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Review

SOME INDICATORS OF COMFORT IN DAIRY COWS – A REVIEW PART 1

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ABSTRACT
Dairy industry is focused on optimizing production. Humane treatment and cow welfare are key points in achieving this. This review aims to assist farmers and any professional related to dairy industry in evaluating and improving dairy cattle comfort by utilizing some indicators. The literature search done is on studies of conditions of the housing environment and level of feeding affecting welfare. Heat stress due to annual increase of global temperature becomes a constant obstacle for dairy cattle farming and not only. Three cow comfort indices are the most used to assess comfort of cows through quantitative parameters - Cow Comfort Index (CCI), Stall Usage Index (SUI) and Stall Standing Index (SSI). Cows spend more time standing when the stall does not provide the comfort they need. Body Condition Score (BCS) is key for herd management and good health. This assessment should be done at each stage of lactation, so that timely and effective measures could be taken if adjustments in nutrition are necessary.

Key words: cow comfort, dairy cattle, cow welfare.

INTRODUCTION

The current developments in animal husbandry are directed toward ensuring humane treatment and welfare of animals. The focus of relevant scientific research is set on optimizing cattle comfort which is mainly prompted by the need to increase production output. Following the new recommendations, farmers are modernizing existing farms to improve animal welfare (1). Various intensive farming systems for dairy cows can guarantee suitable environmental condition throughout the year on the production premises (2). Facilities used for dairy cows must be well-designed to encourage maximum animal comfort and mitigate the effects of climatic and physical factors (3). The structures and materials used in the construction of the buildings for rearing dairy cows, together with technological equipment and ventilation systems can affect the quality of the environment in the animal area.

Dairy cattle buildings must be designed and maintained in such a way as to provide an adequate microclimate, safe breeding and exploitation of animals, securing animals with a healthy environment (7).

Temperature Humidity Index (THI).

Climate change, considered a long-term imbalance in regional climatic conditions, such as temperature, wind and rainfall, is probably one of the major challenges that humankind is facing in recent years (8). Even in regions traditionally considered to have less extreme climatic conditions, cows will experience temperatures outside their "comfort zone" (9). The growing interest in the thermal comfort of farm animals is justified, not only for countries located in tropical zones, but also for those in the temperate zone, where high ambient temperatures have become problematic (10, 11). The problem of thermal comfort in dairy cows is exacerbated not only because of climate change, but also due to an increase in their sensitivity to heat stress that is a consequence of the higher milk yield, which lowers the temperature threshold at which cows react with a decrease in milk yield. This is due to the fact that the released metabolic heat increases with the higher productivity of the animals (12).

Heat stress is the nonspecific physiological response of animals to environmental temperature when they produce more heat than

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they can release into the environment (13). Heat stress directly and indirectly affects feed intake, cow body temperature, metabolic processes, feed utilization efficiency, milk yield (quantitative and qualitative changes), cow reproduction, behaviour and disease risk (14-18).

Animal tolerance to high air temperatures depends on the amount of water vapor in the air, as this affects the rate of heat loss through evaporation. Temperature Humidity Index (THI) is a widely used bioclimatic index for studying heat stress in animal husbandry (19). THI is a single value representing the combined effect of air temperature and humidity, an index commonly used to assess the degree of thermal discomfort in dairy cows (20). According to Collier et al., this index is used to assess environmental conditions that affect animals. A disadvantage of this index is that it does not include the influence of solar radiation (21). Mahdy et al., however, believe that this index is one of the most important indicators reflecting the overall comfort of dairy cows (22). Temperature Humidity Index is an excellent assistant to dairy farmers. All necessary information for determining this index is available and no special skills are needed to use this index, and any farmer could obtain this information and determine the Temperature Humidity Index (23). Initially, this index was used only for humans (24), but was quickly adopted and used in a variety of animal species. (25). Over the past 50 years, this index has undergone numerous modifications in terms of measurement range to adequately address the level of heat stress in dairy cows. (23). There are different formulas for calculating THI, but the easier and more accessible way for every farmer is by using different devices to directly determine THI values in production conditions (23).

Based on the reported effects of different THI values in dairy cows, a scale was developed reflecting the different zones with THI values associated with different degrees of risk of temperature stress **(Figure 1).**

	Relative Humidity %																			
Deg C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
23.8														72	72	73	73	74	74	75	75
26.7							72	72	73	73	74	74	75	76	76	77	78	78	79	79	80
29.0			72	72	73	74	75	75	76	77	78	78	79	76	76	77	78	78	79	79	80
32.0	72	73	74	75	76	77	78	79	79	80	81	82	83	80	81	81	82	83	84	84	85
35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	84	85	86	86	87	88	89	90
37.8	77	78	79	89	82	83	84	85	86	87	88	90	91	88	89	90	91	92	93	94	95
40.5	79	80	82	83	84	86	87	88	89	91	92	93	95	92	93	94	95	97	98	99	
43.3	81	83	84	86	87	89	90	91	93	94	95	96	96	96	97						
46.0	84	85	87	88	90	91	93	95	96	97											
48.9	86	88	89	91	93	94	96	98													

Figure 1. Temperature-humidity index. Source:Pennington & van der Deven (25).

It can be seen from the figure that THI values lower than 70 mean that the animal's body is in favourable environmental conditions and is not subjected to heat stress. With THI values from 75 to 78, animal organisms are in heat stress, but the mechanisms of thermoregulation still manage to cope, when THI values are above 78 stress is assumed to be at such high levels that it is impossible for thermoregulatory mechanisms to cope and sustain normal body temperature levels (27). The prevailing opinion is that milk production begins to decline when the THI reaches a value above 72 (this corresponds to a temperature of 25°C and a humidity of 50%) and this value of the index is accepted as an upper limit (28). Upadhyay et al. come to the conclusion that high THI values have a negative impact on the milk productivity of cows (29). Herbut et al. provide a detailed review of the use of THI to detect heat stress and summarize that the THI threshold for reduced milk yield due to heat stress ranges from 68 to 74 (30). This wide range is the result of differences between breeds, production levels, premises, facilities, use of different cooling systems, etc. in various studies.

In **Table 1** are shown values of THI corresponding to levels of stress in animals, as well as the signs observed at different levels.

Table 1. *Effect of heat stress in dairy cows (31)*

THI	Stress level	Comments
< 72	None	
72-79	Mild	Dairy cows begin to seek shade if exposed to direct sunlight, an increase in breathing rate and dilation of blood vessels is observed. The effect on milk production will be minimal.
80-89	Moderate	Respiration rates and saliva production increase. Food intake decreases, water intake increases. An increase in body temperature is observed. Milk production decreases. Reproduction deteriorates.
90-98	Severe	Milk production and reproduction deteriorate, respiration becomes as rapid as possible. Cows are subjected to severe heat stress.
> 98	Danger	Cows are exposed to potential danger of death.

The author believes that heat stress severity is determined by many different factors, but the key ones are:

- air temperature and humidity;
- the length of time cows are exposed to heat stress;
- the degree to which temperatures drop at night to cool the animals;
- air movement and ventilation status;
- the size of the cow, the breed and the coat colour;
- availability and accessibility of water.

The topic of heat stress and its impact on dairy cows has been widely studied in many parts of the world. Of particular interest is the question of the adaptability of dairy cattle to heat stress and its effects on their physiological, productive and reproductive performance (32). Given that the global temperatures are rising annually and the future trend is for further temperature increases, heat stress will become a constant challenge for dairy cattle farming and also pose further problems (23).

Indices of comfort in dairy cows.

On one side, undoubtedly, comfort is an element of well-being that is extremely important for cows and their health in order to prolong their productive life. On the other hand, owners strive to obtain high-quality production accompanied by a significant economic effect (33). According to certain authors, cow comfort is a management system that aims to preserve animal health and increase the duration of use of productive animals (34, 35). According to Borshch et al., (36) cow comfort is ensured when the animals act naturally and feel free as they would on a pasture. The most widely used method for evaluating cow comfort is the calculation of quantitative parameters, which include the duration of four main behavioural reactions: lying in the stalls; standing on all fours in the stalls; "perching" on the stall (standing with both feet in the stall and two on the alley); lying or standing in the technological alleys (37), as well as other activities, such as eating and drinking (38). On this basis, so-called comfort indices have been created and calculated (39). The method is easy to apply when assessing the comfort of dairy cows in widely used dairy farming practices. Comfort indices are easily applicable indicators of the quality of comfort that cows receive in new husbandry systems. Their application in cattle breeding practice is expected to increase for quantitative and qualitative determination of comfort in dairy cows (33). Three cow comfort indices are mostly used to assess resting conditions of animals in dairy farms: Cow Comfort Index (CCI), Stall Usage Index (SUI) and Stall Standing Index (SSI) (40). According to the author, the indices are calculated as follows:

Cow comfort index (CCI) = number of cows lying down/ number of cows in a stall, either standing or lying x 100

Stall use index (SUI) = number of cows lying down in the stalls/ number of cows not feeding x 100

Stall standing index (SSI) = number of cows standing or perching with front feet in the stall /total number of cows in the barn x 100

The most commonly used index to quantify dairy cow comfort is the Cow Comfort Index (CCI). It was developed in the 1990s, but it has become widely used in the last 10 to 20 years (40). This index measures the behaviour of the cow in the box. These behavioral patterns include standing on all fours in the box, "landing" (with two feet in the box and two on the manure alley), lying completely in the box (41) or lying half in the box half on the alley. This index does not include cows on manure tracks, whether lying down or standing on them (42). Cow Comfort Index (CCI) reflects the proportion of cows in stalls that are used for lying down and respectively the level of comfort that stalls provide for cows when they lie down. Animal comfort is greater with higher CCI values. It is desirable for values to be above 70% (43, 44). High CCI values are an indicator for very good welfare and comfort of dairy cows (38). Dimov et al. (45) found that floor surface temperature above 20ºC leads to a significant decrease in the number of cows preferring to lie in the stalls and as a consequence to lower values of CCI and SUI. A major drawback of CCI according to Grant is that it does not account for the time cows spend lying down (40). Low values of this index indicate that there is a problem with the stalls, most often when the dimensions of the technological parameters of the stalls are not optimal, which hinders animals from lying down and getting up. Floor or bedding of the box can also influence CCI. Examples of that are short distances from the neck rail to the front edge of stall or very short lengths of the stall from the neck rail to the rear curb. This does not give cows enough room to stand on all fours in the stall and space in front of them for normal movement when lying down (43, 44).

The time of the day when observations take place in relation to calculating these indices is very important. The most appropriate time for measurement related to comfort indices is 2 hours before morning and afternoon milkings. A single measurement of comfort indices cannot be indicative (46).

Stall Usage Index (SUI) is the proportion of cows lying in the stall out of the total number of cows not feeding in the manger. This index also shows what proportion of cows that are not actively engaged in feeding and prefer to rest by lying down in the stalls rather than stand in them or on the technological alleys. The Stall Usage Index (SUI) is used more often because it also takes into account the number of cows that are feeding (43, 44). Similar to CCI, this index should be determined when the cows are not engaged in any manipulation (milking, hoof trimming, pregnancy testing, insemination, etc.) and new feed has not been placed in the feedlots soon (41). The recommended value for CCI is above 75% (31). Rao et al. (42) recommend values above 90% for this index, which according to the authors is an indicator of the "acceptance" and "approval" of individual stalls by the cows. Low values of this index according to Dimov (44) mean that a large proportion of cows stand on the technological alleys and in the boxes. High values of this index are an indication that cows that are not feeding prefer to lie in the stalls. Based on the different results obtained, it can be assumed that SUI depends to a greater extent on the position of the neck rail and the type of bedding used (43, 44).

While in search of a relation between CCI, SUI and the total amount of time for rest, one more index called Stall Standing Index (SSI) has been found. This index reflects how comfortable the stalls are for the cows to lie down and stand up, as well as the adequacy of the bedding in the stall (43,44). According to Grant, the recommended values of this index should not exceed 15-20%. Exceeding these values, according to the author, can be a prerequisite for various health or hoof problems (40). When calculating these indices, the recommendation is to take into account the ratio between the number of stalls and the number of cows. Stall Usage Index is considered most suitable because it also includes cows standing or moving onto the technological alleys. If there is a problem with the comfort that stalls provide, cows spend more time standing. Low index values are an indication of comfortable stalls for lying down and getting up and partly for good bedding (47).

The time of the day when cows are fed, the frequency of milking, the microclimatic characteristics of the environment are all reasons for obtaining different CCI values in dairy cows, so these factors must be taken into account when determining cow comfort indices (43, 44).

Body Condition Score (BCS)

Although it has been known for centuries that cows lose and then regain body energy reserves during lactation, there was no simple measure to estimate the body energy reserves of cows until

the 1970s (48). Live weight of animals is not an accurate indicator of body reserves, as it is influenced by a number of factors, such as calving interval, lactation period, body size, pregnancy and breed (48, 49). Body condition was defined as early as 1919 by Murray (50) as the proportion between body fat and lean body mass of a live animal. In the 1970s and 1980s, scores were developed to measure the accumulated energy reserves of dairy cattle, which are scored differently in different countries. These assessments are called Body Condition Scores (BCS). Lowman et al. (51) first developed a 4-point BCS for dairy cows, which is an adapted assessment system used in beef cattle. Later, the system was improved independently in different countries around the world, i.e. a 6-point scale for the United Kingdom (from 0 to 5), an 8-point developed for Australia (from 1 to 8), a 5-point for the USA (from 1 to 5) and a 10-point applied in New Zealand (50). In Bulgaria, Todorov et al. (52) studied and adapted a similar system to the United Kingdom system for assessing body condition (from 0 to 5) specifically for the Bulgarian Black and White Cattle Breed. BCS or the quantity of subcutaneous fat reserves is a powerful tool for herd management and good health (53,54). This assessment should be carried out at each stage of lactation, so that timely and effective measures could be taken if adjustments in nutrition are necessary. Body Condition Score is an indicator of how much energy the cow has stored in the form of subcutaneous fat. Cows use this energy both for the normal functioning of physiological processes and for the production of milk and meat (55). BCS is a rapid, noninvasive, inexpensive, and only slightly subjective method for assessing fat stores in dairy cows regardless of size and live weight (56). During lactation energy balance in the cow's body changes and respectively BCS does too (57,58). **Figure 2** shows the Body Condition Score (BCS) scale according to Todorov et al. (52). With the 5-point Body Condition Score (BCS) scale cows scored 1 are too thin, and those scored 5 are obese. Body zones evaluated to determine BCS are tailhead, hook bones, ribs and loin. Body Condition Score helps to understand what the animal's nutritional status has been and why the productive and reproductive performance of that animal is good or poor. BCS has been developed to help farmers to prepare their animals well for each stage of the production cycle.

Score 0. Emaciated cows The spinous (vertical) and transverse (horizontal) processes of the lumbar vertebrae are clearly defined, and the dorsal line and flank line are serrated. Lack of fat and no soft tissue on the bones lining the depression around the root of the tail. The skeleton is covered with very little soft tissue and is clearly outlined. Bone structures are highly prominent. Ribs are clearly defined. Animals appear very emaciated and unhealthy, often with an abnormal posture. Animal movement is difficult and painful, typical of sick animals. Cows lag behind their herd.	 
Score 1. Very thin cows The spinous (vertical) and transverse (horizontal) processes of the lumbar vertebrae are sharp and easily distinguished from each other by palpation. There is a large depression between the root of the tail and the ischial bones, without adipose tissue covering. The skin covering the depression is soft and flexible. Pin bones are prominent and without soft tissue covering. The line between the vertical and horizontal processes of the thoracic and lumbar vertebrae is concave. There is a large depression between iliac crests and ischial bones. Thighs are small and soft. At least a few ribs are visible to count. Animals appear thin, with protruding bone structures, but healthy.	 

Score 3. Average fed cows The transverse (horizontal) processes of the lumbar vertebrae are covered with soft tissue and can be felt only when applying strong pressure. The depression around the tailhead is considerable in size, but covered with fat. Pins are rounded when palpation is performed, but the bone could be felt. Musculature is relatively well developed, although it does not fill the space on either side of the spine and the rump, the line is slanted to the side, not concave. Ribs are covered with soft tissue and fat to the touch, but they can be distinguished from each other. Animals appear in good condition. They display agility and vitality.	 
Score 4. Well fed cows When palpating the transverse (horizontal) processes of the lumbar vertebrae, a rounded edge is felt and individual processes cannot be distinguished even through applying strong pressure. A considerable amount of fat has accumulated around tailhead, which almost fills the depression between the tail and ischial bones. Back is almost flat and broad, and the line from the hook bones to the ischial bones is sloping, without a depression. Ribs are difficult to distinguish from each other through palpation. Animals are round, but easily display agility and vitality.	 
Score 5. Obese cows The spinous (vertical) and transverse (horizontal) processes of the lumbar vertebrae are covered with fat and cannot be distinguished by palpation and pressure. Tailhead is immersed in fat, and the gap between it and the ischial bones is filled. Animals are well muscled and rounded, and bone structures are rounded and almost sunk into the abundant soft tissue around them. Individual ribs cannot be distinguished by palpation and applying pressure. Animals are heavy and not very agile.	 

Figure 2. Body condition score (BCS) according to Todorov et al. (52)

It is good to do BCS at calving, at the first postpartum check-up, at insemination, at pregnancy check, during late lactation and dry-off. The evaluation is carried out on each group of cows that are fed the same ration. If the cow is too weak during early lactation, her ration should be adjusted to increase dry matter consumption. The presence of a possible metabolic problem that may be the cause of body weight loss should be watched out for and controlled. Late-lactation cows use forage energy to build body reserves more efficiently than dry cows (75% vs. 60% efficiency). Therefore, it is recommended that the cow be brought to the desired body condition (BCS 3.5) in the mid or late lactation period (75 to 100 days after calving), rather than waiting for this to happen during the dry period (59). If the cow is obese in late lactation, then the energy content of the ration should be reduced or even put the animal on a diet to reduce the Body Condition Score to the required level.

CONCLUSION

The dairy cow comfort indicators presented in this article are an excellent tool for farmers to monitor the welfare of their animals. It is undeniable that if we have a high level of animal welfare, only then can we expect high production results from animals. The specifically listed indicators are easily applicable even for people outside the scientific circles. No large financial investments are required for their implementation. Sufficient willingness on the farmers' part to use them is required.

ABBREVIATIONS

CCI – Cow Comfort Index
SUI – Stall Usage Index
SSI – Stall Standing Index
THI – Temperature Humidity Index
BCS – Body Condition Score

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