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A TECHNICAL ANALYSIS OF BARNS ON LARGE DAIRY FARMS IN NORTHERN POLAND

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Abstract

The aim of this study was to analyze the existing barns in terms of cow maintenance systems, structure and technological solutions of buildings at large dairy farms in northern Poland. The studies were conducted in northern Poland in West Pomeranian, Pomeranian, Kuyavian-Pomeranian, Warmian-Masurian and Podlaskie voivodships. The study included field inventory and questionnaire studies at some chosen farms of these voivodships.The farm size criterion was set at the herd size of 150 or more head of cattle. Based on the obtained study results and their analysis, it was established that in northern Poland the highest number of large dairy farms (41%) was located in the Kuyavian-Pomeranian voivodship and the majority of dairy farms comprised 1-3 barns built of reinforced concrete and equipped with a gravity ventilation system. In all regions prevailed farms keeping 150 – 200 head of cattle and the largest average herd size of 460 head of cattle was in the West Pomeranian voivodship. The most often barns were equipped with herringbone milking parlours (45%) for 21-25 cows milked at once and the indoor feeding table (63%).

Keywords: barn, maintenance systems, technical solutions, dairy cattle

INTRODUCTION

Poland's accession to the European Union forced farmers of dairy cattle to introduce changes in cow maintenance systems, improve the welfare of animals and implement more restrictive regulations to hygienic requirements of milk production. Current buildings for cattle such as dairy barns, maintenance facilities for heifers, bullocks and calves differ in function, and use type and strictly adhere to the directions and technological requirements of production (Boćkowski and Gaworski 2013). They can be divided into:

- tied-up maintenance systems, where each cow is restrained in a tie stall,
- freestall maintenance systems, where cows are free to move and stay in single stalls or group pens,
- loose maintenance systems, where cows can walk around in the building and adjacent yards (Pawłowski and Pawłowski 1987).

In large dairy farms, optimisation of the milking zone is of crucial significance (Gaworski and Boćkowski 2012). Barns should be equipped with special milking centres because the milking system indirectly influences milk output and its chemical composition. In the milking room, farmers are also able to control udder condition and the health of the cows. For these reasons, the milking zone is often thought to be the most important part of a dairy barn (Oprządek and Oprządek 2008)

According to cow positioning, the following milking parlours can be distinguished: tandem, herringbone, side-by-side and carrousel (Oprządek and Oprządek 2008). Milking robot with automatic milking machines operating around the clock is also increasing in popularity (Olechnowicz *et al.* 2006). However, mostly due to economic constraints, automatic milking systems can be used only on large dairy farms. For this reason, only several dozen such systems operate on the Polish market.

In recent years, a special focus has been placed on maintaining microclimatic conditions in the dairy barn at the optimal level for cows, especially with regard to air parameters: temperature, relative humidity and airflow velocity, as well as exposure to solar radiation (Nawalany and Sokołowski 2015). These parameters have strongly impact on future increasein the milk yield of cows. Therefore, parallel to advances in improvement of rearing, maintenance and feeding methods, work aimed at optimisation of the factors determining barn microclimate are also in progress. This optimisation at least has to account for outdoor air parameters and sunlight exposure (Angrecka and Herbut 2016). It is recommended also to take into consideration the number of cows using the barn because animals are the source emitting heat and humidity as well as chemical and biochemical pollutants (carbon dioxide, ammonia, hydrogen sulfide etc.) to the indoor environment (Herbut and Angrecka 2014).

The optimal air temperature for dairy cattle ranges from 8 to 16 °C. It is assumed that above 20 °C cows are at risk of heat stress. Due to their quick metabolism, high-producing dairy cows emit large amounts of heat and are most vulnerable to heat stress. Long-lasting heat stress reduces the milk yield of dairy cows, worsens their physical conditions and is a cause of detrimental physiological changes (Herbut *et al.* 2015b). The most often used methods for improvement of disadvantageous microclimatic conditions include the use of air mixers, fans and low-pressure sprinkler systems above the feeding table, and also changes in feeding and drinking regimens.

Indoor air parameters can be improved by efficient ventilation system (Herbut and Angrecka 2012). The exchange of used, contaminated air and an influx of fresh air are achieved by using the gravity or mechanical (positive, negative or balanced pressure) ventilation systems (Herbut *et al.* 2012). Ventilation is applied to keep the indoor air temperature and humidity at the optimal level; in addition, in summer it serves to induce air movement and to remove excess heat (Herbut *et al.* 2015a). In winter, its task is to reduce too high air humidity

Philosophical and technological changes in the rearing of dairy cattle have forced farmers to build new or remodel old barns and to modernise existing machinery. Constant progress in livestock production and implementation of new technologies has significantly reduced the work burden and increased the milk yield of dairy cows that has been associated with an improvement in cow welfare and increased cost-effectiveness of milk production. In such a way, Polish dairy farms, benefiting from agricultural subsidies and agricultural development funds, have become increasingly more competitive, not only in Poland but also in the EU.

The aim of this study was to analyse the existing barns of the large dairy farms in northern Poland in terms of cow maintenance systems and structure and technological solutions of buildings. The studies encompassed field inventory and questionnaire studies at some chosen farms.

MATERIALS AND METHODS

The studies were conducted in northern Poland in West Pomeranian, Pomeranian, Kuyavian-Pomeranian, Warmian-Masurian and Podlaskie voivodships in 2014 (Figure 1). The farm size criterion was set at the herd size of 150 or more head of cattle. Data on the number of dairy farms meeting the above criteria were obtained from the information yearbook of the Polish Federation of Cattle Breeders and Dairy Farmers, region of Poznań and Parzniew (PFHBiPM 2013). Based on satellite images (www.geoportal.gov.pl; www.maps.google.com) for the selected farms, an inventory questionnaire was developed, which

is presented in Table 1 (Sowińska 2014) and a survey was carried out. The data obtained in this way were analysed using the Microsoft Excel program.

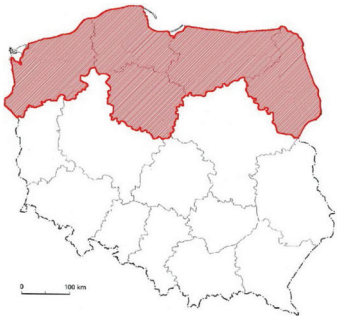

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Figure 1. Location of the analysed voivodships in Poland

Table 1. A representative example of the inventory questionnaire

Farm (name):		Voivodship	District	Municipality	Locality	Phone	Email
		Kuyavian--Pomeranian	Inowrocław	Kruszwica	Polanowice		
No.	Building structure	Year of construction / modernisation	Dimensions width / length [m]	Ventilation	Thermal insulation	Milking room	
1.	reinforced concrete	2005	25 / 85	gravitational	no	Type	herringbone
2.	reinforced concrete	2005	25 / 85	gravitational	no	Seats	2 x 10
3.	reinforced concrete	2005	25 / 85	gravitational	no	Ventilation	ridge
No.	Maintenance system	Location of feeding table	Breed	Herd size [heads]			
1-3	freestall	indoor	HF black-and--white	500			
Management of the surroundings:							
The farm is located in the southern part of the village. From the north the farm is protected from the wind by other buildings and from the west by trees. The manure pad is located in the southern part of the farm. From the east, the buildings are not shielded from the wind.							

Source: Sowińska 2014

RESULTS

According to data from the Central Statistics Office, as of June 2013 all cattle in Poland totalled 5,520,345 head, including dairy cattle of 2,346,097 head (GUS, 2013). Overall employment in agriculture in Poland was 15.8 % and the respective values in the studied voivodships were: 8.9% in West Pomeranian, 8.3% in Pomeranin, 17.1% in Kuyavian-Pomeranian, 12.6% in Warmian-Masurian and 33.9% in Podlaskie. The unemployment rate in Poland was 12.4% and by voivodship: 17.8% in West Pomeranian, 12.3% in Pomeranin, 17% in Kuyavian-Pomeranian, 20% in Warmian-Masurian and 13.8% in Podlaskie (GUS, 2011). Average utilised agricultural area per holding in Poland was 10.2 ha and in the studied voivodships: 30.3 ha in West Pomeranian, 18.8 ha in Pomeranian, 15.0 ha in Kuyavian-Pomeranian, 2.0 ha in Warmian-Masurian and 12.1 ha per holding in Podlaskie voivodship (GUS, 2013). Cattle populations in the analysed region are presented below in Table 2.

Table 2. Cattle numbers by voivodship in northern Poland

Voivodship	Number of cattle overall (head)	Number of dairy cattle (head)
Kuyavian-Pomeranian	452925	155257
West Pomeranian	95832	28896
Pomeranin	187948	62226
Warmian-Masurian	434954	186210
Podlaskie	881972	448897

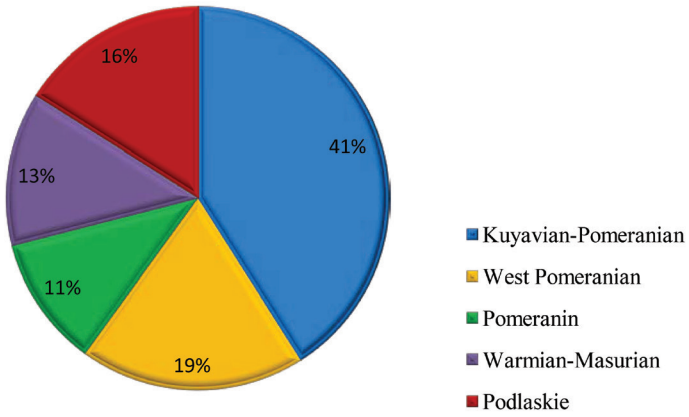

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Figure 2. The share of large dairy farms in the analysed voivodships

Based on the obtained results, the share of large dairy farms maintenance more than 150 cows was analysed in the individual voivodships of northern Poland (Figure 2).

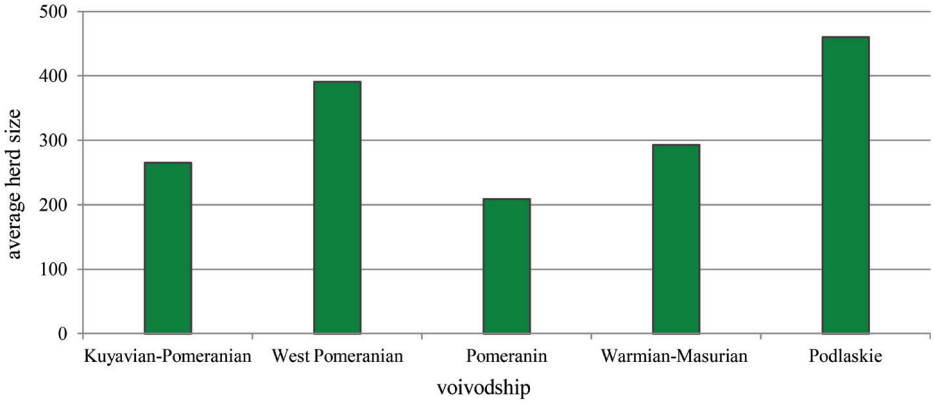

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Figure 3. Average herd size on the studied farms

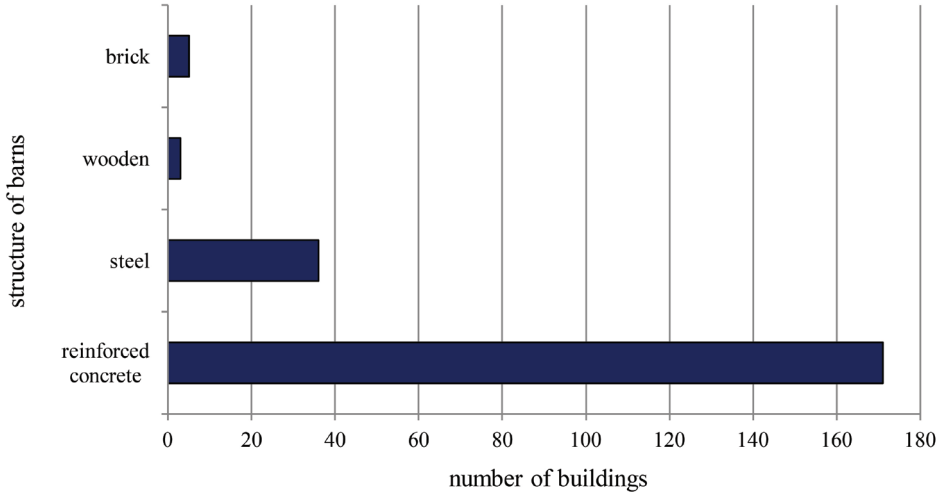

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Figure 4. Structure of barns

As shown in Figure 2, the Kuyavian-Pomeranian voivodship had the highest share of large dairy farms amounting to 41%, while the lowest share of 11% was recorded in the Pomeranian voivodship. The highest average herd size was

noted in the Podlaskie and West Pomeranian voivodships (450 and 400 head, respectively) and the lowest in the Pomeranian voivodship (200 head on average) (Figure 3).

Freestall maintenance system was the dominant system and was installed in 209 barns, while in the remaining 6 barns the tied-up maintenance system was applied.

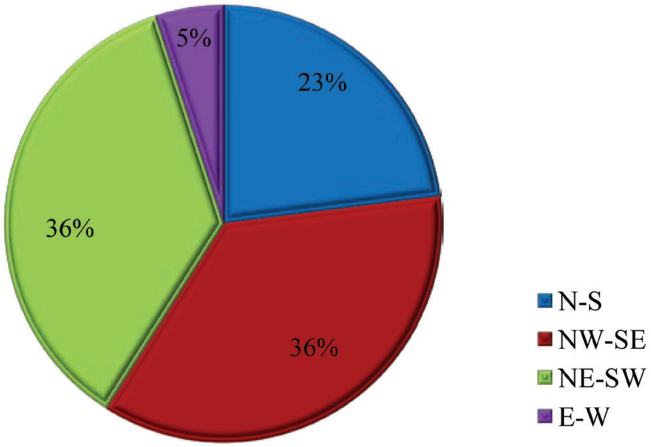

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Figure 5. Barn longitudinal axis orientation towards the cardinal points

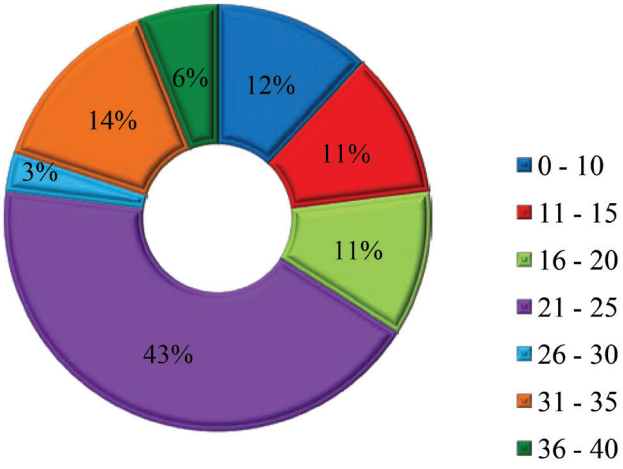

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Figure 6. The number of cows milked at once in the milking parlour in the analysed dairy farms

A great majority of existing dairy farms operate based on the former state-owned agricultural holdings, which were bought by companies or private owners. For this reason, the existing, most common barns of Fermbet or Fermstal type with individual modifications have been modernised and adjusted to valid standards in the last decade. In contrast, newly constructed barns usually have a steel structure (Figure 4).

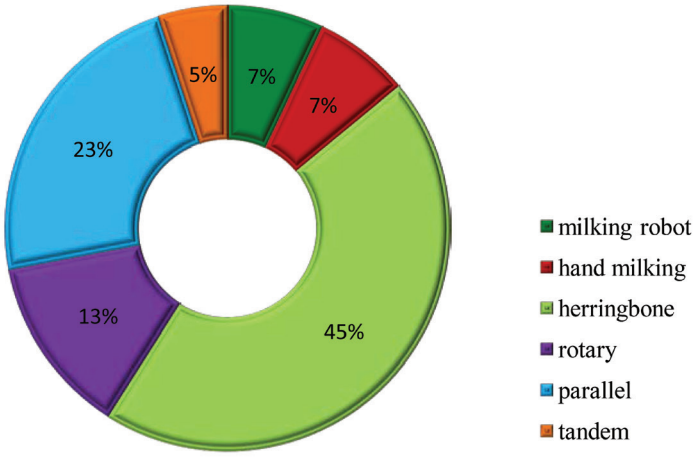

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Figure 7. The shares of the different types of milking parlours on the dairy farms under analysis

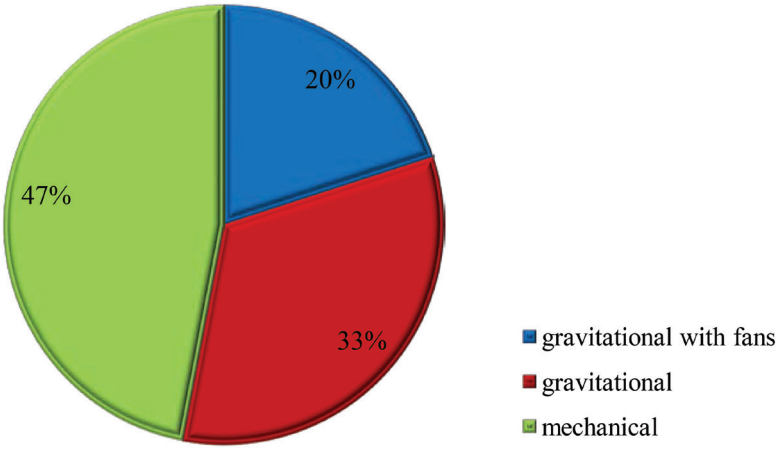

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Figure 8. The shares of ventilation systems in the milking centres

The necessity of the replacement of a tied-up by freestall maintenance system, change of feeding in TMR (total mixed ration) system and structural constraints in the modernised barns forced farmers to build outdoor or indoor feeding tables (79 and 136 barns, respectively).

A majority (as many as 191) of barns are equipped with gravity ventilation comprised of wall air supplies covered by curtains and ridge exhausts. Only 19 barns were equipped with mechanical ventilation while 5 other barns used a combination of gravity and mechanical ventilation.

The orientation of the barns towards cardinal points is significant for gravity ventilation efficiency and disadvantageous sunlight exposure of the building during the summer. Figure 5 presents the distribution of barn orientations, more specifically barn longitudinal axis orientations.

The milking centre is the heart of the dairy farm, affecting cow welfare, milking time and work comfort of the staff. Milking time depends mostly on the number of cows to be milked and on the type of milking parlour (Figures 6 and 7).

Since, in the milking centre, a relatively large number of cows are gathered in a small space, the internal ventilation should be exceptionally efficient in order to reduce cow discomfort. Figure 8 presents the shares of different ventilation systems in the milking centres under analysis.

CONCLUSIONS

Based on the obtained study results and their analysis, it was established that in northern Poland:

- the highest number of large dairy farms (41%) was located in the Kuyavian-Pomeranian voivodship,
- a majority of dairy farms comprised 1-3 barns built of reinforced concrete and equipped with a gravity ventilation system,
- freestall barns (209) with the indoor feeding table (136 barns) were the most commonly used,
- NE and NW facing barns prevailed (38% each),
- most farms (45%) had herringbone milking parlours,
- most often (43%) from 21 to 25 cows could be milked at once in the milking parlour,
- farms keeping 150 – 200 head of cattle were the most abundant (28%),
- a farm in the West Pomeranian voivodship had the largest average herd size of 460 head of cattle,
- studies show that most dairy farms use modern technical infrastructure,
- in order to protect cows from overheating, the share of farms using mechanical ventilation in barn should be increased,

- the designing of new dairy cattle farms must take into account the optimization of the barn location with respect to directions of the world.

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