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IMPACT OF PRECISION LIVESTOCK FARMING ON WELFARE AND MILK PRODUCTION IN MONTBELIARDE DAIRY COWS

Robert MIHAI[1], Gheorghe Emil MĂRGINEAN[1], Monica Paula MARIN[1], Ayman Abdel Mohsen HASSAN[2], Iuliana MARIN[3], Gina FÎNTÎNERU[1], Livia VIDU[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania
[2]Animal Production Research Institute, Ministry of Agriculture, 9 Nadi Al-Saeed St., Al-Doki, Gizza, Egypt
[3]University Politehnica of Bucharest, Faculty of Engineering in Foreign Languages, Splaiul Independenței 313, Bucharest, Romania

Corresponding author email: liviavidu@gmail.com

Abstract

The concept of "precision livestock farming" represents the optimization of the contribution of each animal to the integrated economy of the farm. During more than three decades of applied research, precision zootechnics has gone through several stages, namely from process automation, developed to reduce human labor, to focusing attention on monitoring animal needs (health, well-being). All information collected at the farm level has the role of supporting the farmer in making optimal and fast decisions, in accordance with the animal's condition and the efficiency of the farm. Sensor technologies are being used to monitor the production and physiological condition of the animals, thereby contributing to animal welfare, animal health and food safety. Farm management is assisted by sensor systems collecting information about milk production, reproduction and animal health status. Increasingly, these innovations are leading to a more efficient performance of dairy farms, in terms of both physiology and profitability.

***Key words**: microclimate, milk production, precision livestock farming.*

INTRODUCTION

Modern world's challenges are growingly diverse, ranging from the increase in the number of people on the planet, to the higher food demand (70% increase amid a rapid urbanization and the surge in the purchasing power / revenues), to climate changes, which will affect relatively large areas of the Globe (extreme weather events, water shortage, soil depletion) and price volatility, as a result of regional conflicts or enzootics / pandemics (African swine fever, Avian influenza, Foot and Mouth Disease, Bluetongue to Covid19, which affects the entire planet). In this general context, farmers must follow a strategic plan to optimize resources and reach the estimated yield potential. The EU-level average milk production is expected to increase up to 8,340 kg milk/cow until 2030, compared to 7,300 kg milk/cow in 2010.

The expected growth rate is +1.2% / year, lower than in the previous 2009-2019 period, namely +1.9% per year.

Due to this efficiency requirement, the number of dairy cows could be reduced by 1.4 million heads (21.2 million heads in 2019). Additionally, production systems will have an increasing influence on the total milk production (thus, the organic milk production will increase to 7% of the total milk production until 2030, compared to 3% in 2017) (EU Agricultural Outlook for markets and income, 2019).

The National Institute of Statistics data indicate a lower number of dairy farms, namely less by 14.8% in 2016 compared to 2013. At the same time, the number of dairy farms with capacity of 10-30 milk cows seems to have increased by 16.6%. Although commercial farms in Romania accommodate 11.8% of the total number of dairy cows, yet, the average yield per cow is 8,741 kg of milk.

Precision livestock farming (PLF) is an instrument available to farmers is which focuses on real-time monitoring and management of livestock and production factors, in order to improve livestock life, quality and productivity, alerting whenever problems occur, so farmers can take immediate action. PLF's main purpose is to combine existent hardware and software to obtain a wide range of information that will produce added value, to monitor health, well-being, productivity and environmental impact (Berckmans, 2014).

Sensor technologies are being used to monitor the production and physiological condition of the animals, thereby contributing to animal welfare, animal health and food safety. (Kelemen, A. et al, 2016) Farm management is assisted by sensor systems collecting information about milk production, reproduction and animal health status. Increasingly, these innovations are leading to a more efficient performance of dairy farms, in terms of both physiology and profitability (Lokhorst, 2018; Vidu et al., 2016).

In dairy farms, sensor-based technologies are mainly used to:

- identify each animal;
- detect physiological changes in reproduction and monitoring the health status;
- record the activity and location of each animal;
- monitor feeding and ruminating;
- automate milking and feeding;
- monitor milk quality.

MATERIALS AND METHODS

The purpose of the paper is to conduct a study on the impact and benefits of using precision farming means on milk production and on the welfare of dairy cows.

The researched material consists of the lot of lactating cows from the Moara Domneasca teaching farm. The cow breed is Montbeliarde, a breed with very good environmental adaptability and resilience. The study was conducted over a 4-month period, respectively (1 March 2019 - 30 June 2019). The experimental group consisted of 28 cows at different stages of lactation.

The working methodology is based on two precision farming systems, namely system to monitor microclimate parameters in dairy cow shelter and the second one is system to monitor milk quantity and quality. (for microclimate monitoring in the cow shelter (*SMART Zoo Tech*; to identify animals in the milking parlor, to monitor reproduction and rumination - *Dairyplan C21*) *SMART Zoo Tech* solution for measuring, logging, monitorig the temperature, humidity, dew point, carbon dioxide (CO_2) concentration, ammonia (NH_3) and dust particles (PM 2.5).

To evaluate the welfare, analyses were conducted in the shelter, at animal level, in the milking parlor.

The evaluation was performed based on the methodology included in the *ANI 35 system*. The findings were processed and interpreted in order to define the welfare and the influence on production. Specifically, 5 groups of factors were analyzed:

- freedom of movement;
- social interactions;
- type and characteristics of outdoor floors and surfaces;
- lighting, air quality and noises;
- conditions of care and maintenance.

The *ANI score* is calculated by cumulating the scores awarded for each of the 5 groups of factors separately. An individual sheet is drawn up for each of the 5 groups of factors.

The evaluation of animals focused on:

- separate evaluation of welfare for the cattle category;
- determination of welfare in the period (March-June 2019).

In the ANI system, animal welfare is studied based on 5 groups of factors and details are presented below on how each group of factors can influence the cattle welfare. According to the ANI 35 system, the cattle welfare, at the end of the evaluation, falls into the following categories:

- below 16 points - very poor welfare;
- between 16 and 20 points - poor welfare;
- between 20 and 25 points - average welfare;
- between 25 and 28 points - satisfactory welfare;
- between 28 and 32 points - full welfare;
- above 32 points - optimal welfare (Gavrilă, 2015).

The dairy cow breeding technology is modern, offering European standard tools and equipment for the maintenance, feeding and milking of dairy cows.

The maintenance of dairy cows is carried out in a free maintenance shelter. Indoors, there are delimited areas for animal feeding (with feeding front), area for movement and manure disposal (with delta-shaped plough), individual cubicle-type resting areas.

The floor is covered with various types of rubber mats (fig. 1).

Figure 1. Cows rest in individual cubicle with rubber mat flooring

Cow feeding is done with optimized feed based on the nutritional needs, production level and physiological state, without being differentiated seasonally. The distribution of feeds is done by technological trailer. The milking technology is based on the use of a herringbone milking parlor, 1x3 places. The milk produced at farm level is marketed in fresh form through milk vending machines.

RESULTS AND DISCUSSIONS

The studied data indicated that, during the experimental period (March-June), the total milk production at farm level was as follows: in March, the total production was 10,226 kg milk, with a daily average of 342.77 kg; in April, the total production was 10,058.3 kg, with a daily average of 335.27 kg, in May, the total production was 10,533 kg and the daily average 339.77 kg and, in June, the total production was 8,541.09 kg, with a daily average 284.7 kg (fig. 2).

As for the link between individual production of cows and microclimate parameters, findings were that there is a close correlation between them. Thus, on the first day of the experiment, the average milk production per dairy cow was 11.79 kg milk, the air temperature was 16°C on that day, according to the National Meteorological Administration (ANM). At shelter level, the temperature was recorded on hourly basis and the data were transmitted, thus, the variation interval ranged between 10.80°C at 9:00 a.m. and 15.78°C at 5:00 p.m. Fig. 3 illustrates the variation of all the microclimate parameters. The CO_2 (ppm) and NH_3 (ppm) concentration had the most interesting dynamics, with very high values during nighttime. Thus, the peak of NH_3 concentration was reached at 9:00 p.m., when the CO_2 concentration was maximum, as well (fig. 4).

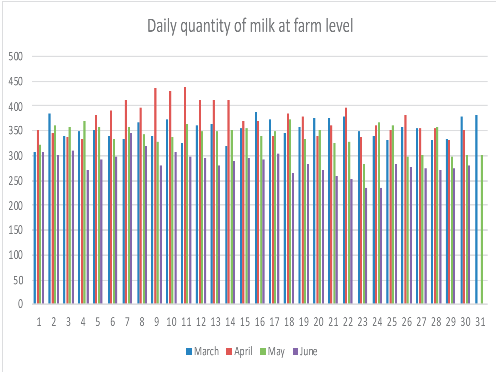

Figure 2. Total daily milk production during March-June

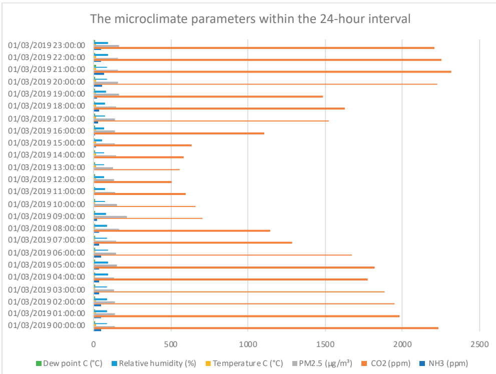

Fig. 3 Microclimate parameter values on 1 March 2019

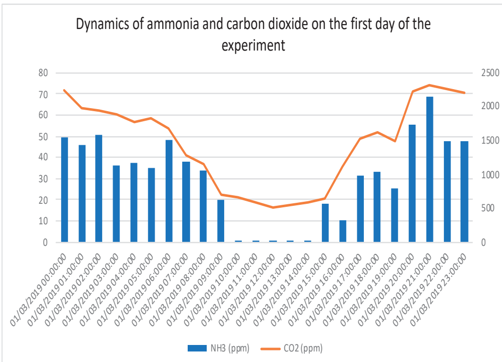

Fig. 4 Dynamics of ammonia and carbon dioxide concentration on 1 March 2019

From the entire experiment period, we have selected to show as an example the day of 13

June 2019, which was the warmest day of that period. Air temperature on that day was 34°C and the shelter-level temperature varied between 23.45°C at 4:00 a.m. and 31.04°C at 5:00 p.m. Moreover, the dew point followed the same dynamics. The relative humidity had several fluctuations after 4:00 pm. After that time, the ammonia level maintained high until the end of the day. During that day, the farmer received individual alerts on the mobile phone for each microclimate parameter on hourly basis in the second part of the day (fig. 5, 6).

As for milk production, it is known that the optimal temperature range for dairy cow is between 9 and 16°C. June had the lowest milk production of the 4 experimental months. On June 13, cows' milk production was 20 kg less than two days before (fig. 7).

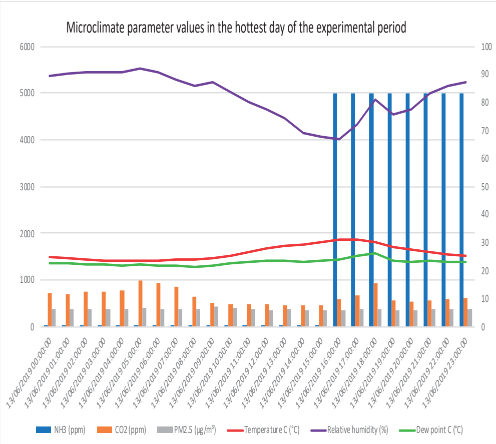

Fig. 5 Microclimate parameter values on 13 June 2019

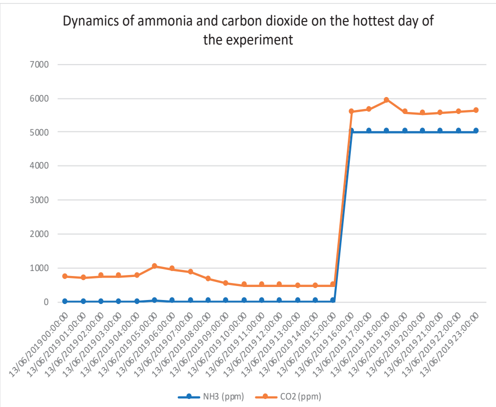

Fig. 6 Dynamics of ammonia and carbon dioxide concentration on 1 March 2019

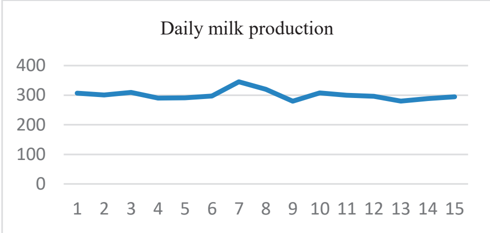

Fig. 7 Dynamics of milk production in the first 15 days of June

As for the ANI 35 system-based analysis of the welfare of Montbeliarde cows from the experimental farm, the evaluation sheets were completed and the scores obtained were reported at grid reference intervals.

For the freedom of movement criterion, the main deficiency of the farm identified during the study was the fact that the farm does not have access to a pasture, therefore, the score awarded to this chapter is 0. as for the access to paddock, it was found that the animals have access to pasture for a period of at least 230 days per year. Out of the maximum 12.5 points that can be obtained for this criterion, the farm received 10.5 points (Table 1).

As for the second criterion - social interaction, the evaluation showed that the farm received 7 points out of maximum 10 points possible. The access to pasture is one of farm's drawbacks in that case, as well. Additionally, the access to paddock is restricted to over 230 days per year. (Table 2)

Table 1. Freedom of movement

Group of Factors	Score awarded
Minimum surface area available m²/head	3
Comfort during rest day	3
Comfort provided by tie-stalls	1
Amplitude of the possible movements in tie-stalls	1
Access to the paddock days / year	2.5
Access to pasture days / year	0
TOTAL Score	10.5

Table 2. Social Interaction

Group of Factors	Score awarded
Minimum surface area available m²/head	3
Group structure	1
Calf and young cow management	0.5
Access to paddock days / year	2.5
Access to pasture days / year	0
TOTAL Score	7

The floor characteristics in terms of elasticity, cleanliness are analyzed within criterion 3.

Table 3. Type and characteristics of the floor and outdoor areas

Group of Factors	Score awarded
Elasticity of the rest area	1.5
Cleanliness level in the rest area	1
Risk level in terms of sliding in the rest area	1
Floor quality in activity areas	1
Type and characteristics of paddocks	0.5
Type of pastures	0
TOTAL Score	5

We can conclude that the welfare in terms of the type and the characteristics of the floor and outdoor surfaces is very good and receives 5 points out of maximum 8 possible points. But the points are lost due to the lack of pasture and paddock surface (fig.8 and Table 3)

Fig. 8 Aspect of the paddock surface

Table 4. Lighting, air quality and noise

Group of Factors	Score awarded
Natural light	1.5
Air quality	1.5
Ventilation in the rest area	1
Noises in the shelter	1
Access to outdoor areas day / year	2
Access to outdoor areas hours / day	2
TOTAL Score	9

Criterion 4 analyzes shelter's lighting, air quality, ventilation in the rest area, noises and access to outdoor areas during the whole year and during an entire day. The farm received a score of 9 points out of a maximum of 9.5 for this criterion. (Table 4)

Table 5 lists the items considered to assess the animal health, as well as the health of skin and nails. The farm received 7.5 points out of a total of 8 possible points for this criterion.

Table 5. Tending and maintenances conditions

Group of Factors	Score awarded
Sanitation of surfaces in accommodation, feeding, milking areas	1
Equipment wear and tear	1
Skin health	1
Animal body hygiene	0.5
Trotter health	1.5
Incidence of technopathies	1
Livestock health	1.5
TOTAL Score	7.5

The farm cumulated a total of 39 points, which indicates optimal welfare conditions for the dairy cows. That means that the farm management is high-level and special attention is paid to the welfare of the animals, understanding that welfare and productive performance are closely connected.

CONCLUSIONS

The farm of the Moara Domneasca teaching station accommodates Montbeliarde cows, brought in from France 10 years ago, this breed being characterized by good adaptability, resistance and hardiness.

The analysis of milk production over 4-month experimental period indicated that milk production was lower in the month with the highest temperature, although, physiologically, the lactation curve was ascending.

The use of precision livestock farming proves useful at farm level, because it records the microclimate parameter values throughout the day and, in case of excess level, alerts are sent to farm administrator's phone / email so he can take immediate action.

In terms of welfare, through the ANI 35 system-based evaluation showed that the farm received a good score, which places it at the "optimal welfare" level.

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REFERENCES

Berckmans, D. (2014). Precision livestock farming technologies for welfare management in intensive livestock systems. *Revue scientifique et technique (international office of epizootics*, 33 (1), 189-196.

Gavrila, M.I. (2015). *Cercetări privind aplicarea normelor de bunăstare și performanțele de producție la vacile de lapte în fermele din județul Teleorman,* Teză doctorat, USAMV București.

Gavrila, M.I., Marginean, G.E., Vidu, L., Stanciu, N. (2015). The impact of modern technology on the welfare and milk production in dairy farms. *Journal of Biotechnology, 208*

Gavrila, M.I., Marginean, G.E., Vidu, L. (2015). Study on the interrelation between animal welfare and production in dairy cattle. *Scientific Papers: Series D, Animal Science-The International Session of Scientific Communications of the Faculty of Animal Science, 58*

Kelemen, A., Mărginean, G.E., Vidu, L. (2016). Practical and theoretical aspects regarding the precision dairy farming concept in Romania. *Scientific Papers: Series D, Animal Science-The International Session of Scientific Communications of the Faculty of Animal Science,* 59

Lokhorst, K. (2018). *An introduction to Smart Dairy Farming*. Van Hall Larenstein University of Applied Sciences Publishing House

Vidu, L., Lloyd, R., Piccart, K. (2016). *Industry Innovations Report.* Data Driven Dairy Decision 4 farmers H2020-ISIB-2015-1 /696367 / 4D4F

***EU Agricultural Outlook for markets and income, 2019-2030

***www.4d4f.eu