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Assessment of housing conditions in selected horse stables

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The objective of the study was to assess housing conditions for horses. Both new and adapted stables were selected for the study. Measurements of the buildings were made, the area of the boxes was calculated, and the equipment was evaluated. The microclimate of the stables was evaluated by means of direct measurements in the boxes and in the corridors in six replications, at 7 am, 2 pm and 7 pm, taking into account the season of the year. The temperature, relative humidity and air speed were measured with a Kastrel 3000 anemometer, and light intensity with a TES-1335 light meter. The concentration of gaseous impurities (CO_2, H_2S and NH_3) was measured with a GAS-HUNTER meter. The results obtained were statistically analysed using STATISTICA 10.0. Several of the boxes in the adapted sheep building did not have the recommended minimum area of 9 m^2, and also had smallest the cubic area per head. The air temperature was within the recommended range, but in one of the stables a temperature of 4°C was recorded in winter. The air movement in the passageways exceeded the recommended levels due to aeration through open doors. The skylights in the stable located next to the riding halls improved the natural lighting. In contrast, the stable adapted from a sheep building, with its low ceiling and small windows, was dimly lit and required artificial lighting. Despite the significant differences in the construction of the buildings, when they were erected, and the size of the stud, the microclimatic conditions were not found to differ significantly from the recommended standards.

KEY WORDS: horse / housing conditions / microclimate

Horses are generally believed to be kept in near-optimal conditions, unlike poultry or pigs. A study by Visser and Van Wijk-Jansen [25], however, has shown that horse lovers and horse owners often have insufficient knowledge of issues related to horses' welfare.

Horse housing systems and conditions are governed by EU and national legislation, including Council Directive 98/58/EC [5], the Animal Protection Act of 21 August 1997 [23], the Regulation of the Ministry of Agriculture and Rural Development of 10 September 2015 on minimum conditions for the maintenance of livestock species other than those for which protection standards are specified in EU legislation [21], and since 1 January 2013, Area C requirements concerning welfare.

Factors influencing the environmental conditions in livestock housing depend on the type of building, their functionality, and technological solutions [6, 7]. The environmental requirements result from the ethology and behaviour of horses [15, 16]. The construction of stables and housing systems should enable the animals retain a normal physical and mental condition, as their performance depends on their motor predispositions and behaviour [3, 20, 24].

The aim of the study was to assess the housing conditions of horses in buildings adapted for use as stables as well as in new ones, in different seasons of the year.

Materials and methods

The research was conducted at three sites located in Podkarpackie Voivodeship. The horses at each site were kept in a stable + grazing system. In the stables, the horses were kept in individual stalls with wheat straw litter. Site A (equestrian centre in Lubenia) had a new building, while site B (stud farm in Żabno) had a building adapted from a barn for fattening cattle, and site C (stud farm in Dylągówka) had one stable adapted from a sheep building (C1) and one new one (C2), integrated with the riding hall. Stables A, B and C1 had usable lofts, while C2 had a flat roof with skylights. Three stables had a typical stall layout along the walls with a passageway in the middle, but the fourth building had just one row of stalls. The basic feed ration consisted of hay, oat grain and green fodder (the animals used pastures during the growing season). Water was provided from automatic drinkers. Roughage feed was placed on the litter and concentrate feed in troughs. The horses were fed twice a day at all study sites. The equestrian centre in Lubenia (A) housed 12 horses, including two Hucul geldings, a mare and a gelding of the Haflinger breed, and Polish Half-Bred horses. During the study, the stud farm in Żabno (B) housed a herd of mares with their offspring, juveniles, and one stallion of the Małopolska breed. Dylągówka (C) kept Polish Half-Bred horses, used for sport and recreation. No foals were born during the study.

To determine the living conditions of the horses, the buildings were measured, the surface area of the stalls was calculated, and the equipment was evaluated. The microclimatic conditions in the stables were assessed by direct measurements, taking into account the season – spring, summer, autumn and winter. Measurements were made in the stalls and in the passageways, with six repetitions (the average was calculated), at 7 am, 2 pm and 7 pm. The air temperature, relative humidity and air speed were determined with a Kastrel 3000 anemometer, and light intensity with a TES-1335 light meter according to Kośla [12]. The concentration of gaseous impurities (CO_2, H_2S and NH_3) was tested with a GAS-HUNTER meter.

The results were statistically analysed using STATISTICA 10.0. The arithmetic mean ($\bar{x}$) and standard deviation (SD) were determined, and significance of differences was tested by Tukey's test.

Results and discussion

The horses were kept in individual stalls in all stables. According to Fiedorowicz [6], Bombik et al. [1, 2] and Kwiatkowska-Stenzel et al. [14], this type of system ensures favourable microclimatic conditions in the stable. Some of the stalls in the adapted sheep building in site C did not have the minimum required area of 9 m^2, and these stalls also had the smallest the cubic area per head (Table 1). The design of the stalls at all sites allowed the horses to observe their surroundings and to maintain eye contact with other horses. According to Cooper et al. [4], this reduces the frequency of stereotypical weaving. The NEWC [17] recommends that the surface area of stalls for large horses should be 3.64 x 4.25 m. Large stalls enhance freedom of movement and allow the horses to lie down and rest. Raabymagle and Ladwig [19] report that the time horses spend resting in a lying position is longer in larger stalls.

Table 1
Housing conditions of the horses in the stables

Item	A	B	C1	C2
Number of boxes	11	34	15	11
Number of horses	10	28	15	11
Box surface area (m^2/no of boxes)	9/10 16/1	12/16 9/18	16/8 10/3 8.5/4	9/11
Cubic area per head (m^3/head)	60.1	64.1	32.1	74.6

Air temperature is one of the most important factors influencing the microclimate of the stable. The temperature in the spring ranged from 8.6°C to 14.2°C (Table 2). These results were similar to those obtained by Bombik et al. [1] in three sites located in the Masovian Voivodeship. The lowest temperature in summer was noted in the stable in the equestrian centre in Lubenia (18.5°C), possibly due to the stable's proximity to a complex of trees. The measurements made in autumn at 7 pm showed huge differences in temperatures between buildings at different sites, which ranged from 5.1°C (in stable C2 in Dylągówka) to 14.1°C in Lubenia. The lower temperature in the stable in Dylągówka may have been linked to both its geographical location and its situation in a valley. Prokulewicz and Tomza-Marciniak [18], who studied the temperature conditions in 7 buildings in the autumn, obtained values between 10.2° and 14.9°C. The lowest air temperature in winter in the present study, 4.0°C, was noted in stable no. 2 in Dylągówka. This was below the reference value of 5°C stipulated in the Regulation of the Minister of Agriculture and Rural Development of 2 October 2003. According to Jodkowska [10], proper adaption to prevailing conditions enables horses to endure even sub-zero temperatures. The results obtained in this study were similar to measurements reported by Kupczyński and Mazurkiewicz [13] in Książ, but lower than the results obtained by the same authors in Panków. They were also lower than the averages recorded by Bombik et al. [3] in a stable with stalls.

Table 2
Air temperature (°C) in the buildings in each season of the year

Season	Time of measurement	Air temperature (°C)						
		A		B		C1	C2	
		in stable $\bar{x}$ ±SD	outside	in stable $\bar{x}$ ±SD	outside	in stable $\bar{x}$ ±SD	in stable $\bar{x}$ ±SD	outside
Spring	7 am	13.1 ±0.6	8.5	13.9 ±0.2	10.8	14.2 ±0.6	10.6 ±0.3	10.5
	2 pm	12.4 ±0.4	13.8	12.8 ±0.4	14.5	11.6 ±0.2	8.6 ±0.4	14.2
	7 pm	11.3 ±0.2	11.7	13.6 ±1.0	11.2	12.0 ±0.3	8.7 ±0.3	12.5
Summer	7 am	19.6 ±0.2	15.4	22.4 ±0.3	14.3	25.5 ±0.6	21.9 ±0.5	15.5
	2 pm	18.5 ±0.3	22.8	21.9 ±0.6	25.6	23.4 ±0.4	22.0 ±0.1	26.5
	7 pm	18.8 ±0.3	18.5	20.6 ±0.3	17.1	24.0 ±0.2	20.6 ±0.4	18.1
Autumn	7 am	15.3 ±0.7	9.5	8.6 ±0.5	10.5	8.3 ±0.4	7.4 ±0.6	9.5
	2 pm	13.8 ±0.2	13.5	8.0±0.3	14.6	6.8 ±0.6	5.3 ±0.4	13.2
	7 pm	14.1 ±0.4	11.8	7.2 ±0.4	9.6	5.8 ±0.4	5.1 ±0.3	10.8
Winter	7 am	8.8 ±0.5	–6.0	6.3 ±0.4	–5.5	7.3 ±0.2	5.6 ±0.2	–8.3
	2 pm	5.3 ±0.1	–3.6	5.7 ±0.1	–3.2	6.6 ±0.2	4.1 ±0.2	–6.0
	7 pm	5.2 ±0.4	–5.9	5.5 ±0.3	–7.5	6.3 ±0.3	4.0 ±0.2	–6.5

The relative humidity in the buildings studied did not exceed recommended standards (Table 3). The highest humidity, 77.4%, was observed in stable C2 in Dylągówka in autumn. The range of values obtained in autumn was wider than that reported by Prokulewicz and Tomza-Marciniak [18]. However, in a study conducted in a stable in Kladruby in 2011 and 2012 by Kališek et al. [11], the relative humidity in autumn (November) was 80.0%, which is much higher than the values obtained in the present study. The recommended maximum relative humidity in buildings where horses are housed is 80% (Journal of Laws No. 167, item 1629). Jodkowska [10] suggests an optimal relative humidity in stables in the range of 30-70%. High humidity can cause breathing difficulties in animals, and the structural elements of the building may be damaged by vapour condensation.

Higher air movement was noted in the aisles, due to airing of the buildings through open doors and windows in summer (Table 4). These differences were statistically significant. However, the draughts were not present in the living areas of the horses.

Analysis of the lighting conditions indicated that both natural light (via windows) and artificial sources were used to light the buildings. Stables A and C1 required artificial light irrespective of the time of day, and building B in the morning. The location of the skylights next to the riding area contributed to better natural lighting in the stable (Table 5). The adapted building, however, with its low ceiling and small windows, was dimly lit and

Table 3
Relative humidity (%) in the buildings in each season of the year (at 7 am)

Location		Relative humidity (%)			
		season			
		spring	summer	autumn	winter
A	$\bar{x}$	61.5	51.6	67.9	58.4[a]
	SD	5.15	2.22	4.15	2.48
B	$\bar{x}$	53.4	65.9	69.8	69.2[ab]
	SD	5.10	2.11	5.45	3.33
C1	$\bar{x}$	71.3	58.3	76.7	74.6[b]
	SD	4.8	2.11	5.25	4.45
C2	$\bar{x}$	64.5	55.4	77.4	67.28[ab]
	SD	3.15	2.23	3.75	2.75

a, b – means with different letters in a column are significantly different at P≤0.05

Table 4
Air flow (m/s) in the buildings in each season of the year

Location			Air flow (m/s)			
			season			
			spring	summer	autumn	winter
A	box	$\bar{x}$	0.0	0.1	0.0	0.0
		SD	0.0	0.01	0.0	0.0
	passageways	$\bar{x}$	0.2	0.4[a]	0.01	0.1
		SD	0.01	0.02	0.0	0.01
B	box	$\bar{x}$	0.0	0.31	0.0	0.0
		SD	0.0	0.11	0.0	0.0
	passageways	$\bar{x}$	0.1	0.9[b]	0.1	0.1
		SD	0.01	0.24	0.01	0.01
C1	box	$\bar{x}$	0.0	0.3	0.01	0.0
		SD	0.0	0.11	0.0	0.0
	passageways	$\bar{x}$	0.0	0.7[b]	0.1	0.0
		SD	0.0	0.11	0.01	0.0
C2	box	$\bar{x}$	0.0	0.3	0.0	0.0
		SD	0.0	0.3	0.0	0.0
	passageways	$\bar{x}$	0.01	0.8[b]	0.01	0.01
		SD	0.0	0.07	0.0	0.0

a, b – means with different letters in a column are significantly different at P≤0.05

required artificial lighting. The differences, both between farms and between seasons in each stable, were statistically significant (Table 5). Kośla [12] recommends that the light intensity in buildings where horses are kept should be 15-30 lx. The results obtained in our study indicate that this value was exceeded in many cases and that the buildings were better lit. However, values below the recommended standard were obtained in winter in the stable adapted from a sheep building (Table 5). The recommended value for the natural light (glazing) index (W:F) in stable buildings is 1:15 [6, 7, 10]. Stables A, B and C1 did not meet this requirement and did not provide access to daylight at a level ensuring good physical health and the proper growth and development of the horses.

Table 5
Lighting (lx) in the buildings in each season of the year (at 7 am)

Location		Lighting (lx) season spring	summer	autumn	winter	Natural light index (W:F)
A	$\bar{x}$	32.9^{ab}	37.4^{b}	24.15^{a}	31.8^{a}	1:18
	SD	1.13	2.80	0.87	1.01	
B	$\bar{x}$	21.4^{a}	74.8^{a}	26.9^{ab}	22.5^{ab}	1:20
	SD	1.18	3.88	2.16	0.20	
C1	$\bar{x}$	21.5^{ab}	44.6^{b}	18.2^{b}	14.6^{b}	1:25
	SD	2.99	2.15	2.10	1.13	
C2	$\bar{x}$	32.4^{b}	50.4^{b}	25.4^{ab}	27.6^{ab}	1:10
	SD	2.14	1.4	0.65	3.36	

a, b – means with different letters in a column are significantly different at $P \leq 0.05$

Air exchange in all the livestock buildings in the study was based on natural gravitational flow, with no mechanical ventilation installed. According to Jodkowska [10], natural ventilation in stables is sufficient if the air temperature difference between the interior of the building and the outside environment is at least 5°C. Proper ventilation of the stable is essential to maintaining appropriate temperature, humidity and inflow of fresh air, as well as to clear it of harmful gases, dust and micro-organisms [22].

The hygienic quality of the air in stables is not only crucial for the health of horses, but also for the workers and riders. The recommended level of gas concentrations was not found to have been exceeded in any of the buildings in the present study, just as in research by Bombik et al. [1]. Problems with air quality usually occur in winter, when ventilation of buildings is difficult. In a study conducted by Walinder et al. [26], the use of mechanical ventilation during this period substantially reduced the CO_2 content in stables. According to Fiedorowicz and Łachowski [8], the concentration of gases (CO_2 and NH_3) is significantly correlated with high relative humidity.

Table 6 presents the measurements of gas (CO_2, NH_3 and H_2S) concentrations in the stables. Ammonia and hydrogen sulphide concentrations are given only for the winter, as only then were their levels detectable. The highest concentration of carbon dioxide was observed in stables A, B and C1 in autumn, and the lowest in C2; the differences between stables were statistically significant. The acceptable levels for gas concentrations stipulated by the Regulation of the Ministry of Agriculture and Rural Development (Journal of Laws No. 167, item 1629) were not exceeded in any of the buildings analysed. According to Fleming et al. [9], the use of litter from wheat straw, replenished daily, contributes to a low concentration of ammonia.

A much higher concentration of carbon dioxide was observed in spring and autumn. Similar disparities were observed by Kališek et al. [11] in a stable in Kladruby, with lower CO_2 concentrations in winter than in spring or autumn. The summer concentration of CO_2 in Kladruby was similar (742.8 ppm) to that noted in our study in stable C1 in Dylągówka (740 ppm).

Despite substantial differences in the construction of the buildings, when they were built, and their size, the microclimatic conditions were not shown to differ significantly from their recommended values in any of them.

In conclusion, among the buildings investigated, the new stables intended for boarded or sport horses had the best housing conditions, while the conditions in the adapted buildings were significantly worse. Recommended values for air movement, due to the venti-

Table 6

Concentration of selected gases in the buildings (at 7 am)

Gas		Measurement value			
		A	B	C1	C2
Carbon dioxide CO_2 (ppm)	spring	720	640	1120	720
	summer	530	460	740	540
	autumn	1100^{ab}	1570^{b}	1630^{b}	680^{a}
	winter	980	630	740	660
Hydrogen sulphide H_2S (ppm)	winter	0	0	0	0
Ammonia NH_3 (ppm)	winter	0.7	0	0	0

a, b – means with different letters in a row are significantly different at $P \leq 0.05$

lation of the buildings, were exceeded mainly in the passageways. Additional skylights in the stables improved the lighting, but in summer they may contribute to overheating while in winter the temperature in the building may be too low.

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