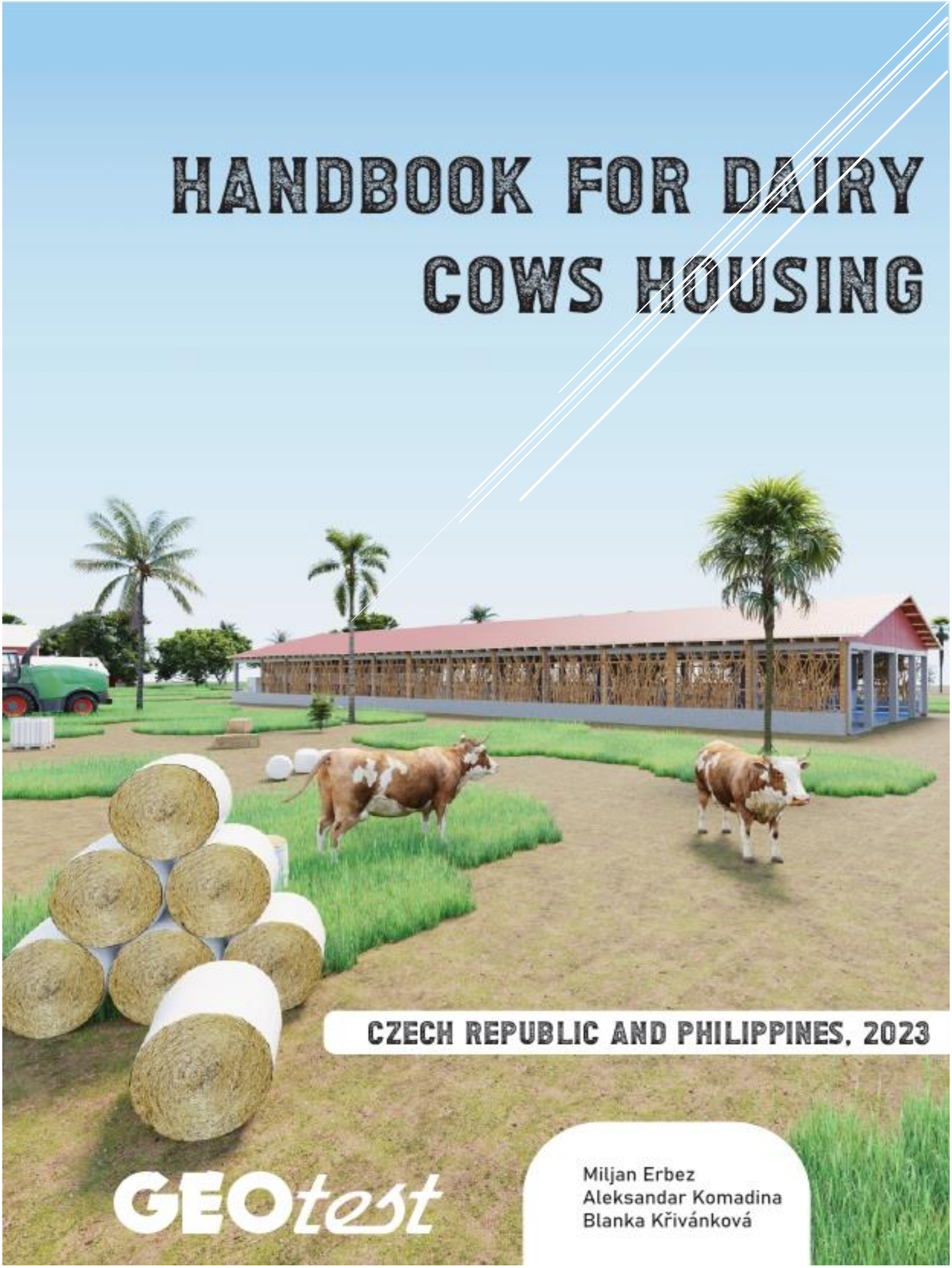
HANDBOOK FOR DAIRY COWS HOUSING



CZECH REPUBLIC AND PHILIPPINES, 2023

GEOtest

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Contents

1. INTRODUCTION

Milk production is very important in the Philippines and employs a significant number of people in the rural areas of the Philippines. The total production of milk in the Philippines in 2022 was about 60 million liters and has a growing trend.

The situation of the market of agricultural products has become very dynamic in recent years, and the production itself has become very demanding and sensitive. Breeders who have remained active and intend to make cattle production their main occupation will have to adapt to the situation, that is, they will have to be competitive and professional. One of the basic conditions that producers must meet is the quality of housing and the well-being of cattle. In this way, their production will be sustainable, stable and competitive.

An additional motivation for improving the housing conditions of cattle is the awareness of buyers of products of animal origin: in order for the product to be of high quality, the animals should be raised in good and high-quality conditions, as this will best preserve their health, and a healthy animal is an equally healthy product. Considering the natural characteristics and the possibility of producing green food almost all year round in the Philippines, there is a really good chance to make a breakthrough.

A breeder who shows the buyer that he is capable of providing a healthy and comfortable life for the animals in his herd will sell his product better. This handbook is based on the practical experiences of the authors and it is aimed to give advice related to the possibilities of improving the housing conditions of cattle in milk production and rearing young animals. The content of the book offers experiences and solutions from the Czech Republic and world, but respecting the natural conditions, materials used in constructions and habits of the Philippines.

This handbook is intended for everyone who has an interest in improving the productivity of their herd, to learn so that they can advise others, but also to place the issue of accommodation among the first topics necessary for the improvement of the entire agricultural production in the Philippines.

2. RECOMMENDATIONS FOR DAIRY COWS HOUSING AT PHILIPPINES

Since this project is related to cattle farming, the architectural approach will focus on the organizational layout, construction, and available materials in the Philippines. The main goal is to create a functional, cost-effective, and sustainable farm that can enhance milk production.

Just like happy employees and a friendly environment can improve work results, the same principle applies to cows. A comfortable and well-maintained environment can have a positive impact on cows' milk production.

Developing cattle farming requires adequate infrastructure and facilities. This includes well-designed farm layouts, barns, milking parlors, storage areas for feed and forage, and proper waste management systems. These facilities should be designed to provide a comfortable and healthy environment for the cattle.

After conducting research on the weather characteristics of the Philippine islands, it has been determined that an open system with natural ventilation is the most recommended approach for cattle farming. Due to significant precipitation, it is essential to plan the farm with a roof to protect fresh grass and straw from excess moisture, which can lead to spoilage. This not only ensures the quality of the food but also prevents the growth of undesirable viruses and bacteria.

In addition to natural ventilation, the farm can benefit from the installation of large fans designed specifically for cattle farming. These fans can be strategically placed on the roof structure and directed in different directions to create a controlled airflow.

2.1. Foundation and slab

Considering Philippine standards, the foundation must be at least 60cm below the surface (compared to European standards, which require a minimum of 80cm below the vegetation surface). It is concluded that the freezing depth in the Philippines is unlikely to exceed 60cm, although freezing is not a common occurrence in the region. However, it is important to have an authorized expert precisely calculate the foundation depth, type, and size for any building. Based on experience, the most recommended foundation system for this type of building is a rectangular base footing measuring 1.2-1.5m x 1m, placed at least 1m below the surface on stable soil. The base footings should be connected with crisscross foundation beams.

Since the climate in the Philippines is tropical and maritime, characterized by high temperatures, high humidity, and abundant rainfall, it is not advisable to keep cows on rough soil in barns, as it can lead to various health issues for the cows. The top surface must be drainable for water and feces, and the best solution is a concrete slab with premade slopes and drainage channels. Proper planning slopes and construction of the concrete slab can permanently solve many problems. As one example is automatizing systems for cleaning. All concrete edges supposed to be rounded to minimize caw injuries (Photo 1).

Photo 1. proper shaping of concrete slab and automatically corridor cleaning Czech Republic, source: Farmtec.cz

It is important to have flat surface so surface fluids can easily be maintained but it is also important to make sure the cows don't slip, In that case best practice is to shape concrete in longitudinal strips.

2.2. Pillars/columns/beams

For durability and resistance to aggressive biological environments, it is recommended to construct the foundation and pillars with reinforced concrete. When we speak about durability and construction strength it is mostly related to situations where concrete pillars can resist accidents by hitting the pillar with some of the heavy-duty machines, and yes, those situations are happening. Let's take the example that some agricultural machines used to deliver food or to maintain a building hits a wooden pillar, it is well expected that depending on the force made on the construction pillar braking construction is well expected. One option is to use a concrete base for the pillars, about 1-1.5m high, and continue with wooden construction above. In this case, we prevent wood to mold and make lower construction parts tougher. Because the lower parts of the open ceiling are planned to be 4-4.5m it is most recommended to go with reinforced concrete columns. The optimal distance between columns for this construction is 4-5m, allowing the beams planned along the building to maintain an optimal static structure. While steel and wood can be used for the beams, reinforced concrete is suggested as a cost-effective and practical option.

2.3. Roof construction

For barns, wooden trusses are the best option due to their performance, cost-effectiveness, and flexibility for future modifications. The choice of wood should prioritize local types that meet the required construction standards. Using wood that grows under similar climate conditions ensures better performance when used in construction. The wooden truss construction can span from 6 to 25m (or even up to 35m), with a distance of 1-1.5m between trusses. Trusses are ideal for placing wooden purlins and finishing with metal profiled sheets. Since the Philippines has issues with insects like termites, it is highly recommended to treat wood with insecticide before using it in construction. This helps protect the wood from termite infestations and extends its lifespan. Additionally, it is important to ensure that the construction materials are dry before assembling them, as moisture can attract termites and contribute to wood decay.

Alternatively, considering options such as steel trusses or concrete prefabricated construction can provide added protection against termite damage. Steel trusses are not susceptible to termite attacks, making them a durable and termite-resistant choice for structural components.

Concrete prefabricated construction, on the other hand, can reduce the amount of wood used in the construction process, minimizing the risk of termite infestations.

However, it is worth noting that using more steel and concrete in construction can create a more artificial living environment for the cattle, which may be far from their natural habitat. It is important to find a balance between the need for termite-resistant structures and creating a comfortable and natural environment for the cattle (Photo 2).

Photo 2: Construction montage / Farm in Prnjavor, Bosnia and Herzegovina, source: authors

2.4. Materials

The materials used for this type of farm should be durable, cost-effective, environmentally friendly, and cow-friendly. Since we planned concrete on the floor and columns, we highly recommend using a wattle stick as a side transparent cover which can make needed barriers that look natural for cattle. Those transparent wattle sticks as side cover give some architectural identity and provide a soft sunshade and rain barrier. Roof parts are wooden construction that needs to be treated with some water base paint. The floor finish is concrete that does not need any special treatment, just to be flat and sloped to train channels. Cattle beds are recommended to be covered with straw or specialized rubber. All metal parts exposed to exterior environment must be galvanized or made from stainless steel. In the Philippines, we took several types of wood are commonly used for construction purposes. Here are some of the popular ones:

1. *Giant bamboo:* Bamboo has a high tensile and compressive strength and can withstand heavy loads and extreme weather conditions. It has a higher strength to weight ratio than other conventional materials. An average Bambusa Blumeana can resist 10-15 tons of compression. If properly used and treated, it is also resistant to pests, rot, and decay, making it a durable and long-lasting material. Bamboo is considered a cost-effective material due to its fast growth rate, low maintenance requirements, and versatility in product applications. Because of all this, it is one of the most commonly used materials in the construction of various buildings in the countryside, and so on. Due to its elasticity, it is resistant to strong winds, which is important in the climatic conditions of the Philippines.
2. *Philippine Mahogany (Lauan):* This wood species is widely used for various construction applications, including framing, flooring, doors, windows, and furniture. It is known for its durability, resistance to decay and termites, and relatively affordable price.
3. *Yakal:* Yakal is a hardwood species native to the Philippines. It is often utilized for heavy construction work, such as beams, columns, and bridge decking, due to its strength and durability. Yakal wood is highly resistant to decay, insect attacks, and weathering.
4. *Molave:* Molave is another hardwood species found in the Philippines that is highly regarded for its strength and durability. It is commonly used for heavy construction and marine applications, such as bridges, piers, wharves, and flooring. Molave wood is known for its resistance to decay, rot, and marine borers.
5. *Gmelina:* Gmelina is a fast-growing plantation tree species that is often used for construction purposes. It is lightweight, moderately durable, and suitable for making doors, window frames, furniture, and plywood.
6. *Acacia:* Acacia wood is utilized in construction for its strength and durability. It is commonly used for beams, posts, flooring, and furniture. Acacia wood is resistant to decay, termite attacks, and fungal growth.
7. *Coconut**:*** This lumber, is a type of construction material commonly used in the Philippines. It is derived from the trunk or stem of coconut palm trees that have reached the end of their

fruit-bearing life. The term "coco lumber" is used to describe the wood obtained from these coconut trees.

Termites are a common problem in the Philippines and can cause significant damage to wooden structures. To prevent termite infestations in wooden constructions, here are some steps you can take: To minimize termite damage to untreated wooden constructions in the Philippines, use termite-resistant materials like treated wood, concrete, steel, or plastic. Create physical barriers by placing metal screens or mesh around the foundation, using sand or crushed rock as a barrier, or installing termite shields made of metal or concrete. Ensure proper ventilation by installing vents in crawl spaces, attics, and areas prone to moisture accumulation. Maintain drainage systems to prevent water buildup around the structure, which can attract termites. Keep the surrounding area well-maintained by removing dead wood, stumps, and debris that can attract termites. If using untreated wood, apply appropriate termite treatment or preservative, such as borate-based solutions, during construction. Conduct regular inspections to detect signs of termite activity, such as mud tubes, damaged wood, or discarded wings near wooden frames. Remember, prevention is key in termite control, so implementing these measures and remaining vigilant can minimize the risk of termite damage. It is to conclude that best wood for this purpose can be Gmelina and Coconut tree. Since we tried to hit best value between price and wood performances those two types came as best choice. In both cases wooden structures have to be treated to prevent problem with termites. Next step comparing with wood construction would be steel or prefabricated concrete construction.

2.5. Small farm with a capacity of up to 10 cattle

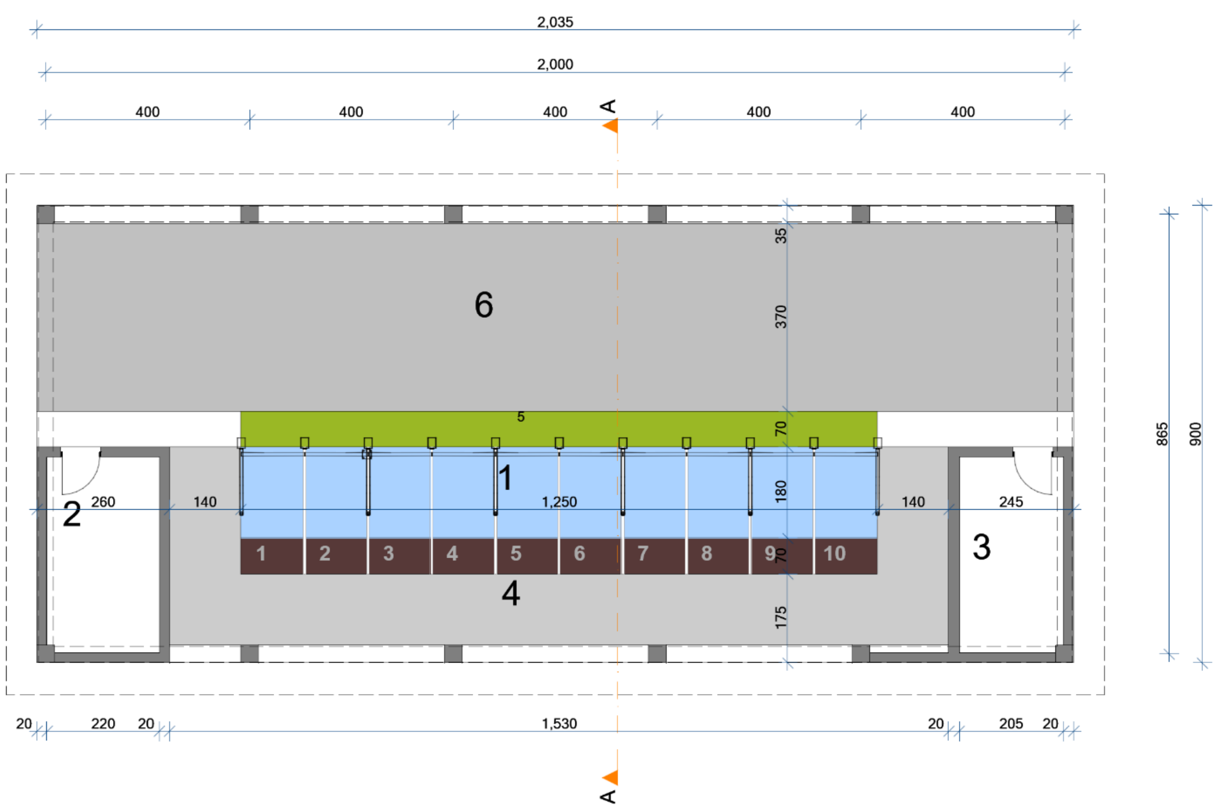
This represents a model for the smallest farmers, but also conforms to standards related to the needs of animals for protor, and the use of different equipment in the barn.

A small farm with up to 10 cattle is a recommended example for farmers who are starting or already have a few cattle and want to pursue farming with a small investment. This type of farm can be organized in a way that keeps the cattle on one side in tied housing with linear milking system.

The layout involves placing the cattle in the middle, with the milk storage and feed storage located on either side. This arrangement helps prevent strong wind blows and provides a convenient setup. The back and front barriers of the cattle area can be covered with wattle sticks, which serve as a transparent cover. These barriers are designed to appear natural for the cattle.

The manipulation area for farm mechanization is marked as number 6 on the layout. This area is designated for farm equipment and machinery to carry out various tasks. For instance, cattle milking is performed by transporting a milking caddy from cow to cow within this area.

By adopting this layout and approach, farmers with limited resources can effectively manage a small cattle farm and carry out essential operations such as milking in a practical and organized manner.



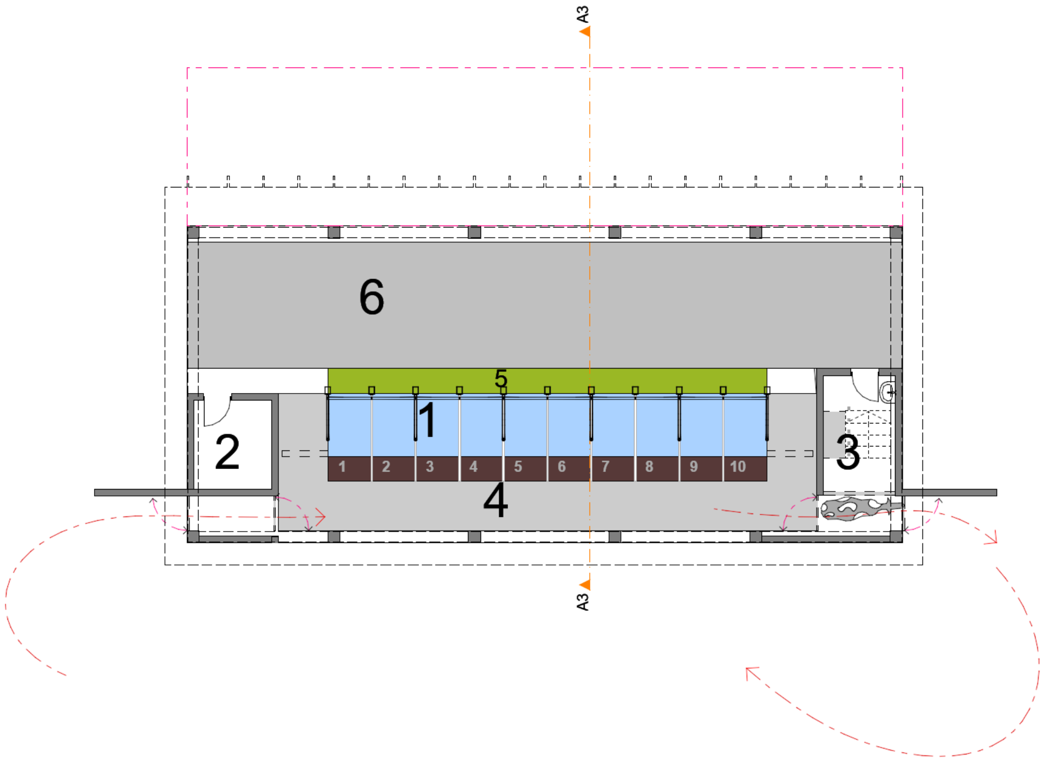
Layout 1: FLOOR PLAN/small farm up to 10 cattle with linear milking 1. Stall/ bed 2. Milk storage room 3. Storeroom (food, medicines, small materials and accessories); 4. Manger 5. Feeding table; 6. Manipulation area, source: authors

Photo 3: Visualization of small farm up to 10 cattle, source: authors

To make the farm more unique and recognizable, we have found an example of how walls can serve a functional and aesthetic purpose with a cost-effective investment. By using a cover like this, natural ventilation can be maintained while also providing protection against rain, wind, and sun exposure. As mentioned earlier in the text, termites can pose a problem for wooden facades. Therefore, we recommend considering a physical barrier with a concrete base wall that reaches a height of up to 1.5 meters. This barrier will help prevent termite infestations and provide added durability to the farm's exterior.

Photo 4: Facade example farm in Switzerland, source: Archdaily

This type of the housing can also offer higher level of the welfare for the cows.

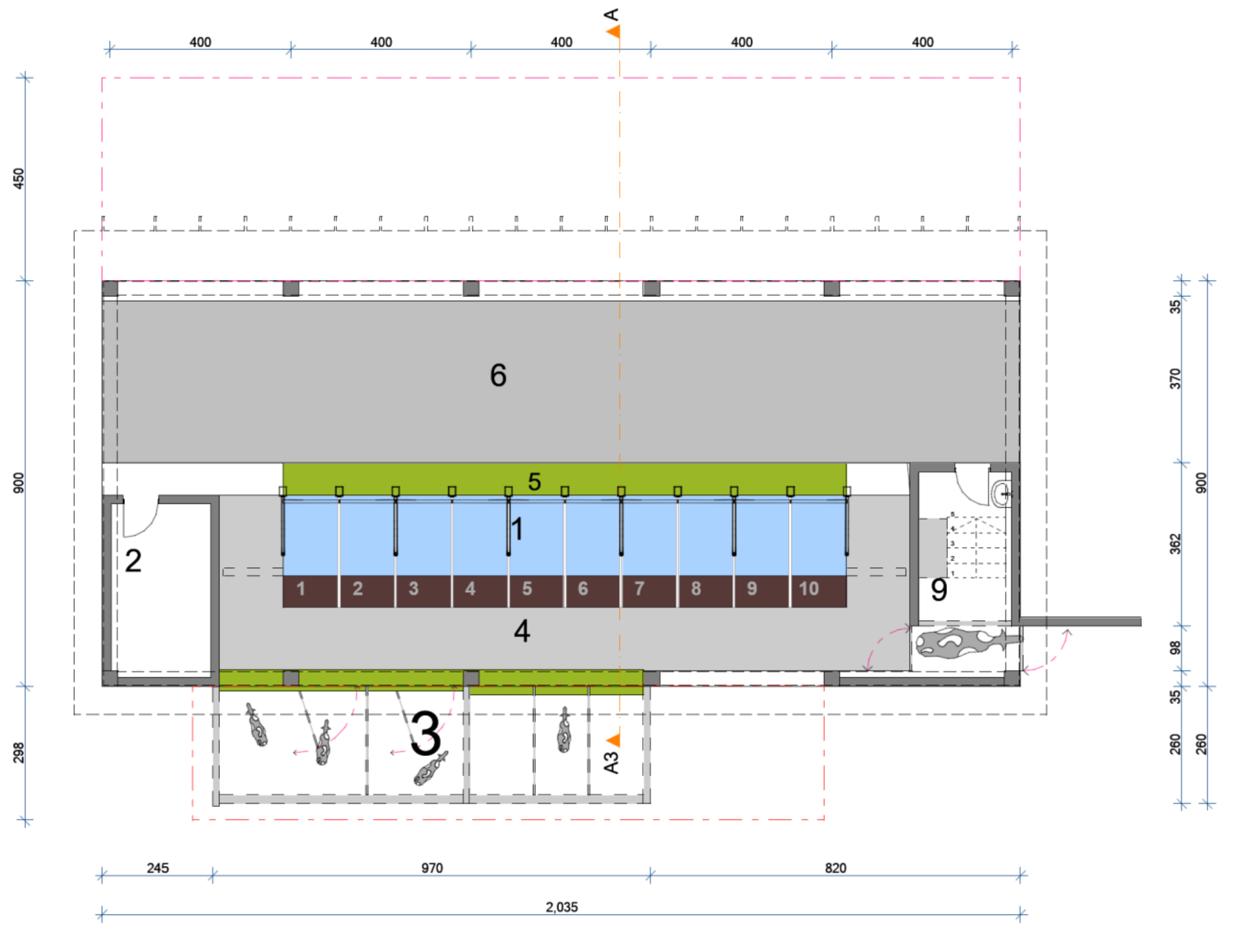


Layout 2: FLOR PLAN/Small farm designed for 10 cattle initially, with ability to expand up to 20 cattle
1. Stall 2. Storeroom (food, medicines, small materials and accessories); 3. Milking parlour; 4. Manager 5. Feeding table; 6. Manipulation area, source: authors

It is recommended that the circle around the barn be fenced off, so that the cows can walk after milking, and if necessary, depending on the proximity of the pasture, to graze. Dashed red arrows show the movement of cows. In this system, we present an upgrade to the basic concept by incorporating a milking on place and reorganizing the flow of cattle exiting the farm. The entrance for the cows is on the opposite side. The system can be reversed depending on the farm's organization and milking cycle. Additionally, an upgrade to the system includes incorporating a sanitizing tub at the entrance from the controlled field to the farm floor. This tub can be used to sanitize the cows' feet and udders, ensuring proper hygiene and health maintenance. This system we can extend in the two directions. On the backward and across the feeding table.

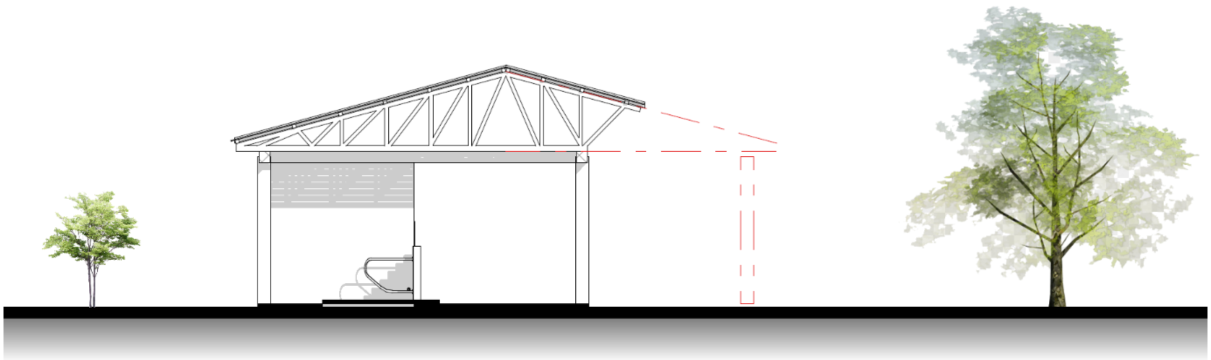
2.6. How to expand small farm for 10 dairy cows?

In the previous chapter, the basics of a ten-head farm were given, with small potential corrections related to the movement of the animals and approach in milking. However, it is to be expected that the farmer will decide to expand production in case of positive developments in the area of milk production and sales. In the first drawing (layout 3) an extension for younger categories is shown.



Layout 3: FLOR PLAN/Small farm designed for 10 cattle initially, with ability to expand up to 20 cattle and space for cows young cows 1. Stalls 2. Storeroom (food, medicines, small materials and accessories).; 3. Individual and group housing of cows 9. Milking parlour; 4. Dung corridor 5. Feeding table; 6. Manipulation area, source: authors

In the case when the extension is back, then this part can be used for housing calves or younger categories. The extended part can be divided into individual and group boxes for calves. Also depending on the level of reproduction, a part can be used as a storage room. For example. for concentrated fodder, hay bales, barn tools or others.



Layout 4: SECTION/Small farm designed for 10 cattle initially, with ability to expand up to 20 cattle, source: authors

If the farm needs to be expanded accross the feeding table, farmers have the option to extend the farm on the side by mirroring the construction from one side to another. In this example, every farm can be lengthwise extended, allowing for additional space and capacity. This mirroring approach ensures symmetry and consistency in the farm's layout and construction, making it easier to scale up operations while maintaining a cohesive design.

This part can be also used as a space for calves or younger categories before filling the capacity with milking cows, and it can be used partly as a place for calving.

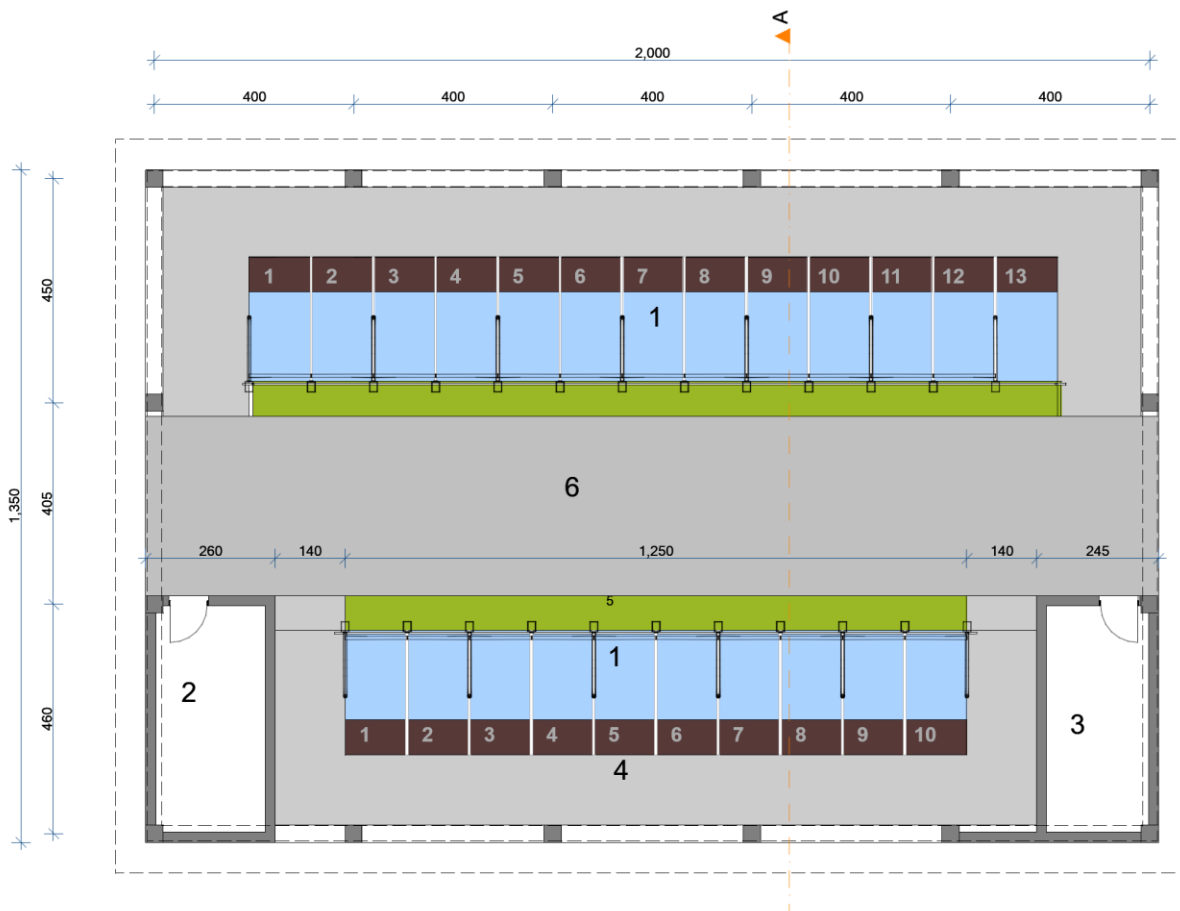
The farmer breeding 10 cows and plans to expand in the future, on this way can optimize future costs and on an easy way make barn extensions.

If we compare with the smallest farm Layout 1: small farm up to 10 cattle it is smarter to go with the concept Layout 3. FLOR PLAN/Small farm designed for 10 cattle initially, with ability to expand up to 20 cattle) and have option to upgrade.

We also have to conclude that even first farm layout is expandable but it will look as attached construction and roof slope will be broken. Roof slope covered with metal sheets not suppose to be smaller than 7 degree.

2.7. Farm design for 20 cattle

Somewhat larger than the previous example is the farm for 20 cattle. With a not-so-big investment in the farm, the number of cattle can be doubled (as shown in the previous example). The organization is more optimal because the feeding tables are on the same aisle. Easier for feeding and maintenance.



Layout 5: FLOOR PLAN/Farm designed for 20 cattle: 1. Stall 2. Milk storage 3. Storeroom (food, medicines, small materials and accessories); 4. Dung corridor 5. Feeding table; 6. Manipulation area, source: authors

A farm for 20 cattle, organized with a manipulation hallway in the middle and a tied housing system on the left and right sides, represents the most optimal organization layout for such dairy cattle housing system. This layout allows for efficient management and movement of the cattle within the farm. This farm is implying linear milking system. When placing the milk pipe between two parts, it is necessary to take care of the height, so as not to damage the same when working with the machinery.

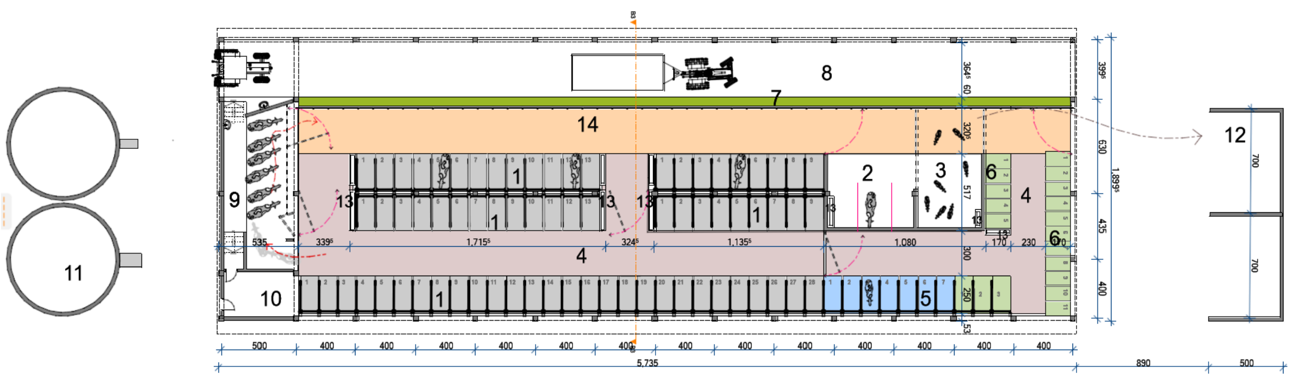
Photo 4. Visualization of small farm up to 20 cattle, source: authors

However, if a farmer plans to keep more than 20 cattle, we highly recommend transitioning to a free-range system, which is the next significant upgrade from the tied system. The free-range system provides more space and freedom of movement for the cattle, allowing for improved welfare and productivity. It is a more advanced system that can accommodate a larger number of cattle and offers benefits in terms of health, behavior, and overall management efficiency.

2.8. Cubicle housing system for 100 cows

In the layout no. 5, there is presented a farm with 72 places for cows in milk, 8 places for cows before calving, 3 boxes for calving, and some individual and group boxes for younger categories. However, this layout implies that some other categories (dry cows, heifer etc.) are kept in other barns or on fenced pastures.

The first option suggests that the main open space for holding the cattle is separated by a fence and organized based on the herd's needs. The beds for dairy cows are marked in grey color. In this system, cows are free to walk to the feeding table, water source, and milking station. Through training, cows can learn to go to the milking station on their own when they feel the need to be milked, as it is a natural instinct. Initially, farmers may need to motivate the cows until they become accustomed to this behavior.

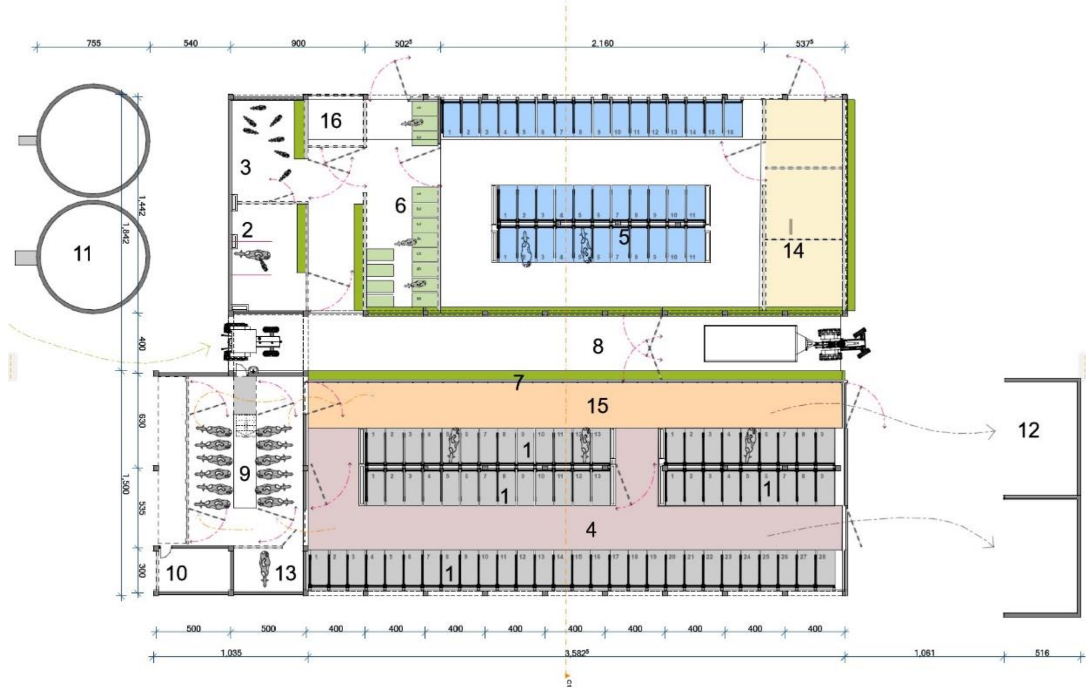


Layout 6: FLOOR PLAN/large farm up to 100 cattle / free-range cubicle system 1. Stall/ bed for dairy cows 2.Calving boxes 3. Group housing of calves; 4. Dung corridor 5. Heifers and dry cows before calving; 6. Individual housing of calves/heifers 7. Feeding table; 8. Main corridor 9. Milking parlor; 10. Milk tank; 11. Storeroom (food, medicines, small materials and accessories); 12. Manure storage; 13. Water trough;
14. Feeding corridor, source: authors

The milking station, marked as no. 9, is located on a lower terrain area, approximately 1 meter below the rest of the farm. This design allows farmers easier access to the udder. It is crucial to maintain high hygiene levels in this area, and a sink with hand sanitizer should be planned for this purpose. An additional tap should be provided for udder cleaning and sanitization before milking. Ceramic tiles are recommended for the finish surface in this part of the farm. Adjacent to the milking station no.10 is a space where the farmer can keep a tank for fresh milk. Proposed milking systems are herringbone (on layout) or parallel parlour. The temperature in this area should be controlled according to the legislation concerning raw milk quality. Fraction no. 2 is designated for cows with newborns, and there is a separate fraction for young calves (up to 2 months old). Positions no. 5 and 6 are for older calves between 3 months and weaning age. The young calves can be kept in individual beds or the space can be organized freely without individual beds. The entire layout is designed to make maintenance and feeding easier. All fractions where the cattle share the same feeding table no. 7 are connected. It is important to mention that the recommended floor finish for the feeding table is ceramic tiles or galvanized metal sheets (preferably stainless steel). By keeping this area easy to clean, farmers can improve hygiene and reduce the growth of unwanted bacteria. The surface between the beds, marked as no. 4, is considered a mostly dirty area. It should be organized in a straight manner to facilitate agricultural mechanization for cleaning and maintenance purposes. Robots and automated cleaning systems can also be utilized to clean this space.

The upgrade of this model can also be through the purchase of a milking robot, which must be able to serve a minimum of 75 cows/day.

A large layout with approximately 180 cattle (+dairy cows, young ones, and bulls) is a system with circled production and organization. On one side of the main corridor are just dairy cows and nothing else. Opposite side is left for the calving area and newborns up to 2 months of age to be housed in individual boxes, and then in groups. Depending on the number of calves and their age, this part can be divided into several sections. The feeding table in this position is split from the feeding table of older cattle.



Layout 7: FLOOR PLAN/large farm up to 180 cattle / free-range cubicle system 1. Cubicles 2. Calving box area 3. Group housing of cows; 4. Dirty corridor 5. Heifers and dry cows; 6. Individual housing of cows 7. Feeding table; 8. Main corridor 9. Milking parlor; 10. Milk tank; 11. Storeroom (food, medicines, small materials and accessories); 12. Manure storage; 13. Stationary; 14. Bulls ;15. Feeding corridor, source: authors

Bulls are kept in 3 separate fractions depending on age. The feeding table for bulls is also separated. It is highly recommended that the feeding table for bulls is covered with a roof shed. The main corridor can easily maintain feeding tables on both sides. On one side of the farm is placed a silo with food and on the opposite is manure storage.

For this type of the housing it is better to use milking parlour with approximately 12 – 14 stalls, then robot, because there will be need for two robots, and those will not work with full capacity, what is approx. 140 cows (70 – 75 per robot per day).

Photo 5. Visualization of large farm up to 100 dairy cows source: authors

2.9. Milking equipment

Milk comes out of the udder in two ways, by sucking the calf or by milking. Sucking the calf creates the perfect stimulus that affects the ejection of milk, which is necessary for it to be available at all. Machine milking is actually an imitation of sucking a calf, in order to obtain milk for human needs. In this way, man secures his food and economic needs through the cow.

Milking parlour is the main contact of an dairy farm with the with the "outside world". It evaluates the quality of our work every day and determines its value on the market. Milking parlour is equipment, which most often consists of mechanical parts, and lately it has been increasingly digitized, and it is also connected to other parts of the infrastructure, such as water, sewage, electricity, etc. Milking parlour is also a place where workers spend a significant amount of time, so care should be also taken about the comfort of the workers who serve there.

In the conditions of not well-developed support in the servicing of these devices (as it is current situation in the most of the Philippines regions), the farmer should have several options in managing the milking process and make it as less vulnerable as possible. Those are:

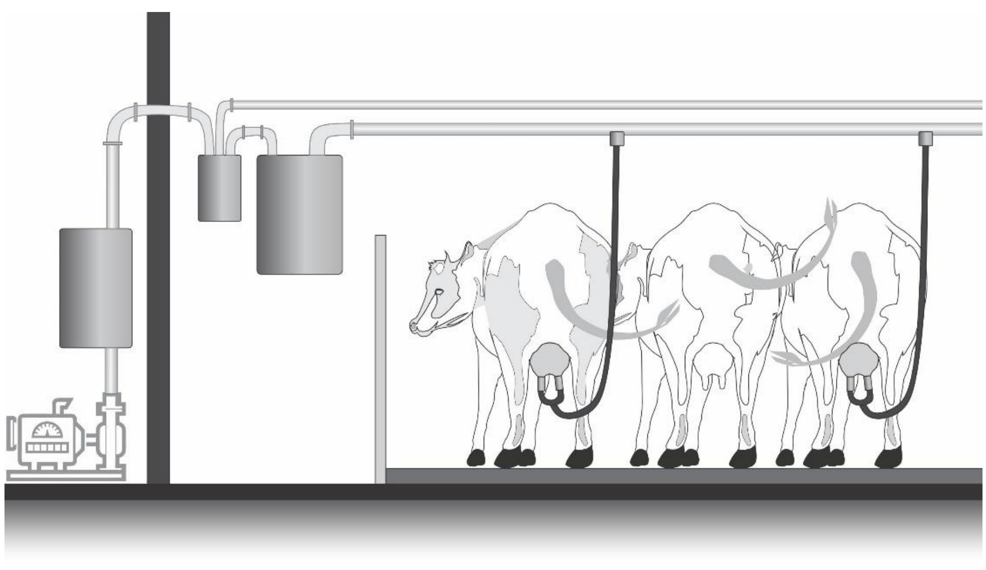
- the employee on the farm, or the owner of the farm, should know the operation of the milking equipment well and have at least basic spare parts on the farm,
- an additional milking system must exist (even manual), in case the milking stops and
- it is necessary to have additional sources of electricity (diesel generator).

Of course, it is best to have an authorized service, but these are just some of the precautionary measures.

When we talk about the proposed barn models in this manual, we can suggest the following types of milking systems.

2.9.1. Pipeline milking system

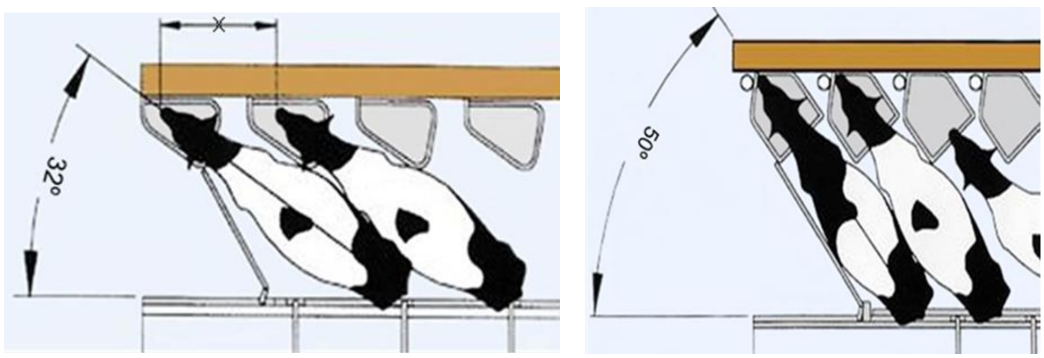
This kind of the milking devices are usually used for milking tethered cows. The milking units are connected to the milk pipe, which is placed above the coupling holder in the barn (170-180 cm) and can be up to 25 m long. This milking system enables faster milk transport to the milk cooling tank (lactofreeze) compared to milking with mobile devices. This type of system is recommended for classically tied cows and can be used in presented type of the farms for 10 and 20 cows.



Layout 8: pipeline milking system, source: authors

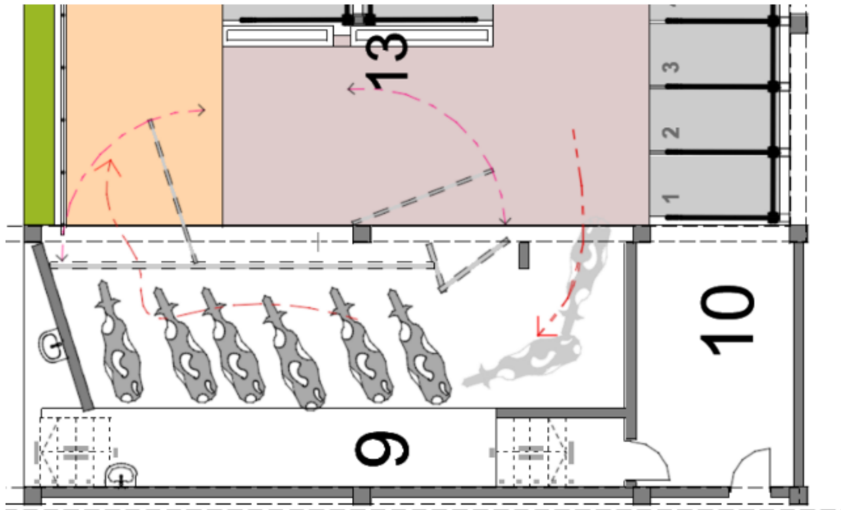
2.9.2. Herringbone milking parlour

The herringbone milking parlour is designed with milking stalls placed at an angle of 32-35° or 50° to the milker channel. In this way, the udder is turned from two sides towards the milker, which gives him greater visibility and better control of the udder. Also, the cows are closer to each other with the udders (the distance between the udders is 0.9 m), which reduces the movement of the milker and allows him to work with several milking units at the same time. The herringbone type parlour has become popular in all major dairy producing countries as it is suitable for herds of 50 to 400 cows.



Layout 9: Herringbone-type milking parlour arranged at an angle of 32° and 50°, source: Fejzić, 2013

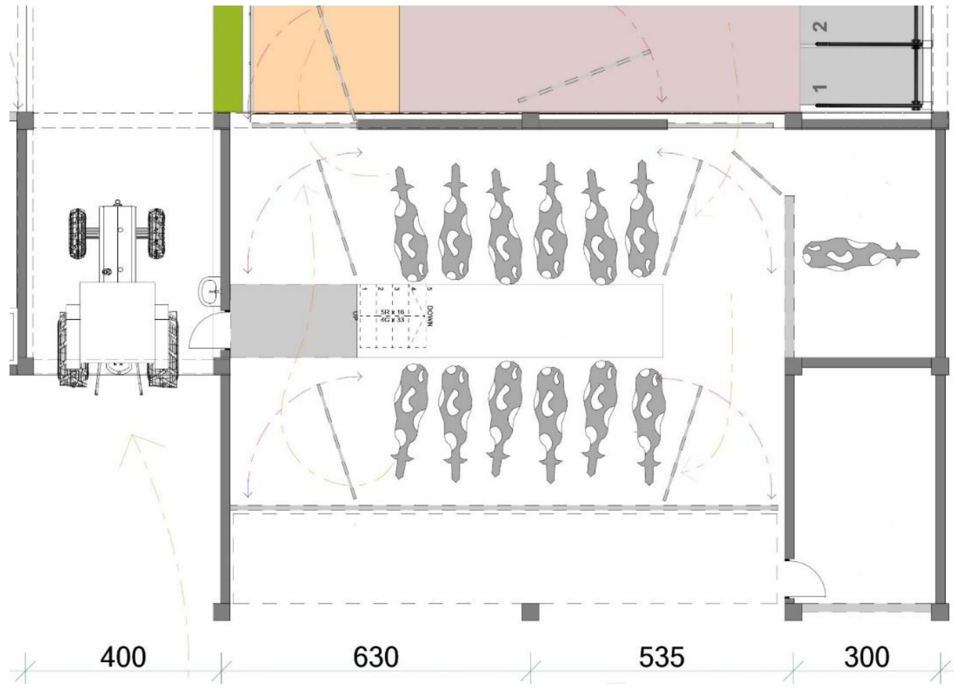
The herringbone milking parlour with 8 stalls (in onw line or 2x4) is usually enough for 100 dairy cows. Proposed milking parlour with 6 places in barn with 72 cows will be enough to have milked up to 100 cows efficiently.



Layout 10: Heringbone bilking parlour, source: authors

2.9.3. Paralel milking parlour

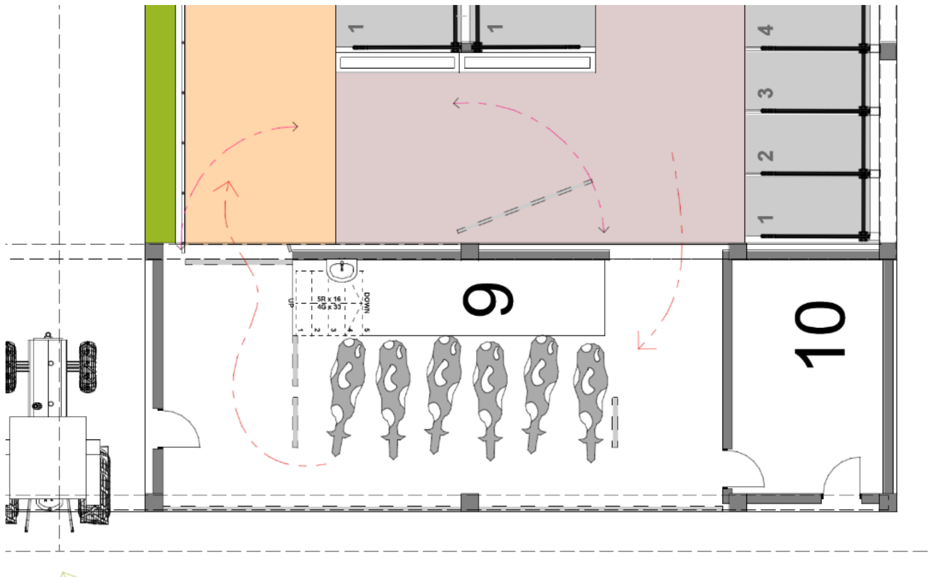
At the parallel milking parlour, the stalls for the cows are placed perpendicular (at an angle of 90°) to the channel for the milker, on the longer side. Three milking stalls occupy the space required for two milking stalls in a herringbone type milking parlour. The milking unit is placed between the rear legs of the cow. The placement of the milking unit, in this case, can interfere with the tail. The channel for the milker is 80-90 cm deep and enables the upright position of his body during milking. Cows enter the milking stalls in groups, which are grouped into sections with 4-5 stalls. When they enter, the sequential gates attached to the front crossbar are closed. After all the cows have been milked, the front crossbar is raised and the cows leave the milking stalls as a group and the sequential gates are rotated by 90° to their original position. This means that the milking of one cow depends on the milking of other cows.



Layout 11: Parallel milking parlour with two rows per 6 stalls, source: authors

This milking parlour has a pronounced required width, so it is often adaptable to wider rooms. The parallel milking parlour allows for a comfortable exit of the cows from the stand, so it is suitable for very large and pregnant cows. The total clear height of the milking parlor is min. 270 cm, and the minimum width of the cow platform is 295 cm (optimally 425 cm). The recommended width of the channel for the milker is 1,4 -240 cm.

On layout 6, we intruduce herringbone milking parlour, but of course, the parallel one can also provide same efficiancy.



Layout 12, parallel one row parlour with 6 stalls, source: authors

3. WELFARE OF DAIRY COWS

The welfare of domestic animals can be presented as a result of its relationship with the environment in which it lives. The living space (environment) creates certain incentives that instruct the animal to react to them. The number and type of reactions depends on the stimulus, i.e. conditions that a specific living space imposes on an animal: the less stressful they are, the better the animal's well-being.

The advantage of raising cattle in the Philippines are large available areas of natural forage for grazing, natural housing of cattle and the possibility of producing a sufficient amount of fodder. On the other hand, the most significant welfare problems are the poor housing conditions of dairy cows, which lead to certain diseases, such as lameness, mastitis, infertility and a shorter lifespan. Also, one of the important problems is the low level of awareness of the importance of animal welfare, as well as the absence of adequate mechanisms and incentives because, even when there is an awareness of welfare, the impossibility of financial investment hinders the producer from improving the technical and technological conditions (larger space, better materialization facilities, balanced diet, etc.). This makes the Philippines an uncompetitive country in an increasingly connected global market, and with increasing number of foreigners/tourists at Philippines demanding milk products in their diet.

One of the most important conditions for the well-being of cows is their state of health. Taking care of health implies providing hygienic, spatial and microclimate conditions for cultivation, as well as regular health care. Cows must be provided with quality food in sufficient quantities, which corresponds to their age, and at intervals that correspond to their physiological needs. An exception exists when the veterinarian decides otherwise, for the purpose of therapy. Also, they need a sufficient amount of clean water, bulk food, in order to reduce the risk of flatulence and laminitis. The housing of the cows should provide adequate shelter from the weather and natural enemies, the necessary microclimatic conditions, the possibility of movement and mutual communication.

4. DAIRY CATTLE HOUSING

Breeding systems, housing conditions, nutrition and the relationship between humans and animals represent important factors that, apart from production, also affect the health problems of dairy cows and other aspects of their well-being. Historically speaking, the goal of animal' housing is to limit them from escaping, to protect from carnivores, or diseases, to provide the needs of the breeders for their products and to enable them to live a healthy life. In many parts of the world, cattle are kept inside barns for at least part of the year, both due to the lack of food (pasture) in one part of the year, as well as to protect production areas from damage that cattle could possibly cause. Housing cattle in barns, when it comes to the well-being of cattle, has the greatest impact on their social relationship, because then they are in much closer contact with each other than when they are outside. Another important factor in housing cattle is susceptibility to certain diseases, which are closely related to production. Cattle easily adapt to different housing conditions, so they can be housed individually or in smaller or larger groups. One of the main issues of domestication is adapting housing to the needs of cattle, because housing can cause different types of unnatural behaviour in cattle. The trend of increasing the number of cows in the barn also conditioned its architectural appearance. The question of the quality of housing for cows is becoming more and more important every day, especially in recent years in the conditions of global warming when the price of fuel and electricity is rising. In poorly built barns, the need to improve the stable space with various equipment such as ventilators, water cooling systems, which aims to improve the well-being of cows, increases, which also increases the cost of housing. They teach a very complex system of environmental factors to cultivate life. Given that man has separated living things from their natural environment, he is responsible when the conditions of housing do not meet natural needs, which are generally different from human needs. It is up to the breeder to remove a large number of x factors, which in extreme values, or in certain combinations, force the living organism to use defense mechanisms, which can lead to a reduction in production. Cattle are still the leading domestic livestock in livestock production, whose products account for around 18% of the total world protein consumed and 9% of the total energy consumed by humans: they are used for work, we use their skin, and the manure is used, apart from fertilizing agricultural crops. area, use also as raw material for biogas production. Under the pretext of intensification of cattle production, people often ignore the fact that the individual in that industrial production is a higher mammal with complex psychophysical needs. An attempt to evaluate the welfare of cattle in a dairy production system begins with an understanding of the system, progress in the selection of the whole system or its parts, and ends with a description of their behaviour towards the system. Their physiological response can also be measured and related to their metabolism, even production, but often has little to do with behaviour and adaptation to the environment. Generally, when we talk about housing of dairy cows we can discuss about housing of dairy cattle, heifers and youngsters. In next tables, there are presented measures for different kind of housing and different segments of barns for cow's housing.

Table 1. The size of stalls, beds, boxes, beds and group boxes

Cattle category	Housing - age category (abbreviation: l. w. = live weight; m. age. = months of age)			Stall, box		Group boxing		
				Minimum standards				
				length (cm)	axis width (cm)	bed surface 5) ($m^2.grlo^{-1}$)	width of feeding area (cm)7	depth of the feeding corridor6) (cm)
Cows	tied animals	short stall (carabao)		170	105			
		short stall		190	110			
		medium stall		230	110			
		calving stall 2)		250 1)	112,5 1)			
		calving stall extended3)		250	220			
	Free-range with and without a mat/litter	combined box		175	110			
		boxes		230	112,5 1)			
	Free8) with mat/litter	group boxing with a mat				5	70	280
		free calving box				9	70	280
Calves	free with mat	Individual box	up to 14 days of age	120	100			
			up to 90 days of age	170	100			
		outdoor individual box – covered part		140	110			
		outdoor pens from the earliest days until weaning		140	110			

	free with and without a mat/litter	boxes	up to 6 m. age	160	70			
	free with mat/litter	group boxes with a litter	up to 3. m. age[4]			1,50	35	140
			up to 6. m. age			1,80	43	160
Heifers	free with and without a mat/litter	boxes	up to 11. m. age	170	75			
			up to 18. m. age	180	90			
			up to 24. m. age	200	105			
	free with mat/litter	group boxes with a litter	up to 11. m. age			2,10	50	190
			up to 18. m. age			2,85	60	200
			up to 24. m. age			3,75	64	220
	free without mat/litter	group boxes without a litter	up to 11. m. age			1,35	50	190
			up to 18. m. age			1,90	60	200
			up to 24. m. age			2,30	64	220
Bulls and fattening cattle	free with mat/litter	group boxes with a litter	up to 350 kg l.w.			2,20	50	190
			up to 550 kg l.w.			3	60	200
			over 550 kg l.w.			3,50	64	220
	free without mat/litter	group boxes with a slatted floor	do 350 kg l. w.			1,40	50	190
			do 550 kg l. w.			1,90	60	200
			over 550 kg l.w.			2,30	64	220

1) During the modernization of the barn, in the case when the possible sizes and internal layout of the building do not allow other solutions, the length of the stall can be 200 cm, and the width 112.5 cm.
2) The 200 cm long calving stall in combination with mobile litter removal has a lowered manure corridor in relation to the rear part of the stall, at most in the range of 5 cm to 8 cm
3) The calving stall can be expanded by connecting it with the neighboring stall/bed.
4) During the period of milk feeding for group housing and individual feeding of calves.
5) Usable surface (parts for resting), ie. the area used for resting (without the areas between the beds, i.e. the feeding table, the feeding corridor, and the longitudinal walls that separate them, if they exist).
6) The depth of the feeding corridor means the size of the lowered part of the resting area together with the step before the feeding table, if there is one, but without the part that longitudinally divides the aft table and the resting area, if there is one. If several categories

of animals are housed in such a barn, then the depth of the forage area corresponds to the oldest category of cattle.

7) The width of the aft space is presented 1:1.
8) Free – Free range

Table 2. The size of the feeding area and drinking troughs for cattle

<table>
<tr><th colspan="3" rowspan="3">Sizes (cm)</th><th colspan="2">Cows</th><th colspan="2">Heifers in free range system</th><th colspan="2">Bulls/beef cattle free system</th><th colspan="2" rowspan="2">Calves in months of age</th></tr>
<tr><th colspan="2">housing</th><th colspan="2">months of age</th><th colspan="2">Live weight (kg)</th></tr>
<tr><th>free</th><th>tied</th><th>to 18</th><th>to 24</th><th>to 350</th><th>over 350</th><th>to 3</th><th>to 6</th></tr>
<tr><td colspan="2">the width of the manger, including the feeding bulkhead [1)]</td><td>min.</td><td colspan="2">80</td><td>65</td><td>75</td><td>65</td><td>75</td><td>40</td><td>50</td></tr>
<tr><td colspan="2">the width of both sides manger including the feeding bulkhead [1)]</td><td>min.</td><td colspan="2">130</td><td>100</td><td>110</td><td>100</td><td>110</td><td>80</td><td>90</td></tr>
<tr><td colspan="2">width of feeding table without feeding bulkhead [1)]</td><td>min.</td><td colspan="2">360 – both sides
320 – one-sided</td><td colspan="4">360 – both sides
320 – one-sided</td><td colspan="2">-</td></tr>
<tr><td colspan="2">width of feeding table without feeding bulkhead</td><td>min.</td><td colspan="2">380</td><td colspan="4">360</td><td colspan="2">360</td></tr>
<tr><td rowspan="2">the height of the upper part of the manger in relation to the standing level</td><td>medium stall and free housing</td><td rowspan="2">max.</td><td>60</td><td>50</td><td>50</td><td>55</td><td>50</td><td>55</td><td>40</td><td>45</td></tr>
<tr><td>short stall and combined box</td><td>30</td><td>30</td><td colspan="6">not used</td></tr>
<tr><td rowspan="2">the height of the bottom of the manger in relation to the standing level</td><td>medium stall and free housing</td><td rowspan="2">min.</td><td colspan="2">7</td><td colspan="4">7</td><td colspan="2">10</td></tr>
<tr><td>short stall and combined box</td><td colspan="2">7</td><td colspan="6">not used</td></tr>
<tr><td colspan="2">the height of the upper edge of the drinking bowl/trough in relation to the standing level</td><td>max.</td><td>80</td><td>65</td><td>70</td><td>80</td><td>70</td><td>80</td><td>50</td><td>60</td></tr>
<tr><td rowspan="2">Animals number</td><td>per 1 trough</td><td rowspan="2">max.
(pcs)</td><td>8</td><td>2</td><td colspan="6">-</td></tr>
<tr><td>per 1 m trough</td><td>30</td><td>-</td><td colspan="6">40</td></tr>
</table>

Explanation:

2) The feeding bulkhead is the partition between the feeding place, that is, the area for animals and the feeding table.
3) The maximum thickness of the stern partition is up to 10 cm

4.1. Housing of dairy cows

Dairy cows must be provided with suitable and as natural housing conditions as possible to satisfy their physiological functions and ethological needs. Such conditions will have a positive impact on their health and well-being, and consequently on optimal production, ie milk quality.

Dairy cows can be housed individually on a chain, or in groups in a free-range housing system (also called loose housing). There is a possibility of a combination of these two ways of housing cattle, what will be further discussed in some of the proposed solutions in Chapter 11 of this manual. This is usually explained by system where cows graze during the day and are tied up in the barn at night. Both methods have their own specifics of the organization of housing technology, and therefore certain advantages and disadvantages. They differ primarily in the construction of facilities, the organization of production technology and, according to the latest research, the achieved production of cows. The main goal when choosing a way to keep dairy cows is the possibility of achieving high milk production and the most efficient use of machines, equipment, labor and preserving the health of the animals. When making a decision on how to keep cows, you should analyze all segments in detail, look at the advantages and disadvantages and make a decision that is very important when designing and building buildings.

FREE VS TETHERED HOUSING

Studies have shown that tethered cows have more problems with mastitis. Thus produce less milk.

Research shows that the tied method of housing dairy cows is profitable for up to 40 head of the basic herd. In a study of productivity in barns with tied and free housing in Norway (a total of 620 herds), they state that the average milk production in herds with free housing is lower by 134 kg/year/head compared to those with tied housing, but only in herds that have 27-45 heads. However, in free-range herds, which had more than 45 production heads, milk production is higher. Better reproductive abilities were recorded in cows that are in the free-range system. The lower rate of disease occurrence is in cows kept in a free manner, such as, for example. mastitis, which is one of the most important diseases in milk production. The lower rate of disease occurrence is in cows housed in a free range housing systems, such as, for example mastitis, which is one of the most important diseases in milk production.

The tied way of housing restricts the movement of cattle due to the small space for lying down, feeding, fertilizing and milking, and the cattle are often in poorer condition. Also, more work is needed by the breeder to bring food, water and mats, and to take away milk and manure, namely 90 hours/head/year.

On the other hand, compared to the free housing, it is easier and safer to control and care for each throat, insemination and examination in tied cows. However, milking is more complicated and slower, and the quality of the milk is *generally worse*; mechanical injuries, limb diseases and udder inflammation are more common. Also, mutual harassment and injury of cattle, as well as competition with the dominant cattle in the herd, is excluded, so there is more peace in the barn than with the free-range housing. But, cows that are tied eat less and have a shorter production life compared to free range housed cows.

The free-range of housing cattle is more natural because it allows the cattle freedom of movement. They have good muscle development and body constitution, better condition and health, have a better appetite, and therefore higher milk yield. Therefore, they have a longer production life. Inside the barns with free range cattle, less transport and work of the breeder is required, which affects the increasingly frequent application of this method of dairy cows housing.

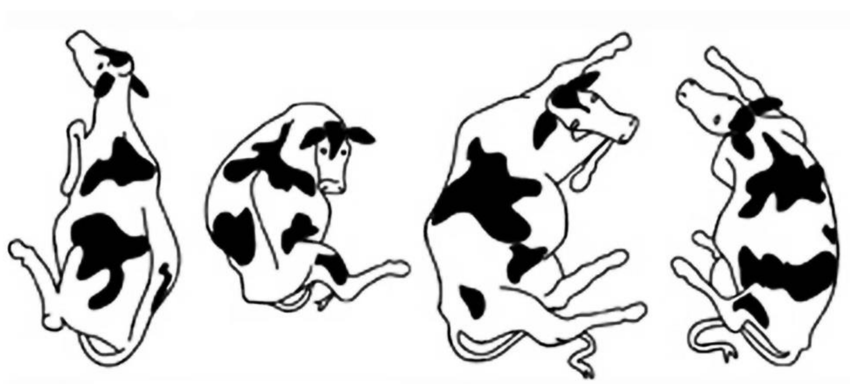
4.1.1. Beds/stalls for dairy cows

The bed or stall is a space where cow is resting, lying, chewing. It should enable the unhindered performance of all normal life functions and bodily actions and needs of cattle: getting down and getting up, comfortable longer lying down, feeding and feeding, milking and excrement. Therefore, this element of the housing should have a comfortable surface: it should be thermally insulated, dry, elastic, clean and non-slippery.

The time that dairy cows spend lying down and resting is an important indicator of bedding comfort and cow well-being. Uncomfortable beds or stalls, which are not properly dimensioned, lead to damage to various parts of the cow's body, especially the udder, legs and hooves. Cows rest for more than nine hours every day, so the bedding is an extremely important part of the stable area. Physical limitation is performed by partitions of each or less often every second bed/stall.

In addition to proper nutrition, a prerequisite for high milk production and good health of the cow is a soft and dry bed base. The base of the bed/stall can be made of a mat made of straw or sawdust, wood, concrete or rubber (combined with plastic materials). For mats made of straw or sawdust, it is important that they are dry and clean and that they absorb as much moisture as possible under the cows. The sawdust must not contain chips. Properly maintained straw reduces the risk of injury, such as skin lesions, compared to hard flooring. The rubber mat (mat or mattress) is 2 to 6 cm thick and should last for at least five to ten years. It is a good insulating material between the cow and the concrete base of the bed, as well as a comfortable resting mat. Cows do not slide when lying down and standing up, and the mat is easy to clean.

The European Food Safety Agency (EFSA) states in its recommendations that the space for housing dairy cows should be designed in a way that allows comfortable lying down so that the cows get the necessary period of rest, lying down and rumination. All cows should be able to lie down at the same time, as dairy cows generally try to synchronize lying or standing behavior so that they all lie down or stand at the same time. Therefore, in stables with a free-range housing, there must never be fewer beds than the number of cows. In cows, four lying positions are common: long, short, wide and narrow (layout 13). Cow lying down itself consists of three phases: the animal bends its front legs and kneels, then lowers its belly and rear part of its body. When a cow stands up, it needs more space than the space it needs to lie down. About 3 m of space is needed for greater freedom of movement for cows to stand up.



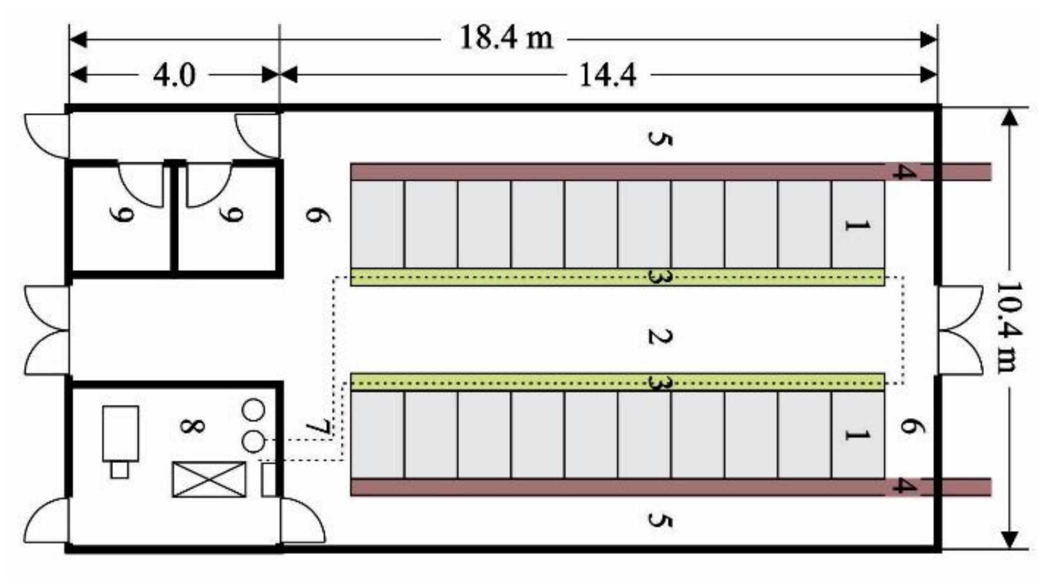
Layout 13: Ways of lying down cows in barns for free keeping: long, short, wide and narrow lying down, source: Fejzić, 2013.

Lying down and standing up can be restricted by lying space or poor stall design, so another EFSA recommendation is that the implementation of tie-stalls and free-stalls should not affect the normal behavior pattern of cows when lying down or standing up.

4.1.2. Tied housing of dairy cows

For the welfare of the animals in barns where cows are tied, they must be allowed to stay freely inside the barn or on the pasture for a period of time during the day and season during the year. For example, younger categories can be allowed to move freely either around the facility, outlet or to be kept on pasture. In addition, free-range housing can be practiced for dry cows. Improvements are also made for lactating cows, so some farms keep cows tied up in barns during the winter, and in the summer period and in periods of good weather, the cows are in the pens or on pasture. It is the most common practice in the world, regardless of the season, for cows to spend part of the day in the barn, during milking and eating, and for the other part of the day to move freely on the pastures or pens with available food.

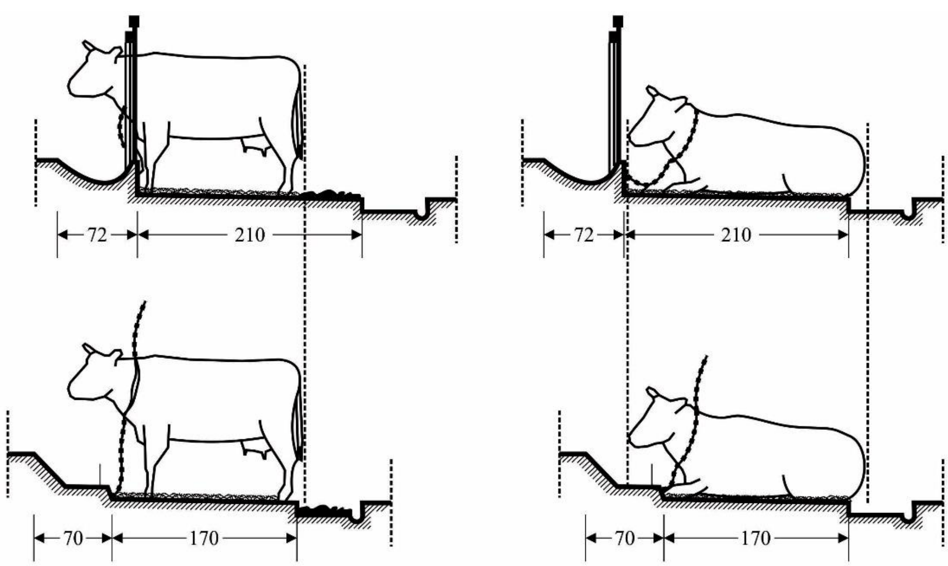
Barns with a tied system of cows' housing have several basic functional parts, namely (Layout 14): 1. beds for cows, 2. feeding corridor, 3. Manger, 4. channel for fertilizing, 5. manipulative corridor, 6. transverse corridor, 7. milk duct, 8. dairy with milking units and 9. premises for concentrated food.



Layout 14: Functional parts of a barn for tied housing for 20 cows, source: authors

There are three types of lying area, long, medium and short bed (Layout 15).

A long stall can be found mostly on older farms, while new buildings with this type of stall are rarely built. The average length of a long stall is 220-250 cm, and the width is 110-120 cm. A straw mat is used at 8 kg/head/day. The height of the manger from the stall is 40-50 cm, and the fertilization channel is shallow, 10-20 cm deep, and is suitable for solid fertilization. With this type of bedding, the manure and excreta remain under the cow, so the cow lies on its dung. In this way, the rear part of the cow's body gets dirty with its udder, and cleaning must be done twice a day, in order to ensure good hygienic conditions. This requires a large expenditure of human labor. Also, high mangers prevent sufficient air exchange in that part and create a dead space for air supply to the cow's head. The medium long bed has the same disadvantages and characteristics. However, apart from its shorter length of 180-220 cm and the need for less straw mats of 5 kg/head/day, it differs from the long one in the possibility of closing the manger with a palisade fence. During feeding, it opens, and the cows move forward. In this way, the stall becomes less soiled, but soiling is still present.



Layout 15: Long bed (up) i middle bed (down) with advantages and lacks, source: Radivojevic 2004

The average length of the middle stall is 160-180 cm, and the width is 110-120 cm. From 2-3 kg/head/day of straw mats are used. The basic feature of these stall is a low crib, which allows normal lying and standing without moving. The height of the manger from the stall is 32-35 cm. Behind the stall there is a shallow fertilization channel, 10-20 cm deep, suitable for firm fertilization. The feces fall directly into the canal, so this stall is always clean and the cows are less dirty, and therefore the cost of human labor is also lower.

The average length of a short stall is 140-160 cm, and the width is 110-120 cm. For short stalls, low cribs, 32-35 cm high, are mandatory. A thermo-insulated rubber bed is not used, because the fertilizing channel is 70-90 cm deep and covered with a grid, and is suitable for liquid fertilizing. The advantage of this stall is that human work is reduced to the minimum possible, but the animals is often injured, primarily the udder, which is often bruised on the grates.

Free-range housing systeOne of the most important elements in the free-range housing system is the stall, bed or cubicle. The bed is a space for cattle kept on a leash. It should enable the unhindered performance of all normal life functions and bodily actions and needs of cattle: getting down and getting up, comfortable longer lying down, feeding and feeding, milking and excrement. Therefore, you should have a comfortable surface: it should be thermally insulated, dry, elastic, clean and non-slippery. The bed continues onto the feeding table and has a concrete base cast in one piece with the feeding corridor and the manger. Also, the bed has a smaller slope towards the fertilization channel.

In addition to proper nutrition, a prerequisite for high milk production and good health of the cow is a soft and dry substrate. The base of the bed can be made of a mat made of straw or sawdust, wood, concrete or rubber. For mats made of straw or sawdust, it is important that they are dry and clean and that they absorb as much moisture as possible under the cows. The sawdust must not contain chips. Properly maintained straw reduces the risk of injury, such as skin lesions, compared to hard flooring. The rubber mat (mat or mattress) is 2-3-4 cm thick and should last for at least five to ten years. It is a good insulating material between the cow and the concrete base of the bed, as well as a comfortable resting mat. Cows do not slide when lying down and standing up, and the mat is easy to clean. Space for housing dairy cows should be designed in a way that allows for comfortable lying down so that the cows get the necessary period of rest, lying down and rumination. All cows should be able to lie down at the same time, as dairy cows generally try to synchronize lying or standing behavior so that they all lie down or stand at the same time. Therefore, in barns with a free-range housing, there must never be fewer beds than the number of cows.

When free-range housed, dairy cows move in a group, they go to the manger for feeding and watering as they wish, and they choose the beds at will and at a time that suits them. When kept in this way, cows feel more natural, have better appetite, higher milk production, better condition and are in better health. This way of holding does not necessarily mean an improvement in well-being, especially if the housing conditions and bedding are inadequate. Also, individual animal control is difficult and there is a possibility of mutual harassment and even injury. That is why it is necessary that the cows, which are kept free-range housing, are dehorned.

With the free-range housing of dairy cows, it is easier to provide more adequate microclimatic and zoo hygienic housing conditions. Cows are milked in a separate room, which in most cases is isolated from the housing area. In that case, milked milk has a better quality from a microbiological point of view compared to tied cows that are milked on the bed. Stands with a free grip allow for greater flexibility. The number of cows can be increased without adding a barn, and in the event of a change or abandonment of production, hall-type barns can be easily remodeled and used for other purposes.

One of the main issues when housing cows free is the size of the group. It is known that cows have a need to stand out from the group and cannot stand lying very close to each other. The manifestation of agonistic phenomena (kicking, pushing, avoiding treatment and fighting) increases linearly with the size of the group. Although the maximum group size is not defined, 50 to 60 cows are common, depending on the level of production. The size of the group should be such that the cow does not stay longer than two hours in the waiting area of the milking parlor and in the milking parlor.

4.1.3. Cubicle dairy farm

The best-known and most widespread way of housing cows with beds is with individual beds often called cubicles (*Photo 6*), where each cow has its own stall, properly dimensioned and protected. This allows the cows to be cleaner, as well as undisturbed rest during rumination. Barns with this approach of housing have several basic functional parts, namely: 1. beds for cows, 2. space for movement and fertilization, 3. manure dump, 4. manger, 5. area for calves, 6. calving 7. milking unit. Within the barn, or separate from it, there can be a milking parlor and dairy, as well as a space for calving and calves.

Photo 6: well organized cubicle barn, Czech Republic, source: Agromont.cz

A very important thing in the construction of these is adjusting the length of the stall i.e. cubicle. The cow spends a lot of time in it, it rests, ruminates, defecates and sleeps. Therefore, a well-determined length and width of the stall is the key to a good milk production when we talk about housing of dairy cows' cubicles (Photo 7). In the picture below we see an example from the Czech Republic, where the cows lie peacefully and rest in their *beds*, which means that they are comfortable, pleasant and good there.

Photo 7. Well-chosen cubicle length, Czech Republic, source: authors.

4.1.4. Deep straw housing of dairy cows

The facility for housing of dairy cows on a deep straw is designed so that the cows move on it over the entire area provided, and that the mat/straw and manure are packed over the entire area provided for animal movement. We can define this way of housing dairy cows as "a free system of housing and breeding dairy cows in the facility with the timely placing of mats on the areas for resting and removal of manure at certain time intervals".

A barn with a deep mat is recommended as an open barn for dry cows or cows before calving and a few days after calving. This is the simplest and cheapest way of housing cows, which is often used in dairy farming around the world. The basic characteristics of this system are large quantities of straw and difficult maintenance of cow hygiene. With a deep straw, the amount of it needed is twice as much as in a classic barn. A good straw is necessary for the comfort of the cows, and it ensures good udder health, good milk quality and prevents injuries to the cows' legs.

The feeding area is separate from the resting area. Thus, a warm and soft bed is created for the animals, regardless of the outside temperature. The feeding corridor and manger, with a length of 0.72 m/head, are completely identical to the barns in which the beds are separated from the manger. The resting space is dimensioned with 5 m^2/head, it is 5-7 m wide and lower than the space for movement and feeding by about 70 cm. This difference in height is usually overcome by 2-3 steps (photo 8 and Layout 10). The resting area has a deep straw of 7-10 kg/head/day which is spread occasionally. The width of the feed area is 70 cm, and the depth of the feed corridor is 280 cm. The level of manure grows at a rate of 0.5-0.8 cm/day and is cleaned periodically, usually every three months, i.e. when the level of the space for movement is approximately equalized with the space for eating. Cleaning of the building is done with a tractor loader. In order to avoid drafts, the ceiling height of these barns was reduced to 2.5 m.

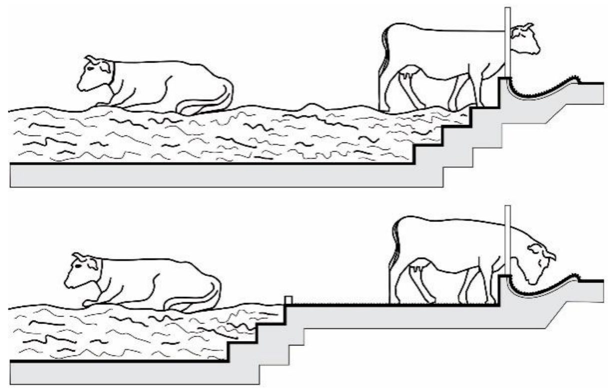
 

Photo 8,layout 10: Barn with deep straw and detail of cross section of barn floor, source: authors, Radivojevic, 2004

4.1.5. Barns with the slope floor

In this approach of housing the cows, the space for movement and feeding is at a lower level than the space for resting/ lying. Barns with sloping floors are recommended as open barns for housing fattening cows, and are not recommended for dairy cows with high milk production. The movement and feeding area is filled with a 3 m wide floor, which is at a lower height than the resting area. Usually is cleaned mechanically, with a tractor loader (photo 9).

Photo 9: Cleaning the barns with sloping floors, Farm Janjić, Bosnia and Herzegovina, source: authors 2013

The area for resting should be 5-7 m wide, with a slope of 4-10% towards the area for movement and feeding. The resting area has a natural mat 5 kg/head/day that is spread near the top, and the cows take it off towards the area for movement and feeding - self-cleaning of the barn (photo 4 and layout 11). Cattle are more often injured in this type of barn than in a barn with beds or a deep mat.

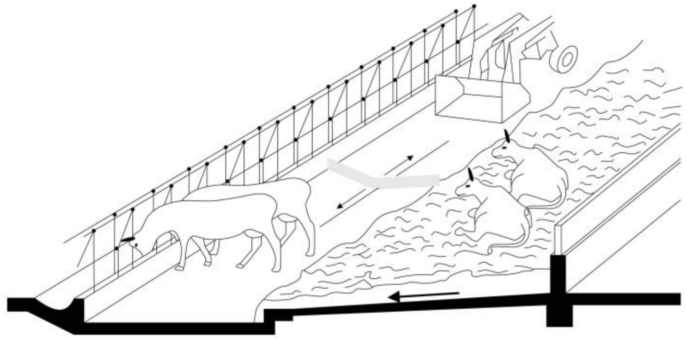
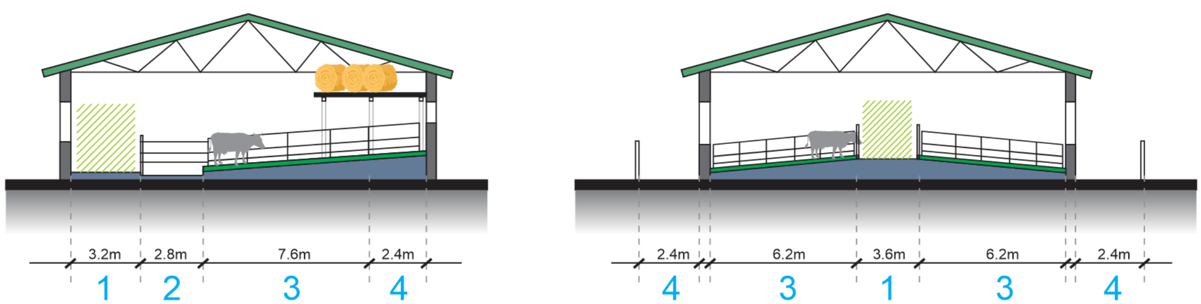



Photo 10 and layout 11: Layout of a barn with a sloping floor, Czech Republic, 2009 and a detail of the cross section of the barn floor, source: authors, Radivojevic, 2004

In the system with a sloping floor, where the feed table is placed lower than the resting area, the partition between the feed table and the bed is placed at least 15 cm in the direction of the bed, and the transition between the feed corridor and the bed is at least 20 cm high, in favor of resting area. Resting can be located on both sides of the stern table (*Layout 10*). Then the cows approach the feed table directly from the bed, which is under a slope of 4-10% in the direction of the feed table towards the dirty corridor. A dirty corridor is located on both sides behind the resting areas.



Layout 12: Cross section of a stable with a sloping floor 1. feeding table 2.feeding corridor 3.resting area with mat; 4. mat spreading corridor, source: authors

4.2. Feeding elements

The manger is an architectural element that is part of the feeding corridor, that is, the feeding space, which limits the edges horizontally and vertically for the animals to scatter the feed. In order to avoid conflicts between cows, it is necessary to take care that each of them has enough space to feed at the same time. The diet of each cow is individual, and each cow, along with the coarse part of the meal, receives a certain amount of concentrate according to its milk production. The manger allows the cows to eat freely, as each cow has enough space to poke its head through the manger and get to the food. The role of the manger is to prevent wastage and interference with food intake. With this in mind, the manger must be designed so that each cow has free access. They must be at the appropriate height and in a position that allows the cows to consume food normally. This is why manger partitions are a good choice or to have enough space for each animals (70 cm per dairy cow in free range housing systems). The shape and dimensions of the manger depend on the way the animal is held, feeding technology and food distribution. An important part of every production is to design a feeding program, taking into account the physiological characteristics of the cows and the specific needs for nutrients, with the aim of high milk production.

The manger must not be too narrow because it is difficult for the cows to take feedstuffs (photo 11). Sharp edges could affect disincentive to the animals' feed intake. In the end, this affects their productivity, as well as the income of breeders.

Photo 11: Too narrow mangers, Bosnia and Herzegovina, source: authors, 2012

In recent times, a feeding table is used more and more instead of a manger. This is a typical practice for newer barns in the Philippines as well. The advantages of the feeding table for the worker are easier access to the manger and easier manipulation of food, it provides easier introduction of new technologies in the barn and thus significantly shortens the time spent on providing nutrition to the cows, and thus makes the work of the man easier.

Feeding table is very exposed to the influence of acids from silage that damage concrete surfaces and thus provide fertile ground for the spread of bacteria and food contamination. This can lead to health problems for cows and reduce milk production. Therefore, it is necessary to protect the feeding table with surface coatings or plastic foils in order to preserve the quality of food and enable good productivity of cows and economic profit, as feeding is about 50-60% of total costs in dairy production (photo 12). The foils for the feeding table are fixed with unique aluminum profiles that hold them firmly in place. They bear heavy loads and will not be damaged by the movement of the tractor. Ceramic tiles that are easy to clean are also often placed on the feeding surface, which enables easy maintenance of the hygiene of the feeding area.

Photo 12: Feeding table with ceramic tiles, Czech Republic, source: authors, 2013

5. HOUSING OF CALVES

The calf begins to feel the influence of the environment while still in the mother's womb. Thus, calves born to mothers that have been transported more often show a greater tendency to stress than those whose mothers have not had transport experience. The influence of nutrition on the calf also begins in the perinatal period, so the need for salt, i.e. sodium, is also determined in this period of the calf's life. During calving, hypoxia can occur, which occurs when the calves are larger and the mothers are smaller. The first contact between cow and calf after calving is when the cow licks the calf. Just licking affects the calf's mobility, encouraging it to look for food, i.e. teats. Behavior in the postnatal period of the calf's life is mainly determined by instinctive requirements, such as the act of sucking or hiding. The angle of the head when taking colostrum, i.e. sucking, also has its importance. If the calf drinks milk from a bucket in the early postnatal period, the esophageal groove will not develop well: it will not close properly and the milk will enter the rumen. In the second case, if the calf is properly fed, i.e. breastfed, the esophageal groove will develop properly and the milk will bypass the rumen. The perinatal periods of suckling and weaned calves differ greatly. Calves on pasture, in the first days of life, spend most of their time lying down while the mother takes care of the nutrition, of course at a suitable distance so that she can look after the calf. Only after 5 days does the calf become more mobile and spends less time lying down. Already in the first few days of life, calves are moved in intensive breeding. The results of research that studied the relationship between standing and lying in calves, showed that calves need 10 to 12 days to get used to a new environment. According to some research, calves that are moved at an early age are up to five times more prone to diseases than calves that were not moved.

Weaning calves on the first day after calving can affect social development. Calves that were separated a little later, e.g. at the age of two weeks and with a larger body mass, they manage better when they move to group housing, and they also have better growth.

In a comparison of boxes with a width of 56, 66 and 76 cm, it was concluded that calves in the widest boxes spend more time scratching, while calves in narrow boxes have problems standing up and stretching their legs in a lying position. So, comfort is very important. When they are not limited in their stalls, calves in the pre-ruminal period naturally lie down, ie. laterally and on their stomachs, while adult cattle almost exclusively lie on their stomachs to facilitate the passage of food at the rumen-esophagus line. Small boxes also affect the quantity and quality of movement, i.e. calf play, so active movements are very rare in smaller boxes, thus growth and development can be limited. In group pens, it is possible to divide the space between the calves, and the calves know how to use this for warmth by lying next to each other. In this way, they leave enough space for playing and movement, which is not possible in individual beds. A sufficient amount of straw as a mat is essential for calves to play: the stimulation to move and play provided by straw improves well-being, compared to housing calves on concrete. Frequent mat changes are really important in the humid conditions of the Philippines. A lower level of illumination reduces the intensity of play and other activities in calves, including feeding. In low light conditions, calves spend more time lying down. However, other studies show that calves in darker housing conditions are more aggressive and reduce activity, probably due to the calves' lack of concern for the environment in which they live. Calves are less sensitive to changes in light intensity than humans, but producers should know that high-intensity light sources, such as, for example, halogen light sources when placed too low can motivate calves to stare at the light, which can cause stress. Sodium lights or regular bulbs are better because the wavelengths are longer (more red/yellow) than fluorescent, mercury or halogen light sources, which emit more light in the shorter wavelengths (violet/blue), which calves are more sensitive to. Temperature and ventilation are closely related to the occurrence of diseases, and therefore directly affect the quality of calf well-being. Appropriate feed will ensure that calves at the age of 1 week successfully cope with different temperatures, the upper critical above 20°C and the lower critical from 8°C below. Food should be tasty and not too dusty, but not too easy to digest. When it comes to air quality, it is best to keep calves outside as long as the calf can withstand the cold temperatures.

After calving, it is necessary to proceed as follows:

- clean the mucus from the nostrils and the calf's mouth; in the event that mucus has accumulated in the respiratory tract, it is necessary to raise the calf by its hind legs. If it is necessary to encourage breathing, the neck and head along with the nape of the neck can be sprinkled with cold water,
- disinfect the umbilical cord; it is a mandatory measure in order to prevent infections,
- let the cow lick the calf; the cow licks and thus dries the calf after giving birth, and at the same time, by licking, it stimulates breathing and increases the blood circulation of the calf,
- dry the hair of the calf; it is necessary to dry the calf additionally, considering that the thermoregulation system of the calf is not yet functioning,

- ➢ milk colostrum (2 liters), then water the calf with colostrum (giving the first colostrum),
- ➢ mark the calf with an ear tag,
- ➢ transfer the calf to the external individual box.

Calves can be housed individually or in groups.

Individual housing of calves means housing calves in stalls and they are kept like this usually for about 8 weeks. A box is an enclosed space, divided into two parts, open and closed, in which the calf has enough space to move, feed and fulfill its basic physiological needs. The box is made of plastic with a metal fence in the open part, of wood, with tarpaulin, etc. Boxing allows the calf to protect itself from bad weather conditions (rain, snow, wind, strong sun), but it also makes it easier for the farmer to control the calves against the possible transmission of various infectious diseases that can affect them during that period of development. This system of rearing calves aged 8 weeks is also called aerial rearing, or milk rearing of calves. In such a system, the calf has a sufficient amount of air, it lives in an environment that is not as intensively contaminated with microorganisms as it is in the classical system. For female calves, this period is very important for the development of lung capacity, due to the amount of fresh and clean air, because in the later period of life, in order to produce large amounts of milk, the cow should have strong and developed lungs (respiratory type), which will bring sufficient quantities into the blood of oxygen to meet the body's needs. During this period, calves can also be kept in group boxes. The basis is the same: to have a covered and an open part. The required space per calf is 1.5 m². If straw is spread, for this age it is necessary to provide 0.10 - 0.20 kg of straw per calf.

Photo 13: Calves in the individual and group boxes, Czech Republic 2017, authors and 2020, Farmtec.cz

Group housing of calves means housing calves in groups that are formed according to the age of the calves. This is a more common form of farming in the Philippines. These are usually groups up to 30 days apart between groups. Although age groups of calves 2–4 months, 4–6 months, or bulls 6–8 months, etc., can also be formed. When it comes to housing, calves at this age can be housed in facilities with deep mats or beds. Facilities with beds are better, because they allow the calf individuality and, if necessary, social relations - communication (playing, sniffing, scratching, etc.). During this period, the animals are already prepared for plant nutrition. The food should be good, high-quality and tasty, and should enable the proper development of the heifer, which should give birth to a healthy calf and produce a sufficient amount of milk. For the mat, it is necessary to provide 0.9–1.5 kg of straw per calf.

Photo 14: not the best example (up) of calves and good example (down) group housing in Phillipines, 2021. Source: unknown autor

6. HOUSING OF HEIFERS

In order to provide quality material for the overhaul of the herd, it is necessary to ensure the successful rearing of calves, as well as heifers. Profitable milk production requires a healthy animal, of good dairy constitution and well-developed organs for milk production. In order to fulfill these requirements, it is necessary to provide appropriate breeding conditions that will ensure their uniform growth and development, and to limit as much as possible the occurrence of circumstances that can cause stress in animals, injuries or insufficient intake of nutrients. A crucial factor in raising heifers is to ensure exercise, especially if it is possible to provide it by grazing during the summer months. It is important to allow the heifers in breeding to move inside the buildings, for which the systems with a deep mat and a sloping floor are especially good and cheap. According different researches, heifers raised on pasture give up to 200 kg more milk after entering production than animals raised in a barn.

Heifers breeding involves a period from age of 6 months until the first calving. This category of animals is essentially non-productive, if we do not count on the production of manure. When it comes to heifer rearing technology, the following should be taken into account:

1. it is necessary to continuously monitor the development of heifers and take adequate measures as necessary,
2. in the case of larger herds and stable breeding, group animals in time (already with 250 kg of body weight)
3. the size of groups in breeding heifers in barns with a free housing system should range from 10 to 30 heads,
4. in order to reduce stress, it is preferable not to change already formed groups of heifers, e.g. inserting new heads,
5. when rearing heifers on pastures, they can be grouped into larger herds of 20-50-100 heads.
6. in the case of rearing in a barn, the available area should ensure the comfort of the heifers, through space for lying down, feeding and watering,
7. in rearing in barns, it is necessary to provide sufficient quantities of high-quality nutrients, primarily hay, but also a portion of nutrients with a higher energy value, and clean water,
8. if the conditions allow, it is necessary to ensure regular weighing of animals, e.g. at the entrance to group housing, at 12 months and before insemination,

9. we admit heifers when they reach a body weight of 55-60% compared to the weight of an adult, so that they calve with a body weight of about 85% compared to the weight of an adult,
10. at the first calving, the heifers should have about 95% height at the withers of the average height of an adult characteristic of that breed of cattle,
11. Holstein heifers should be calved at 24-25 months, Simmental at 25-26 months.

When it comes to rearing heifers, you need to know a few more details that can significantly improve the quality of reared cows, namely:

- a tied system without a mat in raising heifers is also applied, but the negative sides of this system prevail over the positive ones (even in the case if we have quality rubber mattresses),
- barns with a slatted floor are also used in the rearing of heifers, but it is necessary to provide a suitable outlet for animals or grazing,
- for rearing heifers in cubicles, it is necessary to provide min. 1.5 kg of straw/head/day,
- the breeding system in boxes is good but more expensive; savings can be made if we form the boxes under the canopy,
- a deep mat with straw is good for rearing heifers, only if quality ventilation of the facilities is provided. Do not use in closed buildings. In order to ensure the appropriate level of comfort and well-being of heifers kept on deep mats, it is necessary to provide, among other things, 4-5 kg of straw or some similar mat per day.
- in barns with a sloping floor, the slope should be 6-8%, and groups no larger than 20 heads,
- grazing heifers must be divided into at least three age categories, as follows: the first group consists of heifers weighing 170 kg and above, up to the age of one month before the allowance; the second group of heifers that are 30 days before insemination, i.e. heifers that will be inseminated during the grazing period; the third group of heifers that are already pregnant, or especially heifers that will be inseminated in the first month of grazing,
- on pastures, it is necessary to maximally simplify the entire system of grazing organization, while achieving high production, work performance and economic efficiency. To provide a cheap and simple way of fencing the area for grazing, access to watering places or water, feedlots, canopies and possibly a shelter for shepherds. It is useful to have mobile partitions

for animal manipulation, which can be moved according to the movement of the animals. Canopies are necessary in areas where extreme weather conditions can be expected during the summer period, but also for mostly younger categories of animals 200-250 kg of live body weight,

- grazing provides a natural way of feeding ruminants, ensures the harmonious development of animals, supports the development of the locomotor system of animals, helps in the development of lung capacity and generally improves the health of the respiratory organs, has a positive effect on the appetite of animals, helps to activate vitamin D, significantly affects the improvement of reproductive a characteristic of animals and when it comes to conception and calving, it increases resistance to diseases. Grazing can be said to be the most natural and at the same time the cheapest way of rearing heifers, so that it meets all standards of well-being for the animals themselves, and is the most economically acceptable for the breeder.

In practice, there are two ways of housing heifers: tied and free. The common feature of both ways of holding is that simple facilities are used for accommodation that do not require large equipment for the purpose of carrying out technological operations. Practice has shown that heifers feel best in a free way of housing and whenever possible they should be released in a space where they can move freely, regardless of which way of housing is applied. In the photos below we see one bad approach to housing heifers and one good one.


Photo 15: Tied system, Germany, 2015. Free system, Philippines, 2019.

7. MICROCLIMATE AND ITS IMPORTANCE FOR CATTLE WELFARE

When it comes to the climatic conditions in the barn, the breeder must first of all understand that

"THE CLIMATE IN THE BARN SHOULD BE ADJUSTED TO THE ANIMAL, AND IN THE HOUSE TO YOUR OWN MEASURE".

Environmental factors that affect or can affect domestic animals represent a complicated system that can significantly determine the profitability of production. Through the process of domestication, man took animals out of nature and subordinated them to his needs, so he should bear responsibility for them and adapt the living conditions to the needs of the kept animals. When talking about the well-being of domestic animals in relation to climatic conditions, we mean first of all extreme situations, such as high or low temperatures, strong winds, heavy rainfall, etc., which can negatively affect the health of the animals and reduce the income for the owner. Good climatic conditions inside the barn for all categories of cattle, both in milk production and in fattening, are of essential importance for proper growth and development of the animal, good health, production and economy. Climatic conditions reflect the state of several different factors, including: gases, temperature, humidity, lighting and air flow.

Cattle are animals with very well-developed thermoregulatory mechanisms. They are able to adapt to different climatic zones. However, areas with lower average annual temperatures suit them better. Adaptation of animals to high temperature and high humidity is conditioned by their ability to activate organs and mechanisms for body cooling. Blood is distributed to the skin, the work of sweat glands is enhanced (cows do not have typical sweat glands), breathing is accelerated, etc. Heat stress has many negative effects on cattle, and among them are: cows that experience heat stress in the last three months of pregnancy, give birth to smaller and less developed calves; in the next lactation, they produce up to 12% less milk; heat stress negatively affects reproductive characteristics, follicular activity decreases and embryonic losses increase. Furthermore, heat stress prolongs the treatment of sick animals, the animals are more tired, the liver is fatter, frequent and increased mastitis, negative reactions to vaccination occur, and abortions are more frequent. Heat stress in conditions of high ambient temperatures makes the life of high-producing cows difficult, because it negatively affects their behavior, production, health, reproduction, and thus the economy of production. In the event that the body cannot release an excess amount of heat,

heat stroke (hyperthermia) occurs, and in the worst case, the animal dies, which is a very rare case in our areas.In general, the negative consequences of heat stress are:

- lower intake of food,
- poorer conversion of nutrients,
- increased intake of water,
- decline in milk production,
- changes in milk composition,
- changes in the composition of colostrum (colostrum),
- worse fertility,
- weaker embryonic development and
- slower growth and development of the individual.

7.1. Methods of combating heat stress

There are several ways that we can use to combat heat stress when we talk about animals that are kept in barns, of which we list some of them here.

Ventilation. Increased ventilation in the barn affects faster air flow, and thus the cooling of the animals. Horizontal ventilation is more suitable one barn areas with the where the floor is often wet (around milking parlor, robots, water throughs) and aslope ventilation is good where cows eat or rest.

Photo 16: aslope ventilation for calves in Czech Republic, source: Farmtec.cz

Evaporative cooling. This cooling is the spraying of animals with water, i.e. spraying water in the barn using devices specially made for this purpose. Figure 14 shows an example from Israel (May), where cows are sprayed and cooled by fans in front of the entrance to the milking parlor. When it comes to evaporative cooling, there are two different ways:

- indirect - air cooling around the animal's body,
- direct - spraying (spraying) water on the animal's skin.

Evaporative cooling gives the best results if it is combined with ventilation and in conditions of low air humidity. Research has shown that spraying water directly on animals gives much better results. However, when using this method of cooling, you should pay close attention to the type of device used for spraying, because the water droplets should be 0.05 - 0.15 mm, i.e. large enough to reach the skin. For indirect cooling, devices are used for making the so-called fog, where the water particles are 0.02 - 0.05 mm. If animals are directly sprayed with smaller particles, a layer may form on the surface of the animal's body, which slows down cooling. The reason for this is that smaller particles do not pass through the fur to the skin, but "stick" to the surface of the fur. However, the problem of mechanized cooling is not so simple. It is necessary to know the critical points, to constantly measure the climatic factors in the barn, to notice the effects of heat stress on the animals in time, etc. That is why you should sometimes seek the advice of an expert.
In the event that the breeder is not able to provide some of the above measures, it is necessary to splash the animals with a bucket of water or spray them with a hose, at least in the hottest parts of the day, and thus help them. In addition to the problem with high temperatures during the summer period, insects can be a big problem for cattle.

8. PREPARATION OF FEEDSTUFS

Fodder feed can be prepared by drying (hay with 86-88% dry matter) and ensiling: with a lower percentage of dry matter (silage 30-40%) and with a higher percentage of dry matter (hay silage 40-50%).
Drying. Hay is a dried, mowed green mass of grasses, clover-grass mixtures or legumes. Hay is produced by drying grass of standard humidity (12-15%), where it can preserve its nutritional value and quality until its use. Hay is a very important nutrient for feeding dairy and high-fat cows.

It has the role of a structural component of the meal, which means that it satisfies certain physiological needs and ensures the normal function of the digestive organs. Hay, thanks to its cellulose, has a stimulating effect on maintaining the rumination process, and has a positive effect on the synthesis of milk fat. The quality of hay is affected by weather conditions, so hay is a nutrient with the most variable chemical composition and nutritional value. The most important goal of preparing hay is to reduce the moisture content to a level where enzymatic and microbiological degradation of substances in plants is inhibited. This is ensured when the humidity level is reduced to 15 or 20%. As the plants mature, the content of dry matter increases, but they become less digestible. Therefore, plants should be cut when a certain balance between dry matter and digestible nutrients is reached. Quantities of 5-10 kg are recommended per cow per day, depends on the level of milk production.

Ensiling. Silage is a green chopped mass of grain, usually corn, 0.7-1.0 cm long. Properly prepared silage is the highest quality and tastiest food, with preserved vitamins and minerals, so its preparation and storage are among the most important operations in livestock production. Whole corn silage is one of the most important sources of energy in the diet of dairy cows. However, it cannot be the only bulk feed used for feeding cows. It can replace 1/3 to 1/2 of the dry matter of voluminous forage, and the rest of the dry matter of voluminous forage must come from hay. The practical rule is that 3 kg of grass silage, with 70% moisture, or 2 kg of silage, is equivalent in its nutritional value to the amount of 1 kg of hay. The difference in nutritional value is mainly due to higher moisture content in silage or hay. One kg of hay has approximately the same value as 3 kg of silage. The optimal amount of silage of green voluminous nutrients in the rations of dairy cows is 20-35 kg.

Grass silage or haylage can be classified as silage with a low moisture content, which is prepared from grasses and/or legumes, which have been dried before ensiling to a moisture content of 40-60%. Haymaking is of particular importance at higher altitudes, and the vegetation phase is too short for corn production. Compared to corn silage, haylage has a higher protein and carotene content, but lower TDN and vitamin D content. In addition, animals will consume more dry matter when fed haylage than corn silage. The shape of silage is partly similar to silage and partly to hay. Hay contains less water and more nutrients than silage. Well-prepared haylage has a yellowish and brown-green color, a pleasant sour smell, and a stable, unchanged texture of the material. Silage prevents juice from being squeezed out of the silos, which is characteristic of ensiling, which increases losses in nutrients, attracts flies and pollutes the environment. The use of silage reduces transport, handling and other farm costs. Dairy cows can consume up to 20 kg of hay per day. Ensiling is up to 30% cheaper than drying. Losses are usually around 25%, sometimes 30-40%. The advantage of ensiling is that it depends less on weather conditions compared to hay, as well as that 1 m^3 of silage contains twice as much dry matter (160-180 kg/m3) than 1 m^3 of unbaled hay (70-80 kg/m^3). . Almost all processes of ensiling and distribution of silage to animals can be fully mechanized. Durability of well-stored silage, in good silo facilities, is several years. Silage is stored without the risk of possible fire, due to the high moisture content, while hay and similar nutrients obtained by drying are constantly threatened by the potential danger of fire. On the other hand, the disadvantages of ensiling are: manipulation of a large amount of plant mass with high humidity, certain losses of nutrients during ensiling, easy perishability, so it cannot be transported over long distances and is used where it is prepared. Then, ensiling requires larger initial investments, for the purchase of silage harvesters and the construction of silage facilities. Finally, and most importantly, low-quality or poorly prepared silage can cause animal health disorders. Dairy animals ensure the largest part of their body's energy needs from voluminous feed. They also have a laxative effect on the digestive organs and the digestion process. Bighorns consume up to 30 kg of silage per day. Before starting the consumption of silage, it is necessary to determine its quality, usually based on its smell, color and structure, in order to know how to use it for feeding animals. The color of silage can be yellow-green, yellow, olive green and dark, depending on the type of silage material. The smell of silage is best appreciated by rubbing it between the fingers or palms. The smell of quality silage disappears from the hands after a few minutes, while the smell of bad silage lingers for a long time (due to the presence of a lot of butyric acid). Quality silage has a slightly acidic and pleasantly aromatic smell, reminiscent of the smell of sauerkraut, cucumbers, tomatoes or sourdough. Silage made from proven material or haylage has a less pronounced smell that is more reminiscent of the smell of hay. The structure of quality silage should be preserved so that individual plant parts can be easily recognized. The quality of silage is better if the properties of the starting material are less altered.

8.1. Feeding supplements

Nutritional supplements include industrially produced complete, supplementary and protein mixtures of concentrates and sub-mixtures of minerals and vitamins. They are included with 1-2%

in concentrate mixtures. On the animal feed market, there are individual mineral nutrients in the form of animal chalk, ground limestone, phosphonyls, animal salt and baking soda, which, according to a professionally prepared recipe, are added in a certain amount to animal meals. Vitamin supplements in the animal body control the digestion process, reproductive function, production level and general health condition, and for ruminants the most important are vitamins A, D and E. In the diet of cattle, concentrated nutrients and concentrate mixtures are used as a supplement to the coarse feed meal. Large amounts of concentrate can be dangerous for cattle due to changes in the pH value of the rumen and the composition of the microflora. The adverse effect of a larger amount of grain in the rations of high-milk cattle is reflected in the change in the desirable course of food fermentation in the digestive system, which increases the acidity in the rumen, and it negatively affects the quality of milk (milk fat), as well as the disruption of the general health condition of the animal.

9. NEEDS FOR WATER

Water is present in all cells of plants and animals and is an integral part of the structure of animal' body. Thanks to this, animals release and absorb water very easily, as part of the physics of metabolism. The two most important functions of water in the body are: it serves as the most important component of metabolism and regulates body temperature. Water participates in digestion (hydrolysis of proteins, fats and carbohydrates), assimilation of digested nutrients, transport of metabolites and secretion of waste products of metabolism. Regulation of body temperature depends, mainly, on the properties of conductivity for the even distribution of heat throughout the body and for the removal of excess water, released during metabolic reactions in the cells.

Availability and quality of water are extremely important for animal health and productivity. If cows are provided with fresh water, cows drink more water, eat more and produce more milk. It sounds simple, but the amount of water consumed is significant. Drinking water should be available to the animals at all times, potable and of suitable quality when consumed by the animals. Efficient water distribution and delivery systems that provide the necessary amounts of water are essential in all milking parlor systems.

Cows like large, quiet areas of water where they can drink quickly and without stress. This inspires them to continue eating, and also to drink more water, thereby increasing milk yield. Group feeding troughs are used to feed multiple animals (25-30 cows) and are typically used in free-range cow facilities and outfalls.

The length of the water trough should be 3-3.5 cm per cow, with an optimal height of 65-80 cm. The depth of the water should be at least 8 cm in order to prevent the animals from injuring their snouts. To avoid the danger of manure pollution, water troughs should not be too low. Also, cattle water troughs must be easily accessible, no more than 15 m from the feeding table.

For successful production planning, it is necessary to know the needs of different categories of cattle for water, at different ages, stages of production, weather conditions and different ways of housing cattle, as stated in Table 3.

Table 3. Water use for different categories of cattle

1.	**Category of animals/ /water consumption**	**l/head/day**		**m^3/head / year**
		from	**to**	
2.	Calves up to 50 kg	4	6	2,190
3.	Heifers	38	60	21,900
4.	Dried cows	76	114	41,610
5.	Lactating cows above 650 kg live weight	95	190	69,350

During the summer, during higher daily temperatures, the water consumption of cows that produce 35 kg or more of milk per day increases significantly, up to 15% above the upper limit.

10. MANURE STORAGING AND ENVIRONMENT

The main by-product of cattle production is manure. Manure can be solid or liquid. Solid manure is a mixture of feces, urine and bedding material, and liquid manure consists only of feces and urine. The amount of manure produced on farms depends on the way the animals are kept, the cattle's diet and the intensity of the cattle production itself.

Value of manure. Adequate use and storage of manure greatly reduces the need to apply mineral fertilizers in agricultural production. Therefore, it is the most acceptable for the environment, and at the same time the most economical, to apply manure on agricultural land. However, special attention should be paid to when and how much manure may be exported to agricultural areas. Cattle manure contains 0.5% N, 0.3% P_2O_5 and 0.5% K_2O. In addition to primary nutrients, it also contains secondary nutrients and micronutrients and is irreplaceable in agricultural production. That is why manure is a very important by-product of cattle production and should be treated as such, used to improve plant production, as well as to improve soil fertility and structure.

Manure storing. Nitrate leaching from manure leads to multiple damages and it is especially significant in areas with very intensive cattle production. First of all, it represents a potentially large source of surface and groundwater pollution, causing damage to aquatic ecosystems. Second, the leaching of nitrates from manure into groundwater that reaches drinking water harms people's health. Thirdly, by leaching nitrates, a very valuable source of nitrogen for agricultural crops is lost, which is then compensated by the application of expensive mineral fertilizers. That is why proper storage and handling of manure is important in many ways.
When building a manure storage facility, the following should be taken into account:

- The size of the manure storage should be such that it meets the needs of manure collection for a period of 6 months. For one conditional head, it is necessary to provide for six months:
  - for solid manure, at least 8 m^3 of storage space,
  - for liquid manure, 2 m^3 of storage space.

- manure can be stored directly on the field only under the condition that the field is waterproof and that there will be no contamination of groundwater,
- bearing in mind that manure loses nitrogen in contact with air, the storage should be designed in such a way that there are as few open surfaces as possible (this refers to the storage of solid manure),
- if the manure is exposed to the sun, the temperature in the manure increases and anaerobic bacteria work more intensively, methane is released, which evaporates and goes into the atmosphere, so it is necessary to find a cooler place for storage, or place with some shade,
- careful selection of places for manure storage within the farm in relation to food storage and milking parlors. If the terrain is falling, choose the lowest point,
- the choice of place for manure storage is also determined by surface water, at least 10 m from watercourses and 25 m from springs or wells. If the terrain is falling, choose a place that is lower than the place where the source is,
- in the case of uncovered lagoons for liquid manure, it is necessary to include the amount of precipitation in the total capacity of the lagoon,
- attention should be paid to the special fertilization of barns and calving grounds due to antibiotics and chemical substances that can be found in manure,
- the wind rose on the farm site is also a very important thing when it comes to the construction of the manure storage, so to avoid the impact of bad smells on the farm and the neighbors,

In the end, it should be pointed out that lately the use of manure in the production of renewable energy sources has been increasingly used. In this way, it is possible to significantly save the energy necessary for the operation of the farm.

Illustration 1. Composting of the bedding material remains, source: authors 2022

11. VENTILATION

Maintaining air quality in cattle barns in general is imperative in order to maintain the health and productivity of animals, as well as the farm labor. Air quality depends on the way the farm is managed, the type of feed, the method of fertilization, the ventilation system and its effectiveness in its use, the cleanliness of the barn and the category of animals that are raised. Quality air in the barn is necessary in order to ensure the maintenance of a good level of milk production, i.e. the increase of animals. Air quality also changes throughout the year, taking into account the production cycle. For example, cows in milk eat more, convert food energy into milk, urinate and defecate more, release more gas and steam. Considering the increased intake of nutrients, there is also an increase in dust in the air. The origin of dust in the air can be from several sources, which is caused by different production processes on the farm (Table 4).

Table 4. Sources, type and cause of dust in barns

Source of dust	**Kind of dust**	**Cause of dust**
Cereals	mold, actinomycetes	storage problem
Hay	mold, actinomycetes	bad preparation
Straw	mold, actinomycetes	bad preparation
Silage	mold	bad preparation
Animal waste	feces, urine, hair, skin, fungi, bacteria	animal activity, barn cleanliness, ventilation, etc.
Food	various particles of food ingredients	improper placing of feed in front of livestock/poor ventilation

Ventilation is the exchange of polluted air in the building with fresh air. During the winter, it should be minimal, but to enable the expulsion of excess moisture and harmful gases, and in the summer, it should be maximal and to enable the expulsion of excess heat. High standards of air are achieved naturally and artificially. Ventilation of closed buildings is usually carried out naturally. Natural ventilation can be divided into horizontal and vertical. Horizontal natural ventilation is achieved through openings in the building (windows and doors) and depends on the flow of outside air, because the flow inside the building is achieved by equalizing the difference in pressure of the outside air on the opposite sides of the building. Vertical natural ventilation is achieved through exit vents on the roof or ceiling. Artificial ventilation provides the required amount of fresh air and maintains optimal temperature and air humidity in the barn, regardless of the external climatic conditions. Fans are usually used for this purpose. When calculating an adequate ventilation system, the climate zone, heat, moisture and CO_2 emissions per head are taken into account. Inadequate ventilation increases the risk of disease and the concentration of harmful gases in the barn.

The ventilation system is suitable if the composition of the air in the building is of approximate value as the composition of the outside air. It was found that barns with permanently open sides represent the type of accommodation with maximum ventilation. In such barns, the maximum difference in temperature and air humidity inside and outside the barn was 3.84^{o}C and 13.21%, and THI 5.

Air flow in the building is necessary due to the exchange of indoor polluted air with outside fresh air and optimal barn air. The speed of the wind improves the release of heat from the cows in the form of evaporation. The design of housing and ventilation should enable the air speed in the space where the animals are housed to be at least 0.6 m/s in summer heat, while it is limited to 0.2 m/s in winter.

It should be understood that an adult cow releases 12 liters of water from its body during the day through evaporation. That water should be thrown out of the barn. Table 5 shows the need for ventilation depending on the level of production at a temperature in the barn of 20^{o}C and a temperature outside the barn of 25^{o}C.

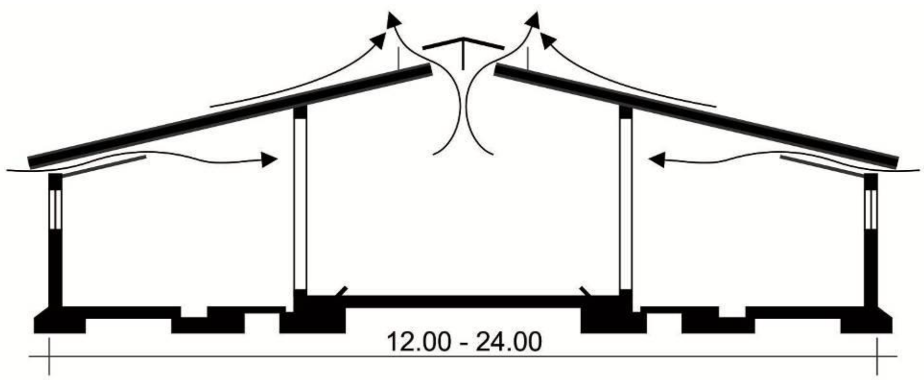
Table 5. Heat production and ventilation capacity per throat

Milk production in kg	**Heat production in watts**	**Ventilation capacity $m^{3/h}$**

6.000	759	460
8.000	865	524
10.000	971	588

Based on the offered table, the ventilation capacity of the entire building can be planned before construction. So, if a facility is built for 100 cows with an average production of 6,000 kg of milk/lactation, the total ventilation capacity is planned to be 46,000 m³/hour.

Layout 13 shows a cross-section of the barn with the indicated directions of air movement. It is a barn with openings on the side walls and under the roof.



Layout 13: Cross section of a barn with an air flow pattern, source: Radivojević i sar., 2004

Providing sufficient amounts of fresh, clean and preferably cold water is also one of the most important methods to reduce the impact of heat stress.

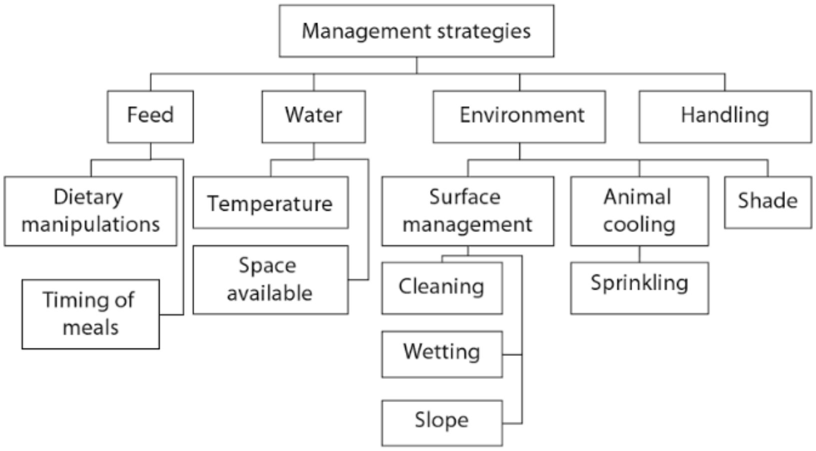
Cattle with darker coats are more susceptible to heat stress than those with lighter coats, because darker cattle absorb more heat from the environment through radiation. If the animal receives excessive amounts of heat, the heat balance in the body will be disturbed, resulting in heat stress in the animal. Given that dairy herds in the Philippines are focused on breeding Holsteins, mostly black, this may be one of the reasons for the very low productivity in these herds. Namely, animals are not capable of effectively fighting heat stress. Therefore, one of the methods of combating heat stress can be a change of approach in the selection of cattle breeds. Therefore, one of the possibilities could be Czech Fleckvieh Cattle (Red Pied, Spotted)[1], which was discussed

[1] https://www.cestr.cz/cs

during the implementation of the project. These animals have lighter coat, and are of dual production characteristics (meat and milk).

Photo 17: Cow of the Czech Fleckvieh breed, source: www.cestr.cz, 2021

Some of the heat stress management practices have been presented in the scheme below:



Scheme 1: A review of management options to reduce heat stress in cattle, Brown- Brandl, 2013

However, these options must be carefully considered, as any management option that has the potential to reduce heat stress is also associated with one or more negative aspects (more workload for workers, lower growth, generation of unpleasant odors, etc.).

12. CONCLUSIONS

In conclusion, the design and construction of cattle farms in the Philippines require careful consideration of the organizational layout, available materials, and climate conditions. Creating a functional and sustainable farm that enhances milk production is the main goal.

A comfortable and well-maintained environment for the cows is essential for improving milk production. Adequate infrastructure and facilities, such as barns, milking parlors, and storage areas for feed and forage, are necessary. Proper manure and waste management systems should also be implemented. The Philippine climate, characterized by high temperatures, humidity, and abundant rainfall, calls for designs that prioritize natural ventilation and protection against excess moisture. Incorporating roof structures and utilizing large fans can help maintain controlled airflow and protect the fresh grass and straw from spoilage.

When it comes to the construction materials, options like Philippine Mahogany, Yakal, Molave, Gmelina, Acacia, and Coconut timber can be used for their durability and resistance to decay and termites. Treating wood with insecticide is highly recommended to prevent termite infestations.

For the foundation and slab, a rectangular base footing connected with crisscross foundation beams is a recommended approach. Concrete slabs with proper slopes and drainage channels ensure easy maintenance and cleaning.

Reinforced concrete is suggested for the construction of pillars and beams, providing durability and resistance to accidents or impacts. Wooden trusses are suitable for roof construction due to their performance, cost-effectiveness, and flexibility. Treating wood with water-based paint helps protect it and extend its lifespan.

Creating a cow-friendly environment involves considering factors such as natural ventilation, space for movement, and proper hygiene. Transparent wattle sticks can serve as side covers to provide shade and protection against rain and wind. The floor finish should be concrete, while cattle beds can be covered with straw or specialized rubber.

Careful planning of the layout, feeding tables, and manipulation areas facilitates efficient management and movement of the cattle. Implementing proper hygiene measures and using durable and cow-friendly materials contribute to a successful cattle farming operation.

Overall, the design and construction of cattle farms should aim for a balance between functionality, cost-effectiveness, and creating a comfortable and natural environment for the cattle.

In the developed dairy countries, the issue of housing cattle has long been a 'solved issue', not only in the sense that all barns are adapted to the needs of the cattle in them, but also in the sense that the majority of interested parties understand the need for a solution to this issue. In these countries, there is a certain legislation in force (laws, regulations, strategies) that provide guidelines for adequate housing of cattle and there is a mechanism for their implementation. However, in order for this issue to become significant, it needs to be publicly present, commented on, discussed and discussed.

That level has not yet been reached in Philippines. Unfortunately, the majority of people (directly or indirectly) involved in the dairy cattle breeding are still not sufficiently aware of the issues related to the well-being, behavior and, ultimately, the quality of the housing of cattle. Of course, there are also positive examples, especially in newer farms, but their number is insignificant. Therefore, we hope that this handbook, as much as possible will make at least small basic step forward.

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