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

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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 vemhességvizsgálati módszerek és szerepük a termelés jövedelmezőségében. Irodalmi áttekintés

Összefoglalás

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

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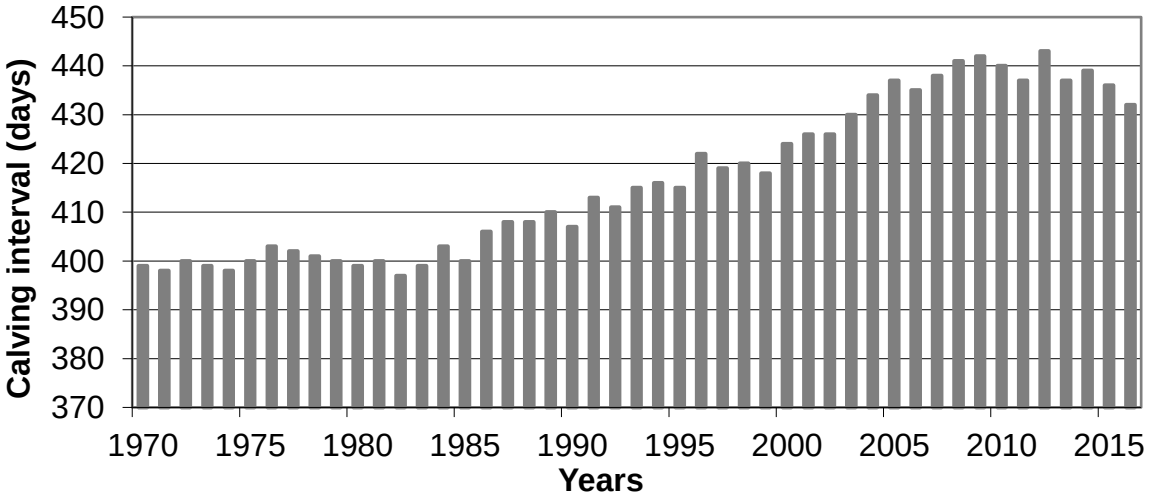
Kulcsszavak: vemhességvizsgálat, tejelő szarvasmarha, jövedelmezőség

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; *Túri*, 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

10.17205/SZIE.AWETH.2018.1.022

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**

	True pregnancy status	
Result of pregnancy examination	**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 $PGF_{2\alpha}$ 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).

10.17205/SZIE.AWETH.2018.1.022

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
Karen et al., 2015	28.	92.7	91.5	88.4	94.7
Romano et al., 2006[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
Romano et al., 2006[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
Silva et al., 2007	27.	94.2-98.9	91.7-97.3	87.3-93.8	97.1-99.5
Szenci et al., 1995[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
Szenci et al., 1995[4]	27-32.	80.0	100.0	100.0	57.1
	34-38.	96.6	100.0	100.0	90.0
Szenci et al., 1998a[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
Szenci et al., 1998a[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
Szelényi et al., 2012	29-35.	100.0	88.9	79.6	100.0
	36-42.	100.0	90.7	85.9	100.0

[1]cows; [2]heifers; [3]5 MHz sector transducer; [4]7.5 MHz linear transducer; [5]based on embryo with proper heartbeat; [6]based 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).

10.17205/SZIE.AWETH.2018.1.022

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 et al., 2004[1]	bPSPB ELISA	blood	30-36.	95.1	68.6	72.6	94.1
Gábor et al., 2004[2]	bPSPB ELISA	blood	30-36.	100.0	89.1	88.4	100.0
Karen et al., 2015	bPAG ELISA	blood	28.	90.2	98.3	97.4	93.7
	bPAG RIA			100	94.9	93.2	100
Lawson et al., 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 et al., 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 et al., 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 et al., 2007	bPAG ELISA	blood	27.	93.5-96.3	91.7-96.8	89.7-92.6	96.9-97.7
Sinedino et al., 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

10.17205/SZIE.AWETH.2018.1.022

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

10.17205/SZIE.AWETH.2018.1.022

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
DesCoteaux and Fetrow, 1998	TRUS on day 27-32 vs. diagnosis at next visit	Loss avoided: 10.08 USD /cow/year	4 USD/open day
Fodor et al., 2016b	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
Giordano et al., 2013	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
Tóth et al., 2006	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

10.17205/SZIE.AWETH.2018.1.022

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 (*Cabrera*, 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 $PGF_{2\alpha}$ treatment, iatrogenic pregnancy loss will occur.

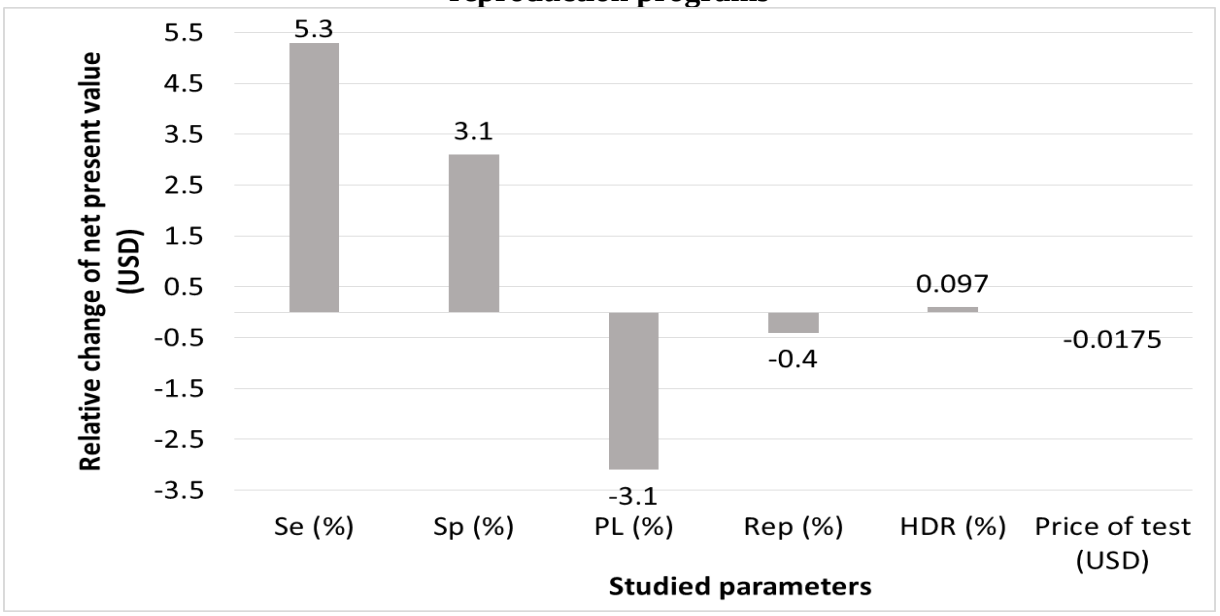
Pregnancy wastage

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).

10.17205/SZIE.AWETH.2018.1.022

Figure 2: **The effect of one-unit change[1] in some parameters on the net present value of the reproduction programs**

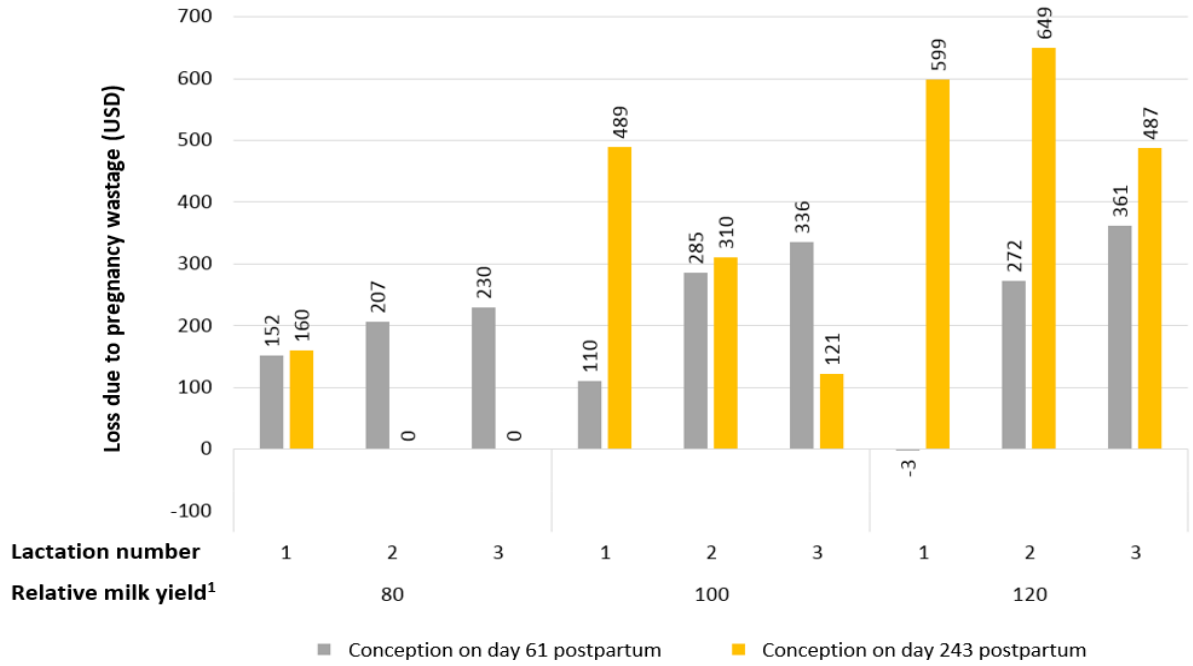


Se: sensitivity; Sp: specificity; PL: pregnancy loss; Rep: proportion of repeat examinations; HDR: heat detection rate

[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)

10.17205/SZIE.AWETH.2018.1.022

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

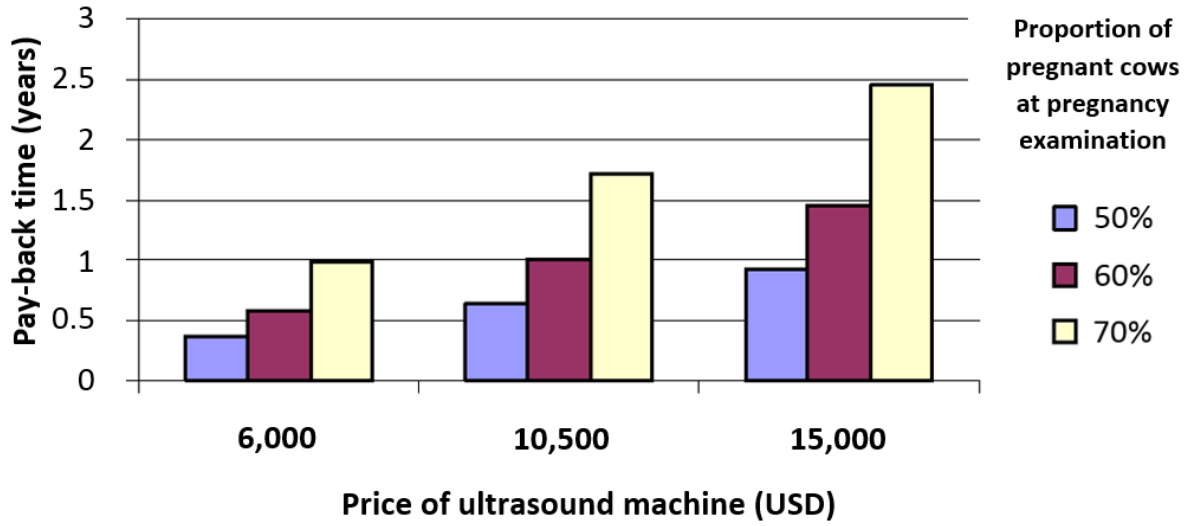
Estrus detection is combined with ovulation synchronization in approximately 80% of the Hungarian dairy herds (*Fodor et al.*, 2016a). In this case the benefit of early pregnancy diagnosis is influenced by the efficiency of detecting open cows after insemination. The return of those reproductive programmes 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).

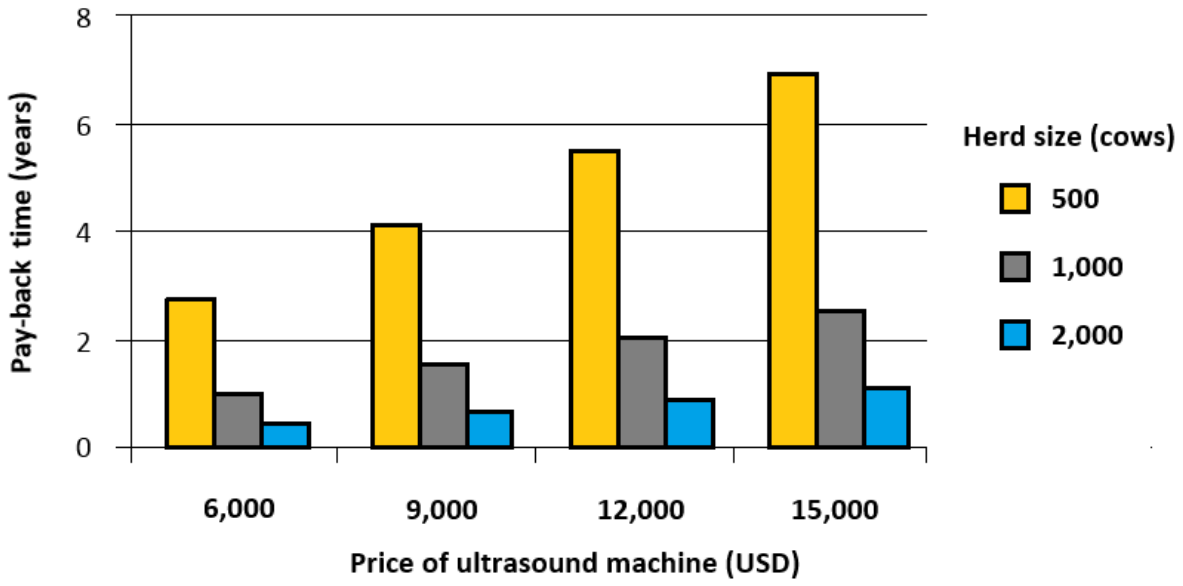
10.17205/SZIE.AWETH.2018.1.022

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

10.17205/SZIE.AWETH.2018.1.022

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.

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References

Cabrera, V. E. (2014): Economics of fertility in high-yielding dairy cows on confined TMR systems. Animal, 8. (Suppl. 1.) 211–221.

Cain, A. J., Christiansen, D. (2015): Biochemical pregnancy diagnosis. In: *Hopper, R. M.* (ed.): Bovine reproduction. Wiley-Blackwell. Hoboken, 320–325.

Chaffaux, S., Reddy, G. N. S., Valon, F., Thibier, M. (1986): Transrectal real-time ultrasound scanning for diagnosing pregnancy and for monitoring embryonic mortality in dairy cattle. Anim. Reprod. Sci., 10. 193–200.

de Vries, A., Bartolome, J., Broaddus, B. (2005): What is early pregnancy diagnosis worth? In: Proceedings 2nd Florida Dairy Road Show, 31–41.

de Vries, A. (2006): Economic value of pregnancy in dairy cattle. J. Dairy Sci., 89. 3876–3885.

DesCoteaux, L., Carrière, P. D., Durocher, J. (2006): Ultrasonography of the reproductive system of the cow: basic principles, practical uses and economic aspects of this diagnostic tool in dairy production. XXIV. World Buiatrics Congress, Nice, France. URL: http://www.uesc.br/cursos/pos_graduacao/mestrado/animal/textos/genetica_reproducao_animal/ultrasonography.pdf

DesCoteaux, L., Fetrow J. (1998): Does it pay to use an ultrasound machine for early pregnancy diagnosis in dairy cows? In: Proceedings 31st AABP Annual Meeting, Spokane, Washington, USA. 172–174.

Ferguson, J. D., Skidmore, A. (2013): Reproductive performance in a select sample of dairy herds. J. Dairy. Sci., 96. 1269–1289.

Fodor I., Abonyi-Tóth Zs., Ózsvári L. (2018a): Management practices associated with reproductive performance in Holstein cows on large commercial dairy farms. Animal, In Press. 1-6. DOI: 10.1017/S1751731118000101

Fodor I., Baumgartner W., Abonyi-Tóth Zs., Lang Zs., Ózsvári L. (2018b): Associations between management practices and major reproductive parameters of Holstein-Friesian replacement heifers. Anim. Reprod. Sci., 188. 114-122.

Fodor I., Búza L., Ózsvári L. (2016a): Reproductive management and major fertility parameters of cows in large-scale Hungarian dairy herds. Magy. Állatorv. Lapja, 138. 653–662. (in Hungarian with English abstract)

Fodor I., Cziger Zs., Ózsvári L. (2016b): Economic analysis of the application of reproductive ultrasound examinations on a large-scale dairy farm. Magy. Állatorv. Lapja, 138. 515–522. (in Hungarian with English abstract)

Fricke, P. M. (2002): Scanning the future – Ultrasonography as a reproductive management tool for dairy cattle. J. Dairy Sci., 85. 1918–1926.

Gábor Gy., Tóth F., Ózsvári L., Abonyi-Tóth Zs., Sasser, R. G. (2007): Early detection of pregnancy and embryonic loss in dairy cattle by ELISA tests. Reprod. Domest. Anim., 42. 633–636.

Gábor Gy., Tóth F., Ózsvári L., Abonyi-Tóth Zs., Sasser, R. G. (2008): Factors influencing pregnancy rate and late embryonic loss in dairy cattle. Reprod. Domest. Anim., 43. 53–58.

Gábor Gy., Tóth F., Sasser, G., Szász F., Bárány I., Wölfling A., Völgyi-Csík J. (2004): Ways of decrease the period between calvings in dairy cows. 1. Early pregnancy detection by Biopryn ELISA-test. Magy. Állatorv. Lapja, 126. 459–464.

Giordano, J. O., Fricke, P. M., Cabrera, V. E. (2013): Economics of resynchronization strategies including chemical tests to identify nonpregnant cows. J. Dairy Sci., 96. 949–961.

Giordano, J. O., Kalantari, A. S., Fricke, P. M., Wiltbank, M. C., Cabrera, V. E. (2012): A daily herd Markov-chain model to study the reproductive and economic impact of reproductive programs combining timed artificial insemination and estrus detection. J. Dairy Sci., 95. 5442–5460.

Green, J. A., Parks, T. E., Avalle, M. P., Telugu, B. P., McLain, A. L., Peterson, A. J., McMillan, W., Mathialagan, N., Hook, R. R., Xie, S., Roberts, R. M. (2005): The establishment of an ELISA for the detection of pregnancy-associated glycoproteins (PAGs) in the serum of pregnant cows and heifers. Theriogenology, 63. 1481–1503.

Karen, A., Sousa, N. M., Beckers, J. F., Bajcsy Á. Cs., Tibold J., Mádl I., Szenci O. (2015): Comparison of a commercial bovine pregnancy-associated glycoprotein ELISA test and a pregnancy-associated glycoprotein radioimmunoassay test for early pregnancy in dairy cattle. Anim. Reprod. Sci., 159. 31–37.

Kerényi J., Mészáros Gy., Szelényi Z. (2013): Tejtermelés, a szaporaság és az élettartam vizsgálata a hazai és külföldi tejtermelés ellenőrzött állományokban I. In: Szenci O., Brydl E., Jurkovich V. (eds.): 23rd International Congress of the Hungarian Association for Buiatrics. A/3 Ltd. Budapest, 145–152. (in Hungarian with English abstract)

Kovács L., Szelényi Z., Szentléleki A., Tőzsér J., Szenci O. (2010): Role of environmental and other factors as the causes of embryonal and foetal mortality in dairy cattle. Animal Welfare Ethology and Housing Systems, 6. 154-176. (in Hungarian with English abstract)

Kranjec F., Fodor I., Földi J., Ózsvári L. (2016): Comparative analysis of the reproductive performance of dairy herds based on standardized parameters in Hungary. Magy. Állatorv. Lapja, 138. 451–462. (in Hungarian with English abstract)

Lang Zs., Földi J., Ózsvári L., Reiczigel J. (2013): Relationship between seropositivity and prevalence on the basis of epidemiological analysis of data of BHV-1 eradication program in Hungary. Magy. Állatorv. Lapja, 135. 525–534. (in Hungarian with English abstract)

10.17205/SZIE.AWETH.2018.1.022

Lawson, B. C., Shahzad, A. H., Dolecheck, K. A., Martel, E. L., Velek, K. A., Ray, D. L., Lawrence, J. C., Silvia, W. J. (2014): A pregnancy detection assay using milk samples: evaluation and considerations. J. Dairy Sci.,. 97. 6316–6325.

LeBlanc, S. J. (2013): Field evaluation of a pregnancy confirmation test using milk samples in dairy cows. J. Dairy Sci., 96. 2345–2348.

Monostori A. (2014): Pregnancy detection from milk samples obtained for routine milk yield measurements – results and evaluation. In: *Szenci O., Brydl E.* (eds.): 24th International Congress of the Hungarian Association for Buiatrics. A/3 Ltd. Budapest, 129–137. (in Hungarian with English abstract)

National Food Chain Safety Office, Livestock Performance Testing Ltd. (2017): Standard lactational milk yield 2016. National Cattle Database.

Ott, T. L., Dechow, C., O'Connor, M. L. (2014): Advances in reproductive management: pregnancy diagnosis in ruminants. Anim. Reprod., 11. 207–216.

Ózsvári L., Kerényi J. (2004): Quantification of losses due to reproductive disorders on a large-scale Holstein-Friesian dairy farm. Magy. Állatorv. Lapja, 126. 523–531.

Ózsvári L. (2013): A szarvasmarha állomány-egészségügy gazdasági kérdései. In: *Winfried, H.* (ed.): Gyakori szarvasmarha-betegségek. Mezőgazda Kiadó – Nemzeti Agrárgazdasági Kamara. Budapest, 211–236. (in Hungarian)

Palgrave, K., Cezon, N. (2011): Improving bovine reproductive management with ultrasound. Veterinary Ireland Journal, 64. 44–47.

Piechotta, M., Bollwein, J., Friedrich, M., Heilkenbrinker, T., Passavant, C., Branen, J., Sasser, G., Hoedemaker, M., Bollwein, H. (2011): Comparison of commercial ELISA blood tests for early pregnancy detection in dairy cows. J. Reprod. Develop., 57. 72–75.

Ricci, A., Carvalho, P. D. Amundson, M. C., Fourdraine, R. H., Vincenti, L., Fricke, P. M. (2015): Factors associated with pregnancy-associated glycoprotein (PAG) levels in plasma and milk of Holstein cows during early pregnancy and their effect on the accuracy of pregnancy diagnosis. J. Dairy Sci., 98. 2502–2514.

Romano, J. E., Larson, J. E. (2010): Accuracy of pregnancy specific protein-B test for early pregnancy diagnosis in dairy cattle. Theriogenology, 74. 932–939.

Romano, J. E., Thompson, J. A., Forrest, D. W., Westhusin, M. E., Tomaszweski, M. E., Kraemer, D. C. (2006): Early pregnancy diagnosis by transrectal ultrasonography in dairy cattle. Theriogenology, 66. 1034–1041.

Rosenbaum, A., Warnick, L. D. (2004): Pregnancy diagnosis in dairy cows by palpation or ultrasound: a survey of US veterinarians. Proceedings 37th AABP Annual Meeting, Fort Worth, TX, USA, 198.

Sasser, R. G., Ruder, C. A., Ivani, K. A., Butler, J. E., Hamilton, W. C. (1986): Detection of pregnancy by radioimmunoassay of a novel pregnancy-specific protein in serum of cows and a profile of serum concentrations during gestation. Biol. Reprod., 35. 936–942.

Sheldon, M., Noakes, D. (2002): Pregnancy diagnosis in cattle. In Practice, 24. 310–317.

Silva, E., Sterry, R. A., Kolb, D., Mathialagan, N., Mcgrath, M. F., Ballam, J. M., Fricke, P. M. (2007): Accuracy of a pregnancy-associated glycoprotein ELISA to determine pregnancy status of lactating dairy cows twenty-seven days after timed artificial insemination. J. Dairy Sci., 4612–4622.

Sinedino, L. D. P., Lima, F. S., Bisinotto, R. S., Cerri, R. L. A., Santos, J. E. P. (2014): Effect of early or late resynchronization based on different methods of pregnancy diagnosis on reproductive performance of dairy cows. J. Dairy. Sci., 97. 4932–4941.

10.17205/SZIE.AWETH.2018.1.022

Sousa, N. M., Szenci O., Taverne, M. A. M., van der Weijden, B., Beckers, J. F. (2008): Pregnancy-associated glycoproteins and their importance in monitoring the progress of bovine pregnancy. Magy. Állatorv. Lapja, 130. (Suppl. I.) 10–13.

Szelényi Z., Kovács L., Bajcsy Á. Cs., Tőzsér J., Szenci O. (2012): Evaluation of pregnancy diagnoses by ultrasonography in a dairy herd. Magy. Állatorv. Lapja, 134. 138–144. (in Hungarian with English abstract)

Szelényi Z., Répási A., de Sousa, N. M., Beckers, J. F., Szenci O. (2015): Accuracy of diagnosing double corpora lutea and twin pregnancy by measuring serum progesterone and bovine pregnancy-associated glycoprotein 1 in the first trimester of gestation in dairy cows. Theriogenology, 84. 76–81.

Szenci O., Beckers, J. F., Humblot, P., Sulon, J., Sasser, G., Taverne, M. A. M., Varga J., Baltusen, R., Schekk Gy. (1998a): Comparison of ultrasonography, bovine pregnancy-specific protein B, and bovine pregnancy-associated glycoprotein 1 tests for pregnancy detection in dairy cows. Theriogenology, 50. 77–88.

Szenci O., Gyulai Gy., Nagy P., Kovács L., Varga J., Taverne, M. A. M. (1995): Effect of uterus position relative to the pelvic inlet on the accuracy of early bovine pregnancy diagnosis by means of ultrasonography. Vet. Quart., 17. 37–39.

Szenci O., Taverne, M. A. M., Beckers, J. F., Sulon, J., Varga J., Börzsönyi L., Hanzen, C., Schekk Gy. (1998b): Evaluation of false ultrasonographic diagnoses in cows by measuring plasma levels of bovine pregnancy-associated glycoprotein 1. Vet. Rec., 142. 304–306.

Tóth F., Gábor Gy., Mézes M., Váradi É., Ózsvári L., Sasser, R. G., Abonyi-Tóth Zs. (2006): Improving the reproductive efficiency by zoo-technical methods at a dairy farm. Reprod. Domest. Anim., 41. 184–188.

Túri I. (1998): A minőségi tejtermelés folyamatos fejlesztése Bólyban. In: *Sári E., Sándor Z.* (eds.): 10 000 literesek klubja. (A Holstein Genetika Kft. és a Magyar Mezőgazdaság melléklete). Magyar Mezőgazdaság, 53. 3-7. (in Hungarian)

Zoli, A. P., Guilbault, L. A., Delahaut, P., Ortiz, W. B., Beckers, J. F. (1992): Radioimmunoassay of a bovine pregnancy-associated glycoprotein in serum: its application for pregnancy diagnosis. Biol. Reprod., 46. 83–92.

10.17205/SZIE.AWETH.2018.1.022