Evaluation of the efficiency of computer monitoring based on selected parameters of dairy herd behaviour in relation to daily milk yield

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SUMMARY

The study analysed indicators of the activity and reproduction parameters of Polish Holstein-Friesian Black-and-White cows to support farmers in making decisions on breeding management. The survey included 236 cows during a 305-day lactation period, kept in an open-sided free-stall barn, before and after implementation of the DeLaval DelPro complete computer management system. The study evaluated the motor activity and breeding parameters of cows assigned to three groups, I, II, III, with daily milk production of <20 kg, 20–25 kg and >25 kg, respectively. It was demonstrated that the highest-yielding cows spent more time (12.5 vs 10.5 h/day) lying down and resting than the lowest-yielding cows. The highest motor activity (29.66% of the herd) was observed in the morning between 3:00 AM and 6:00 AM, and the lowest (6.78% of the herd) in the evening between 9:00 PM and 00:00. The monitoring significantly (P ≤ 0.05) improved all evaluated breeding parameters (insemination index, inter-pregnancy interval, and calving interval) in the highest-yielding group of cows. Based on the outcomes, the use of livestock management software should be recommended to improve the welfare and breeding parameters of Polish Holstein-Friesian Black-and-White cows.

KEY WORDS: dairy cows, welfare, activity, reproduction parameters, computer monitoring
INTRODUCTION

Milk in Poland is mainly produced by livestock farms specializing in supplying milk for market needs. These farms aim to increase productivity, improve milk quality, and reduce production costs (Barłowska et al., 2014; De Vires, 2017; Infascelli et al., 2021; Pytlewski et al., 2022). Maximization of the production yield of large-scale farms is inversely proportional to the animals’ life quality. Intensified rearing has a severe negative effect on animal welfare, understood as a state of harmony between the animal and its environment. The key to success is to ensure optimum satisfaction of life needs while maintaining maximum production yield. Dairy cows’ behaviour is the most reliable indicator of their welfare (Guliński et al., 2014; Kokocińska and Kaleta, 2016; Gu et al., 2017; Mellor et al., 2020; Fan et al., 2022). Fogsgaard et al. (2012) and Baragan et al. (2018) demonstrated that the daily activity of cows depends on their health status. Prolonged standing and reduced total lying duration, with increased step counts and decreased overall activity, can result from induced mastitis (Fogsgaard et al., 2012). The daily lying time of cows diagnosed with clinical metritis has also been shown to be increased (628.9 vs 591.2 min/d) relative to cows without clinical metritis (Barragan et al., 2018).

For the livestock farmer, access to up-to-date information on individual cows, a group, or the whole herd of cows is essential (Szlachta, 2008). High technology, including herd management software, responds to the increasing challenges. Computer systems for cattle monitoring offer long-term and scheduled herd management and can increase the efficiency of dairy cattle farming, owing to reporting on the milk yield, health status and motor activity of cows, aimed at improving their reproductive capacity (Mordak, 2008; Gu et al., 2017). Modern technologies for monitoring the motor activity of a herd involve the use of various devices, including pedometers, transponders, and activity monitors, and counting the animals’ steps (Vessies et al., 2014). These techniques are safe for animals and non-invasive. Computer systems provide an opportunity to optimize nutrition, decrease the incidence of gastrointestinal and udder diseases, manage rearing programmes, and reduce herd management time, thereby boosting profitability and efficiency (Fan et al., 2022). The available literature lacks information about the effectiveness of computer monitoring of cows with different levels of milk yield on their feeding behaviour and motor activity. Therefore, research was undertaken to analyse indicators of activity and reproduction parameters in Polish Holstein-Friesian Black-and-White cows in order to support farmers in taking decisions on breeding management.

MATERIAL AND METHODS

The study involved 236 Polish Holstein-Friesian Black-and-White cows during a 305-day lactation period, kept in an open-sided free stall barn on a farm situated in the Lublin region. The subjects were selected following analysis of data derived from computer monitoring by the Polish Federation of Cattle Breeders and Dairy Farmers (PFHBiPM), due to the completeness of the information. The cows were allocated to three groups (I, II, and III), depending on their daily milk yield according to the PFHBiPM data (Table 1).
Observations of selected reproduction parameters were conducted before and after implementation of the DeLaval DelPro complete computer management system in free-stall barns for dairy cattle. The system relies on wireless communication with the computer to send milk yield and breeding data.

The cows’ motor activity was evaluated based on the number of their steps (measured with Pedometer Plus), depending on the time of day and taking the cows’ daily rhythm into account. The daily activity of cows, including lying and resting, was analysed twice a month in each group.

The breeding parameters of cows were derived from the computer system based on the following:
- calving interval (CI), expressed as days between two consecutive calving dates
- inter-pregnancy interval (IPI)
- number of insemination procedures per conception

The effects of monitoring and group were analysed by statistical methods using a two-way analysis of variance in a cross-classification design with more than one observation in a subclass, according to the following linear model:

$$Y_{ijk} = \mu + M_i + G_j + (M \times G)_{ij} + e_{ijk}$$

where:
- $Y_{ijk}$ – value for trait
- $\mu$ – overall mean
- $M_i$ – fixed effect of monitoring, $i = 1, 2$ (before, after)
- $G_j$ – fixed effect of group, $j = 1, 2, 3$ (<20 kg, 20–25 kg, >25 kg)
- $(M \times G)_{ij}$ – interaction
- $e_{ijk}$ – sampling error

The significance of differences between means was verified at the significance level $\alpha \leq 0.05$. The data were tested using the post-hoc Tukey test. The results were processed with STATISTICA PL 13.3 software (2022).

RESULTS AND DISCUSSION

Table 2 presents the results of the ethological study of cows.
Table 2. Basic daily activities of dairy cows according to daily milk yield under computer monitoring

<table>
<thead>
<tr>
<th>Activity (h/24h)</th>
<th>Group I &lt; 20 kg</th>
<th>Group II 20-25 kg</th>
<th>Group III &gt; 25 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lying down, resting</td>
<td>x̅ 10.5</td>
<td>12.0</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>min 9.5</td>
<td>9.5</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>max 12.5</td>
<td>13.5</td>
<td>14.5</td>
</tr>
<tr>
<td>Feeding</td>
<td>x̅ 6.5</td>
<td>7.5</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>min 5.5</td>
<td>6.5</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>max 7.5</td>
<td>8.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Staying outside the box</td>
<td>x̅ 7.0</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>min 4.5</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>max 9.5</td>
<td>6.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The research showed that the highest-yielding cows (group III) spent more time (12.5 vs 10.5 h/day) lying down and resting than the lowest-yielding ones (group I). The analysis of feeding behaviour revealed that feed intake time was shorter (5.5 h/days) in cows with the lowest daily milk yield than in the highest-yielding cows – group III (8.0 h/day). Huzzey et al. (2006) and Benz et al. (2014) noted that the daily milk yield level affected the feeding behaviour of cows. DeVries and Keyserlingk (2009) claim that pushing feed up encourages cows to approach the feed bank, while Niu et al. (2014) and Kaczor and Kaczor (2019) demonstrated that feeding time determined the daily feed-intake rhythm and resting behaviour of cows.

According to Matzke (2003) and Deming et al. (2013), cows spend on average 5.5 hours eating, 11.8 h resting, 0.5 hours staying in their cubicles, and 0.5 h drinking water. Similarly, Gomez and Cook (2010) noted that the Holstein-Friesian cows kept in a free-stall barn spent 4.3 hours grazing and 11.9 hours resting. Dollinger and Kaufman (2013) reported considerably shorter feed intake time for cows (177.8 to 189.4 min/day). Grant and Albright (2001) suggest that cows require approximately 10 h/day lying or resting time. Recognized benefits of adequate resting time (up to 14 h/day for the most productive cows) include reduced stress on the feet, reduced lameness, increased feeding activity, increased rumination activity, and better overall health (Grant, 2006). According to Cooper et al. (2007) and DeVries et al. (2011), optimum lying time is necessary for sufficient rumination, but also very important psychologically. Grant (2003) claims that longer lying time can be associated with reduced frequency of lameness and increased blood flow to the udder. High-yielding cows have a particularly high requirement for lying down.

The work also analysed the daily motor activity of cows prior to oestrus. Figure 1 presents the results in graphic form.
Cows showed the highest motor activity (29.66% of the herd) in the morning between 3 AM and 6 AM and the lowest (6.78% of the herd) in the evening between 9 PM and 12 AM.

Fogsgaard et al. (2012) and Barragan et al. (2018) report that factors such as disease, hoof correction, and lack of rest can disturb cows’ daily cycle. These elements can also have other adverse effects, such as reducing feed intake, breeding, or milk production (González et al., 2008; Palmer et al., 2012).

Decreased fertility can be due to management errors, indigestion, and metabolic disorders resulting from a poor-quality diet, a negative energy balance, and genetic selection mainly oriented towards milk yield (Chagas et al., 2007).

Analysis of motor activity can help in determining the best time for successful insemination of cows, which improves breeding performance. Monitoring of cattle activity was shown to decrease the number of services per conception, irrespective of milk yield (Table 3).
Table 3.  
Selected reproductive parameters of cows with different daily milk yield levels before and after the use of monitoring

<table>
<thead>
<tr>
<th>Item</th>
<th>Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 20 kg</td>
<td>20-25 kg</td>
</tr>
<tr>
<td></td>
<td>( \bar{x} ) SD</td>
<td>( \bar{x} ) SD</td>
</tr>
<tr>
<td>Insemination index</td>
<td>before</td>
<td>2.32 (^b) 0.97</td>
</tr>
<tr>
<td></td>
<td>after</td>
<td>2.00 (^b) 0.66</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.16 (^y) 0.80</td>
</tr>
<tr>
<td>Inter-pregnancy interval (days)</td>
<td>before</td>
<td>127 (^b) 21.15</td>
</tr>
<tr>
<td></td>
<td>after</td>
<td>124 (^b) 18.75</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>126 (^y) 19.98</td>
</tr>
<tr>
<td>Calving interval (days)</td>
<td>before</td>
<td>409 (^b) 26.55</td>
</tr>
<tr>
<td></td>
<td>after</td>
<td>407 (^b) 30.52</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>408 (^y) 27.62</td>
</tr>
</tbody>
</table>

\(^a\) means within the column for a given trait (insemination index, inter-pregnancy interval, or calving interval) for factor M, are significantly different at \( P \leq 0.05 \).  
\(^x, y\) – means with different superscripts in rows for groups (I, II, and III) for factor G, are significantly different at \( P \leq 0.05 \).  
\(^a, b\) – means with different superscripts indicate an interaction [(MxG)ij] at \( P \leq 0.05 \).

A significantly \( (P \leq 0.05) \) more favourable insemination index \((2.86 \text{ vs } 4.05)\) following implementation of monitoring was noted in cows with the highest daily milk yield. The average value improved by 0.52 \((P \leq 0.05)\) for the whole herd. According to Mordak (2008), monitored farms should have an insemination index close to 1.5. A value of about 2 is acceptable, but values of 3 and higher indicate major problems with breeding organization and herd health. According to Dejneka (2017), repeated insemination of cows in high-yielding herds is the result of misinterpretation of oestrus symptoms. However, repeated oestrus is most often associated with embryonic death or corpus luteum insufficiency.

After the implementation of monitoring, the inter-pregnancy interval (IPI) in the group of high-yielding cows (group III) was favourably reduced by 16 days \((P \leq 0.05)\), while the IPI for the whole herd was 6 days shorter \((P \leq 0.05)\). According to Wierzbowski and Żukowski (2007), if a cow is expected to give birth to one calf a year, the inter-pregnancy interval should be 80 days, whereas the IPI for high-yielding cows is normally 120–150 days, which is consistent with the results of our study.

The calving interval (CI) is the time between consecutive calving days, measured in days. Our study showed that the calving interval was reduced \((P \leq 0.05)\) by 13 and 7 days, respectively, for the...
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highest-yielding cows (group III) and the whole herd after implementation of computer management. The mean CI exceeded 400 days. According to Krzyżewski et al. (2004) and Bauer and Jarnecka (2019), the standard CI should be 365 days, but breeders do not comply with this standard. They often extend the CI due to the use of breeds with high yield potential, including Polish Holstein-Friesian (HF) Black-and-White and Red-and-White cows (Jankowska et al., 2012).

The calving interval (CI) is also one of the most important fertility indicators. Jankowska et al. (2014) believe good fertility in a herd is the basis for cattle farming and breeding, as calf delivery is a factor triggering milk production. Numerous papers (Guliński et al., 2004; Szewczuk et al., 2013) demonstrate that increased milk yield accompanied an extended CI. However, an excessive calving interval can lead to economic losses.

The results of the study are in agreement with the findings of many authors (Dillon et al., 2006; Macdonald et al., 2008; Norman et al., 2009), who have observed antagonism between fertility and overall milk yield in cow herds.

CONCLUSION

Livestock management software should be recommended, as the results of the study showed a significant improvement in the welfare and reproduction parameters of Polish Holstein-Friesian Black-and-White cows following its implementation, especially at > 25 kg daily milk yield.

REFERENCES

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The research was financed with funds designated for charter objectives, project no 166/23/B.