COMFORT INDICATORS IN FREE-STALL HOUSING OF DAIRY COWS

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Abstract

In recent years the dairy farming massively went from tied to free housing of dairy cows, and more widely in conditions of Bulgaria the semi open free-stall barns housing system is applied. One of the main factors associated with cow comfort in this housing system are the dimensions and design of the individual stalls. Indicators for stall comfort can be postures of cows when using the – standing with four or two legs in the stall, standing or lying diagonally, lying back in the stall, and more, these postures can also greatly guide us on the specific design problems that make stalls uncomfortable for the animals. In uncomfortable stalls cows spend less time resting and more time standing on the concrete floor of the technological alleys. Comfort indices are quickly and easily applicable to assessing comfort when used in general practice. For their correct application, careful consideration should be given to factors that affect their values - farm activity schedule, time of reporting during the day, season of reporting, etc.

Keywords: cow comfort, dairy cattle, freestall barn, cow’s comfort indices

INTRODUCTION

Big advantage of free-stalls is possibility of social interactions, although it also allows for negative interaction (competition for resting and feeding), which are not possible in tie stalls. Freestalls also offer better comfort (Mitev et al., 2012) and this type of housing system is mostly used for construction of new dairy farms in Bulgaria (Gregovska et al., 2013), and Europe in general.

In the past, the design of livestock facilities and premises was considered mainly in terms of climate control, economy and relief of work and hygiene. There has been little attention paid to the effect of housing conditions on animal behavior and welfare. However, studies over the last decade have found that animal behavior, well-being or comfort really do have significant effect on their productivity and health (Boone, 2009). Comfort in cattle is one of the important factors that affect the profitability of dairy farms due to its connection with premature culling, longevity of cows and the duration of their productive lives. Productive life is determined by the number of lactations that the cow ends before it is culled. A highly productive cow, which stays longer on
the farm, allows for more permanent earnings and provides greater profit for its housing.

In addition, a lower premature culling is reported and the farmer can concentrate on the selection related culling of cows due to low productivity, increasing the genetic potential of his herd (Garsiq and Endres, 2008). Welfare is defined as a concept that includes both physical and mental health of the animal, as well as a term that refers to the ability of the animals to cope with the conditions of both the environment and with its own interior environment. The external environment includes, but is not limited only to housing conditions and climate. The interior environment includes nutritional and health status. Animal welfare is difficult to be defined or measured because it includes their emotions and behavior.

Since emotions are difficult to identify and classify the evaluation usually focuses on measurable parameters such as the strength of preference to different environments and conditions (Boone, 2009).

To create a comfortable cow environment, two main factors are important: cows welfare and economics of providing such environment (van Gastelen et al., 2011). According to Harizanova and Peneva, (2009), the welfare of cows is one of the main factors on which the economic efficiency of cattle farms depends. The floor surface and the size of the beds have direct impact on the duration of the resting time in cows. These technological elements are also associated with the presence of udder trauma, cow hygiene and their productivity. The main factors and technological elements on which the economic efficiency of milk production depends are: the level of milk production, the environment, the housing system, the level of feeding, the manure cleaning system and the farm management. Greenough, (2007) defines the comfort of dairy cows as: “environmental conditions, including the applied housing system, farm management, feeding, animal hygiene, genetic potential, and others.”

Attempts to improve the comfort of cows are directly related to the drive to increase the production of the animals, improve the health status of the whole herd, high fertility and a longer period of use of the animals. Providing cow comfort comes down to knowing the various activities performed by cows during a 24-hour period, and in particular, the time spent by the animals in lying position, the frequency of lying down and getting up (Haley et al., 2000).

The resting area – individual stalls, should be attractive to the cow as well as to provide minimum conditions for the presence and multiplication of microorganisms. Monitoring the use of stalls is a difficult task because it takes a lot of time and equipment for the purpose. The use of video surveillance is much more appropriate as the influence of external presence is eliminated, which often leads to a change in the normal behavior of cows (Wagner-Storch et al., 2003). According to Plesch, (2011), the use of the term “cow comfort” in cattle farming practice is largely concerned with the place where animals are lying and how it is adapted to their needs. In one of his study Ventura et al. (2015) found that a large part of farmers interpreted the term “cow comfort” as a set of environment (including: temperature, ventilation, supply and quality of water for watering), adequately designed and constructed individual stalls for rest (the required of cows space for lying and standing inside the stalls) and the behavior of the cows (when lying, standing in upright position, etc.). Other respondents include the level of stress, lameness and various other injuries to the term used.

The choice of housing system and management affect behavior, health, duration of use and productivity of cows and also the production efficiency of of the farm (Anderson, 2008). Fear or feeling of insecurity and discomfort at the place where the cow is housed lead to unwanted or unusual behavior and to risk of disease. The behavior and health of cows are directly related to their comfort during housing. Diseases directly related to cow comfort are such as lameness, wounds and lesions on the hock or neck, mastitis, milk fever, ketosis and displacement of abomasum. Behavior during rest, feeding, moving or use of the resting areas, provide additional information about the comfort. The positive interaction between the cow housing conditions and the care they getting, determine their welfare, happy employees and a productive herd (Anderson, 2001).

The natural behavior, which is most important for the health, welfare and productivity of cows, includes several key physiological processes – resting, feeding and ruminating (Krawczel and Grant, 2009). Resting behavior can be used to assess the comfort of the beds, however, such behavior monitoring under production conditions is problematic (Ito et al., 2009).

There is growing evidence that, increasing lying time has a beneficial effect on the lameness prevalence and the health of the hooves, and obviously increasing the lying time spent in clean, dry and comfortable stalls will mean less time to
moving and standing in technological alleys and will lead to a cleaner legs (Cook and Nordlund, 2003). There are several studies that indicate the relationship between lying time and spread of lameness and various hoof problems in dairy cows. Leonard et al. (1994) noted that the decrease in lying time and the increase in the time spent standing with the two front legs in the stall are associated with more problems with cow hooves. The Galindo and Broom, (2000) study shows that cows with low hierarchical status spend more than 45% of their time standing on the alleys in the building and have had significantly more hoof problems.

**STALL COMFORT INDICATORS**

Over the past decade, milk producers are looking for design of the individual stalls, which to provide cows with a comfortable resting area and to ensure maximum cleanliness and minimal injuries. Stalls for rest are a vital element of the cow's environment. The cow should want to enter the stall for rest, not to hesitate and to lie normally in it. The stall must be wide enough for the cow to lie comfortably, but also narrow enough to prevent diagonal lying and back entering. The stall must be long enough to allow the cow to rest comfortably, but also short enough to prevent contamination with urine and manure. The stall shall be so designed as to prevent injury of the cow when entering, exiting or lying in any part of it. The disadvantages in the design and maintenance of individual stalls are significant risk factors associated with mastitis, injuries of hocks, udder and teats, hooves and laminitis (Cook and Nordlund, 2003).

In uncomfortable individual stalls cows spend less time in rest and spend more time standing on the concrete floor along the technological alleys. This increase in time spent standing on the concrete results in increased incidence of lameness and decreased productivity.

Important factors to consider when designing the stalls for lying are: the dimensions of the stall and all other technological elements, including the stall dividers, neck rail, the stall floor surface, and the bedding (McFarland, 2003). Even after several years of study, observation and discussion, it seems that there is still no consensus on the best combination of these elements to provide an ideal place to rest for dairy cows (McFarland, 2003).

There is a set of cow behavior indicators that not only show how comfortable the stalls are, but also is a landmark for problems.

**STANDING POSTURE IN STALL**

The stereotyped behavior of the cows includes a period of normal standing with the four legs inside the stalls. It includes a slight pushing of pipes or placing head on them (Anderson, 2008). It usually precedes the lying of the cow in the stall.

The prevalence of standing in stalls can be observed when the surface of the bed is solid. Cows can also stand in stalls with soft bedding, when the alternative is concrete alleys (Cook et al., 2004). Standing in the stalls is also reported in cows with problems with leg and hooves – lame cows. Some cows stand in stall and turning their heads left and right repeatedly, as if checking traffic before crossing a busy street. This behavior is called a “hesitant waltz”.

**“LANDED” ON THE STALL**

Cows standing with their forelegs in the stall and with the rear legs on the alley, also lying with part of their body on the stall bed and with the other on the alley. Possible reason could be shortening the lying area and making stall uncomfortable for lying, often result of efforts to control stall cleanliness by placing the neck rail more backward, at a greater distance from the front of the stall. In barns, where “Landing” is often observed, more often rear legs hooves problems are reported (Philipot, 1994). When “landing” is in lying posture, there is greater contamination of the udder, teats, legs and tails of the animals and a greater risk of mastitis. Anderson, (2008) points out that “Landing” decreases when the width of stalls increases from 112 to 132 cm. Both versions of “landing” can last from several minutes to more than an hour. This is often seen on farms where cows are not equal in size. For larger cows the provided average distance is small and neck rail hinders them to stand with all four legs inside the stall which is required for the normal lying of the animals and that’s why very often they “land” with the front legs on the stall (Dimov et al., 2015).

**STANDING AND LYING IN A PARALLEL POSITION**

Cows take standing or lying position parallel to stall dividers. It is observed when the front of the stall has enough free space. It allows them to stand, lie, stand up and lie down normally. Taking a parallel position in the stall allows fast entry and lying down, and is associated with less standing and “landing” of the cows in stalls and is an
indication that the provided open space in the front of the stall is enough. Adequate space is provided at a stall length of 5.5 meters at the head-to-head or 3-meter at stalls located against a wall (Anderson, 2008).

**STANDING AND LYING DIAGONALLY IN STALL**

The diagonal position can be in an upright or lying posture, from the one stall corner to the opposite corner. Cows are standing or lying diagonally in stalls due to lack of standing or lying space and inability to stand along the length of stall. The use of the stall diagonally can be accepted as a warning of cow inability to take a normal position in the individual stall (Anderson, 2008). When cows are housed in stalls larger than required, the probability to defecate on the stall surface and pollute the lying area with manure is increased (Tucker et al., 2005; Bernardi et al., 2009; Fregonesi et al., 2009). This position provides a space for placing the four legs in the stall, and is observed when the cow avoids touching face to face with cow of the counter stall or if it willing to lie with its whole body on the stall.

**LYING BACK**

The lying of cow with the head to the manure alley. Calves and heifers get used to such behavior when are housed in stalls not compliant with their age. Most often, this behavior is kept and when they are cows. Adult cows exhibit it in order to avoid the discomfort or some of the stall elements causing pain. It leads to manure pollution at the front of the stall and extra labor to clean. Some cows continue to express such behavior even when the stalls meet all the requirements for normal behavior. Some authors believe that cows lie back when stalls are too wide. This may be true in stalls wider than 130 cm, which is rarely applied as stall width. However, some cows lie back also in stalls with a width less than 112 cm. Lying back perhaps is most unwanted behavior (Anderson, 2008).

Apart from the size, the comfort that stalls have to provide depends on the type and qualities of the floor and the bedding used (van Gastelen et al., 2011). It has been proven that the use of large quantities of bedding improves the comfort of cows, reduces lameness, hocks lesions and increases the life of cows (Tucker and Weary, 2004). According to Fregonesi et al. (2007), solid, dry and consistent in quality and quantity bedding resembles the best conditions on the floor that the animals have on the pasture. According to the authors, bedding should provide thermal comfort, comfort and to allows cows to lie down and stand up without risk of slipping. Bedding have to provide such comfort that cows should prefer to lie inside the stall and not elsewhere (Cook et al., 2004). Furthermore, the bedding should contribute to keep the animals clean with minimal care (Chaplin et al., 2000).

Surveys on a large number of farms show that the lack of bedding in free stall housing decreases the duration of cows’ use (Mitev, 2012). Housing dairy cows only on concrete flooring is one of the main reasons for the lameness occurrence and worsening their comfort in general (Vanegas et al., 2006), although the concrete flooring is more robust, more affordable and easy to clean. In studies of Boyle et al. (2007) and Telezhenko et al. (2009) was found that when they have a choice cows prefer to move and stand on a floor covered with rubber flooring rather than directly on the concrete. Placing rubber mats on the concrete improves comfort and contributes to more normal gait of cows (Schütz and Cox, 2014).

The use of rubber mats for individual free stalls for cows without putting extra bedding on them has its advantages on the quality of the manure obtained, bedding costs and labor for cleaning. On the other hand, there are some undesirable effects. At high air temperatures, the surface temperature of the rubber mats remains higher than that of the concrete during the day and becomes equal late at night (Prasad et al., 2013). Dairy cows prefer to lie on a cooler surface that helps through conductive heat exchange to lower their body temperature. Raising the floor surface temperature above 20 °C, leads to a considerable reduction in cows preferring to lie in the stalls (Dimov et al., 2017a). Because of the inability to cool the body surface of the animals when lying, they prefer to stand at higher ambient temperatures including the air and the surface of the stalls. The surface of the stalls covered with rubberized flooring is heated to the highest temperatures compared with the same, but with the addition of straw or compost (Dimov et al., 2017a).

In his study, Dimov, (2014) found that unclarity still exist about the influence of the various technological parameters of the stall on the behavior and comfort of dairy cows. This influence and its effect should be taken into account especially in intensive dairy cow housing systems in order to maximize their production as the consequences can be extremely unfavorable and affect the health status, their productivity and, ultimately, the financial inputs of
the dairy farms. Recommendations on the size and design of individual stalls are plentiful and varied (Anderson, 2003).

**COMFORT INDICES**

The most widely used method of assessing cow comfort is the calculation of quantitative parameters, which include four main behavioral reactions: lying; standing “Landing” in the stalls and lying or standing in the alleys (Boone, 2009), as well as other activities that cows do as feeding and drinking (Uzal, 2013). On this basis, the so-called comfort indices are developed (Velecka et al., 2014). The method is easy to apply when assessing the comfort of dairy cows in dairy farming practices. Most commonly three cow comfort indices are used to assess the resting conditions for animals in dairy farms, namely: Cow Comfort Index (CCI), Stall Usage Index (SUI) and Stall Standing Index (SSI) (Nelson, 1996; Grant, 2009). Mattachini et al. (2011) offer another index: Cow Staging Index (CSI). This index, according to the authors, is calculated as the number of cows that do not lie and do not eat, is divided by the total number of cows in the barn. Uzal, (2013a) interprets the index in a different way. He defines it as an index of stress in cows. According to him, cows that stand outside the stalls and do not eat are under stress. Cook et al. (2005) offer an index of cows standing with both front legs in stalls. For the determination of this index, they calculate only the number of cows with two front legs in the stall and the rear on the manure alley relative to the total number of cows.

The most widely used index for quantification of cow comfort is the cow comfort index. It does not take into account the behavior of the cow in stall. It can be standing, “landing” or lying in the stall (Overton et al., 2003). Under the conditions of semi-open free stall barns on three dairy cattle farms in Bulgaria, Dimov, (2017) reported attained highest average value of CCI 87%. High CCI values are an indicator of very good well-being and comfort of dairy cows (Uzal, 2013a). A major disadvantage of CCI according to Grant, (2009) is that it does not consider the time the cow spends in lying. Espejo and Endres, (2007) use this index also as an indicator of the prevalence of lameness in dairy cows.

Cook et al. (2005) are looking for a connection between CCI, SUI and total lying time. As a result, they offer another index, which shows the proportion of cows standing in stalls – Stall Standing Index (SSI). The authors also recommend when reporting these indices to consider and the availability of stalls for lying relative to the number of cows. If there is a problem in the comfort that stalls provide, cows spend more time standing (de Ondarza, 2000). According to Grant, (2009), SSI was created to help interpret the CCI. The author found that the normal values of SSI should be below 15–20%, when the values are over 20%, this may be related to lameness in cows and other health problems. The low values of the index are indicative of comfortable for lying down and standing up stalls and partly for good bedding (Miteva et al., 2012).

A very important point in the observations related to the calculation of the indices is the time during the day when they are reported. Overton et al. (2003) found the highest average value of the SUI (86%) at 06:00 and a slightly lower (81%) around 22:00. Both cases correspond to two hours after morning and evening milking. They conclude that the cow comfort index is a good indicator of the overall comfort of cows, with a target value of 85% for a herd. They recommend the most appropriate daytime for collecting data related to the evaluation of the use of the stalls to be one hour after the cows return from morning milking (or two hours after milking). As well as the CCI, this index should be determined when the cows are not engaged in any manipulation (milking, hooves trimming, gestation testing, insemination, etc.), and new feed is not soon placed in the feeding areas. Overton et al. (2003) recommend that SUI must be over 75%, which coincides with the value recommended by Hippen et al. (2007) and Grant, (2009). Rao et al. (2014) recommend values above 90% for this index, which according to the authors is an indicator of the “acceptance” and “approval” of individual stalls from the cows. The low values of this index, according to Dimov, (2017), means that a large part of the cows stand on the technological alleys and in the stalls. The high values of this index are an indication that cows that do not feed prefer to lie in the stalls for rest. The comfort indices used in the practice are influenced both by the technological dimensions of the provided rest stalls and the surrounding microclimate.

Dimov et al. (2017) found negative and statistically significant regressions between the temperature-humidity index (THI) and the CCI and the SUI, indicating that the increase of the THI values by 1 above 68 would lead to a reduction in the values of the SUI by 1.41% and of CCI with 0.84%. The increase in THI over 68 leads to a slight tendency to increase the percentage of cows standing in stalls. Standing of cows helps them for
more easily cooling during hot periods of the day. Mahdy et al. (2014) establish a positive dependency between the values of THI and SSI. At enhanced values of THI, the number of animals who prefer to stand for better ability of body cooling by evaporation is also increased.

In the summer season, the percentage of cows that prefer to stand upright ranges between 10% and 30%. Dimov, (2017) found that the values of the temperature-humidity index (THI), the farm conditions and the reporting season had a statistically significant effect (P < 0.001) on the comfort indices (CCI, SUI, SSI). The time at which cows are fed, the number of milking per day and the environmental microclimatic factors are the reason for obtaining different assessments of dairy cows comfort, therefore all these factors should be taken into account when determining the comfort indices for dairy cows (Overton et al., 2002). Dimov et al. (2015) found that the season, milking frequency and feeding management had an influence on the values of the three dairy cow comfort indices (CCI, SUI, SSI).

Cook et al. (2005) indicate that dairy cow comfort indices are widely used by dairy farming consultants, with the common understanding that they are representative for assessment of the lying behavior.

Krawczel et al. (2008) found that the percentage of cows standing along the alleys has increased when the housing density increased above 113% (10.9, 12.0, 14.4 and 16.5% respectively for 100, 113, 131 and 142% housing density). The CCI and SSI differ slightly when the density in the group increases, but the SUI decreases at a stocking density above 113% (70.1, 70.2, 68.6 and 66.3% respectively at 100, 113, 131, and 142% stocking density). At the peak of the lying, SUI decreased with an increase in the density above 113% (80.3, 79.5, 74.8 and 69.6, respectively, at 100, 113, 131, and 142% of stocking density), while in CCI and SSI a slight change is reported. In none of the indices a change depending on the stocking density is reported, when they were evaluated one hour after milking. These results indicate that it is necessary to report more than one dairy cow comfort index in order to assess both the use of stalls and standing of animals with no reason on the alleys. At a higher stocking density, the SUI is reduced because it shows not only the use of stalls but also the number of cows that just stand on the alleys, do not feed and have no opportunity to use the stalls. CCI and SSI can be used to assess the actual use of the stalls (% of cows lying or standing in the stalls).

**CONCLUSION**

The main indicators of stall comfort are the postures that cows occupy in them. For stall design problems can be judged by the frequency of reporting of various cow postures in their use: standing in stall, “landing” in stall, lying only with the front part inside the stall, standing and lying diagonally in stall, lying back and more. To assess the comfort of dairy cows in dairy practice, fastest and easy to use are the comfort indices.

Most commonly, three cow comfort indices are used, through which the resting conditions of dairy farms can be assessed, such as Cow Comfort Index (CCI), Stall Usage Index (SUI) and Stall Standing Index (SSI). They will be increasingly used in cattle breeding for quantitative and qualitative determination of dairy cow comfort. For their correct application, careful consideration should be given to factors that affect their values, respectively: farm activity management, hour of reporting during the day, reporting season, etc. Good knowledge, correct interpretation and application of the assessment systems and behavior of dairy cows can contribute to improving their comfort and well-being, leading to increased efficiency of the dairy sector.

**REFERENCES**


**Abbreviations**
cow comfort index (CCI), stall usage index (SUI), stall standing index (SSI), temperature humidity index (THI)

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