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ANALYSIS OF BUILDING THERMAL DIMENSIONING AND HOUSING SYSTEM OF WHITE KOŁUDA GEESE IN TERMS OF ASSESSING THEIR WELFARE

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Abstract. The aim of the study was to analyze building heat retention and the housing system of White Kołuda geese and their effects on animal welfare. The analyses were carried out on two farms located in Lubelskie province, Poland. The facilities differed in the stock size, housing system (on litter bedding, on grid), and the type of roof (sloped roof with attic or flat roof/ceiling). The analysis of thermal properties of the buildings was carried out basing on the Thermal Properties Index (TPI). The welfare was estimated observing the pattern of air temperature and humidity changes during winter. The results suggest that the welfare of the breeder geese was at a lower level. Better conditions, though still far from the welfare optimum, were observed in the goose house with litter floor bedding and with usable attic, with a lower cubature and a higher TPI values.

Key words: goose, house thermal properties, housing system, welfare

INTRODUCTION

The White Kołuda geese, Poland's most common breed, are characterized by a high genetic potential, which enables the farmer to aim at a number of posi-

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tive, valuable performance traits [Pingel 1992, Pakulska et al. 2003, Badowski 2007]. One of the basic factors that affect geese reproduction is their optimal environment [Harmita and Mitchell 1999, McLean et al. 2002, Freire et al. 2003, Bombik et al. 2014]. Only a warm building can address all the required parameters of the physical microclimate [Bombik and Kolbuszewski 1995, Olkowska 1995, Iwańczuk-Czernik 1997, Kośla 2011].

In the recent years the European Union has been allocating 70 million Euro per year to support actions related to animal welfare. As a result of a cooperative effort of various European institutions, the rules of welfare quality have been elaborated [Scott et al. 2001, Keeling and Veissier 2005].

The welfare is defined as the condition of physical and mental health of an animal that can be reached under full harmony between the animal and the environment it lives in [Duncan and Dawkins 1983, Hamrita and Mitchell 1999].

Environmental factors that affect the health of birds and their welfare include [Sobczak and Vinstrup 2003]:

- microclimate (temperature, humidity, chill, air movement, noxious gaseous agents, lighting),
- feeding (quality and quantity of feed, water access),
- care (supervision, behavior of working people, noise, companionship),
- housing conditions (floor, litter, stocking densities, equipment).

Poultry farming welfare is evaluated using the following aspects: stocking density per square meter, water and food access, ventilation and heating solutions, the control of temperature, air humidity, noise and lighting, carbon dioxide concentrations, ammonia concentrations, and mortality indices [Keeling and Veissier 2005].

The aim of this study was to compare building heat retention and management system of White Kołuda geese in terms of their welfare.

MATERIAL AND METHODS

We analyzed two buildings (referred to as A and B), located in Lubelskie province, Poland. Both farms managed 3-year-old White Kołuda geese (lines: maternal W11 and paternal W33). The analyzed farms differed in the number of geese, management systems, and the type of roof/ceiling in the building (Table 1). The house A hosted 410 geese, and B had 711 geese. Geese in the house A were housed on litter bedding, while in B the geese remained on a wooden slat flooring. The facilities were constructed with different types of roof-ceiling: A had a sloped roof with usable attic, B was covered with a flat roof/ceiling. Both natural ventilation and natural lighting were applied on both farms.

Table 1. The characteristics of the buildings

Tabela 1. Charakterystyka budynków

Item Wyszczególnienie	Building – Budynek	
	A	B
Number of geese Liczba gęsi	410	711
Flooring system System utrzymania	litter ściółkowy	slatted rusztowy
Ceiling type Rodzaj stropu	usable attic poddasze użytkowe	roof-ceiling stropodach
Building diameters, m: Wymiary budynku, m:		
lenght – długość	30.0	48.0
width – szerokość	10.0	11.5
height – wysokość	2.3	2.4
Indexes – Wskaźniki		
floor area, geese · m^{-2} powierzchniowe, szt. · m^{-2}	1.37	1.29
room cubature, m^3 · $goose^{-1}$ kubaturowe, m^3 · $szt.^{-1}$	1.68	1.86

In order to determine the thermal balance of the buildings, we have conducted an animal hygenic survey according to Kośla [2011], which included: building dimensions. material and construction solutions, ventilation systems. Basing on these data, surface and cubature indices were additionally calculated for the geese houses.

The analysis of the building heat retention properties was performed based on the thermal properties index (TPI). This index expresses the percentage quotient of the heat gain from the animals to the heat loss through the building (four walls, ceiling, floors, windows and doors) and ventilation. Thermal surveying was adopted for the third climatic zone, which comprises Lubelskie province. The third climatic zone is characteristic for –20°C as by the minimum outdoor temperature during the severe frosts, and calculated temperature –12°C. The detailed methodology for calculating the heat balance of livestock buildings was taken from Bombik and Kolbuszewski [1995].

The welfare of geese was rated on the basis of two basic physical air parameters, i.e. temperature and relative humidity. These parameters were measured using a hytherograph COMET D3121 during winter for 14 days, three times a day (at about 8.00, 13.00 and 17.00 hours). Measurements were made in the places occupied by birds, in three fixed points of the building. The resulting values of temperature and relative humidity in the buildings were compared with the animal-welfare standards recommended for breeder geese. At the same time, temperature and relative humidity were measured outside of the buildings. The measurements were summarized as the minimum and maximum values, and the arithmetic means and coefficients of variation were calculated [Trętowski and Wojcik 1991]. These characteristics are given for the temperature and relative humidity inside buildings (A, B) and the external conditions (weather).

These results of basic microclimate and weather parameters were also used in calculations of thermal balance of the buildings.

RESULTS AND DISCUSSION

The animal hygienic survey showed that the buildings A and B differed in stocking density in terms of floor surface (respectively, 1.37 and 1.29 birds · m^{-2}) and room volume (respectively 1.68 and 1.86 m^3 per goose; Table 1), which can affect the heat balance of buildings and the thermo-humidity pattern. Badowski [2007] and Mazanowski [2008] indicate that each reproductive goose should have about 1 square meter of floor area. The legislation on animal welfare recommends a maximum of 6.5 kg per 1 m^2 of floor [Rozp. 2010]. Bombik et al. [2014], who analyzed the conditions for housing breeding geese, demonstrated the density of birds within the range of 1.35–1.70 indiv. · m^{-2} floor area and 1.58–1.85 m^3 of room volume per bird. Other studies, carried out on the effects of building heat retention on the microclimate in laying geese houses [Bombik 1993], revealed higher values of this index (1.98–2.48 m^3 of room volume per bird).

Table 2 shows values of the thermal properties index (TPI) of the buildings. On the basis of this indicator, we can predict the thermal and humidity conditions in the animal houses which may occur in the winter at very low outdoor temperatures. TPI for the third climatic zone, with the assumed minimum outdoor temperature of –20°C, was 58.2% for the building A and 44.9% for B. The lowest TPI, according to Bombik and Kolbuszewski [1995], should be as follows: 70% for a building with a usable attic, 80% with a non–usable attic, and 85% for buildings with a flat roof. It should be noted that the minimum temperature outside the buildings during the test ranged from –13.0 to –16.2°C (Table 3).

Under severe frost, neither of the buildings rated by TPI met the requirements in terms of heat retention. At a higher outdoor temperature (–12°C) only the building A attained TPI at a minimal level (77.5%). The low index values of thermal properties in both houses were due to the large cubic volume and low thermal insulation of the walls. In addition, the flat roof of the B facility lacked any thermal insulation. Hence, it is considered expedient to implement methods aimed at increasing the thermal capacity through insulation of walls and flat roof.

In the wintertime, extreme air temperatures were varied and were 3.7 to 9.5°C and –1.2 to 7.3°C in buildings A and B, respectively (Table 3). A higher (by 2.6°C)

Table 2. The values of thermal properties indices (TPI) in buildings for geese

Tabela 2. Wartości wskaźnika właściwości termicznych (WWT) gęśników

Item Wyszczególnienie	Building – Budynek	
	A	B
TPI (%) at outside temperature: WWT (%) przy tz:		
–20°C	58.2	44.9
–12°C	77.5	56.1
The minimum value of TPI (%) for building: [Bombik and Kolbuszewski 1995] Wartość minimalna WWT (%) dla budynku: [Bombik i Kolbuszewski 1995]		
with usable attic z poddaszem użytkowym	70.0	
with roof-ceiling ze stropodachem	85.0	

Table 3. The temperature-humidity conditions inside and outside buildings during winter

Tabela 3. Warunki termiczno-wilgotnościowe w budynkach i na zewnątrz w okresie zimowym

Item – Wyszczególnienie	Inside – Wewnątrz		Outside – Na zewnątrz	
	A	B	A	B
Air temperature, °C – Temperatura powietrza, °C				
min.	3.7	–1.2	–16.2	–13.0
max.	9.5	7.3	3.6	0.9
mean – średnia	6.8	4.2	–4.9	–5.1
V%	16.1	29.8	52.3	44.8
Air relative humidity, % – Wilgotność względna powietrza, %				
min.	79	84	69	70
max.	89	95	92	94
mean – średnia	83	88	77	86
V%	11.2	16.9	24.8	31.0

average daily air temperature was measured in the geese house A (6.8°C). Data in Table 3 show that better thermal conditions were in the building A. The parameter showed lower deviation from the optimum value (5–18°C), as reported in the literature [Mazanowski 2008]. Also the coefficient of variation calculated for air temperature was lower in building A, 16.1%, which reflects a higher thermal autonomy of the building. In addition, temperature inside buildings was influenced by outdoor conditions (–13.0 to –16.2°C). According to Bielińska [2005], adult geese tolerate low temperatures well; however, during egg laying, temperature should not fall below 5°C.

Low temperatures in the facilities contributed to a growth in relative humidity. In winter, the variations of this parameter in buildings A and B were similar: 79–89% and 84–95%, respectively (Table 3). A lower average, 24-hour relative air humidity (about 5%) was found in building A (83%). In both buildings the changes in relative humidity remained at a similar level (V = 11.2–16.9%). The analysis of relative humidity in the buildings shows that the parameter exceeds the acceptable welfare level. For breeding geese, humidity is recommended to remain within the optimal range 65–75% [Bielińska 2005, Mazanowski 2008]. It should be noted that excessive relative humidity inside the building – in addition to the negative impact on the health and productivity of geese – causes water condensation on the walls and ceiling, which additionally deteriorates their heat retention properties. Bombik [1994] indicates that thermal conditions and humidity in the animal facility to a large extent depend on their thermal insulation, building volume, and the external climate.

CONCLUSIONS

The results of the study enable formulation of the following conclusions:

1. The welfare of the breeder geese evaluated on the observations of air temperature and relative humidity proved reduced. The buildings did not provide the birds with optimum thermal and humidity conditions.
2. Winter temperature and humidity in the buildings depended on their heat retention, flock management system, and the cubature index.
3. The analysis of thermal measurements revealed that the values of thermal properties index (TPI) of the buildings were too low in relation to recommended standards.
4. Better air temperature and humidity conditions were attained with litter floor bedding and with the usable attic, with lower cubature and higher TPI values.
5. The analyzed buildings require restoration (insulation of the walls and ceiling), which will provide microclimate within the welfare limits.

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ANALIZA WYMIAROWANIA CIEPLNEGO BUDYNKÓW I SYSTEMU UTRZYMANIA GĘSI BIAŁYCH KOŁUDZKICH W ASPEKCIE OCENY ICH DOBROSTANU

Streszczenie. Celem pracy było określenie wpływu ciepłochronności budynków i systemu utrzymania gęsi białych kołudzkich na ich dobrostan. Badania przeprowadzono w dwóch gospodarstwach położonych na terenie województwa lubelskiego. Gęśniki różniły się liczbą ptaków, systemem utrzymania (ściółkowy, rusztowy) i rodzajem stropu (poddasze użytkowe, stropodach). Analizę ciepłochronności budynków przeprowadzono w oparciu o wskaźnik właściwości termicznych (WWT). Dobrostan gęsi oceniono na podstawie kształtowania się w budynkach temperatury i wilgotności względnej powietrza w okresie zimowym. Z przeprowadzonych badań wynika, że dobrostan gęsi reprodukcyjnych był obniżony. Korzystniejsze warunki utrzymania gęsi, ale również odbiegające od optymalnych norm zoohigienicznych, uzyskano w budynku ściółkowym z poddaszem użytkowym przy niższym wskaźniku kubaturowym i wyższych wartościach WWT.

Słowa kluczowe: gęś, ciepłochronność budynku, system utrzymania, dobrostan

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