10 years - **ANNIVERSARY EDITION** ***TRAKIA JOURNAL OF SCIENCES***
Trakia Journal of Sciences, Vol. 10, No 2, pp 102-108 , 2012

Available online at:
http://www.uni-sz.bg

ISSN 1313-7050 (print)
ISSN 1313-3551 (online)

Original Contribution

EVALUATION OF SOME ZOOHYGIENIC PARAMETERS IN A SEMI-OPEN FREE-STALL DAIRY BARN

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ABSTRACT
The aim of the present research was to evaluate some of most important zoohygienic indicators on the basis of a preliminary technical and technological layout of a semi-open free-stall dairy barn for housing of 74 cows. The study was performed on a large dairy barn with longitudinal sidewalls replaced by retractable curtains, with three rows of cubicles (one outer row and one inner double row) located on one side of an external feeding alley, and manure cleaning system using electrically driven delta scrapers. The latter move the manure from alleys to a transverse collecting channel located in one end of the barn. By means of a back-and-forth conveyer, the manure is transferred to an earthen manure collecting pit to the south part of the barn and by an inclined conveyor belt, entered directly into an adjacently located solid manure storage facility. Feed is dispensed by a feed wagon (mixer) on the periphery of the feed alley, lined with terracotta pots. The milking is done in a 2x4 herringbone-type milking parlour. The investigated modern half-open large three-row dairy barn for free rearing of 74 dairy cows provided a technological solution for ensuring the comfort of animals according to the following zoohygienic parameters: relative built-up area, built-up volume, drinking space width and lighting parameters. The evaluated technological layout of a large barn with curtain longitudinal sidewalls, perpendicularly located milking parlour with machinery and sanitary rooms, offices, parturition room created good preconditions for animal housing, suitable for newly constructed barns or modernization of dairy cattle farms for 70-80 cows in Bulgaria.

Key words: semi-open building, cows, technological decision, hygienic indicators

INTRODUCTION

Technological modernization is an important tool of development in modern dairy cattle industry. The worldwide tendencies towards free housing systems, large farms, milking of cows in parlours, utilization of semi-open buildings with lightweight construction and replacement of longitudinal sidewalls with curtains are already adopted in Bulgaria (1, 2, 3). The more efficient utilisation of built-up areas and the elimination (reduction) of heat insulation of such buildings allow for a substantial reduction of housing costs per animal (1, 4, 5, 6).

In order to guarantee the comfort of animals and the personnel, the compliance with animal hygiene requirements is mandatory throughout the entire process of barn construction. For instance, Bulgarian legislation (7, 8) requires minimum allowances of 6.0 m2 built-up area, manger width of 0.70-0.80 m, water trough width of 0.05 m. The built-up volume is not specified in these norms. Some authors (1, 4) established that the relative space of 2- and 3-row buildings with capacity of 40-100 cows

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and curtain longitudinal sidewalls varied within 64.41-74,32 m^3/cow (2-row buildings) and 56.33 – 72.31 m^3/cow (3-row buildings).

According to Dinev (1) the microclimate in semi-open buildings without longitudinal sidewalls is regulated through curtains that close (partially or completely) the long facade depending on air movement velocity, in case of during rainfalls and at very low ambient temperatures. In order to prevent the overheating of cows by sun radiation during the summer and to facilitate the natural air exchange and ventilation of the building, its height at roof awnings and the ridge was increased and roof tin was insulated with 4 cm polyurethane foam. The author has investigated a large-dimensional facility in Tvarditsa for free rearing of 500 cows in individual cubicles to conclude that the technological solution ensured the normal allowances of some important zoohygienic parameters (temperature, air movement velocity, humidity) and met their biological needs as shown by behavioural indices.

In Bulgaria, the zoohygienic parameters in dairy barns of smaller capacity (up to 100 cows) are not fully investigated. Therefore, the aim of the present research was to evaluate some of most important zoohygienic indicators on the basis of a preliminary technical and technological layout of a semi-open free-stall dairy barn for housing of 74 cows.

MATERIAL AND METHODS

The subject of the study was a detailed technical and technological layout of a semi-open dairy barn for free rearing of 74 cows (62 lactating and 12 dry). The building was large, with internal (neat) dimensions by layout as followed: length 47.75 m and width 17.10 m **(Figures 1 and 2)**. The design was a shelter-type, semi-open, with lightweight steel supporting structure of three-nave frames (2 rows of internal columns). Longitudinal sidewalls were replaced by retractable curtains and permanent insect- and bird-proof netting. The curtains were completely or partially closed in case of adverse weather conditions (depending on air velocity, temperature and humidity).

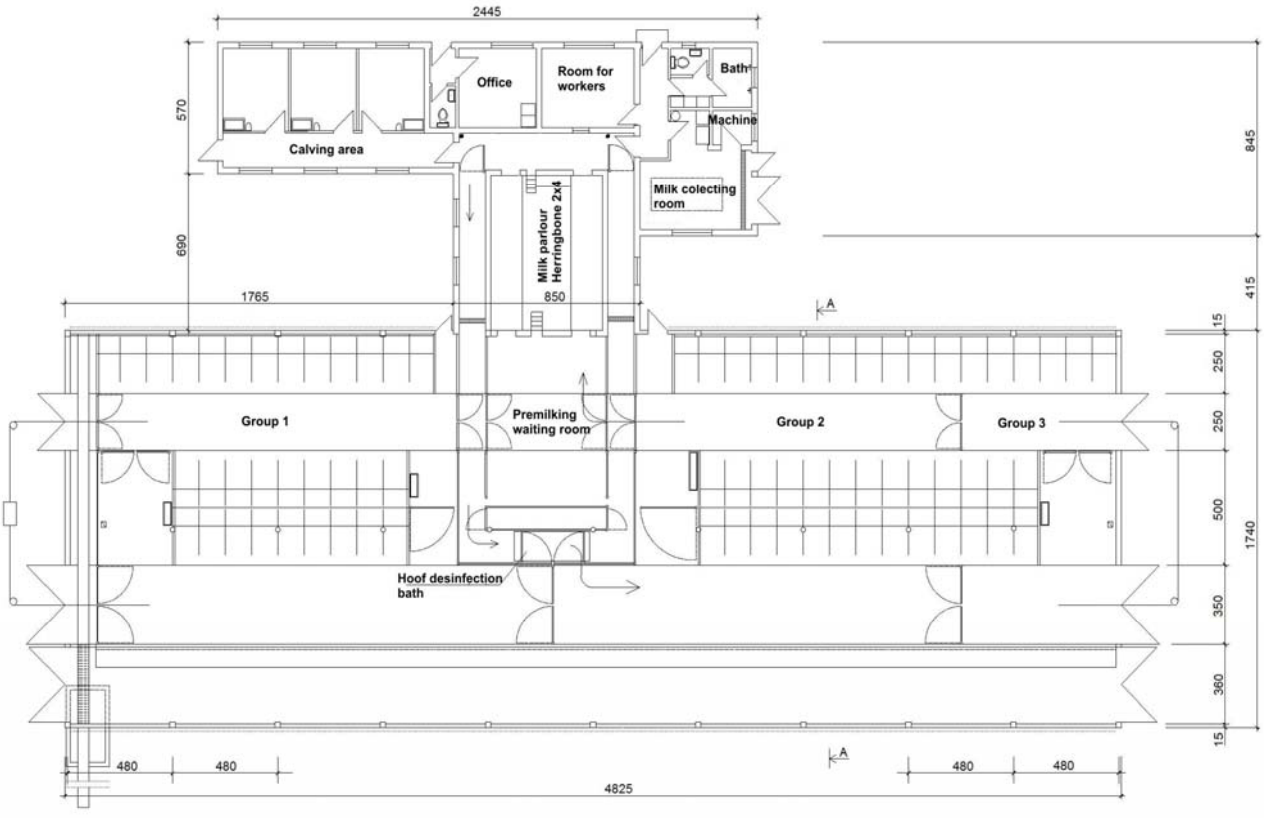

Figure 1. Dairy barn for free rearing of 74 cows in individual cubicles with milking parlour and parturition room

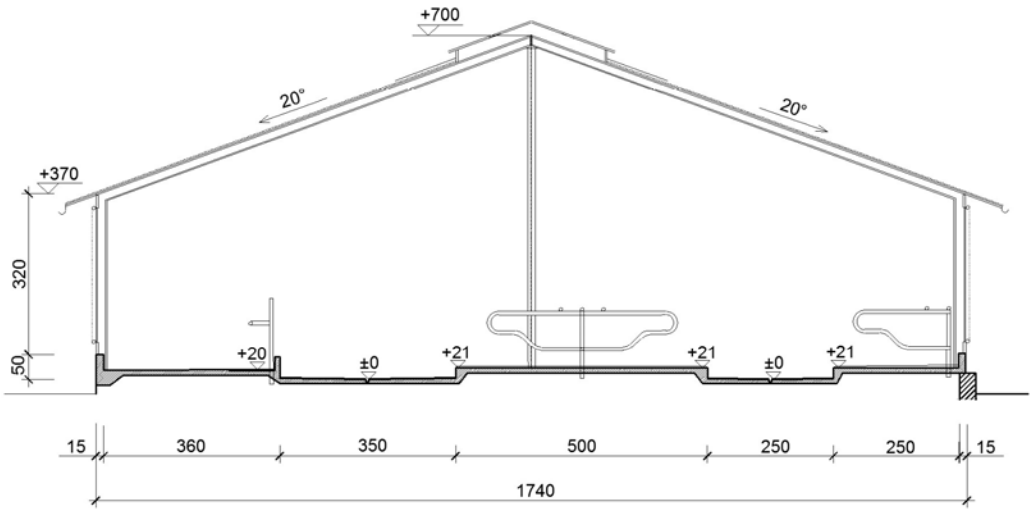

Figure 2. Cross-section through a building for free rearing of 74 dairy cows

The layout of the barn was developed in compliance with normative allowances (7, 8). The roof awnings height was bigger (370 cm) as did the roof's ridge (700 cm), and the roofing was made of plasticized LT tin, heat-insulated with 4 cm polyurethane foam. To ensure an optimal airflow for natural ventilation of the barn with permanently open ventilation slots at roof's top, a slope of 20^{o} was provided. To increase the natural lighting coefficient and for even natural lighting of the middle part, the barns' roof was covered with transparent polycarbonate sheets.

Only female cattle are housed in the barn (breeding females and feedlot calves are reared in other premises which are not subject of this study). The number of places matched the number of cows, divided into three groups" *group 1* – consists of 31 lactating cows housed in the west part of the barn near the waiting room;; *group 2* - 31 lactating cows housed in the part on the east to the waiting room; *group 3* - 12 dry cows in the east part of the barn. The barn had three rows of individual cubicles (one single outer row and one inner double row) located on one side of an external feeding alley. The dimensions of elements were higher than the allowances specified by Bulgarian legislation (7, 8): feeding alley width - 360 cm, width of alleys between cubicle rows - 250 cm (minimum allowance 180 - 200 cm), feed and movement alley width - 350 cm (minimum allowance 300 cm), cubicle length - 250 cm (minimum allowance 220 - 240 cm) etc. which was anticipated to improve the welfare of cows.

The floor of cubicles (resting area) and technological and manure alleys was covered with rubber mats. A solid manure cleaning, storage and processing system was designed. Using delta scrapers, the manure is moved from alleys to a transverse collecting channel located in one end of the barn. By means of a back-and-forth conveyer, the manure is transferred to an earthen manure collecting pit to the south part of the barn and by an inclined conveyor belt, entered directly into an adjacently located solid manure storage facility. Feed is dispensed by a feed wagon (mixer) on the periphery of the feed alley, lined with terracotta pots (without mangers). A self-feed system was designed due to the impossibility to provide the minimum allowances of feeding space width, i.e. 70-80 cm/cow.

To the barn, there was a 2 x 4 herringbone-type milking parlour, waiting room, the needed technical, sanitary and office rooms, and a parturition room with 3 parturition boxes. All rooms (without the waiting room) were located in an adjacent combined premise, the milking parlour being adjoined to the barn and connected by corridors. The storage facilities and equipment (for hay, straw and other roughages, for concentrate feeds and machinery) are not subject of this investigation.

For implementation of study's purpose, the following important zoohygienic parameters were evaluated on the basis of the technological layout of a semi-open dairy barn: relative (per cow) built-up area and volume, feeding and drinking space widths; lighting regimen parameters. The first two indices were investigated also for the

parturition room. Built up areas and volumes were not evaluated for the milking parlour and machinery premises, as they were compliant with the requirements of the respective equipment' manufacturers. The dimensions of these premises are selected on catalogs.

Calculations of built-up areas and volumes were made using the internal dimensions of the building. For the dairy barn, the following parameters were determined and evaluated:
- total built up area and the relative area per one cow in the barn;
- useful built-up area per cow in the respective group. The total resting and movement areas of the group were determined without including feed alley area and waiting room area.;
- the relative built-up area (per 1 cow) used by each group of lactating cows before entering the milking parlour (including the waiting room area and the external technological and manure alleys areas belonging to the territory of the group).
The evaluation of the lighting regimen was determined on the basis of natural lighting, and the allowances for artificial lighting and the location of lamps are specified.

The anticipated values for harmful gases, dust and microorganisms in the air, ambient temperature, air relative humidity and air velocity could not be determined at that phase, as the building was not yet constructed and put into operation.

The results per layout of studied zoohygienic parameters were presented in tables and compared to respective allowances from Bulgarian normative documents (7, 8). The study used therefore a comparative analytical approach.

RESULTS AND DISCUSSION

Table 1 presents the total and relative (per one cow) built-in areas for the studied technical and technological solution of a semi-open building for free-range rearing of 74 dairy cows, as well as the areas of the parturition room and the waiting room to the milking parlour.

Table 1. *Built-up areas at a farm for free rearing of 74 dairy cows*

Biulding for cows	**Zoohygienic parameters**	
	by layout	allowance
Total built-up area		
Total, m^2	816.5	444.0
Relative, m^2/cow	11.03	6.00
Useful built-up area*		
Group 1		
Total, m^2	239.1	186.0
Relative, m^2/cow	7.71	6.00
Group 2		
Total, m^2	215.3	186.0
Relative, m^2/cow	6.95	6.00
Group 3		
Total, m^2	97.9	72.0
Relative, m^2/cow	8.16	6.00
Built-up area of waiting room before milking **		
Group 1		
Total, m^2	105.4	55.8
Relative, m^2/cow	3.40	1.80
Group 2		
Total, m^2	104.3	55.8
Relative, m^2/cow	3.36	1.80
Parturition room – useful built-up area		
Total, m^2	33.3	27.0
Relative, m^2/cow	11.10	9.00

*built-up area including the total space for resting and movement of animals at the territory of their group (without the feed alley and the waiting room);

** built-up area used by each group of lactating cows before entering the milking parlour (incl. the waiting room area and the external technological and manure alley belonging to the group).

It could be seen that the technological solution ensured the necessary comfort for cows – cows were provided with 11.03 m^2/cow area vs the reglamented allowance of 6 m^2/cow, i.e. by 83.8% more. Smaller differences were established for useful area (resting and movement at the territory of the group, without including the feeding alley and the waiting room to the milking parlour. It is also demonstrated that lactating cows had a relative built-in area higher by 15.9 to 28.5% than the specified allowances – 6.95 m^2/cow (group 1) and 7.71 m^2/cow (group 2) respectively. The dry cows (group 3 – 8.16 m^2/ск.м.), were provided with an area by 36.0% higher. Data reported by Dinev (1) showed that the relative built-in areas of modern three-row buildings with curtain longitudinal walls ranged from 6.96 to 8.40 m^2/cow – a range, corresponding to the present results.

Similar ratios between parameter values by layout are observed for areas, used by lactating cows before entering the milking parlour. The dimensions of the waiting room were not sufficient to house the entire group, so some of cows are within and the others are on an outer technological and manure alley at the territory of the respective group to wait their turn after the milked cows had already left. The table showed that the anticipated space of the waiting room by layout differed insignificantly (by 1.2%) in both groups (3.40 m^2/cow and 3.36 m^2/cow for group 1 and group 2 respectively), but compared to allowances, group 1 had by 88.9% more space, while group 2 - by 86.7%. The parturition room area was by 23.3% more – 11.10 m^2/cow by layout vs the allowance of 9.00 m^2/cow.

Table 2 presents the total and relative built-up volumes in the cattle premise and the parturition room. The norms do not specify minimum allowances for this parameter, but the relative volume of three-row barns with capacity of 40-100 cows according to published data (1; 4) with curtain longitudinal sidewalls varied from 56.33 to 72.31 m^3/cow. The parameters of the barn layout (shown in the Table) are compliant with those of cited authors.

Table 2. *Built-up volumes at a farm for free rearing of 74 dairy cows*

Zoohygienic parameters	**Built-up volume**			
	Building for cows		**Parturition room**	
	Total, m^3	Relative, m^3/cow	Total, m^3	Relative, m^3/cow
by layout	4368.4	59.03	172.0	57.33
allowance		-	-	-

Table 3 presents the data for total and relative feeding space width in the dairy barn and the parturition room. It showed different values for the specific groups (0.66 m/cow – *group 1*, 0.61 m/cow – *group 2*, 0.59 m/cow – *group 3*) and lack of providing the necessary space in the building. This, however, is not necessary as the feeding mode was ad -libitum. An exception was the parturition room, where every cow had a personal manger with a feed face of 0.80 m/cow.

Table 3. *Feeding space width at a farm for free rearing of 74 dairy cows*

Building for cows	**Zoohygienic parameters**	
	by layout	allowance
Total feeding space width		
Total, m^2	46.5	59.2
Relative, m^2/cow	0.63	0.80
Feeding space width for cows from production group I		
Group 1		
Total, m^2	20.5	24.8
Relative, m^2/cow	0.66	0.80
Group 2		
Total, m^2	18.9	24.8
Relative, m^2/cow	0.61	0.80
Group 3		
Total, m^2	7.1	9.6
Relative, m^2/cow	0.59	0.80
Parturition room – Feeding space width		
Total, m^2	2.40	2.40
Relative, m^2/cow	0.80	0.80

Data about the relative drinking space width **(Table 4)** showed that the allowances were met both in the dairy barn and the parturition room.

Table 4. *Drinking space width at a dairy barn for free rearing of 74 cows*

Building for cows	**Zoohygienic parameters**	
	by layout	allowance
Total drinking space width		
Total, m	4.6	3.7
Relative, m/cow	0.06	0.05
Drinking space width for cows from production group I		
Group 1		
Total, m	2.0	1.6
Relative, m/cow	0.06	0.05
Group 2		
Total, m	1.6	1.6
Relative, m/cow	0.05	0.05
Group 3		
Total, m	1.0	0.6
Relative, m/cow	0.08	0.05
Parturition room – drinking space width		
Total, m	0.45	0.15
Relative, m/cow	0.15	0.05

The lighting regimen parameters in the premises are shown in **Table 5**. The built-up areas and those of sidewall openings (windows) related to determined light coefficient (LC) values are presented.

Table 5. *Light regimen parameters at a dairy barn for free rearing of 74 cows*

Room purpose	**Built-up area, m^2**	**Area of sidewall opening (windows etc.), m^2**	**Natural light, LC***		Artificial light	
					lx/m^2	location
	by layout	by layout	by layout	allowance	allowance	allowance
Building for cows	816.5	241.1	0.295	1/13 – 1/15 or 0.077 – 0.067	30 - 50	feeding place
Milking sector (milking parlour with access alleys)	63.0	3.6	0.057	1/15 – 1/30 or 0.067 – 0.033	100	milking place
Milking parlour	34.7	3.6	0.104	1/15 – 1/30 or 0.067 – 0.033	100	milking place
Parturition room	48.8	11.0	0.225	1/10 or 0.100	100	calving place
Parturition box	11.1	1.5	0.135	1/10 or 0.100	100	calving place
Milk collecting room	17.3	2.8	0.162	1/15 – 1/30 or 0.067 – 0.033	100	over the cooling tank
Machinery room	2.7	1.2	0.444	1/15 – 1/30 or 0.067 – 0.033	100	place for the machinery
Sanitary rooms	15.8	0.9	0.057	1/15 – 1/20 or 0.067 – 0.050	20 - 30	dressing room, bathroom, WC
Personnel room	14.6	3.5	0.240	1/15 – 1/30 or 0.067 – 0.033	100	resting place
Offices of the manager and the veterinarian	12.1	2.7	0.223	1/15 – 1/30 or 0.067 – 0.033	100	working place

* LC – light coefficient

Data showed that the necessary level of comfort with regard to natural lighting was guaranteed in all areas. For instance, the LC in the dairy barn was 0.295, i.e. 3.8 times higher than the allowance of 0.077; in the milking parlour it was 0.104 – 1.6 times higher than the allowance of 0.067), in the parturition room: 0.225 i.e. 2.25 times higher than the allowance of 0.100 etc.

CONCLUSIONS

The investigated modern half-open large three-row dairy barn for free rearing of 74 dairy cows provided a technological solution for ensuring the comfort of animals according to the following zoohygienic parameters: relative built-up area, built-up volume, drinking space width and lighting parameters. The evaluated technological layout of a large barn with curtain longitudinal sidewalls, perpendicularly located milking parlour with machinery and sanitary rooms, offices, parturition room created good preconditions for animal housing, suitable for newly constructed barns or modernization of dairy cattle farms for 70-80 cows in Bulgaria.

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