely a physical sensation; it is an emotionally distressing experience for the animal, signaling an unmet need that causes psychological suffering. Low BCS may also be linked to pain caused by injuries or illnesses such as lameness. A cow avoiding standing at the feed bunk to reduce pain from a sore limb is not only physically constrained but emotionally affected by the stress and isolation that may result from this behavior. Pain, as a negative emotional state, can lead to anxiety and withdrawal, further reducing the cow's welfare.

7.1.2. Lameness score:

When comparing BSC with lameness score (LS) in the same cows no notable relation was detected. Although some of the cows having a low BCS also had a high LS, which may have a relation. When analyzing lameness at the farm for the lactating cows, below 50% were detected to show no sign of lameness, with above 50% showed a LS between 1 and 3, with the majority being 1. The results from the lameness score assessment can be found in appendix 4.

By comparing these observations with the disease assessment from DMS, only 15 hoof and limb disorders were detected, but 41 symptoms were observed according to DMS. This indicates that the focus on this on the farm might be too small compared to the detected problem. When analyzing the disease assessment, it was found that the herd had a high incidence of mastitis (53 in the last 12 month) and ketosis (50 in the last 12 month).

When cows experience lameness, their behavior often changes to compensate for the pain, with noticeable increases in lying time. While rest is essential for recovery, excessive lying in suboptimal conditions can lead to additional health complications such as mastitis. This condition not only worsens physical pain but contributes to a negative emotional state, as the cow endures ongoing discomfort and stress associated with illness. The frustration and distress caused by this physical state further underline the interconnectedness of health and emotional welfare in animals.

Moreover, lameness frequently results in reduced feed intake, as the pain makes prolonged standing and walking to feeding areas difficult. This reduction in feeding impacts the cow's ability to meet its biological energy requirements, leading to metabolic disorders such as ketosis. Hunger, coupled with the physiological stress of disease, places the cow in a prolonged state of physical and emotional distress. The resulting imbalance affects not only the animal's health but also its capacity to interact socially and engage in instinctive behaviors, critical components of its overall well-being.

7.1.3. Mastitis and Ketosis:

According to health analysis from DMS the cases of ketosis are recorded by the veterinarian. This may indicate that only the severe cases which are treated by the veterinarian, are included in 50 cases. Due to the treatment of less severe cases of ketosis not necessarily include use of medication, but other means, these cases may not be recorded. Ketosis is a metabolic disease which reduces the animals' welfare, and production. The high incidence of ketosis might influence the variations in BCS, due to the reduced feed intake caused by the sickness.

Mastitis, an inflammatory condition affecting the udder, causes considerable pain and discomfort for cows. Swelling, heat, and sensitivity in the affected areas interfere with their ability to rest and lie comfortably.

Ketosis, on the other hand, results from an energy imbalance, often during peak lactation, when cows struggle to meet the metabolic demands of milk production. This condition leaves animals feeling weak, lethargic, and unwell, reducing their capacity to eat, move, and engage in normal behaviors.

The feelings of these cows are central to assessing the herd's welfare. Cows with mastitis likely experience acute physical pain and localized distress, while those with ketosis endure persistent weakness and discomfort. These conditions not only reduce their productivity but also undermine their ability to experience positive states, such as comfort, satiety, or social connection. Effective DMS should aim to mitigate these negative experiences through preventative strategies, timely treatments, and environmental adjustments to promote overall health and well-being. By addressing these issues, caregivers can reduce suffering and improve the herd's quality of life while ensuring a sustainable and productive farming operation.

7.1.4. Usage of brushes:

The observation proved that the young cows are more likely to experience ringworm than older cattle, partly because they used grooming brushes more frequently and enthusiastically for pre-venting irritation or itching. Calves often interact with brushes more eagerly than adult cows, using them not only for grooming but also as a way to relieve itchiness and explore their environment. However, when brushes are not properly cleaned,

they can become a source of ring-worm transmission. We also observed that there are no brushes for pregnant heifers. But according to legislation all animals must have access to brushes.

Ringworm, a skin condition caused by fungal spores, spreads through direct contact with contaminated surfaces. Because young cows are still developing their immune systems, they are more susceptible to infections. Their energetic and frequent brushing behavior increases the likelihood of coming into contact with spores left by infected animals. Older cows, who tend to use grooming brushes less actively or less often, are less exposed to the same risk.

7.1.5. Standing in the waiting area:

When the cow pusher was not used, the cows displayed a range of behaviors that indicated varying levels of comfort and social interaction. In groups where there was ample space, the cows appeared more relaxed and voluntary in their movement towards the milking parlour. Some cows walked around freely, which suggests they were not experiencing undue stress. However, when the cows were more crowded, particularly at the front, the situation became more tense. Heads-up behavior was observed in these areas, a sign that the cows may have felt anxious or threatened by the confined space. Despite this, they still entered the parlour voluntarily, which could indicate a degree of familiarity and comfort with the process, though the presence of the milker's whistling suggests some level of communication or guidance being necessary.

In contrast, when the pusher was used, the cows were forced to stand closer together, which limited their ability to move freely. This resulted in some cows showing heads-up behavior, likely due to the discomfort of being in close quarters. The forced proximity caused some distress, especially when the pusher's movement directly impacted their space. For some groups, especially those that were more tightly packed, the cows seemed eager to escape the cramped conditions of the waiting area, which might indicate discomfort or a desire to avoid the stress of crowding. However, as soon as the group size was reduced, more movement was observed, suggesting that less crowded conditions allowed for more natural social behaviors and a sense of relief.

7.1.6. Sick pen:

Currently, sick cows are housed with cows close to calving in a smaller group. Animals in poor health require a quiet, clean, and comfortable environment that allows them to recover without added stress from the herd dynamics or unsuitable living conditions. The absence of a sick pen can lead to feelings of fear, anxiety, and discomfort in the affected animals. They may struggle to compete for food or space, exacerbating their physical weakness and slowing their recovery.

From an animal welfare perspective, the lack of individualized care can result in a sense of neglect or vulnerability in the sick animals. Isolation from the herd in a designated sick pen, if provided appropriately, not only helps in recovery but also prevents the spread of infectious diseases within the herd. This arrangement acknowledges the emotional and physiological state of the sick cows, providing them with a safe haven where they can heal without undue stress or fear, which aligns with the principles of animal welfare.

7.1.7. Mortality:

The high mortality rate among calves in this herd, particularly the 9.2% death rate for those aged 0-2 months, is a concerning indicator of potential welfare issues. When an animal dies at such an early stage of life, it suggests significant distress and suffering before the death. The calves may experience pain, discomfort, and fear, often compounded by inadequate care during calving, birthing complications, or postnatal conditions that are not addressed in a timely or effective manner.

From an animal welfare perspective, the mortality figures point to a failure to adequately safeguard the lives of both the calves and their mothers. In such a context, the animals are likely to experience heightened levels of distress, anxiety, and suffering, either through the direct pain of illness and injury or indirectly through the neglect or lack of appropriate intervention. A system that allows such a high mortality rate reflects poorly on the overall health care and management practices of the herd, suggesting that animal welfare considerations

are not being met to the necessary standards for the animals to thrive and live free from unnecessary pain or fear.

7.1.8 Social interaction

During the farm visit, several behaviors were observed among cows that highlighted negative social interactions, particularly in the vicinity of the feed bunk. These behaviors included physical nudging, where one cow used its head to bump another, prompting the recipient to move away. In most cases, the nudged cow would vacate its position at the feed bunk, allowing the initiating cow to access the feed. However, there were also instances where a cow attempted to push or nudge another without eliciting any movement, leading to prolonged physical contact or tension between the individuals. Such interactions suggest a competition-driven dynamic within the herd, often associated with limited feeding space or overcrowding.

These observations highlight the importance of adequate feed bunk design and space allocation in managing herd dynamics. Providing sufficient linear feed bunk space for all cows to feed simultaneously can help minimize competition and reduce the frequency of such negative interactions. Additionally, strategic placement of feed and ensuring consistent access throughout the day can alleviate bottlenecks and promote a more harmonious feeding environment. Addressing these issues is essential for optimizing feeding behavior and maintaining overall herd productivity and health.