Biotechnology in Animal Husbandry 40 (1), 1-13, 2024
Publisher: Institute for Animal Husbandry, Belgrade-Zemun

ISSN 1450-9156
UDC 636.083.31'62
https://doi.org/10.2298/BAH2401001S

MICROCLIMATE CONDITIONS AS AN INDICATOR OF CALF WELFARE QUALITY

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Original scientific paper

Abstract: Microclimatic conditions in facilities for housing and rearing young category of breeding dairy cattle at the first 30 days after birth, have a significant impact on the quality of welfare, especially in intensive production. The parameters most often taken into account when evaluating microclimate conditions are: temperature and air humidity, the mutual relationship of which represents the THI (temperature-humid index) index; speed of air flow; air quality (presence of dust and ammonia) and level of light in the facility.

The quality of the microclimate in the facilities is directly influenced by the climatic conditions in the external environment, therefore study period on 2 farms (A and B) with an intensive production system was divided into 4 seasons (autumn, winter, spring and summer). Holstein Friesian calves were observed in the period from birth to 30 days of age.

The worst microclimatic conditions were recorded during the summer season on both farms (1129 on farm A and 1114 calves on farm B suffered), while the situation was more favorable during the colder period. Also, the best conditions, on both farms, were provided for calves in the first 7 days of life. The most unfavorable impact was the high air temperature, while the air flow, paradoxically, improved the air quality, especially during that period.

The overall welfare quality score was similar on the observed farms, 2.25 on farm A and 2.12 on farm B, which can be considered acceptable. At the same time, it indicates the presence of serious problems, the solution of which must be approached most seriously.

Key words: microclimatic factors, calves, welfare

Introduction

The concept of microclimate can be defined as a series of parameters forming the ambient conditions for living in a certain space. Therefore, they represent one of the indirect indicators of the quality of welfare, and belong to the so-called resource indicators.

The most important microclimate parameters are temperature and air humidity, as well as their mutual relationship (TH index), the speed of air flow and the appearance of drafts in the facility, the presence of dust and ammonia (NH_3) and level of light in the facility.

Air temperature and humidity, ventilation, concentration of harmful gases and dust in the air, and noise intensity in facilities where animals stay must be within limits that are not harmful to animals, taking into account the type and category of animals. Animals must be protected from adverse weather conditions and other dangers to their health, which is also regulated by the Rulebook on Animal Welfare, (2010). Special attention must be paid to the conditions in which the youngest categories (calves) stay in the first month of life.

In the report of EFSA (2006), it was precisely stated that the welfare of calves can be endangered by various factors, including the housing conditions. Recommendations are given related to the design of the farm, where thermal comfort in facilities, air quality, lighting, presence of noise, quality of accommodation, equipment in facilities, adoption of a plan of emergency measures and procedures in case of emergency must be foreseen.

Material and Methods

In order to determine the influence of microclimatic conditions on the quality of welfare of calves in the period from birth to the 30 days of life, research was carried out on 2 farms with Holstein-Friesian cows. The farms are marked with A and B. The period of one year, which was the duration of the study, was divided into four seasons, I (autumn - October, November, December), II (winter - January, February, March), III (spring - April, May, June) I IV (summer - July, August, September).

Both farms had a similar capacity for housing cows and a similar technological process of milk production, nutrition and work organization related to the housing system for dairy cows. Also, on both farms, animals were kept in a tied system on short beds.

On the first farm - A, the facilities for housing of animals were walled up, without the possibility of opening the side walls. Ventilation in buildings was natural, horizontal. Cows in the maternity ward were tied on one side of the feeding corridor. Calves were separated from their mothers 2-4 h after birth and tied to beds on the other side of the feeding corridor. After 2-3 days, the calves were moved to pens for group housing, 10 calves were placed in a pen with a range. In the maternity ward, removal of manure was automatic, while the manure from boxes for housing of calves was manually removed.

Farm B differed from the previous farm, first of all, in the construction of the facilities. Namely, the buildings were of an open type, and if necessary, in the cold period of the year, the side walls could be closed with straw bales. Also, the calves in the maternity ward were not tied to beds but placed in individual boxes. In the nursery, the groups were in boxes with a capacity of 5 heads, without ranges.

The following microclimate parameters were monitored in the nursery facilities and the boxes with the calves in the first month of life: air temperature, air humidity, air flow and the presence of dust and ammonia. Measurements were made in 5 places at the height of the animals' heads, in the boxes for calves and along the beds in the case of tied animals. Temperature, air humidity and air flow speed were measured with the "TESTO 410-2" instrument. Depending on the deviation from the standard, the measured values of the mentioned parameters were graded from 5 to 0, where: 5 - excellent, 4 - very good, 3 - good, 2 - satisfactory, 1 - unsatisfactory, but with a possibility to improve, and 0 – unsatisfactory and without the possibility to improve (EFSA, 2006). Air quality was subjectively assessed based on the concentration of ammonia and the presence of dust particles in the air that could be registered by the sense of smell.

Only cases that deviate from the optimal level were analysed in the study (grades excellent and very good, 5 and 4), i.e. parameters that were evaluated with lower grades and that had caused the reduced quality of calf welfare, grades from 0 to 3. When it comes to temperature, these are values below 8^0C and above 32^0C, and for air humidity above 80%.

Calves were grouped based on age into 5 groups: 0-7 days (while housed in the nursery), 8 days (transfer to rearing facility), 15, 22 and 30 days.

Quality of welfare was assessed at the end of the one-year trial period.

Results and Discussion

The obtained research results are presented in the following tables. Table 1 shows the frequency of exposure of calves in the first month of life to adverse microclimatic conditions on farm A, depending on the calving season.

Table 1. Number of calves exposed to adverse effects of microclimatic factors in the first month of life, observed by age and season of birth on farm A

	A					
Age, day	**0-7**	**8**	**15**	**22**	**30**	**Σ**
I Season - Autumn						
Temperature						
Air humidity						
Air flow		75	75	34	15	**199**
Dust and ammonia						
Σ		**75**	**75**	**34**	**15**	**199**
II Season - Winter						
Temperature		24	30	11		**65**
Air humidity						
Air flow			9	28	30	**67**
Dust and ammonia						
Σ		**24**	**39**	**39**	**30**	**132**
III Season - Spring						
Temperature	21	32	41	42	20	**156**
Air humidity						
Air flow	25	20		11	28	**84**
Dust and ammonia			8	21	11	**40**
Σ	**46**	**52**	**49**	**74**	**59**	**280**
IV Season – Summer						
Temperature	67	72	63	42	48	**292**
Air humidity	20					**20**
Air flow		26	50	34	30	**140**
Dust and ammonia	20	21		25		**66**
Σ	**107**	**119**	**113**	**101**	**78**	**518**
ΣΣ, Disturbed microclimate	153	270	276	248	182	1129

Observed by the seasons, on farm A, it can be stated that in the first season - autumn (October, November, December), the situation was the most favourable in respect to the parameters - air temperature and humidity. Only increased air flow was recorded, which affected a total of 199 heads at the age of 8 to 30 days. In the second season - winter (January, February, March), 65 calves were exposed to low temperatures, below 8^0C, and 67 were kept in a facility with increased air flow, which in low temperature conditions had an additional adverse effect on the calves' comfort. The third season, spring, included months of April, May and June. In this season, 156 calves of all ages were exposed to high temperatures, above 25^0C, 84 were exposed to increased air flow, and 40 of them, older than 15 days, were found in facilities with an increased amount of dust and ammonia in the air. The fourth season, summer, was the most unfavourable for the welfare of the calves in the first month of life, because it included three warm months, July, August and September, with very high temperatures, above 30^0C, (292 calves exposed) and the presence of dust and ammonia was recorded (66 heads exposed). In these circumstances, increased air flow (140 calves exposed) had a positive impact on the quality of the microclimate in the calf facilities.

Observed by age, calves at the earliest age, immediately after birth (2-3 days) and at the age of 30 days, were exposed to adverse microclimate factors in a slightly smaller number (153 and 182, respectively) than calves at other ages (270, 276 and 248 head at the age of 8, 15 and 22 days, respectively).

The values of the observed parameters at farm B are given in Table 2. At the farm B, in the first season, the situation was less favourable than at farm A, because 122 calves of all age categories were exposed to the effects of inadequate temperature, and 100 of them to the effects of increased air flow speed. Moreover, in October the temperatures were above 25^0C (42 calves), and in December lower than 8^0C (80 calves exposed). In the second season, 105 calves stayed in facilities with a temperature below the bottom limit, 7 with increased air humidity and 11 with increased air flow. In the third season, in June, 150 calves were exposed to a temperature above 25^0C. Also, 32 calves stayed in a space with an increased % of air humidity, and 78 breathed air with a high concentration of dust and ammonia. The fourth season, as in farm A, was the most unfavourable in terms of microclimatic conditions. Total of 172 calves were exposed to high temperature in the facilities, 95 of them were exposed to increased air humidity, and 73 were exposed to poor air quality with increased dust and ammonia content. In this case too, the increased air flow (169 heads) had a positive effect on the conditions in the facilities.

Immediately after birth (2-3 days) the calves were kept in the best microclimatic conditions, only 130 cows were exposed to the adverse influence of microclimatic factors. The needs of the 30-day-old calves were the most difficult to meet because 331 heads were under the influence of adverse microclimatic conditions.

Table 2. Number of calves exposed to adverse effects of microclimatic factors in the first month of life, observed by age and season of birth on farm B

	B					
Age, day	**0-7**	**8**	**15**	**22**	**30**	**Σ**
I Season - Autumn						
Temperature	26	17	34	26	19	**122**
Air humidity						
Air flow		53	26		21	**100**
Dust and ammonia						
Σ	**26**	**70**	**60**	**26**	**40**	**222**
II Season - Winter						
Temperature		17	25	38	25	**105**
Air humidity				2	5	**7**
Air flow	11					**11**
Dust and ammonia						
Σ	**11**	**17**	**25**	**40**	**30**	**123**
III Season - Spring						
Temperature	33	31	26	21	39	**150**
Air humidity		19	9	4		**32**
Air flow						
Dust and ammonia		18	20	18	22	**78**
Σ	**33**	**68**	**55**	**43**	**61**	**260**
IV Season - Summer						
Temperature	40	46	31		55	**172**
Air humidity		19		22	54	**95**
Air flow	7	22	50	26	64	**169**
Dust and ammonia	13	19		14	27	**73**
Σ	**60**	**106**	**81**	**62**	**200**	**509**
ΣΣ, Disturbed microclimate	130	261	221	171	331	1114

Figure 1 shows the share of the number of calves that were exposed to the negative influence of microclimatic factors in relation to the total number of calves by farms, seasons and days of age.

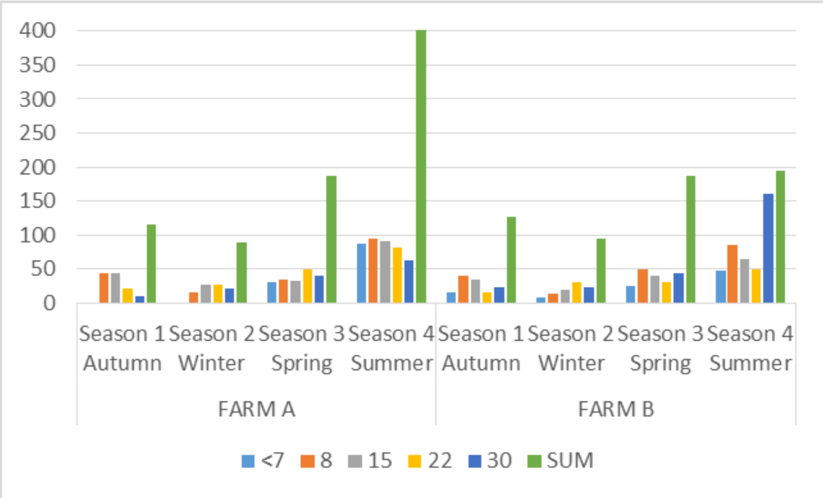

Figure 1. Number of calves exposed to the negative influence of microclimatic factors in relation to the total number of calves by farms, seasons and age

On both farms, within the overall assessment of the quality of calf welfare, the microclimate factors were rated "acceptable", 2.25 on farm A and 2.12 on farm B, which indicates major problems, but also major opportunities for improving conditions in facilities for calves in the first month of life.

Air temperature and humidity can be considered key factors of microclimate for several reasons. In case of high temperature, food intake decreases, metabolism slows down, food conversion decreases. High temperature with increased air humidity leads to an increase of the TH index. A value of the TH index above 72 leads to the appearance of heat stress, which occurs already at a temperature of 25^{0}C if the air humidity is over 50%, and heat stress is considered one of the most common factors that threatens the quality of animal welfare. Numerous authors have dealt with the problems caused by increased temperature and air humidity in farm facilities buildings and their impact on the quality of animal welfare.

The results obtained in the research are largely in accordance with numerous published research results, especially with those conducted in the same or similar climate zone. Also, the recorded conditions slightly deviated from the standard recommended by the Rulebook on Animal Welfare (2010), which states that the optimal air temperature in the facility for raising young cattle is 15 to 20°C with a relative humidity of 70 to 75% and an air flow speed of 0.1 to 0.3 m/s.

According to Beskorovajni et al. (2012), in research conducted in very similar conditions, the values of microclimatic parameters were in the interval from -16.3 to 38°C, temperature, and from 53 to 100%, air humidity, while the THI index was between 53.4 and 94.0. According to numerous studies such as Bernabucci et al. (2010), Nemečkova et al. (2013), Kamal et al. (2014), Mijić et al. (2014), Dado-Senn et al. (2020), Samolovac et al. (2023), heat stress can be prevented by improving ambient conditions, primarily by good ventilation and providing natural or artificial shade although there are some contrary statements like Montevecchio et al. (2023).

On the other hand, lower-than-optimal temperatures also have multiple effects on the general condition of animals, on the rate of morbidity and mortality in the herd, on growth, etc. In the case when the temperature is lower than optimal, animals are forced to spend metabolic energy on preserving body temperature and maintaining basal metabolism as stated by Hepola et al. (2006). According to Borderas et al. (2009) and Bonizzi et al. (2020) in some cases there is also an increase in the rate of morbidity and mortality in the herd. Similar results are reported by Samolovac et al. (2019), when it comes to the effect of the season on the incidence of diseases of the digestive and respiratory system. Also, there are contrary statements made by Bickert et al. (2011) which indicate that low temperature has no negative impact if there is no draft in the buildings and if the animals are placed on a dry and clean litter.

Both temperature extremes, high and low temperature, especially if they are accompanied by high air humidity, give the same results from the point of view of economic production. Feed conversion decreases, gain and growth decrease, the degree of morbidity and mortality in the herd increases, which leads to an increase in the cost price of the product and a decrease in the quality of the final product as stated by Roland et al. (2016). Therefore, there is a constant aspiration to improve the conditions of keeping/housing in order to maximize the use of the genetic potential for high quality production of farmed animals, especially from the aspect of health status and efficiency of food utilization as reported by Hristov et al. (2011), De Vries et al. (2013), Petrovska et al. (2018).

The comfort zone for lactating cows is between 10 and 20^0C, even up to -5^0C according to Samolovac, (2016) while some authors like Majkić et al. (2017) state -16 to -37°C as the critical lower temperature limit. Younger categories (calves up to the 30 days of life) should be kept in conditions where the optimal temperature is in the range of 15-20°C, the optimal relative humidity is in the 70-75% range and the optimal speed of air flow is from 0.1 to 0.3 m /s as reported by Samolovac (2016), while Wang et al. (2020) state the temperature optimum for calves in the first month of life is from 13 to 25°C. When it comes to the top temperature limit above which the conditions for the occurrence of hyperthermia are created, it is around 25°C as reported by Kadzere et al. (2002). According to the data reported in the literature in the middle of the last century as of Beakley and Findlay (1955), Aishir calves reacted to an increase in temperature over 20^0C with rapid breathing, an increase in pulse frequency and an increase in rectal temperature.

When it comes to the presence of dust and ammonia in the air, it is inevitable considering the type of production. Every activity of people and animals in the facility leads to the creation of dust of organic origin (food, litter/bedding, animal body surface - skin and hair, dried faeces, etc.), while ammonia, along with some other gases (most often CO_2), occurs as a product of metabolism of ruminants and chemical processes in manure.

The quality of the air in the building directly depends on the ventilation and air flow, which ensure the exchange of polluted air from the building with clean air. Proper ventilation also reduces the concentration of pathogenic microorganisms in the air, which, according to various authors such as Bickert (2002), Lundborg et al. (2005), Lago et al. (2006), and Nordlund (2008), is also a measure of air quality, However, if it happens that the air flow is directed directly at the animals, if it is too strong (speed greater than 0.3 m/s) or the air temperature is very low, the air flow can have a negative impact on the health and welfare of the animals, especially younger categories.

If optimal microclimate conditions are provided in facilities for housing calves, the first prerequisite for raising healthy animals is met, whose genetic production potential will be maximal due to the positive effect on health, metabolism, feed conversion and animal welfare. Despite modern knowledge and production technology, it is still difficult to ensure optimal conditions for high quality welfare of calves according to Hristov et al. (2011), De Vries et al. (2013), Petrovska et al. (2018). Although cattle, as a species, have a pronounced ability to adapt to different microclimatic conditions, as stated by a number of authors in their studies like Beakley and Findlay (1955), Kadzere et al. (2002), Samolovac (2016), Majkić et al. (2017), Angel et al. (2018), Wang et al. (2020) this does not mean that they are insensitive and that they should not be provided with the best conditions in facilities, especially when it comes to the youngest categories, i.e. calves in the first month of life. As reported by Roland et al. (2016) any impact on the health, production capacity and welfare of animals, positive or negative, has an indirect impact on the economics of production.

Conclusion

Observing the microclimate parameter that had the most influence on the quality of rearing and the level of quality of calf welfare in the first 30 days of life on farms with an intensive method of production in closed facilities, it can be concluded that:

- Air temperature is one of the most important factors. It exceeded 30^0C on observed farms and dropped below 10^0C in facilities, depending on the season.
- The relative humidity sometimes exceeded 80%, which indicates that there is a risk of heat stress in the calves

- The appearance of increased air flow was recorded, which was expected considering that the ventilation in the facilities was natural, horizontal. In the cold period of the year, this phenomenon had a negative effect on the state of the microclimate, but in the warm summer months, it improved the overall air quality in the facilities.
- As a consequence of the lack of a ventilation system (except for natural ventilation), an increased concentration of ammonia dust in the air was observed, especially in the summer period.
- On both farms, in all four seasons, the most favorable microclimate conditions were provided to the youngest category, calves in the first 2-3 days after birth.
- On both farms, in facilities for rearing calves, more favorable microclimatic conditions were recorded during the colder period of the year.

Considering the importance of quality rearing of young animals on the overall efficiency of cattle production, as well as the importance of microclimatic factors on the conditions of rearing young animals, it is necessary to improve the quality of microclimatic factors. Along with the regulation of temperature and air humidity, it is important to introduce additional methods of ventilation, and in the summer months, cooling of animals. The use of good quality litter/bedding and adequate equipment are baseline prerequisites.

Mikroklimatski uslovi kao indikator kvaliteta dobrobiti teladi

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Rezime

Mikroklimatski uslovi u objektima za smeštaj i odgoj priplodnog podmladka mlečnih goveda u najranijem uzrastu (prvih 30 dana nakon rođenja) imaju značajan uticaj na kvalitet dobrobiti, a samim tim i na kvalitet života životinja, posebno u intenzivnom načinu proizvodnje.. Parametri koji se najčešće uzimaju u obzir kod ocene mikroklimatskih uslova su: temperatura i vlažnost vazduha, čiji međusobni odnos predstavlja THI (temperaturno humidni indeks) indeks; brzina strujanja vazduha; kvalitet vazduha (prisustvo prašine i amonijaka) i osvetljenost. Kvalitet mikroklime u objektima je pod direktnim uticajem klimatskih uslovu u spoljnoj sredini, tako da je period istraživanja na 2 farme (A i B) sa intenzivnim sistemom proizvodnje podeljen na 4 sezone (jesen, zima, proleće i leto). Posmatrana su telad Holštajn frizijske rase u periodu od rođenja do 30 dana života. Najlošiji mikroklimatski uslovi su zabeleženi tokom letnje sezone na obe farme, dok je situacija bila povoljnija tokom hladnijeg perioda. Takođe, najbolji uslovi, na obe farme, su obezbeđeni za telad u prvih 7 dana života. Najnepovoljniji uticaj je imala visoka tempertura vazduha, dok je strujanje vazduha, paradoksalno, popravljalo kvalitet vazduha, naročito tokom tolijeg perioda. Ukupna ocena kvaliteta dobrobiti bila je slična na posmatranim farmama, 2,25 na farmi A i 2,12 na farmi B, što se može smatrati prihvatljivim. Istovremeno ukazuje na postojanje ozbiljnih problema čijem se rešavanju mora najozbiljnije pristupiti. Obzirom na značaj odgoja najmlađih kategorija životinja neophodno je unaprediti kvalitet mikroklimatskih faktora, kako bi se dobile što kvalietnije i zdravije jedinke koje će biti kasnije uključene u proizvodnju mleka.

Ključne reči: mikroklimatski faktori, telad, dobrobit

Acknowledgment
This study was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, based on the Agreement on the realization and financing of scientific research work of SRO No. 451-03-66/2024-03/200022.

Conflict of interest
The authors declare that they have no conflict of interest.

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Received 31 October 2023; accepted for publication 10 February 2024