Reproductive management and its associations with performance on large commercial Holstein-Friesian dairy farms

Summary of PhD thesis

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Budapest
2018
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1. Introduction and aims of the studies

Reproductive performance of dairy herds has been in the focus of attention in the recent decades. According to the results of the international and Hungarian surveys, suboptimal reproductive performance can lead to 150,000-300,000 EUR annual loss in a 1000-cow commercial dairy herd. Therefore, dairy producers make every effort in improving reproductive results, and invest a lot in implementing new techniques and protocols. However, it seems that the declining trend in reproductive performance has come to an end in the recent years both in Hungary and in the USA.

A wide range of technologies and products for reproductive purposes are developed and marketed for dairy herds. Considering the management of estrus in cows it is possible to perform the insemination based on the observed estrus, but also estrus detection aids can be used (pedometers, activity meters, tail chalks, pressure-activated estrus detectors, etc.). Moreover, the farm management may decide to apply hormonal synchronization protocols (e.g. Ovsynch, Cosynch, Presynch-Ovsynch, Double-Ovsynch and their different variants) and perform fixed-time artificial insemination. Efficient reproductive management in dairy cattle requires that the farm manager makes beneficial choices from the available protocols and techniques that will fit into the circumstances of the given farm and will presumably improve effectiveness of the management.

The management of reproduction and its impact on profitability in dairy herds is one of the most complex areas of animal health economics. The aims of our studies were:

- to survey the reproductive management practices and the most important reproductive parameters of Holstein-Friesian heifers and cows in large commercial dairy herds in Hungary,
- to explore the associations between management practices and reproductive parameters in heifers and cows, and
- to assess the relationship of parity and management practices with reproductive performance of cows.
2. Data collection

Information about the management practices applied to heifers and cows were gathered between 22 May and 6 November 2015 during personal interviews performed on farm visits in 34 large Holstein-Friesian dairy herds in Hungary. The inclusion criteria for the farms were as follows: (1) use of computerized on-farm records, (2) continuous participation in milk recording at least since 1 January 2011, (3) herd size above 250 cows, and (4) willingness to provide data to the authors. At least two dairy herds were surveyed from each of the seven regions of Hungary (Figure). The total number of cows in the surveyed herds was 25,672 (as of 1 January 2014) that accounted for 14.6% of the Hungarian milk recorded Holstein-Friesian population. Farm managers and veterinarians of each herd were interviewed about the management practices applied to heifers and cows in 2014. Individual animal data from the farms participating were gathered from the Livestock Performance Testing Ltd. (Gödöllő, Hungary). Herd, animal ID, date of birth, date and number of inseminations, results of pregnancy diagnoses, date and number of calvings, 305-day milk yield and culling date were collected. The number of individual animal records taken into account in the analyses are indicated in the respective chapter of the thesis. Data were managed in Microsoft Excel 2013 (Microsoft Corporation, Redmond, WA, USA).

Figure. The number of surveyed farms and their cumulative herd size in each of the statistical regions of Hungary.
3. Dairy heifer reproductive management and performance on large Hungarian commercial farms

The aim of this study was to survey the reproductive management practices and to evaluate the reproductive performance of replacement heifers in large commercial dairy herds.

3.1. Materials and methods

The survey of reproductive management practices applied to heifers contained questions regarding estrus detection, insemination, culling policy, pregnancy diagnosis, housing and feeding. Individual data of 50,396 heifers first inseminated between 1 January 2011 and 31 December 2014 were analyzed. Age at first service (AFS), first-service conception risk (CR1), age at first calving (AFC), days from first service to culling (FSC) and age at culling (AC) were calculated.

3.2. Results

Mean size of the surveyed herds was 755 cows (range: 291–2,502), with a 10,014 kg (range: 8,330–12,541 kg) 305-day corrected milk yield, on average. Heifers were first inseminated at 15.53 ± 1.59 months of age (mean ± SD). 8.6% of the inseminated heifers were culled or died prior to first calving; these heifers exited from the herd 246.25 ± 107.1 days after first AI, at 23.94 ± 3.95 months of age. Altogether 46,085 heifers reached first calving. 47.10% of those heifers that calved had conceived to first service. Following 276.66 ± 4.47 days of gestation, heifers calved at 25.61 ± 2.22 months of age.

A reproduction advisor was employed by 50.0% of the farms. Estrus detection aids (pedometers, activity meters, tail chalking) were used in 14.7% of the herds. Visual estrus observation was performed during daytime or in 24 hours in 52.9%, continuously in certain part of the day (e.g. in the morning) in 8.8%, and in short (≤40 min) periods in 32.4% of the herds. Estrus observation was not performed in two herds (5.9%), these farms relied on estrus detection aids, exclusively. The large majority (94.1%) of the farms used sex-sorted semen in heifers, mainly for the first and second inseminations (43.8%), but 25% of the sex-sorted semen users applied this sort of semen for the first AI only. 46.4% of the responding farms had been using sex-sorted semen for ≥ 7 years, 17.9% for 4-6 years, and 35.7% for ≤ 3 years. Early pregnancy diagnosis in heifers (by means of reproductive ultrasonography or pregnancy-associated glycoprotein examinations) was performed in 38.2% of the herds. Performing pregnancy checks weekly was the most prevalent practice (34.4%), however, diagnosing pregnancy in heifers on a monthly basis was very common (25.0%), as well. On the majority of the farms (79.4%) pregnancy status was not confirmed after the initial diagnosis.
4. Associations between management practices and major reproductive parameters of Holstein-Friesian replacement heifers

In this study we aimed to assess the associations between management practices and the major reproductive indices in dairy heifers on large commercial dairy farms.

4.1. Materials and methods

In this study the associations of 13 general and reproductive management practices with the major reproductive parameters of heifers were analysed. Data of heifers first inseminated between January 1, 2014, and December 31, 2014, were analysed retrospectively. One farm had only 12 complete heifer records, and therefore was excluded from the study. After data editing, a total of 14,763 heifers from 33 farms remained in the dataset. AFS, AFC, CR1 and pregnancy status at 20 months of age were evaluated. The relationships between the continuous variables (i.e. AFS, AFC) and the management practices were examined by linear mixed effects models using the lme4 package in R software. The relationships between dichotomous dependent variables (i.e. CR1, pregnancy status at 20 months of age) and reproductive management practices were analysed by logistic regression, including mixed effects using the lme4 package in R software. Univariate analyses were performed, and in each mixed model a reproductive parameter was the outcome variable, whereas a management practice was included as a fixed effect, whereas herd was chosen as a random effect. When three options were examined within a given management practice, pairwise comparisons of the options were performed by Tukey’s post-hoc test using the glht procedure from the multcomp package in R. The statistical analyses were performed in R version 3.3.2.

4.2. Results

Altogether, 14,763 heifers were inseminated during the study period, and these were included in the analyses of AFS and CR1. First calving was achieved by 13,818 heifers, and these were included in the analysis of AFC. Few inseminated heifers were culled or died before 20 months of age; therefore, pregnancy status at 20 months of age was assessed in 14,608 heifers.

Median AFS and AFC were 15.16 and 24.97 months, respectively (interquartile range, IQR = 1.55 and IQR = 2.34, respectively). 49.6% of the first inseminations were successful. In the herds, 89.6% of the heifers were pregnant by 20 months of age.

Employing a reproduction advisor was associated with higher success rates for first inseminations (p=0.028). The use of estrus detection aids was associated with reduced AFS and AFC compared to solely visual observation (p<0.001 and p=0.001, respectively). The use
of estrus detection aids showed a tendency toward higher probability of pregnancy at 20 months of age (p=0.074).

Heifers from herds with discontinuous estrus observation tended to have lower AFC than their companions that were subject to continuous observation (p=0.057); however, the lowest AFC was achieved when no visual observation was performed. A larger number of 20-month-old heifers were pregnant in herds with discontinuous estrus observation compared to those with visual estrus detection throughout the day (p=0.020).

The exclusive use of conventional semen was associated with higher AFS and CR1 compared to the farms which use sexed semen (p<0.001 and p<0.05, respectively). On farms where conventional semen was used exclusively, AFC was higher than that on farms that used sexed semen only for the first AI (p=0.049). The probability of pregnancy at 20 months was lower in heifers from herds which had less experience (1-3 years), compared to those who had at least 4 years of experience, in sexed semen use (p=0.020).

Reproductive ultrasonography was not associated with any of the analysed parameters in heifers. Checking pregnancy status more than once per week was related to lower AFC, compared to weekly or less frequent pregnancy checks (p=0.023). The probability of pregnancy in 20-month-old heifers was higher when a pregnancy recheck was performed (p=0.009).
5. Reproductive management and major fertility parameters of cows in large-scale Hungarian dairy herds

In this study we aimed to assess the major reproductive parameters and the reproductive management practices applied to cows on the surveyed farms.

5.1. Materials and methods

In this study, the major production and reproductive parameters, and the management practices including estrus detection, ovulation synchronization, insemination, pregnancy diagnosis, calving, housing and feeding were surveyed in 34 dairy herds regarding 2014.

5.2. Results

The number of cows on the surveyed farms (as of 1 January 2014) was 755 ± 470 (range: 291 – 2,502), with a 305-day milk yield of 10,014 ± 965 (range: 8,330 – 12,541 kg), on average. The mean number of lactations in the herds was 2.2 ± 0.2. On an annual basis, 29.5 ± 8.2% of the cows were culled, and 31.7 ± 16.5% of these occurred due to reproductive reasons. The mean calving interval, number of services per conception and first-service conception risk were 435.2 ± 23.7 days, 4.0 ± 0.7 and 26.5 ± 9.4%, respectively.

A voluntary waiting period after calving was applied in 76.5% of the herds, with an average length of 50.2 days (range: 30 – 80 days). Visual observation was the predominant method of searching for cows in estrus (88.2%), activity monitoring devices were used in 67.6%, and tail chalking was applied in 20.6% of the herds. On 79.4% of the farms estrus synchronization was performed; 74.1% of these farms applied the Ovsynch protocol. In those herds that did not apply ovulation synchronization (20.6%) estrus was induced by prostaglandin products. Sexed semen was used for cows in 8.8% of the herds, but in all of these herds the decision to inseminate cows with sexed semen was based on strict criteria (e.g. primiparous cows, showing pronounced estrus signs, not synchronized, high milk production, rather in the cold seasons). The average time of the first pregnancy check was 35.1 days (range: 27–60 days) after insemination, which was performed via transrectal ultrasonography in 67.6% and by pregnancy-associated glycoprotein tests in 5.9% of the herds. Regarding pregnancy diagnosis frequency, weekly pregnancy check was the most prevalent practice (48.5%), pregnancy diagnoses were performed > 1x per week on 30.3%, and < 1x per week on 21.2% of the farms. Pregnancy status was rechecked once in 47.1% and twice in 32.4% of the herds.

Regarding heat abatement, 88.2% of the farms used ventilators in the milk producing barns, whereas only 64.7% of the farms used sprinklers to cool cows, as well. Daily milk production was the most prevalent criterion in reproductive culling decisions (94.1%).
6. Management practices associated with reproductive performance in Holstein cows on large commercial dairy farms

The aim of this study was to examine and evaluate the associations of herd characteristics, general and reproductive management practices in cows with reproductive indices on large commercial dairy farms.

6.1. Materials and methods

The data of cows that calved between 1 January 2014 and 31 December 2014 were analysed. After data editing a total of 23,784 cows from 34 farms remained in the dataset. The associations of the management and fertility practices with the following reproductive indices were evaluated: days to first service (DFS; n = 19,796), breeding interval (IBI; n = 11,648), calving to conception interval (CCI; n = 15,709), first-service conception risk (CR1; n = 19,796) and pregnancy status at 200 days in milk (P200; n = 19,134). The statistical methods were basically the same as those used in heifers (Chapter 4.), but in this study the emmeans R package was used in addition to the lme4 package, as well. In this study, those management practices that were not independent based on the Fisher’s exact test (p < 0.05) were analysed together as fixed effects, and herd was the random effect. The statistical analyses were performed in R version 3.4.0.

6.2. Results

Regarding heat abatement we found that ventilation with sprinklers was associated with the shortest breeding interval (p < 0.01), the shortest calving to conception interval (p < 0.01), and the highest odds of being pregnant by 200 days in milk (p < 0.01). Solely ventilation showed similar (p > 0.05) results to no heat stress protection. Lack of a well-established voluntary waiting period (VWP) or a VWP shorter than 50 days was associated with less days to first service (p < 0.01), shorter breeding interval (p < 0.01) and calving to conception interval (p < 0.05), as well as higher odds of carrying a calf by 200 days in milk (p < 0.01) compared to those using a VWP of at least 50 days. Those farms that applied transrectal ultrasonography with one of the aforementioned practices were more likely to use ventilation with sprinklers (p = 0.03), hormonal synchronization (p < 0.01) and to perform early pregnancy diagnosis followed by pregnancy recheck (p = 0.03). The application of transrectal ultrasonography with one of the aforementioned practices was associated with reduced days to first service (p < 0.05), shorter breeding interval (p < 0.05) and higher odds of pregnancy at 200 days in milk (p < 0.05).
7. Relationship of parity and management practices with reproductive performance in Holstein-Friesian dairy cows

In this study we aimed to analyse the associations among management practices and reproductive performance by parity in dairy cows.

7.1. Materials and methods

Individual data of 23,781 cows that calved between 1 January 2014 and 31 December 2014 on the farms were analysed retrospectively (9,346 primiparous and 14,435 multiparous cows). The associations of the parity and the management practices with the following reproductive indices were analyzed: days to first service (DFS), breeding interval (IBI), calving to conception interval (CCI), first-service conception risk (CR1) and pregnancy at 200 days in milk (P200). The statistical methods were basically the same as those used in heifers (Chapter 4.). However, in the mixed models used in this study, parity and a management practice and the interaction between parity and management were included as fixed explanatory variables, and herd was the random effect. The statistical analyses were performed in R version 3. 4. 0.

7.2. Results

Primiparous cows had shorter breeding interval (p < 0.001), higher first-service conception risk (p < 0.001), and reduced calving to conception interval (CCI, p < 0.001) compared to multiparous animals, moreover, primiparous cows were more likely to be pregnant by 200 days in milk (p < 0.001).

Lack of a voluntary waiting period and a VWP shorter than 50 days were linked to larger improvement in calving to conception interval (p = 0.015) and probability of pregnancy at 200 days in milk (p < 0.001) in multiparous cows. Primiparous cows experienced larger improvement in days to first service (p < 0.001), breeding interval (p = 0.026), calving to conception interval (p = 0.005) and pregnancy status at 200 days in milk (p < 0.001) than their multiparous counterparts when estrus synchronization was used (vs. not used). Early pregnancy diagnosis was associated with larger advantage in primiparous compared to multiparous cows regarding breeding interval (p = 0.001), calving to conception interval (p = 0.006) and pregnancy status at 200 days in milk (p < 0.001). Pregnancy recheck was associated with larger improvement in primiparous compared to multiparous cows regarding breeding interval (p = 0.002), first-service conception risk (p = 0.020), calving to conception interval (p < 0.001) and pregnancy status at 200 days in milk (p < 0.001).
8. Discussion

8.1. Heifers

The heifers involved in our research were first inseminated later than optimal and their first-service conception risk could be improved, as well, since 47.0-67.8% success rate of first inseminations can be found in the literature. Age at first calving is the economically most important reproductive index of dairy heifers, since it determines the length of the non-productive period until the first lactation. However, the mean AFC in our research was better than that in many other studies, but it was still much higher than the economically optimal age (23-24 months). Therefore, lowering AFC could result in significant economic benefit.

The use of estrus detection aids was associated with better reproductive indices in our study. On the large commercial farms involved in our studies, the large number of replacement heifers could potentially limit the efficiency of visual observation; therefore, the use of estrus detection aids was advantageous. Observing estrus only in certain periods of the day instead of continuous visual estrus detection was related to improved AFS, AFC and probability of pregnancy at 20 months of age in dairy heifers. Visual observation was more efficient when performed only at certain parts of the day, which in most cases meant short periods (≤ 40 minutes) dedicated to observation, probably due to the responsible employee’s higher level of commitment to this activity. Higher AFS among exclusive conventional semen users was presumably related to some other management decision, not to the semen type itself. Possibly, herds not inseminated with sexed semen experienced poor heifer fertility, and farmers tried to compensate for this by using exclusively conventional semen, which generally yields higher success rates compared to sexed semen; however, it is also possible that CR1 was reduced due to the use of the sexed semen itself. The use of reproductive ultrasonography was not associated with an improvement in the parameters; this might be caused by better heifer fertility, which diminishes the possible gain acquired by early pregnancy diagnosis via transrectal ultrasonography, coupled with less frequent pregnancy checks compared to cows. Performing pregnancy checks frequently (more than once a week) was linked to reduced AFC, possibly because the time lost until open heifers were found was reduced. Pregnancy recheck was lacking on the majority of farms, however, this practice tended to be associated with reduced AFC, and was related to a greater chance of pregnancy at 20 months of age. This suggests the need for pregnancy rechecks, despite pregnancy wastage being more common in cows than in heifers.
8.2. Cows

It has become clear that the benchmark values of reproductive parameters often used in Hungary are outdated, because even the best performing herds were unable to achieve these values (calving interval: 365-395 days; first service conception risk: 50-60%; services per conception: 1.5-2.2).

In our study, ventilation coupled with sprinklers was associated with the best reproductive performance, however, applying ventilation fans only was hardly better than using none of the available heat abatement methods. Efficient heat abatement is very important, since the metabolic rate of lactating dairy cows is so high, that they are extremely sensitive to heat stress. The application of a minimum 50-day long voluntary waiting period was associated with longer time to first insemination, longer breeding interval and delayed conception after calving, resulting in a lower proportion of pregnant cows by 200 DIM, but no relationship was found with the success rate of first inseminations. Multiparous cows experienced larger improvement in time to conception postpartum when VWP was not applied vs. when VWP was applied, than primiparous cows, which suggests that lack of a minimum 50-day-long VWP is more beneficial for multiparous cows. The use of hormonal synchronization protocols was associated with the application of transrectal ultrasonography, but no associations between synchronization and reproductive parameters were found. When analysed by parity, the use of hormonal synchronization protocols was related to a larger advantage in terms of DFS, IBI, CCI and P200 in primiparous compared to multiparous cows, which confirms that synchronization programmes behave differently in primi- and multiparous cows. Estrus synchronization protocols have become so popular, because herds with poor oestrus detection are able to shorten DFS and CCI, however, CR is often negatively affected. The most widespread method of pregnancy diagnosis in cows was transrectal ultrasonography. Farms that applied transrectal ultrasonography were more likely to use ventilation with sprinklers for heat abatement, hormonal synchronization protocols, and to perform pregnancy recheck. Those reproductive management programs that applied ultrasonography were generally superior regarding reproductive performance compared to those that did not use this practice. Performing early pregnancy diagnosis was associated with larger improvement in the reproductive parameters in primiparous cows compared to the multiparous animals. Early pregnancy diagnosis methods create the opportunity to identify cows that fail to conceive early postbreeding, and coupled with management measures aiming at the quick reinsemination of open cows IBI can be reduced.
9. Conclusions and suggestions

Despite the common perception that heifer fertility is much less problematic than cow fertility, huge production losses might occur in this area due to the extended non-productive period of replacement heifers. Reproductive management of heifers is much less intensive than that of the cows, however, our studies have shown that a number of intensive reproductive management practices is associated with improved reproductive performance. Our results suggest that the implementation of estrus detection aids (pedometers, activity meters, tail chalking), observing estrus for short (< 40 min) periods instead of continuously, and frequent pregnancy checks (i.e. more than once per week) are associated with younger age at first calving. Moreover, there are still large opportunities in improving tracking of growth rate in heifers, which is a fundamental element of reaching optimal age at first calving. Therefore, the use of these practices is suggested to improve the reproductive results of replacement heifers.

The reproductive performance of primi- and multiparous dairy cows is far from the optimum values that were established decades ago. This has two implications: (1) the optimum values of reproductive parameters are outdated and should be reconsidered, and (2) further improvements are needed in the reproductive management of dairy cows. Technologies and protocols that are associated with better reproductive results are used on many – but not all – dairy farms. Those herds that use transrectal ultrasonography (usually together with ventilation and sprinklers, hormonal synchronization, and pregnancy recheck) achieve better reproductive results. The application of voluntary waiting period should be improved (e.g. by using dynamic voluntary waiting period), because the present approach of this practice is not advantageous. Moreover, the efficiency of the efforts made is sometimes suboptimal: e.g. farm managers strive to protect cattle against heat stress, but due to the errors in planning, implementation or due to technical maintenance problems, sprinklers are not used, only the ventilation fans are turned on, and the efficiency of heat abatement is significantly deteriorated. Our studies have also shown that the associations of reproductive management practices and parameters are different in primi- and multiparous cows. The application of estrus synchronization, and performing early pregnancy diagnosis with recheck are associated with larger improvement in calving to conception interval in primi- than in multiparous cows.

If the efficiency of reproductive management on a dairy farm is improved, the relative cost of reproductive management decreases. Therefore, efficient reproductive management is essential for sustainable and profitable dairy production.
10. New and novel results

1. The use of estrus detection aids (pedometers, activity meters, tail chalking) was associated with significantly reduced age at first service and first calving in heifers.

2. Observation of estrus for short (< 40 min) periods instead of all day long was associated with significantly higher probability of pregnancy at 20 months of age. The probability of pregnancy by 20 months of age was significantly higher when farms had at least four years of experience in sexed semen use compared to less experienced sexed semen users. Heifers calved at a significantly younger age on farms performing pregnancy diagnosis more than once per week.

3. Most large commercial dairy herds applied heat abatement methods. However, on a significant proportion of farms ventilation was used without sprinklers. Ventilation with sprinklers was associated with the shortest breeding interval, the shortest calving to conception interval, and the highest odds of being pregnant by 200 days in milk. Solely ventilation showed similar results to no heat stress protection in the milk producing barns.

4. Lack of a voluntary waiting period (VWP) or a < 50-day-long VWP was associated with reduced calving to conception interval compared to those farms that used a VWP of ≥ 50 days. The improvement was larger in multiparous than in primiparous cows.

5. Transrectal ultrasonography was usually applied together with ventilation and sprinklers, hormonal synchronization, and pregnancy recheck, and was associated with reduced days to first service, shorter breeding interval, and higher odds of pregnancy at 200 days in milk. Primiparous cows experienced larger improvement when transrectal ultrasonography was used (vs. not used) compared to their multiparous herdmates.
11. Scientific publications

11.1. Publications related to the topic of the dissertation

11.1.1. Full text papers in peer-reviewed journals


11.1.2. Books, book chapters, monographs


11.1.3. Presentations at international conferences


Fodor I., Ózsvári L.: How to better use the resources available on dairy farms through herd health management. In: Káposzta J. (ed.): Multifunctionality and Regional Development. 3-5 October 2013, Gödöllő, Hungary. 80-85.


11.1.4. Presentations at Hungarian conferences


11.2. Publications not related to the topic of the dissertation

11.2.1. Full text papers in peer-reviewed journals


11.2.2. Presentations at international conferences


Fodor I., Biczó A., Matyovszky B., Ózsvári L.: Decision analysis of the surgical correction of left displaced abomasum in a large-scale dairy herd. 25th Jubilee International Congress
of the Hungarian Association for Buiatrics. 13-16 September 2015, Budapest, Hungary. Magy. Állatorvosok Lapja, 137 (Suppl. 1) 103-104. (in Hungarian with English abstract)


11.2.3. Presentations at Hungarian conferences


11.2.4. Other scientific publications

Fodor I., Ózsvári L.: How to better use the resources available on dairy farms through herd health management. Journal of Central European Green Innovation, 2. 43-50. 2014