Dairy Cows' Welfare Quality in Relation to Housing System

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SUMMARY

The objective was to assess the dairy cows' welfare quality in relation to the housing system: loose (LHS) vs. tie-stall (THS). A survey was done according to the Welfare Quality® Protocol for Cattle on 16 dairy farms (7 in LHS and 9 in THS) in Serbia. From a total number of 4833 dairy cows (2392 cows in THS and 2441 cows in LHS) 551 cows in THS and 470 cows in LHS have been sampled randomly for clinical scoring (body condition score, health state, and cleanliness). The assessment was based on the evaluation of 29 welfare measures, 12 criteria, and 4 principles that are relevant for determining risks and final categorization of farms into one of four welfare categories: not classified, acceptable, enhanced, and excellent. The results obtained in this study showed that the housing system affected many parameters of cows' welfare referring to their comfort, health, and behaviour. The high proportion of animals lying outside the lying area (49.5%) and colliding with equipment (16.7%) indicate lack of space and movement restriction as major welfare risks in THS. Consequentially, scores for injuries (AI=45.8 points) and emotional state (ES=43.2 points) were estimated significantly lower than in LHS (58.9 and 60.4 points respectively). LHS has advantages when it comes to freedom of movement, body condition, skin health, and emotional state, but the proportions of cows with dirty lower legs, flank, and upper legs (93.4% and 80.66%) were significantly higher than in THS as well as the frequency of lameness (31.4%). According to the overall assessment, most of the LHS farms (5 of 7) were classified as enhanced, while the majority of THS farms (6 of 9) were acceptable. This study showed that despite the welfare quality parameters were not exceptional in both housing systems, LHS meets the requirements of welfare assurance to a greater extent than THS and therefore should be promoted and widely implemented.

KEY WORDS

Assessment, dairy cows, housing system, welfare.

INTRODUCTION

The widely accepted definition of animal welfare is that it comprises the state of the animal's body and mind, and the extent to which its nature (genetic traits manifest in breed and temperament) is satisfied[1]. Animal welfare is a multidimensional concept comprising both physical and mental aspects and requires an assessment of all component dimensions through specific indicators[2]. Some of these indicators relate to environmental conditions (housing, feeding, watering, etc.) and farm management are called resource-based indicators. Those, which refer to the actual state of the animal, are known as output or animal-based indicators (health, behaviour, emotional state, reproductive performance, production). Assessment of mentioned indicators by appropriate methodology leads to the conclusion about the state of farm animal welfare as well as opportunities for its improvement. According to some studies[3-6], the housing system is a factor that strongly affects the dairy cows' welfare quality, particularly in terms of comfort, health status and behaviour expression. In spite of many different variations of existing housing systems, they can be broadly classified into two major groups: the loose (LHS) and the tie-stall system (THS). The main difference between them is reflected in the freedom of movement, which is by default better in LHS and thus support more natural cow housing. Still, the results of several studies show that both systems are characterized by advantages and disadvantages. Compared to the world prevalent, THS, LHS has the advantage of better udder health[7], lower risk of ketosis and better fertility[3]. The possibilities for behaviour expression are also better in LHS[8] which, together with the previously stated, declares this system as more acceptable in terms of dairy cows' welfare. On the other hand, a higher risk of lameness and parasitic infections are considered as main disadvantages of LHS[3]. Previous studies generally considered the relationship between welfare and the housing system partially and just a few studies were conducted in order to estimate the overall welfare of dairy cows in different hous-

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ing conditions. Also, the results obtained from various studies are not always comparable, because of the different methodologies used. In that regard, the aim of this study was to examine both, partial and overall dairy cows' welfare quality in relation to the housing system (LHS vs. THS) and to test the hypothesis that the welfare of dairy cows in LHS is better than the welfare of cows kept in THS.

MATERIAL AND METHODS

The farms

The study was conducted on 16 selected commercial dairy farms, 9 with THS and 7 with LHS housing in Serbia. In order to obtain required and reliable data for the investigation, farms were selected according to management practices, farm size, availability of veterinary records and, other information necessary for the welfare assessment. In relation to management practices, there was a tendency to include farms that are typical representatives of LHS and THS in Serbia. That is why the research did not include grazing herds (otherwise few and small-sized) where natural mating is applied. An additional complication on these farms would be the presence of bulls and the possibility of their separation from the herd during the assessment. Herds less than 30 cows were not included because of the minimum sample size required by the Protocol. Farms from which reliable veterinary records could not be obtained (milk somatic cell count, mortality, dystocia, downer cows) and other information (access to outdoor loafing area or pasture, disbudding/dehorning) were also excluded from the study. Dairy cow breeds represented in both housing systems were Domestic Simmental and Holstein Friesian cattle, 80% and 20%, respectively. All the THS farms were closed, with solid flooring. Cows were kept in stalls of length between 140 cm and 240 cm and width between 100 cm and 120 cm. Straw bedding was used in all THS farms (3 kg/head/day or less). Cows had access to an outdoor loafing area on 4 THS farms and pasture only on one farm (24 hours a day for 60 days a year). Farms with LHS were both closed and half opened, with cubicles (4 farms) or straw yards (3 farms) for the cows' rest. Straw bedding was used in the majority of the LHS barns. In the summer season, cows were on pasture, on one farm, for 12 hours a day for 210 days a year. Each farm was visited twice a year, in the winter and summer seasons, and the average value of each welfare measure was calculated.

Welfare assessment

Welfare assessment of the cows was done according to the Welfare Quality® Assessment Protocol for Cattle[9] where detailed information about the methodology can be found. This Protocol includes 4 major welfare principles, 12 criteria and 29 measures (Table 1).

Three trained assessors (experienced in cows' welfare assessment) evaluated cows on each farm. Measures for clinical scoring (body condition score-BCS, health state, lameness, and cleanliness) were sampled randomly (by marking every n^{th} cow in the milking parlour on the LHS farms or every n^{th} cow in a row on the THS farms), according to the instruction for the sample sizing given by the Protocol (Table 2). On each of the LHS farms (1-7) and THS farms (8-16) the appropriate number of animals was sampled: 1) 97 of 1235; 2) 65 of 266; 3) 72 of 318; 4) 72 of 350; 5) 50 of 123; 6) 68 of 103; 7) 46 of 46; 8) 121 of 1150; 9) 118 of 900; 10) 80 of 110; 11) 52 of 52; 12) 30 of 30; 13) 51 of 51; 14) 35 of 35; 15) 33 of 33 and 16) 31 of 31. Hence, from a total number of 4833 dairy cows, 551 cows in THS and 470 cows in LHS were sampled for clinical scoring. The BCS was determined relevant to the breed (dairy or dual purpose) and condition of four body regions (cavity around the tail head; vertebrae; tail head, hipbones, spine, and ribs). Given that the main purpose of BCS assessment from a welfare point of view is the detection of animals with inappropriate conditions, it is simplified within the Protocol to only three classes:

0-regular;

1-very lean (dairy breeds: Lowman/Mulvany score <2; Edmondson et al. score < 2,5; dual purpose breeds: Lowman/Mul-

Table 1 - Welfare principles, criteria and measures - Welfare Quality® Assessment Protocol.

Principles	Criterions	Measures
Good feeding (GF)	Absence of prolonged hunger (APH)	Body condition score (BCS)
	Absence of prolonged thirst (APT)	Water provision; cleanliness of water points; water flow; functioning of water points
Good housing (GH)	Comfort around resting (CAR)	Time needed to lay down; animals colliding with housing equipment during lying down; animals lying partly or completely outside the lying area; cleanliness of udders, flank/upper legs, lower legs
	Ease of movement (EM)	Presence of tethering; access to outdoor loafing area or pasture
Good health (GHE)	Absence of injuries (AI)	Lameness; integument alterations
	Absence of disease (AD)	Coughing; nasal discharge; ocular discharge; hampered respiration; diarrhoea; vulvar discharge; milk somatic cell count; mortality; dystocia; downer cows
	Absence of pain induced by management procedures (APIMP)	Disbudding/dehorning; tail docking
Appropriate behaviour (AB)	Expression of social behaviours (ESB)	Agonistic behaviours - assessed by observation of head butts; displacements; chasing; fighting; chasing-up
	Expression of other behaviours (EOB)	Access to pasture
	Good human-animal relationship (GHAR)	Avoidance distance
	Positive emotional state (PES)	Qualitative behaviour assessment (QBA) - by observation of the cows' body language regarding 20 behavioural terms (active, relaxed, fearful, agitated, calm, content, indifferent, frustrated, friendly, bored, playful, positively occupied, lively, inquisitive, irritable, uneasy, sociable, apathetic, happy, distressed)

Table 2 - Sample size for clinical scoring depending of the herd size -Welfare Quality® Assessment Protocol.

Herd size	Number of animals to score (suggestion A)	If A is not feasible
30	30	30
40	30	30
50	33	30
60	37	32
70	41	35
80	44	37
90	47	39
100	49	40
110	52	42
120	54	43
130	55	45
140	57	46
150	59	47
160	60	48
170	62	48
180	63	49
190	64	50
200	65	51
210	66	51
220	67	52
230	68	52
240	69	53
250	70	53
260	70	54
270	71	54
280	72	54
290	72	55
300	73	55

vany score <3; Edmondson et al. score < 3,25);
2-very fat (dairy breeds: Lowman/Mulvany/Edmondson et al. score ≥ 4; dual purpose breeds: Lowman/Mulvany/Edmondson et al. score ≥ 4).
On the herd level, the calculated percentage of very lean cows served as an indicator of food provision on farm.
Processing of data collected on the farms was carried out using the Welfare Quality® Scoring System Software Program[10] for the calculation of the scores for the welfare criteria and principles and for classifying the farms into one of four welfare categories:
1) Excellent (81-100 points) - the welfare of animals is of the highest level.
2) Enhanced (56-80 points) - the welfare of animals is good.
3) Acceptable (21-55 points) - the welfare of animals is above or meets minimal requirements.
4) Not classified (under 20 points) - the welfare of animals is low and considered unacceptable.

Statistical analysis

All statistical analyses were performed using Statistica v.10 commercial software (StatSoft, Inc., USA, 2010). Descriptive statistical parameters were determined (mean, standard error of the mean, standard deviation, minimal and maximal values) for 29 assessed measures, the scores of the 11 criteria and the scores of the four welfare principles. The statistical significance of the effect of the housing system on welfare (measures, criteria and principles of welfare) in the studied farms was determined by the t-test or the Mann-Whitney test, depending on the normality of data distribution, established with the Kolmogorov-Smirnov test. Normally distributed data were analyzed by the t-test and for the data which were non-parametrically distributed the Mann-Whitney test was applied. P values less than 0.05 were considered statistically significant.

RESULTS

Good feeding

Table 3 comparatively presents descriptive statistical parameters for the principle of Good feeding-GF, and the appurtenant criteria and measures assessed in different housing systems. According to the average principles and criteria scores, no significant difference (P>0.05) was found between the two systems. Within criterion Absence of prolonged hunger-APH, the percentage of very fat cows, although not included in software analysis, was higher in THS compared to LHS (P≤0.01). The share of cows with regular body condition was significantly higher (P≤0.05) in LHS.

Good housing

A significant statistical difference (P≤0.01) was found between housing systems for the score for the principle Good housing-GH (Table 4). All LHS farms had maximum scores (100 points) for the criterion Easy of movement-EM, while in six of the nine THS farms continuous tethering was applied. Cows in LHS had

Table 3 - Comparison of welfare measures related to the "Good feeding".

Welfare criterion/measures	LHS							THS							
	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	P
Principle Good feeding. points	71.09 ± 7.55	28.26	13.30	100.00	71.80	62.88	91.18	79.76 ± 5.39	22.86	12.20	100.00	84.75	64.85	98.68	0.344
Criterion Absence of prolonged hunger, points	80.13 ± 4.79	17.90	52.40	100.00	85.15	65.58	97.25	77.84 ± 4.98	21.14	40.30	100.00	80.35	71.95	98.18	0.747
Very lean, %	3.06 ± 0.81	3.02	0.00	8.20	1.93	0.35	5.18	3.77 ± 1.00	4.26	0.00	12.50	2.63	0.23	3.99	0.597
Regular body condition, %[N]	95.59 ± 1.00	3.75	88.38	100.00	96.07	93.48	98.42	89.48 ± 1.85	7.86	75.87	99.10	90.00	83.07	96.87	0.012*
Very fat, %[N]	1.08 ± 0.41	1.53	0.00	4.17	0.00	0.00	1.99	6.75 ± 1.41	5.96	0.00	18.00	7.15	0.93	11.94	0.001**
Criterion Absence of prolonged thirst, points	80.43 ± 9.57	35.79	3.00	100.00	100.00	70.00	100.00	94.61 ± 5.39	22.86	3.00	100.00	100.00	100.00	100.00	0.182

[N]=not included in software analysis, * = significant statistical differences at *P*< 0.05, ** = significant statistical differences at *P*< 0.01

significantly greater (P≤0.01) access to the outdoor loafing area (average 168 days/year) than those kept in THS (average 61 days/year). No significant difference was found between the two systems for the criterion Comfort around resting-CAR. However, some measures included in this criterion differed significantly among systems. The frequency of collision with housing

Table 4 - Comparison of welfare measures related to the "Good housing".

Welfare criterion/measures	LHS							THS							
	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	P
Principle Good housing, points	56.16 ± 1.74	6.52	47.30	65.4	53.90	53.90	60.08	21.37 ± 2.25	9.54	7.30	37.80	19.00	15.68	22.90	0.001**
Principle Good housing, points	56.16 ± 1.74	6.52	47.30	65.4	53.90	53.90	60.08	21.37 ± 2.25	9.54	7.30	37.80	19.00	15.68	22.90	0.001**
Criterion Comfort around resting, points	30.38 ± 2.77	10.35	16.40	45.1	26.70	26.70	36.60	22.18 ± 3.09	13.11	2.70	45.10	17.45	16.40	26.70	0.064
Time needed to lie down, s	6.00 ± 0.22	0.81	4.50	7.58	5.81	5.53	6.43	6.44 ± 0.14	0.60	5.40	7.20	6.40	6.21	6.88	0.086
Colliding with housing equipment during lying down, %	1.19 ± 1.19	4.46	0.00	16.70	0.00	0.00	0.00	16.72 ± 2.56	10.85	0.00	37.00	18.50	7.57	23.60	0.001**
Animals lying partly/completely outside the lying area, %	19.86 ± 5.96	22.29	0.00	69.23	6.70	1.02	37.65	49.51 ± 8.50	36.05	0.00	100.00	36.20	22.44	77.80	0.011*
Cows with dirty lower legs, %	93.40 ± 1.75	6.56	78.00	100.00	94.34	91.03	99.33	77.83 ± 5.84	24.76	14.81	100.00	85.00	64.93	99.27	0.029*
Cows with dirty udder, %	63.05 ± 5.98	22.37	22.22	100.00	63.65	57.21	78.96	57.75 ± 6.03	25.57	9.26	91.70	67.55	36.29	76.35	0.543
Cows with dirty flank and upper legs, %	80.66 ± 2.99	11.20	61.11	100.00	82.25	72.75	86.02	64.10 ± 5.46	23.18	3.70	89.65	66.85	56.28	82.27	0.020*
Criterion Ease of movement, points	100.00 ± 0.00	0.00	100.00	100.00	100.00	100.00	100.00	23.44 ± 2.29	9.71	15.00	34.00	15.00	15.00	34.00	0.001**

* = significant statistical differences at *P*< 0.05, ** = significant statistical differences at P< 0.01

Table 5 - Comparison of welfare measures related to the "Good health".

Welfare criterion/measures	LHS							THS							
	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	P
Principle Good health, points	40.04 ± 1.07	4.00	35.10	50.00	39.40	36.98	41.55	42.06 ± 2.42	10.29	23.90	56.60	41.75	34.05	51.68	0.494
Criterion Absence of injuries, points	58.94 ± 3.12	11.68	41.10	81.10	56.10	53.23	67.85	45.83 ± 3.48	14.76	21.00	81.10	45.20	38.08	52.48	0.011**
Not lame cows, %	74.24 ± 3.22	12.06	49.00	90.00	74.25	65.55	84.38	88.5 ± 1.47	6.24	79.70	100.00	59.44	50.79	70.10	0.004**
Moderately lame cows, %	20.05 ± 2.40	8.98	6.98	32.00	21.35	12.68	28.23	-	-	-	-	-	-	-	-
Severely lame cows, %	11.31 ± 5.91	22.13	0.50	86.55	5.23	2.42	7.33	10.67 ± 1.41	5.98	0.00	20.30	10.15	6.13	16.15	0.907
Cows with at least one hairless patch, %	10.92 ± 1.21	4.51	2.32	17.88	11.64	6.91	13.97	23.16 ± 4.76	20.21	0.00	73.68	16.97	9.42	32.73	0.034*
Cows with at least one lesion, %	4.54 ± 0.94	3.50	0.00	12.50	3.32	2.44	5.21	8.01 ± 2.01	8.54	0.00	30.00	5.52	3.18	9.09	0.164
Cows with no lesion, %	95.46 ± 0.94	3.50	87.50	100.00	96.69	94.80	97.57	91.99 ± 2.01	8.54	70.00	100.00	94.49	90.91	96.83	0.164
Criterion Absence of disease, points	57.56 ± 4.10	15.32	40.40	100.00	56.60	44.80	64.60	61.07 ± 6.11	25.91	30.20	100.00	56.60	37.63	83.08	0.658
Nasal discharge, %	0.60 ± 0.60	2.23	0.00	8.33	0.00	0.00	0.00	1.21 ± 0.85	3.61	0.00	15.18	0.00	0.00	0.00	0.582
Cows with increased respiratory rate, %	0.14 ± 0.10	0.36	0.00	1.00	0.00	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.104
Ocular discharge,%	4.16 ± 2.25	8.43	0.00	29.17	0.52	0.00	2.85	3.84 ± 1.43	6.05	0.00	19.83	1.15	0.00	4.62	0.903
Diarrhoea, %	2.47 ± 0.81	3.02	0.00	8.16	1.44	0.00	4.60	1.64 ± 0.45	1.90	0.00	6.15	1.63	0.00	2.18	0.350
Vulvar discharge, %	0.91 ± 0.25	0.94	0.00	2.50	0.88	0.00	1.42	1.86 ± 0.41	1.76	0.00	5.55	1.75	0.19	2.80	0.079
Frequency of coughing, per cow per 15 min	0.08 ± 0.07	0.27	0.00	1.00	0.00	0.00	0.00	0.11 ± 0.08	0.32	0.00	1.00	0.00	0.00	0.00	0.748
Mastitis, %	2.38 ± 0.35	1.31	0.70	5.26	1.85	1.68	2.89	2.23 ± 0.18	0.75	0.80	3.70	2.37	1.78	2.68	0.688
Dystocia, %	6.21 ± 1.88	7.04	0.82	21.30	3.30	1.25	8.59	2.60 ± 0.70	2.96	0.00	8.30	1.96	0.00	3.85	0.058
Downer cows, %	1.32 ± 0.25	0.94	0.00	2.30	1.70	0.28	2.09	0.93 ± 0.39	1.67	0.00	5.10	0.00	0.00	1.25	0.434
Mortality, %	5.74 ± 1.20	4.49	1.10	14.48	4.62	1.94	8.04	7.43 ± 1.61	6.85	0.00	21.30	5.88	3.45	7.80	0.432
Criterion Absence of pain induced by management, points	28.00 ± 0.00	0.00	28.00	28.00	28.00	28.00	28.00	51.11 ± 8.41	35.66	20.00	100.00	28.00	28.00	100.00	0.022*
Disbudding/dehorning %	98.34 ± 1.13	4.22	88.37	100.00	100.00	100.00	100.00	63.40 ± 11.09	47.04	0.00	100.00	100.00	0.00	100.00	0.010**

* = significant statistical differences at *P*< 0.05, ** = significant statistical differences at *P*< 0.01

equipment during lying down was statistically higher (P≤0.01) in TSH, as well as the frequency of animals lying outside the lying area (P≤0.05). In terms of hygiene, the share of animals with dirty lower legs, flank and upper legs were statistically higher (P≤0.05) in LHS.

Good health

The housing system did not significantly affect (P>0.05) overall estimated health of dairy cows although two of three component criteria, Absence of injuries-AI and Absence of pain induced by management procedures-APIMP, were significantly different between systems (P≤0.01and P≤0.05 respectively), as shown in Table 5.

Within the criterion AI, the share of not lame cows was significantly higher in THS (P≤0.01) as well as the share of cows with at least one hairless patch (P≤0.05). The criterion APIMP was significantly better estimated (P≤0.05) in THS due to the significantly lower application of disbudding (P≤0.01) than in LHS.

Appropriate behaviour

The results obtained by the assessment of behavioural parameters in the two housing systems are shown in Table 6. No significant difference (P>0.05) was observed between LHS and THS for the principle Appropriate behaviour-AB and criterion Expression of other behaviours-EOB. The criterion Expression of social behaviours-ESB was estimated as better on THS farms where a lower frequency of butts and displacements was determined. Although criterions Positive emotional state-PES and Qualitative behaviour assessment-QBA were significantly better (P≤0.05) estimated in LHS, the score for criterion Good human-animal relationship-GHAR was significantly higher (P≤0.01) in THS.

The overall assessment

Based on the scores obtained from all welfare principles, each farm was classified in one of four welfare categories: not classified, acceptable, enhanced and excellent. The acceptable level of welfare quality was determined on two LHS (28.6%) and six THS (66.7%) farms, while an enhanced level of welfare was estimated on five LHS (71.4%) and three THS farms (33.3%). None of the examined farms was assigned not classified or excellent welfare category (Figure 1).

DISCUSSION

The purpose of including body condition scoring within the welfare assessment is to identify the share of animals that are undernourished or overfed. Both of these conditions can lead to serious health problems and thus can be regarded as a potential welfare risk[3]. In our study, the percentage of very thin cows according to Webster[11], on average corresponds to the interval of 0-11% assigned for farms with the best welfare quality. Contrary to the above, the results of Popescu et al.[4] show a notably higher share of thin cows in both systems (10.2 and 13.1% for THS and LHS respectively). A higher percentage of very fat cows in THS compared to LHS alarm the risk of metabolic diseases and dystocia[3]. Stated differences can be explained as a result of feeding management (e.g. no competition of cows at a feeding place in THS) as well as more intensive physical activity of cows in LHS.

In general, scores for principle GF and its criteria indicate adequate food and water provision in both systems. The potential risk in water supply, especially on some LHS farms, comes from poorer hygiene of troughs. Results obtained by Popescu et al.[4],

Table 6 - Comparison of welfare measures related to the "Appropriate behavior".

Welfare criterion/measures	LHS							THS							
	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	Mean ± SEM	SD	Min	Max	Median	Q_1	Q_3	P
Appropriate behaviour, points	31.38 ± 1.89	7.09	22.00	44.40	30.80	25.85	33.15	32.37 ± 4.13	17.51	15.40	81.10	26.95	22.40	32.05	0.844
Expression of social behaviour, points	97.66 ± 0.36	1.35	95.00	99.40	98.20	97.23	98.55	99.47 ± 0.21	0.88	97.60	100.00	100.00	99.35	100.00	<0.001**
Frequency of butts per cow per hour	0.05 ± 0.01	0.02	0.02	0.09	0.05	0.03	0.06	0.02 ± 0.01	0.02	0.00	0.06	0.00	0.00	0.03	<0.001**
Frequency of displacement per cow per hour	0.02 ± 0.00	0.02	0.00	0.06	0.02	0.01	0.03	0.00 ± 0.00	0.01	0.00	0.02	0.00	0.00	0.00	<0.001**
Expression of other behaviour points,	4.07 ± 2.77	10.35	0.00	28.50	0.00	0.00	0.00	8.79 ± 6.03	25.58	0.00	79.10	0.00	0.00	0.00	0.522
No. of days on pasture per year	8.57 ± 5.82	21.79	0.00	60.00	0.00	0.00	0.00	23.33 ± 16.01	67.91	0.00	210.00	0.00	0.00	0.00	0.441
No. of hours on pasture per day	3.43 ± 2.33	8.72	0.00	24.00	0.00	0.00	0.00	1.33 ± 0.91	3.88	0.00	12.00	0.00	0.00	0.00	0.368
Good human-animal relationship points,	45.71 ± 3.90	14.57	24.40	76.10	43.55	38.45	49.35	78.41 ± 2.24	9.51	67.70	93.90	77.05	70.43	85.28	<0.001**
Cows that can be touched, %	45.69 ± 4.65	17.42	20.00	81.80	40.39	35.85	52.64	73.29 ± 1.77	7.52	58.33	86.21	72.20	68.97	77.82	<0.001**
Cows that can be approached by 50 cm but not touched, %	20.22 ± 2.98	11.15	4.54	37.50	18.98	12.85	28.94	18.94 ± 0.98	4.14	13.79	29.70	18.25	16.30	19.58	0.657
Cows that can be approached between 50 and 100 cm, %	20.63 ± 2.24	8.39	3.33	37.93	19.80	17.59	25.99	6.33 ± 1.01	4.30	0.00	16.67	7.40	4.47	8.23	<0.001**
Cows that cannot be approached,%	14.46 ± 2.64	9.88	1.70	36.00	13.07	9.30	14.58	1.66 ± 0.47	2.01	0.00	5.90	0.35	0.00	3.58	<0.001**
Positive emotional state, points	60.40 ± 3.59	13.43	32.30	89.30	61.50	52.33	68.95	43.23 ± 5.39	22.85	10.20	92.70	38.35	27.13	51.78	0.018*
QBA	0.95 ± 0.39	1.44	-2.20	4.21	1.04	0.21	1.78	-1.07 ± 0.65	2.74	-5.72	4.72	-1.41	-2.92	0.16	0.018*

* = significant statistical differences at $P< 0.05$, ** = significant statistical differences at $P< 0.01$

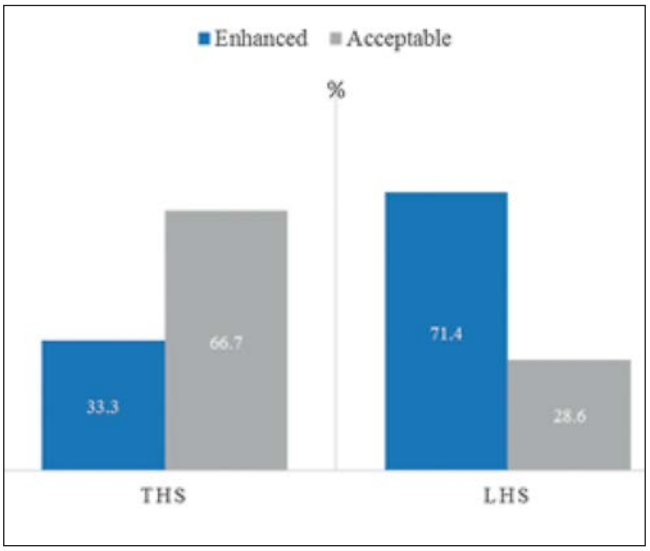

Figure 1 - Classification of the THS and LHS farms according to the welfare category.

on contrary, show significantly lower water supply in THS compared to LHS, due to the insufficient number of drinkers and their malfunctioning.

Cattle need exercise to keep healthy and productive, while in permanently tethered cows the normal behavioural patterns become modified, the frequency of all social and investigative behaviours lowers and abnormal behaviours may occur[8]. A study by Gemma et al.[12] shows that cows spend 57.8% of the total time outdoors when given free choice, while in our study time spent on pasture was similar and insufficient in both housing systems (approx. 30 hours/year). Results obtained for EM are consistent with those established by Popescu et al.[4], indicating similarity in housing technology in Serbia and Romania.

In contrast to earlier findings of Popescu et al.[4], no significant difference was found between the two systems for criterion CAR. However, some measures included in this criterion were significantly different between the two systems. Collisions with housing equipment indicate disturbances of resting comfort for dairy cows and are often related to technopathy occurrence[6]. In the nature of things, the frequency of collisions during lying down was higher in THS than in LHS, but collisions may also occur in some painful conditions (lameness) when animals, by avoiding to bear weight on the painful leg, rely on construction elements of the barn[16]. Despite the fact that Popescu et al.[4] have found a serious welfare problem in the frequency of collisions during lying down in THS (>30%), in our study frequency of collisions in both systems was acceptable (≤20%) as recommended by Welfare Quality Consortium[9] and corresponded to earlier findings of Ostojić Andrić et al.[13].

Laying is a high-priority behaviour and disturbances of resting are highly welfare relevant as they may be associated with insufficient recuperation and frustration[8], increased risks for lameness[17,18] and alterations or injuries regarding hair, skin and joints[19]. Extremely high and, from the welfare point of view, an unacceptable share of cows lying partly or completely outside the lying area (>3%) according to Welfare Quality Consortium[9] was determined in both systems. Improper, short stalls were the main reason for a significantly higher frequency of cows lying outside the lying area in THS, much higher than those found by Popescu et al.[4]. Inappropriate stall dimensions seem to be the leading problem in assuring the comfort of cows on Serbian farms, as many of them originate from a peak of the industrial livestock period known for maximum space savings. In addition, selection for increased milk production has also increased the body size and weight of cows[3], which altogether does not contribute to their comfort on farms. In LHS, the occurrence of cows lying outside the lying area may be attributed to hierarchical relations in a herd[20] or cooling in the slurry during the hot season[21], which consequently leads to poor hygiene condition.

Values of the indicator- time needed to lie down, indicate that cows in LHS had moderate (5.2 ≤ 6.3 sec) while cows in THS had a serious problem (> 6.3 sec) from a welfare standpoint[9]. These values are in line with those obtained by Ostojić Andrić et al.[13], but somewhat higher than those obtained by Popescu et al.[4] where, contrary to our study, no problems were found in LHS. Considering that both studies, Serbian and Romanian, were carried out mainly in housing conditions with cubicles, these discordances may be attributed to different technical characteristics of stalls as well as used bedding materials (straw vs. sawdust) in LHS as reported by Veissier et al.[14]. Extended lying time indicates inappropriate housing conditions such as short stalls, poor hygiene, and bad design of the tethers or a neck bow being in the way in THS[3]. Many of the factors associated with cow comfort measures are caused by farm management omissions and are closely related to the incidence of legs and udder injuries and diseases which also result in extended lying time[15].

The hygiene of dairy cows influences their health, milk quality and behaviour expression[3,16]. Two of three measures of cow hygiene (dirty lower legs, dirty flank, and upper legs) relevant for comfort estimation, indicate a significantly higher level of dirtiness in LHS, similar to the results of Regula et al.[7] and Ostojić Andrić et al.[13]. Larger spaces that allow cows to stand fully in the stall increase the soiling[15] and also impose difficulties in maintaining stall hygiene (machinery malfunctioning, inability to access, irregular cleaning etc.) more frequent in LHS, and may be the reason for stated differences between systems. Compared to previously noted results, a study by Popescu et al.[4] indicates better overall hygiene of cows but, on the contrary, a significantly higher share of cows with dirty udder and flank in THS. In addition to poor hygiene and irregular manure disposal as the main causes of cows' soiling, very high dirtiness of the flank and upper legs indicates possible rumen dysfunction[22]. The udder seems to be the cleanest body region in both systems which may be attributed to the regular procedure of udder cleaning prior to milking. Generally, considering high deviations from recommendations (>19% of cows with the dirty udder, flank and upper legs; >50% of cows with dirty lower legs)[9], cow hygiene in both systems can be evaluated as very poor and welfare endangering. Overall scores for GH showed that this principle was evaluated as better in LHS, similarly to the results of Popescu et al.[4]. The greatest risks to the welfare of dairy cows in this segment of assessment were the improper stall length and inability to exercise in THS, as well as poor hygiene of cows in both housing systems. In addition, noted problems may increase the risk of mastitis and lameness in the herd[3].

Nowadays, lameness constitutes a major welfare issue in cattle, causing pain, decreasing mobility and impairing normal behaviour[18]. The majority of recent studies show a higher prevalence of lameness in LHS than in THS, ranging from 20%[23] to almost 50%[24] for LHS, and from below 1% up to 21% for THS[25]. Because of different assessment methods and scoring systems being applied in LHS and THS, a reasonable measure for comparing

lameness levels between systems seems to be the percentage of non-lame cows. Accordingly, the results of our study are in line with previously mentioned studies, confirming the significant influence of the housing system on lameness prevalence. Housing conditions are the main predisposing factors in lameness aetiology and obviously, cows in LHS are much more exposed to them[16]. Referring to Nordlund et al.[17], the proportion of lame cows in LHS, determined in our study, exceeds 15% which requires the implementation of appropriate measures for the prevention and treatment of lameness on evaluated farms.

Integument alterations are strongly affected by calving parity, housing and feeding conditions and therefore are important for welfare assessment[19]. A significantly lower share of cows with mild alterations (hairless patch) found in the LHS is in line with the results of other studies[7,26]. Tethering of cows leads to frequent collisions with housing equipment (short chains and resting beds) making them more prone to skin alterations. Similarly to the results of Popescu et al.[4], the frequency of lesions (swellings) was lower in both systems compared to the study by Zurbrigg et al.[25] but much higher than those (≤0,2%) recently stated by Blanco-Penedo et al.[6] for LHS. Still, referring to the findings of Webster[11], the frequency of skin alterations in our study corresponds to those on farms with a higher category of welfare quality.

Previously published studies[7,13] associate THS with a higher incidence of disease in dairy cows. On the other hand, a study by Simensen et al.[26] shows that cows' health doesn't need to be universally better in LHS than in THS. Our results confirmed this statement because no statistical significance in the criterion Absence of diseases-AD between systems was established. Most of the observed measures of health state were acceptable from a welfare point of view[9]. Exceptions were the frequency of cows with ocular discharge (>3.00% in both systems), mastitis (>2.25% in LHS) and dystocia (>2.75% in LHS), which to some extent exceeded set welfare thresholds[9]. According to Welfare Quality Consortium[9], mortality rates in both systems were above the acceptable values (> 4.5%) and were mainly caused by emergency slaughter because of leg injuries and calving difficulties. Similar to the study of Reimus et al.[27], a higher mortality rate was determined in THS than in LHS but no statistical difference was established. Due to exposed critical health indicators in our study, criterion AD in both systems had a lower score than those in a study by Popescu et al.[4] where on the contrary, a significant difference between systems was determined.

Management procedures, tail docking and dehorning, are a considerable source of pain and stress for animals, particularly if performed without anaesthesia and analgesia[28]. This is the main reason why those procedures were included in the assessment of criterion APIMP. Tail docking of dairy cows is not practised on Serbian farms but in the majority of the medium and large farms, the farmers prefer the cows without horns. All of the assessed farms applied solely disbudding of calves, mostly by thermal and less by chemical method. Established, more frequent use of disbudding in LHS is in compliance with the general practice in cattle breeding because cattle in LHS are more prone to risk from horn injuries, such are bruises and lacerations. Considering the validity of disbudding in dairy herds, it is also important to consider the use of anaesthetic or/and analgesic treatment as routine procedures in such painful interventions. Unfortunately, in assessed dairy herds none of the pain relief medications was applied during disbudding, nor are they widely practised in Serbia. This resulted in a lower score of APIMP in LHS where disbudding was more frequently performed.

The criterion Expression of social behaviour-ESB was estimated as better on THS farms where lower frequencies of butts and displacements were determined. This is in agreement with the results of Popescu et al.[4] though they found somewhat higher occurrences of butts and displacements in herds. When estimating these measures in different housing systems, it is important to note that LHS enables greater freedom of movement to cows and consequently more social interaction including those that are agonistic.

Estimation of criterion EOB relies on cow's ability to access pasture, hence, to express the large scale of natural behaviour forms (grazing, explorative, social etc.). Compared to Krohn's[8] findings, time spent on pasture by cows in our study was short and insufficient for normal expression of cows' natural behaviour. The low EOB score in our study was similar to those of Popescu et al.[4] where also no significant statistical difference was found between the two housing systems. In spite of the fact that nowadays, pasturing is widely recommended and implemented in livestock developed countries, in Serbia and most Eastern Balkans countries, pasturelands are not sufficiently utilized.

Cows learn to be fearful of humans from the previous behaviour of the handler towards them. The level of cows' fear of humans can be assessed by measuring the distance that cow allows when humans are approaching. Four measures were taken for the final estimation of the criterion GHAR. This criterion, similar to the results of Popescu et al.[4], was significantly better estimated in THS representing more favourable handling of cows. However, despite the high reliability of allowing distance test[29], the interpretation of the results should take into account the fact that in THS, animals are more prone to habituation, whereas animals kept free have a greater ability to avoid certain stimuli and situations in which they feel unsafe[30].

The QBA considers the expressive quality of how animals behave and interact with each other and the environment, i.e. their «body language»[9]. Similarly to our results, Popescu et al.[4] also found more expressive positive behaviour tendencies (QBA) in LHS. According to Krohn[8], a lack of stimulating environment and social contacts in THS lead to behavioural deprivation and disorders which may be an explanation for the results obtained in our study.

AB was estimated as similar (approx. 30 points) on LHS and THS farms, indicating that conditions for normal expressions of cows' behaviour met only minimal requirements[9]. Contrary to this, the results of Popescu et al.[4] show an advantage of LHS in terms of behavioural needs provision.

Based on the overall score obtained for all welfare principles, THS farms were predominantly categorized as acceptable and LHS farms as enhanced welfare category. In line with the results obtained in other countries[4,10], no farm had achieved an excellent level of welfare. Contrary to our study, Popescu et al.[4] found that approx. 20% of THS farms were assigned to the not classified category. According to Welfare Quality® Statistics[10] based on an evaluation of 716 dairy farms from ten European countries, the same share of farms (48%) were categorized as acceptable and enhanced while only 4% were determined as not classified.

CONCLUSION

The initial hypothesis of the better welfare quality in LHS can be accepted if taking into account that the majority of the farms with LHS were classified into a better category compared to THS

farms. However, by perceiving values and relations of welfare parameters between housing systems in more detail, it can be concluded that the welfare quality parameters were not exceptional in any of them. The most pronounced problem of THS is certainly a limitation of movement and associated problems in cows' body condition, comfort and emotional state. Allowing cows to exercise daily in the appropriate area (outdoor, pasture) could have a positive impact on the alleviation of poor comfort (short stalls and inappropriate equipment), as an alternative to building the new stalls and financial investment. In LHS, more attention should be paid to measures for the prevention of locomotor disorders, regular manure disposal, a sufficient amount of bedding, floor quality and cleaning of cows supported by regular hoof trimming and appropriate nutrition. Although the overall assessment in our study showed that the welfare of dairy cows was not substantially endangered, mentioned essential steps should be undertaken to ensure enhancement in both housing systems.

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Authors' contributions

OAD performed the investigation, interpreted the results and wrote the paper. HS designed investigation and co-wrote the paper. PM and CPV performed the statistical analysis, analyzed the data and reviewed the manuscript. ND, SA and ZZ helped performed the investigation and co-wrote the paper. All authors read and approved the final manuscript.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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