

Animal welfare, etológia és tartástechnológia



Animal welfare, ethology and housing systems

Volume 14

Issue 1

Gödöllő
2018

EARLY PREGNANCY DIAGNOSIS ON LARGE DAIRY FARMS AND ITS ROLE IN IMPROVING PROFITABILITY LITERATURE REVIEW

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Received – Érkezett: 04. 04. 2018.
Accepted – Elfogadva: 02. 07. 2018.

Abstract

The authors reviewed the factors related to the accuracy of the early pregnancy diagnosis methods used on dairy farms, and summarized the results of the studies on the production and economic consequences of early pregnancy diagnosis. Transrectal ultrasonography and pregnancy-associated glycoprotein tests allow for accurate diagnosis about one week earlier than rectal palpation. Therefore, the breeding interval can be shortened and days open can be reduced. However, a drawback of the early diagnosis is that a larger proportion of the naturally occurring pregnancy losses is observed. Since iatrogenic pregnancy loss is more costly than the increase in the number of open days, it is important to use a diagnostic method with high sensitivity and negative predictive value. The economic advantage of early pregnancy diagnosis is higher in herds with poor reproductive performance. Higher cost per day open and larger herd size result in shorter payback time of the investments in early pregnancy diagnosis methods.

Keywords: pregnancy diagnosis, dairy cattle, economics

A nagy létszámú tejelő tehenészetekben alkalmazott korai vemhességvizsgáló módszerek és szerepük a termelés jövedelmezőségében. Irodalmi áttekintés

Összefoglalás

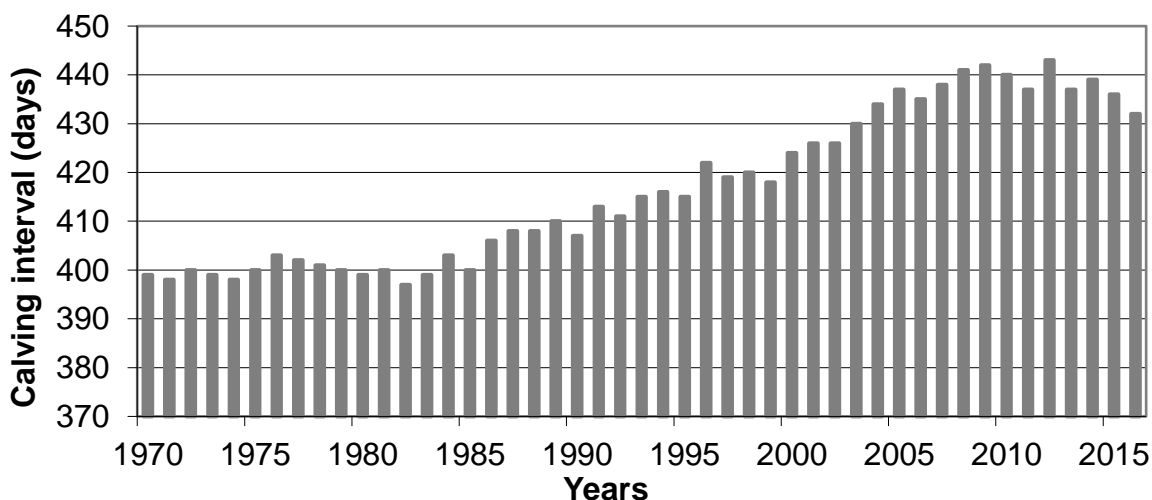
A szerzők ismertetik a tejelő tehenészetekben alkalmazott korai vemhességvizsgáló módszerek pontosságával összefüggő tényezőket, továbbá áttekintik a korai vemhességvizsgáló módszerek termelési és gazdasági következményeiről szóló kutatások eredményeit. Szaporodásbiológiai ultrahangvizsgálatok, ill. vemhességi fehérjevizsgálatok révén egy héttel hamarabb pontos diagnózishoz lehet jutni a rektális tapintással végzett vizsgálatokhoz képest. Ezáltal csökkenthető a két termékenyítés közötti és az elléstől újravemhesülésig eltelt idő. Ugyanakkor a korai vemhességvizsgáló módszerek hátránya, hogy nagyobb arányban figyeljük meg a természetes jelenségeként előforduló vemhesvesztést. Mivel a iatrogén vemhesvesztés nagyobb gazdasági kárt okoz, mint a késedelmes újravemhesülés, fontos, hogy magas szenzitivitással és negatív prediktív értékkel rendelkező diagnosztikai módszert használjanak a tehenészetekben. A korai vemhességvizsgáló módszerek által elérhető gazdasági előny nagyobb a gyengébb szaporodási eredményekkel rendelkező állományokban. Nagyobb üres naponkénti veszteség, ill. nagyobb állományméret esetén a korai vemhességvizsgáló módszerekbe történő befektetés gyorsabban megtérül.

Kulcsszavak: vemhességvizsgálat, tejelő szarvasmarha, jövedelmezőség

Introduction

Reproductive disorders are responsible for the largest economic losses among the herd-level animal health problems on the large Hungarian dairy farms (Ózsvári and Kerényi, 2004). The average calving interval increased gradually in the previous decades: it was about 420 days around the millennium, however, it extended to approximately 440 days in the 2010s (Kerényi et al., 2013). In the recent years, the increasing trend in calving interval has stopped (Figure 1) (Kerényi et al., 2013; National Food Chain Safety Office – Livestock Performance Testing Ltd., 2017). Reproductive parameters have been deteriorating for many decades worldwide, and e.g. in the US reproductive performance of dairy cattle started to improve. Ott et al. (2014) explained this beneficial change with the widespread use of reproductive biotechnology, improved management of high-yielding cows, and with the increasing importance of reproductive traits in genetic selection. Timely detection of those cows that remain open or experience embryonic/fetal mortality and their timely reinsemination is still challenging for farmers (Ott et al., 2014).

Figure 1: Calving interval in Hungarian dairy herds (1970-2016)



Source: National Food Chain Safety Office – Livestock Performance Testing Ltd., 2017

One method of finding those cows that remained open after insemination is to detect their return to estrus. However, not all open cows will show estrus signs, and many of those cows that are in estrus are not found, because of the poor efficiency of estrus detection. The other way of finding open cows after insemination is to perform early pregnancy diagnosis (actually non-pregnancy diagnosis), and to reinseminate those that did not conceive (Ferguson and Skidmore, 2013; Sheldon and Noakes, 2002; Turi, 1998).

In this article we review transrectal ultrasonography and pregnancy-associated glycoprotein (PAG) tests as means of pregnancy diagnosis. We discuss their usability and the main economic issues arising from their application.

The use of early pregnancy diagnosis methods in Hungary

Early pregnancy diagnosis is still not performed on many Hungarian dairy farms. A survey comprising 34 large dairies (25,672 cows, that was about 15% of the total Hungarian milk recorded dairy cow population) from every region of Hungary found that rectal palpation was performed exclusively on 29.4%, transrectal ultrasonography was applied on 64.7%, rectal palpation was combined with PAG tests on 2.9%, and transrectal ultrasonography was combined with PAG tests on 2.9% of the farms for pregnancy diagnosis (Fodor *et al.*, 2016a). On the contrary, a survey conducted in 2012 found that 72.1% of the responding herds performed rectal palpation, however, only 16.8% used transrectal ultrasonography for pregnancy diagnosis (Monostori, 2014). The difference between the results of the two surveys may be traced back to the large, more intensively managed herds being overrepresented in the 34-herd study.

The accuracy and usability of early pregnancy diagnosis methods, similarly to other diagnostic test, can be characterized by sensitivity (Se), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) (Table 1) (Lang *et al.*, 2013; Szenci *et al.*, 1998a).

Table 1: Observed frequencies by the result of the pregnancy examination and the true pregnancy status

Result of pregnancy examination	True pregnancy status	
	Pregnant	Open
Pregnant	a (true pregnant)	b (false positive)
Open	c (false negative)	d (true open)

Sensitivity= $a/(a+c)$; Specificity= $d/(b+d)$; Positive predictive value= $a/(a+b)$; Negative predictive value= $d/(c+d)$. Source: own construction based on Szenci *et al.* (1998a)

Early pregnancy diagnosis with transrectal ultrasonography

Transrectal ultrasound devices can be used for many purposes in the reproductive management on dairy farms: in addition to the examination of ovarian status and uterine disorders, it is also suitable for early pregnancy diagnosis and for the detection of twin pregnancies (Descôteaux *et al.*, 2006; Fricke, 2002; Palgrave and Cezon, 2011; Szelényi *et al.*, 2012). Since pregnancy status can be determined with great accuracy 26-28 days after insemination, it is a suitable tool for improving the efficiency of reproductive management, and, therefore, profitability (Chaffaux *et al.*, 1986; Descôteaux *et al.*, 2006; Fricke, 2002; Romano *et al.*, 2006). The accuracy of transrectal ultrasonography examinations has been evaluated by many authors; their results are summarized in Table 2.

The accuracy of transrectal ultrasonography improves with the days after insemination during the early stages of pregnancy. The occurrence of false negative diagnoses during early pregnancy checks was more frequent in those cows that had a large uterus, far cranial from the pelvic inlet. This can lead to pregnancy loss following PGF_{2α} treatment (Romano *et al.*, 2006; Szenci *et al.*, 1995; Szenci *et al.*, 1998b). Inaccuracies in the results of pregnancy diagnoses are influenced by the criteria of pregnancy, as well: significantly more false negative and less false positive diagnoses were made when cows were regarded pregnant if an embryo proper with a beating heart was found, compared to using allantoic fluid as the criterion of pregnancy (Szenci *et al.*, 1998a). Maximum sensitivity and negative predictive value were reached three days earlier in heifers compared to cows, and pregnancy could be diagnosed earlier in heifers, as well (Romano *et al.*, 2006).

Table 2: Sensitivity (Se), specificity (Sp), positive (PPV) and negative predictive values (NPV) of transrectal ultrasound examinations according to different studies

	Days after AI	Se	Sp	PPV	NPV
<i>Karen et al., 2015</i>	28.	92.7	91.5	88.4	94.7
<i>Romano et al., 2006</i> ¹	24.	74.5	90.3	77.8	88.6
	28.	97.6	95.6	89.1	99.1
	30.	100.0	97.4	91.9	100.0
<i>Romano et al., 2006</i> ²	21.	50.0	87.5	80.0	63.6
	24.	91.6	96.5	95.6	93.3
	26.	100.0	96.7	94.4	100.0
<i>Silva et al., 2007</i>	27.	94.2-98.9	91.7-97.3	87.3-93.8	97.1-99.5
<i>Szenci et al., 1995</i> ³	24-26.	82.9	66.7	88.7	55.2
	27-29.	97.4	91.7	97.4	91.7
	31-33.	97.4	95.8	98.7	92.0
<i>Szenci et al., 1995</i> ⁴	27-32.	80.0	100.0	100.0	57.1
	34-38.	96.6	100.0	100.0	90.0
<i>Szenci et al., 1998a</i> ⁵	26-27.	45.3	98.6	96.6	67.5
	29-30.	76.1	97.9	97.9	83.1
	33-34.	90.0	100.0	100.0	92.5
	39-42.	94.5	100.0	100.0	95.3
<i>Szenci et al., 1998a</i> ⁶	26-27.	82.8	94.5	92.9	86.4
	29-30.	90.4	96.0	95.0	92.3
	33-34.	96.6	98.6	98.3	97.3
	39-42.	100.0	100.0	100.0	100.0
<i>Szelényi et al., 2012</i>	29-35.	100.0	88.9	79.6	100.0
	36-42.	100.0	90.7	85.9	100.0

¹cows; ²heifers; ³5 MHz sector transducer; ⁴7.5 MHz linear transducer; ⁵based on embryo with proper heartbeat; ⁶based on presence of allantoic fluid

Romano et al. (2006) suggested that each veterinarian should make a decision about the timing of pregnancy diagnosis based on their own experience, lactation number of the animals, the equipment and the accuracy of their previous diagnoses in order to distinguish between pregnant and open animals with sufficient accuracy.

Based on the analysis of the data of more than 14,700 heifers, *Fodor et al. (2018b)* found that the use of transrectal ultrasonography was not associated with better reproductive performance in heifers. They explained it with better heifer fertility, which diminishes the possible gain acquired by early pregnancy diagnosis, coupled with less frequent pregnancy checks compared to cows. In the same study it was found that recheck of pregnancy status tended to be associated with reduced first calving age, and was related to a larger probability of pregnancy at 20 months of age. In cows, the application of transrectal ultrasonography was associated with reduced days to first service, shorter breeding interval and higher probability of pregnancy at 200 days in milk (*Fodor et al., 2018a*).

Pregnancy-associated glycoprotein (PAG) tests

Pregnancy-associated glycoproteins (e.g. bPSPB, bPAG-1) are produced by the trophoblast cells of the ruminant placenta, and since these molecules are specific for placental tissue, their presence in the maternal circulation indicates pregnancy (Gábor *et al.*, 2007; Piechotta *et al.*, 2011; Sousa *et al.*, 2008).

PAG tests can be used with good accuracy from day 28 after insemination (Zoli *et al.*, 1992). PAG concentration reaches an early peak around day 32 of the pregnancy, which is followed by a decrease in PAG levels that lasts for 5-6 weeks, then, after day 67-74 the PAG concentration starts to increase again, and this increase continues until the end of gestation (Ricci *et al.*, 2015; Zoli *et al.*, 1992). The transient decrease in the PAG levels increases the occurrence of false negative and repeat examinations (Ricci *et al.*, 2015).

The usability of the tests is limited by the maximum of PAG levels at the end of gestation combined with its relatively long half-life (4.3-9 days). Thus, the tests can be used only about 90 days after the previous calving, because of the PAGs remaining in the maternal circulation from the previous gestation (Gábor *et al.*, 2004; Green *et al.*, 2005; Sasser *et al.*, 1986; Sousa *et al.*, 2008; Zoli *et al.*, 1992). Moreover, PAG concentration shows individual variations, as well (Zoli *et al.*, 1992). The accuracy of the results of the PAG tests is independent from the examiner, however, it is influenced by the order of sampling and sample transportation (e.g. exchange of samples) (Gábor *et al.*, 2004). The accuracy of the PAG tests according to different authors is summarized in Table 3.

Table 3. Sensitivity (Se), specificity (Sp), positive (PPV) and negative predictive values (NPV) of pregnancy associated glycoprotein tests according to different studies

	Method	Sample	Days after AI	Se	Sp	PPV	NPV
Gábor <i>et al.</i> , 2004 ¹	bPSPB ELISA	blood	30-36.	95.1	68.6	72.6	94.1
Gábor <i>et al.</i> , 2004 ²	bPSPB ELISA	blood	30-36.	100.0	89.1	88.4	100.0
Karen <i>et al.</i> , 2015	bPAG ELISA	blood	28.	90.2	98.3	97.4	93.7
	bPAG RIA			100	94.9	93.2	100
Lawson <i>et al.</i> , 2014	bPAG ELISA	milk	33-52.	100.0	97.9	98.5	100.0
LeBlanc, 2013	bPAG ELISA	milk	≥ 60.	99.2	95.5	99.8	80.8
Piechotta <i>et al.</i> , 2011	bPSPB ELISA	blood	26-58.	98.0	97.1	99.3	91.9
	bPAG ELISA			97.8	91.2	97.8	91.2
Ricci <i>et al.</i> , 2015	bPAG ELISA	blood	32.	100	87	84	100
		milk		98	83	79	99
Romano and Larson, 2010	bPSPB ELISA	blood	28.	93.9	95.5	94.7	94.7
			30.	96.0	93.9	92.2	96.8
			35.	97.2	93.6	92.0	97.8
Silva <i>et al.</i> , 2007	bPAG ELISA	blood	27.	93.5-96.3	91.7-96.8	89.7-92.6	96.9-97.7
Sinedino <i>et al.</i> , 2014	bPAG ELISA	blood	27.	94.6	89.9	86.6	96.0
			28-30.	96.1	90.7	89.2	96.7
			31-35.	98.7	88.1	83.7	99.1
			> 35.	94.4	85.2	94.2	85.6

¹ based on 23 dairy herds; ² based on a single dairy herd

Piechotta *et al.* (2011) could not detect any significant differences when comparing the accuracy of PSPB and bPAG-1 ELISA tests. Similarly, in the study of Ricci *et al.* (2015), blood and milk PAG ELISA tests proved to be equally accurate. In the same study, embryonic and fetal losses were detected 7-14 days later by PAG tests compared to transrectal ultrasonography due to the half-life of PAG. Twin pregnancies cannot be distinguished from the singleton ones before day 85 of the pregnancy by PAG tests, however, the method is promising (Szelényi *et al.*, 2015).

The ideal pregnancy test is able to distinguish between pregnant and open cows shortly after conception, non-invasive (i.e. does not cause embryonic or fetal mortality), cheap, not influenced by the examiner, and can be performed quickly and easily on site. That is, the ideal pregnancy test would be very similar to the hCG- (human choriongonadotropin) based tests available to humans (Cain and Christiansen, 2015). However, such a test is not available in bovine medicine yet. Rectal palpation, transrectal ultrasonography and PAG tests are compared in Table 4 based on several practical aspects.

Table 4. Comparison of pregnancy examination procedures: rectal palpation, transrectal ultrasonography and pregnancy-associated glycoprotein (PAG) tests

	Rectal palpation	Transrectal ultrasonography	PAG tests
From which day after insemination can the technique be used accurately?	Day 35	Day 26-28	Day 28
Invasivity	minimal	minimal	milk: no blood: minimal
Cost of implementation and operation	minimal	large	large
Does accuracy depend on the examiner (sampler)?	yes	yes	no
How quick is the result available?	immediately	immediately	depends on the laboratory

The effect of early pregnancy diagnosis on reproductive performance and profitability

The profit-generating potential of high-yielding dairy herds improves along with improving reproductive performance. Income over feed cost (IOFC) increases, since a larger proportion of the herd is in the earlier stage of the lactation, when the feed conversion efficiency is better. Better reproduction results in more calves that can be either sold or raised to become replacements, thus, allowing for the optimization of the culling policy. When the reproductive performance of the herd is better, less cows will be culled involuntarily due to reproductive disorders, and the cost of reproduction will be relatively lower, as well (Cabrera, 2014; Ózsvári and Kerényi, 2004). Improving reproductive performance follows the law of diminishing returns, i.e. the return of a one-unit increase in reproductive performance is lower when the reproduction is better (Cabrera, 2014).

Relatively few research has been published about the economics of early pregnancy diagnosis to date. Different authors and research teams conducted their studies using different methods and aspects. Some authors based their calculations on the cost of open days (Fodor *et al.*, 2016b), while others ran computer simulations to investigate herd dynamics, and performed

economic calculations based on these results (Giordano *et al.*, 2013). It is important to note that the figures may differ by country, year and farm but the basic principles are the same.

Earlier diagnosis is economically more beneficial in herds with poorer reproductive results. In these herds, more cows are open at pregnancy diagnosis, which can benefit from the earlier diagnosis of non-pregnancy (de Vries *et al.*, 2005; Descôteaux *et al.*, 2006). On the other hand, each additional open day is more costly (increasing marginal cost), therefore, a one-unit improvement is more beneficial economically if the initial performance is poorer.

Several factors influence the profitability of early pregnancy diagnosis beyond the actual reproductive performance of the herd, including the time from insemination to pregnancy check, the accuracy of pregnancy diagnosis, pregnancy wastage and heat detection efficiency.

Interval from insemination to pregnancy diagnosis

Pregnancy status can be determined earlier by performing early pregnancy diagnosis, however, earlier diagnosis is only beneficial if open cows are involved in a strategy that leads to quick reinsemination and conception (Table 5.) (Fricke, 2002). Early identification of open cows enables quick reinsemination, therefore, breeding interval is shortened, more cows conceive in a given time period (pregnancy rate increases), the number of open days decreases, and reproductive performance improves (de Vries *et al.*, 2005; Fricke, 2002; Kranjec *et al.*, 2016). Studies conducted in Hungary found that the cost of an open day is 2.5 EUR (1 EUR = 300 HUF), on average, but in some herds it reached 6.5 EUR (Fodor *et al.*, 2016b, Ózsvári, 2013). Reducing breeding interval by one week (investigating breeding intervals of 28-56 days) yielded 37-47 USD return on an annual basis (Cabrera, 2014; Giordano *et al.*, 2013).

Table 5. Results on the economic consequences of early pregnancy diagnosis in several studies

Study	Methods compared	Economic outcome	Note
<i>DesCoteaux and Fetrow, 1998</i>	TRUS on day 27-32 vs. diagnosis at next visit	Loss avoided: 10.08 USD /cow/year	4 USD/open day
<i>Fodor et al., 2016b</i>	TRUS on day 30-36 vs. RP on day 40-46	Return: 45.36 EUR/cow/year	3.5 EUR loss/open day, in the TRUS group every reproductive examination performed via TRUS
<i>Giordano et al., 2013</i>	PAG test on day 31 vs. RP on day 39	Return: 8.77 USD/cow/year	PAG test Se: 98%, Sp: 98%, Rep.: 3.3%, 6.0% pregnancy loss between days 31 and 39, price of PAG test: 2.4 USD
<i>Tóth et al., 2006</i>	TRUS on day 28-42 and ovulation synchronization vs. RP and estrus observation	Return: 63,919 EUR /herd/ 3 years	2.5 EUR loss/open day, TRUS also for examination of ovaries 40-60 days postpartum

TRUS: transrectal ultrasonography, RP: rectal palpation, PAG test: pregnancy-associated glycoprotein test, Se: sensitivity, Sp: specificity, Rep.: repeated examination needed

Tóth *et al.* (2006) introduced ovulation synchronization and reproductive ultrasonography (for the examination of ovaries and for early pregnancy diagnosis) into a dairy herd, which resulted in a 20-day decrease in calving interval, and a concurrent 0.8-point decrease in services per conception, while the annual milk production increased by 600 kg in a three-year period. The losses avoided by reducing calving interval and semen usage were 70,257 EUR, whereas the cost of the program was 6,338 EUR only, so the profit amounted to 63,919 EUR during the three years of the experiment on herd-level. It means that the profit was 10 times the cost of this programme (return on investment, ROI = 10).

Fodor *et al.* (2016b) compared the reproductive performance of cows managed by performing reproductive ultrasonography (including ultrasonographic pregnancy diagnosis 30-36 days after insemination) with those managed by rectal palpation (including rectal palpation for pregnancy diagnosis 40-46 days after insemination). In this study the economic analysis of reproductive ultrasonography was also performed. Days to first service, breeding interval and calving to conception interval of the pregnant cows in the ultrasound group were reduced by 7, 29.6 and 12 days, respectively, compared to the pregnant cows in the palpation group. Altogether, reproductive ultrasonography generated 45.4 EUR profit compared to rectal palpation annually.

Early pregnancy diagnosis enables accurate diagnosis earlier than rectal palpation, thereby reducing breeding interval and days open.

Economic aspects of the accuracy of pregnancy diagnosis

Earlier pregnancy diagnosis reduces accuracy, which has an impact on the economic outcome. Giordano *et al.* (2013) compared the results of Ovsynch and estrus detection combined with PAG tests on day 31 after AI with rectal palpation on day 39. They found that sensitivity of the PAG test was the most important factor from an economic point of view, since a one percentage point improvement in sensitivity increased the net present value of the reproductive program by 5.3 USD/cow/year compared to the program that applied rectal palpation (*Figure 2*). The effect of the price of the test was negligible.

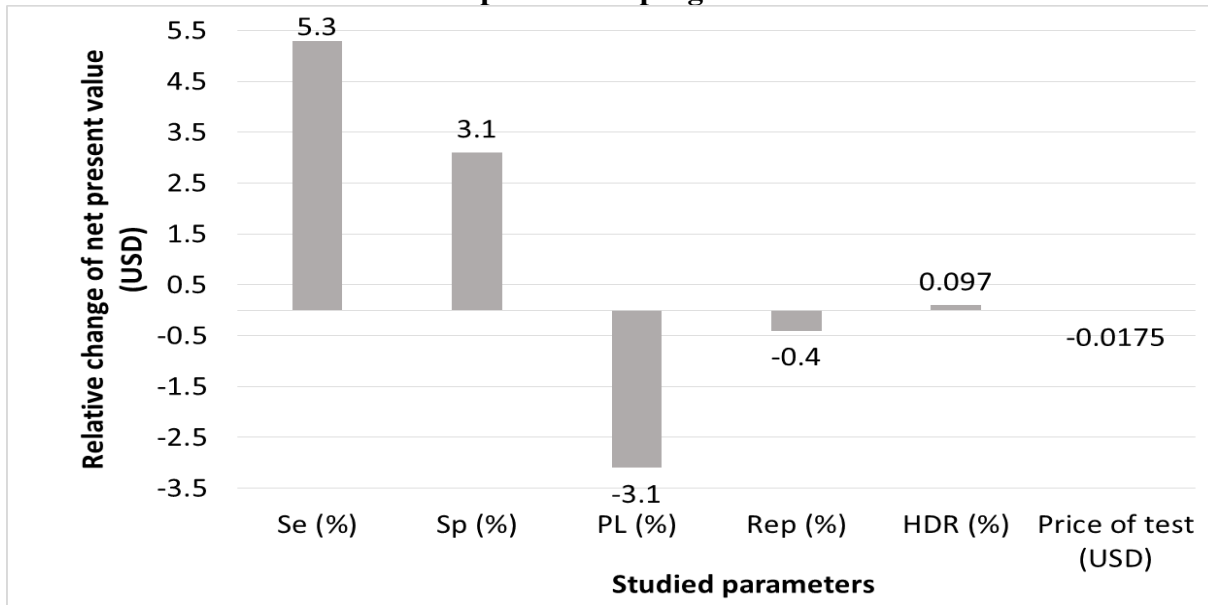
When the specificity of the pregnancy diagnosis is lower, more open cows will be diagnosed pregnant, i.e. the proportion of false positive diagnoses increases. This leads to delayed reinsemination of the open cows (increased breeding interval) and more open days. In case of PAG testing, breeding interval can also increase when repeat examination is required and the cow is actually open; in this case the cost of pregnancy testing increases, as well (Cabrerá, 2014; de Vries *et al.*, 2005). When the sensitivity of the diagnosis is lower, more pregnant cows will be diagnosed open, i.e. the proportion of false negative diagnoses increases. If these cows undergo PGF_{2α} treatment, iatrogenic pregnancy loss will occur.

Pregnancy wastage

By performing early pregnancy diagnosis, one can be either an observer or a cause of pregnancy loss. False negative diagnosis – and the resulting iatrogenic pregnancy loss – leads to larger economic loss than the false positive diagnosis and the resulting delayed reinsemination. Pregnancy loss at the end of the first month of gestation can lead to 649 USD loss per case depending on the level of milk production, lactation number and calving to conception interval (*Figure 3*) (de Vries, 2006).

Maximum sensitivity and negative predictive value of the pregnancy diagnosis method is required to exclude pregnancy of the animal with large confidence, thus, the majority of iatrogenic pregnancy losses can be avoided (de Vries *et al.*, 2005; Romano *et al.*, 2006).

Figure 2: The effect of one-unit change¹ in some parameters on the net present value of the reproduction programs

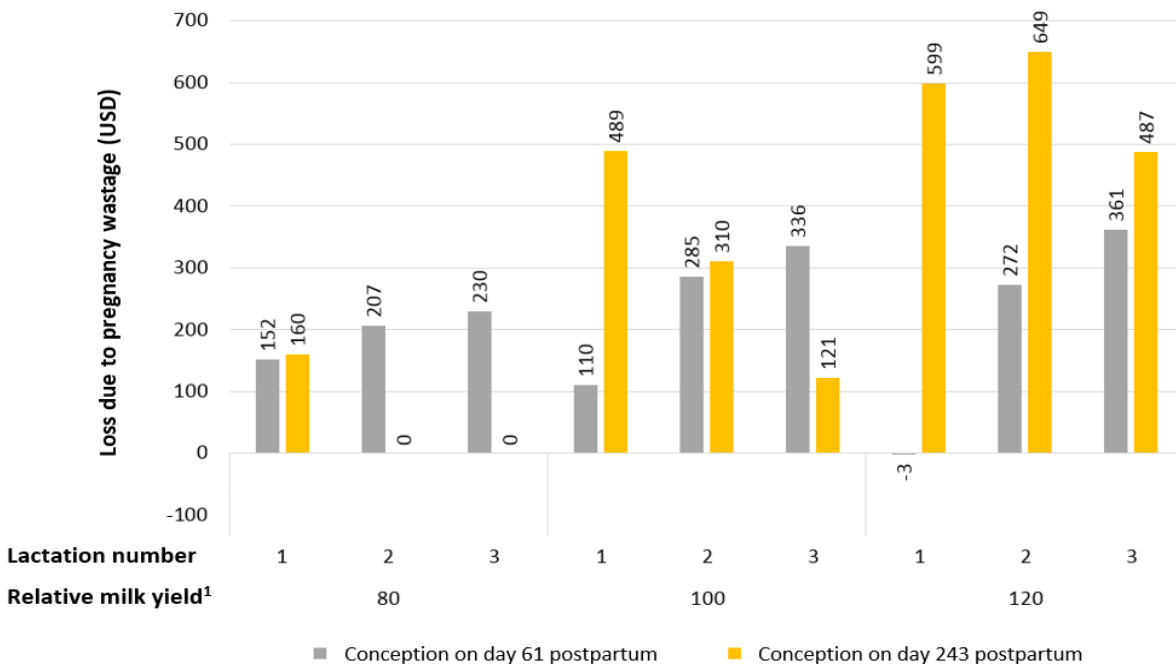


Se: sensitivity; Sp: specificity; PL: pregnancy loss; Rep: proportion of repeat examinations; HDR: heat detection rate

¹ one percentage point or 0.1 USD increase

Source: own construction based on *Giordano et al.* (2013)

Figure 3. Economic loss caused by pregnancy wastage at the end of the first month of pregnancy by relative milk yield and lactation number



¹ herd average: 100%

Source: own construction based on *de Vries* (2006)

Pregnancy wastage is a naturally occurring phenomenon, which is observed more often via early pregnancy diagnosis, because these examinations take place at the time when the probability of embryonic or fetal death is high. Therefore, a cow that was diagnosed pregnant correctly may become open later (Descôteaux *et al.*, 2006; Ricci *et al.*, 2015). The occurrence of pregnancy loss was 14.0-18.3% between days 30 and day 60 of pregnancy (Gábor *et al.*, 2008), 8.6% between days 26 to 58 (Szenci *et al.*, 1998a), and 16.8% from day 29-42 to the end of gestation (Szelényi *et al.*, 2012). Pregnancy loss leads to more false positive diagnoses (e.g. PAG tests will be positive a couple of days after embryonic/fetal mortality), which reduces test specificity (Ferguson and Skidmore, 2013).

Due to the large incidence of embryonic/fetal mortality after early pregnancy diagnosis, pregnancy recheck is required on day 60-70 in order to detect those cows that undergo pregnancy loss after the first pregnancy examination. Thereby, the loss due to open days can be effectively reduced (de Vries *et al.*, 2005; Kovács *et al.*, 2010; LeBlanc, 2013; Szelényi *et al.*, 2012).

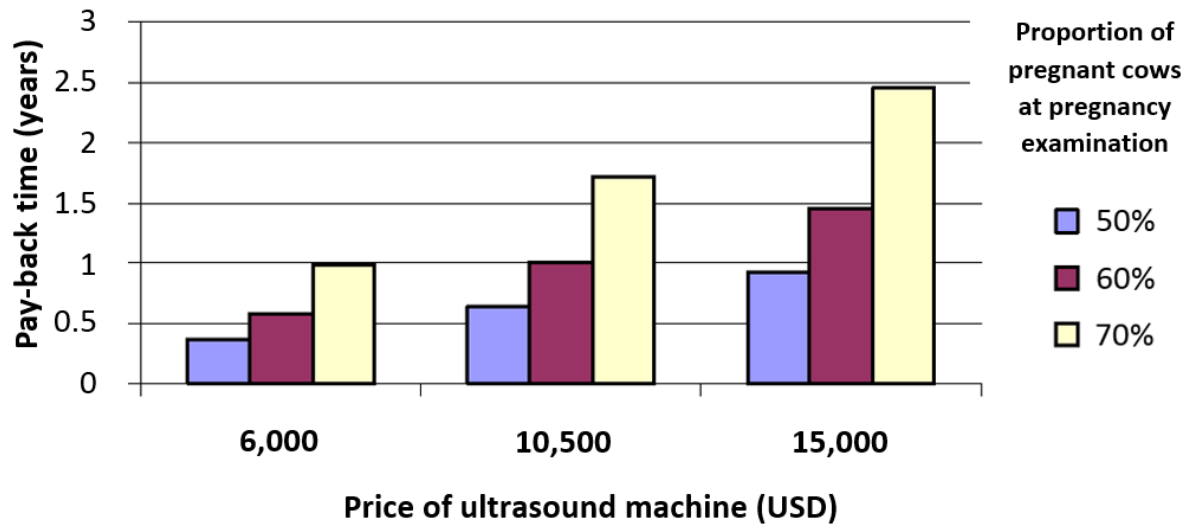
The effect of estrus detection efficiency

Estrus detection is combined with ovulation synchronization in approximately 80% of the Hungarian dairy herds (Fodor *et al.*, 2016a). In this case the benefit of early pregnancy diagnosis is influenced by the efficiency of detecting open cows after insemination. The return of those reproductive programmes that use ovulation synchronization in combination with estrus detection depends on the proportion of cows being inseminated to detected estrus, as well as the conception risk to detected estrus compared to that of timed AI (Giordano *et al.*, 2012). Sinedino *et al.* (2014) compared the efficiency of PAG ELISA on day 28 to rectal palpation on day 46, both followed by resynchronization based on the Ovsynch protocol in 972 cows. Besides, estrus detection was performed, as well, and those cows that exhibited estrus signs were inseminated. In the PAG group, breeding interval and calving to conception interval were significantly shorter (28.5 vs. 41.5 and 132 vs. 140 days, respectively), and a larger proportion of cows were pregnant 72 days after first AI (52.1 vs. 50.0%), however, the latter difference was not significant. They concluded that high estrus detection efficiency and the majority of open cows having a detected return to estrus prior to pregnancy examination decrease the advantage of early pregnancy diagnosis (Sinedino *et al.*, 2014). However, poor estrus detection efficiency is one of the most common problems on dairy farms, therefore, early pregnancy diagnosis and timed AI of open cows probably yield large economic benefit in the majority of herds.

Investment analysis of early pregnancy diagnosis methods

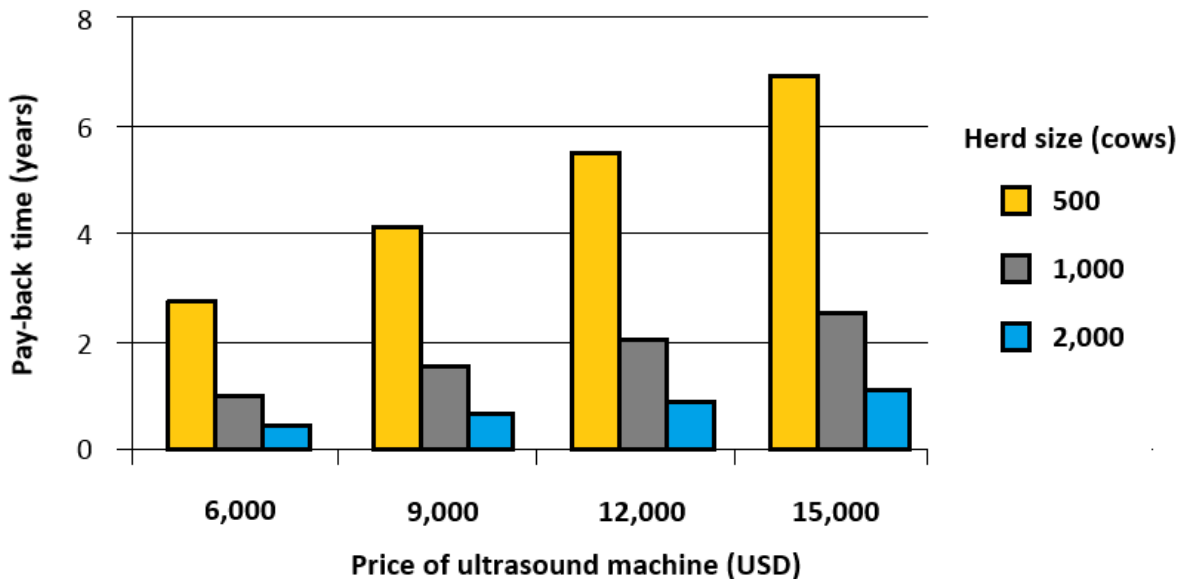
Early pregnancy diagnosis requires significant investment, which increases the cost of pregnancy checks. De Vries *et al.* (2005) analysed the pay-back time of purchasing an ultrasound machine in a 1000-cow herd at 3 USD/day loss due to days open and at varying percentages of cows being pregnant at pregnancy examination (Figure 4). An ultrasound equipment that cost 6,000 USD was paid back within a year when 70% of the cows were pregnant at the time of pregnancy check. Under these circumstances but only 50% of the cows being pregnant at the time of diagnosis, even a 10,500 USD ultrasound equipment was paid back in about half a year. In the same study, the pay-back time of a new ultrasound machine was analysed at different prices of the equipment and at different herd sizes, assuming that reproductive ultrasonography reduces calving to conception interval by 7 days (Figure 5) (de Vries *et al.*, 2005; Rosenbaum and Warnick, 2004). Lower ultrasound machine prices and larger herd sizes result in shorter pay-back time (de Vries *et al.*, 2005).

Figure 4. Payback time of the investment in a new ultrasound machine in a 1000-cow herd by purchase price and percentage of pregnant cows at pregnancy diagnosis



Source: de Vries et al. (2005), edited

Figure 5. Payback time of the investment into an ultrasound machine by purchase price and herd size



Source: de Vries et al. (2005), edited

Conclusions

Regarding the timing of pregnancy diagnosis one has to compromise between the earlier diagnosis (less open days) and more frequent pregnancy losses. Following early pregnancy diagnosis pregnancy recheck is suggested in order to detect those cows that experienced embryonic/fetal mortality as soon as possible. The introduction of early pregnancy diagnosis methods into reproductive management programmes – when implemented properly – has the potential to significantly improve profitability, however, their return on investment should be calculated for each individual farm, due to the different production level, economic environment, and management.

Acknowledgements

The Project was supported by the European Union and co-financed by the European Social Fund (grant agreement no. EFOP-3.6.1-16-2016-00024, project title: Innovations for intelligent specialization on the University of Veterinary Science and the Faculty of Agricultural and Food Sciences of the Széchenyi István University cooperation).

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