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STUDI ON THE ENVIRONMENT IN HOUSING FOR DAIRY CATTLE

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Abstract

The present study evaluates the environment in three buildings used for rearing dairy cattle, living in separate boxes on deep litter bedding. Both the construction and technical and technological features of the buildings as well as their zoo - hygienic indexes were analysed. Technologically, all buildings provide enough relative area per each animal - respectively 34%, 91,6% and 56, 6%. Only in building 1, it was ascertained that the built-up area per animal is between 33,6 and 46,5%. The feeding zones in building 1 and 2 are sufficient and even more spacious than the recommended, while in building 3 the feeding area is 6,5% smaller.

Of all parameters characterising the environment, the temperature and the relative humidity in the controlled buildings during the three seasons are relatively the same. There are noticeable differences in building 2 and the other buildings when it comes to the cooling value. Lower values of lighting and bed temperature are measured in building 3 during all three seasons.

Keywords: dairy cows, living environment, comfort, welfare

INTRODUCTION

The technical and technological solutions involved in the formation of the microclimate in the buildings are often in contradiction with the biological and physiological requirements of the animals bred there, and are thus a reason for damaging their health, productivity and resistance (Gaughan et al., 2000; Miteva, 2012; Hansen, 2007; Šimková et all., 2016). Therefore, guaranteeing the optimal vital parameters as well as the necessary comfort in the dairy cattle buildings (Samarin, 2018; Ventura et al., 2015) require the observance of a range of norms during the construction and equipment process. Under Ordinance 44 (2006) and the Technological norms for constructing animal and poultry farms and complexes (1982), each dairy cow should be provided with an area of at least 6 m^2. Netsov and Stoyanchev (1999) established that 3- and 4-row- box buildings require 30-35 m^2. Dinev and Dimova (2006) and Dinev (2007) recommend that the 2- and 3- row buildings provide space from 56,3 to 72,3m^2. Ensuring the airflow which is appropriate for the productivity of the animals may be performed not only by provision of enough space in the parlour but also by the effective ventilation which secures enough fresh air and no draught of air. According to Gooch (2007) the airflow intensity appropriate for dairy cows with a live weight between 570 and 800 kg during the winter is 2,8 times/h and during the summer 28 times/h

Both the efficiency of a certain building and the technology implemented there might be successful provided a synchrony of engineering-construction, zoo-technical and veterinary-prophylactic activities is achieved. In other words, as Trofimov et al. (2016) put it

- when the necessary balance between the animals and the environmental factors, is stricken. According to the latter, the importance of the light in the farms and its influence on the health, metabolism, milk productivity and reproduction appears to be pushed into the background. Harner et al. (2008) claim that the sufficient duration and intensity of the lighting contributes to the better animal orientation and control over the different technological processes in the buildings.

Everything stated above comes to show that it is advisable that the zoo-hygiene parameters applied so far upon rearing of dairy cows be revised through the use of data from the parameters characterizing the vital activities in the organism in response to the environmental factors affecting them. For this purpose we set the aim to analyse both the construction and the technical and technological characteristics of the building and the basic zoo-hygiene parameters created there.

MATERIALS AND METHODS

The study is carried out in three different capacity dairy cattle rearing farms situated in Plovdiv region. The breeding technology in two of them is free in separate boxes, and in the third one- in groups on deep litter bedding. The farms examined are provisionally nominated C1, C2 and C3.

Building C 1 shelters 67 dairy cows on deep litter bedding. The total area of the building is 598,5m². Each cow is provided 8,06 m² . The building is a semi-open brick masonry, and the roof structure is of galvanized steel with no thermal insulation. The ventilation is natural but there are 8 additional ventilators installed above the rest and movement areas (De Laval). The ventilators are turned on stepwise automatically upon reaching temperatures of over 18 and over 25º C. The feeding is unlimited with a total mixed ration and a permanent access to water (automatic troughs or drinkers). Apart from the natural lighting, there are 5 x 100 W lamps installed above the feeding lane and 3 x 200 W ones- above the rest and movement zones. The manure is cleaned with a bulldozer peel and hay is periodically added.

Building C 2 shelters 200 dairy cows which are bred free in separate boxes and are divided into 4 groups. The total area of the building is 2 310 m² and each cow is provided with space of 11,5 m². The building is a reinforced concrete structure with concrete walls and roof panels. The individual boxes are placed on each side of the side walls, and the manure alleys are between them and the feeding zone. The floor in both the building and the individual boxes is made of cement. The boxes themselves are covered with soft rubber mats. The feeding is unlimited with a total mixed ration and the watering is performed via automatic troughs. The main lighting is natural and is ensured by 30 windows. Part of the side windows and the ridge vents are covered with polyethylene sheets during the winter period. The artificial lighting is performed via 97 fluorescent lamps. The mechanical ventilation is effected by 10 ventilators - 5 installed on each side of the feeding line above the movement and feeding zone. The manure cleaning is done by a delta scraper device every 3 hours.

Building C 3 shelters 130 dairy cows which are reared free in individual boxes and are divided into two groups of 65 each. The farm is an open metal construction with a thermo roof panel. The side walls are made of concrete with thickness of 0,25 m and height of 1,5 m. The end walls are also made of concrete and are 3,0 m in height. The feeding zone lane has no doors and is entirely open. The total area of the building is 1 248 m², and the area per animal ensured is 9,4 m². The feeding lane is centrally situated. On either of its sides there are rows of individual boxes (1,25/2,20) which are separated from the side walls and the feeding lane by manure alleys. The floor is made of cement and that of the boxes is covered with hard rubber mats. The natural lighting is ensured by the open spaces with a total area of 170 m². The artificial lighting is provided by 14 fluorescent lamps. The mechanical ventilation is performed by 8 ventilators (4 on each side of the feeding lane) above the rows of individual boxes. Half of the ventilators work at temperatures of up to 18º C, and when the temperature is above 25º C, the rest of them are turned on, too. The manure is cleaned with a delta scraper device every 6 hours. The feeding is unlimited with a total mixed ration and there is an uninterrupted access to water (automatic troughs).

We measured the air and the bed temperature in the controlled buildings with a manual multifunctional Compact infrared thermometer 105518 with a range from – 50 to +550ºC and resolution 0,1ºC, the relative humidity (%) was reported via Assman aspiration psychometer, the airflow velocity (m/s) and the cooling rate (mJ/cm²)- via a kata thermometer, and the lighting via a lux meter PU 150 PRAHA (the measurements are performed in different parts of the feeding and rest zone of the animals). The ammonia content was determined following the sulfuric acid titrimetric method. The calculation of the actual and the necessary air changes as well as the change intensity was performed in compliance with the established hygiene methods (Hristev, 2008).

RESULTS AND DISCUSSION

According to Hristev et al., (2013) part of the architectural elements of the building determine the frames of the artificial micro ecosystem which is concentrated in the production premises, and another part such as doors, windows, and ventilation openings connects the micro ecosystem with the biosphere. This requires the design and construction of the buildings to observe established norms guaranteeing optimal zoo hygiene parameters regarding the animals bred there. The main differences between the buildings examined by us are related to the architecture-construction elements. The first building is a brick construction, the second one is comprised of entirely reinforced concrete elements, and the third one is a steel construction with concrete walls with height of 150 cm. The roof of the first building is from galvanized steel with no thermal insulation, the one in the second building is made of concrete roof elements, again with no thermal insulation, and in the third one- of thermo panels. The ventilation in all three buildings is mixed (natural and mechanical), the feeding is unlimited with an uninterrupted access to water. The manure cleaning in building 1 is performed via a bulldozer peel, and in the other two- with a delta scraper device(Table 1).

In a previous study we carried out (Hristev et al., 2018), it was ascertained that in order the temperature neutrality minimum (5º C) in building 1 to be maintained during the cold period of the year, the air exchange should be 15 times more intensive in relation to the heat released and 5 times more intensive in relation to the humidity. This, in our opinion, is not a prerequisite the excess humidity in the premises during the winter to be retained and to exceed the hygiene norms. In the summer, apart from the humidity, the heat also considerably increases.

The higher air exchange in building 2 during the same period does not allow the heat released to be retained. The lack of fresh air in the respective building during the summer increases substantially which requires turning on an additional ventilation. This has made us call into question whether the new constructive solution applied upon the reconstruction of the building is economically justified.

The air exchange in building 3 is insufficient in the both seasons. The shortage is most noticeable with reference to the excess heat. Furthermore, if we assume that each cow needs 1700m³/h of fresh air (Hristev et al., 2018), building 1 will require an air exchange of 115 000m³/ h, building 2 - 340 000 m³/h, and building 3 - 221 000 m³/h. In order the desirable minimum temperature of 5º C during the winter and 15º C during the summer to be maintained, it is necessary the airflow velocity in the animal zone to be increased but without harming the health of the cows.

The total built-up and relative area per animal (Table 2) in all three buildings exceeds the established norms, i.e. each dairy cow is provided with respectively 11,5 m^2, 9,4 $m^2$and 8,06 m^2 instead of the required 6 m^2. This suggests that the animals have conditions for sufficient comfort.

The building volume is not considered in our normative documents. However, according to the research of some authors it should be 52 -72 m^3 per cow (Dinev, D., 2007).

Our study ascertained that only in building 2 the total building volume corresponds to the relative volume per animal.

In the other two buildings the respective volume is almost cut in half- 46,5 % and 44,6 % for buildings 1 and 3 respectively. This explains the need for an increase in the ventilation volume or its frequency.

Table 1. Characteristics of the buildings

	Building 1	Building 2	Building 3
Type of building	Brick masonry, semi-open	Reinforced concrete construction and walls	Open metal construction
Roof construction	Galvanized steel without thermal insulation	Concrete roof panels	Thermo panels
Breeding technology	In groups on deep litter bedding	Free, individual boxes	Free, individual boxes
Ventilation type	Natural + mechanical	Natural + mechanical	Natural + mechanical
Feeding	unlimited with a total mixed ration	unlimited with a total mixed ration	unlimited with a total mixed ration
Lighting	Natural+ artificial	Natural+ artificial	Natural+ artificial
Manure cleaning	Bulldozer peel	Scraper	Scraper
Watering	Automated troughs drinkers	Automated troughs	Automated troughs
Air exchange necessary m^3/h	113 900	340 000	221 000

Exchange intensity necessary (times/h)			
in the winter	2,8	2,8	2,8
in the summer	19-28	19-28	19-28

*Building: 1 - Rogosh , 2 - Tsalapitza , 3 –Asenovgrad

It can be observed that the feeding front ensured in the built-up area is more than 0,8 m with the exception of building 3. Dinev (2007) also ascertains a decrease in the width of the feeding area from 0,59 to 0,66m per dairy cow, which, however, does not deprive it of free access to food.

Establishing a norm in the zoo-hygiene parameters in the premises for dairy cows is considered an important stage in the technological process of commercial milk production (Trofimov et al., 2016). According to the latter, so as good health and high productivity to be ensured, it is necessary an optimal balance between the animals and the environmental factors to be achieved.

Table 2. Built-up area, building volume and feeding front in the buildings examined

	Building	Actual	Due
Total built-up area, m^2	1	598,5	402
	2	2310	1200
	3	1248	780
Relative area per animal, m^2	1	8,06	6,0
	2	11,5	6,0
	3	9,4	6,0
Total building volume , m^3	1	1620	3485
	2	10393	10400
	3	3744	6760
Relative volume per animal, m^3	1	24,2	52-72
	2	52,0	52-72
	3	28,8	52-72
Feeding front, m			
total	1	90	54
	2	210	160
	3	96	104
per animal	1	1,34	0,8
	2	1,05	0,8
	3	0,74	0,8

Ordinance 44 specifies an optimal temperature of 10-15 ^{O}C with a minimum of 5^{O}C and maximum of 28^{O}C. Miteva (2012) claims that the temperatures between 18 and 20^{O} C are quite often the reason for temperature discomfort. The average values of the hygiene parameters examined in the controlled buildings exhibit their own properties and dynamics but also a certain dependence on the environmental factors. When the values recommended in Ordinance № 44 are taken into account, it can be stated that during the winter the cows will be bred in environment with temperatures below the lower limit (5^{O}C), and during the summer- close to or exceeding the upper limit (28^{O}C). The average relative humidity is within the tolerable hygiene levels in all three buildings during the three seasons, with the exception of that in building 1, which during the winter is 85%.

Table 3. Living environment parameters examined during the different seasons

	Building 1	Building 2	Building 3
Temperature , ^{O}C			
Transitional season	22	21,8	22,5
summer	28,2	27,8	27,6
winter	7,1	5,8	6,9
Relative humidity, %			
Transitional season	73	68	70
summer	79	64,8	75
winter	85	73	76
Airflow velocity, m/s			
Transitional season	0,28	0,22	0,36
summer	0,56	0,49	0,55
winter	1,2	1,5	0,9
Cooling rate, mJ /cm^2/s			
Transitional season	9,5	8,8	10,2
summer	4,5	3,1	4,8
winter	9,5	13,8	7,8
Lighting, lux			
Transitional season	400-600	350-750	200-450
summer	400-1200	400-700	250-700
winter	250-550	220-700	180-450
Bed temperature, ^{O}C			
Transitional season	18,5	16,2	12,5
summer	25,9	25,7	22,6
winter	9,8	6,3	2,5
Ammonia content (NH_3),mg			
Transitional season	14,4	8	15,2
summer	0,25	0,22	0,28
winter	0,21	0,18	0,24

Average temperature during the three seasons : Temperature, ^{O}C Relative humidity, % Air velocity, m/s	 18,9±1,2 74,4±0,9 0,35±0,025	Min 5,2 65 0,15	Max 28,8 88 0,66

The bed temperature is most often influenced by the external temperature, especially in building 3, and in building 1 it is also affected by the bedding humidity (Table 3). The airflow velocity in the three buildings exceeds the adopted hygiene norms during the winter. The reason for this are the so called whirling areas formed not only in the winter but also in the transitional period when the highest cooling rate is reported. Using the correlation analysis, Hristev et al., (2020) ascertain a high correlation dependence of the air temperature, the floor temperature and the airflow on the architecture- construction and technological solutions in the production buildings. The relative humidity was in a negative correlation not only with the type of the respective building but also with the temperatures maintained there. To a large extent the season of examination also influences the temperature of the air and the floor, as well as the air flow but not their humidity.Usually the airflow velocity during the winter should not exceed 0.3m/s and the cooling rate 5-8 mcal/cm²/s. In the overview work of Petkov and Baykov (1976) are cited some authors who consider that the airflow should not exceed 0.6m/s, and others who claim that it can even exceed 4m/s. Therefore, we stick to the conclusion drawn by Gregoriadesova and Dolezal, (2000) according to whom the cows' well-being, their health and productivity during the summer are mainly influenced by the temperature and humidity of the air, and during the winter by its velocity.

The natural daylight duration is of vital importance for the dairy cows not only in terms of their proper feeding but also for their normal sexual activity (Trofimov et al., 2016). The above mentioned duration should be at least 16 hours, especially during the winter, with reference to the lactating cows, and around 8 with reference to the non-lactating cows. The light intensity in the feeding zone has to be 300 lux, and 200 in the resting area. The data in table 3 shows that the level of lighting in the examined buildings meets the physiological requirements of the animals.

The ammonia concentration in the buildings examined by us varies within the acceptable norms (up to 20 mg/m^3) in all three seasons. The only exception from this trend is shown in buildings 1 and 3 where the content of the gas is three times higher during the transitional period. We assume that this is caused by the higher seasonal temperatures and shortcomings in the organization of the ventilation system.

CONCLUSIONS

The technological realization of the buildings ensures sufficient relative area per each animal of respectively 34%, 91,6% and 56,6%. Only the building volume is up to 46,5% and 44,6% smaller in buildings 1 and 3. The width of the feeding zone in buildings 1 and 2 is in compliance with the norms while that in building 3 is 6,5% smaller.

Of all parameters characterizing the living environment, the temperature and the relative humidity in the controlled buildings are roughly the same during the three seasons. There are noticeable differences with reference to the cooling value in building 2 when compared to the other two buildings. Lower values of lighting and bed temperature are measured in building 3 during the three seasons which shows a certain dependence on the same factors on the external environment. The ammonia concentration in the three buildings is within the norms during all three seasons.

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