P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2024.211

Effects of Age at First Calving, Cow's Age, Parity, and Days in Milk at First Service on Number of Services per Conception in Holstein Cows

Bui Van Dung [1], Man Thi Thanh [2] and Nguyen Hoai Nam [1]*

[1]Department of Animal Surgery and Reproduction, Faculty of Veterinary Medicine, Vietnam National University of Agriculture, Trau Quy Town, Gia Lam District, Ha Noi, Viet Nam
[2]Department of Experimental Animals, National Institute of Vaccines and Biologicals, Ministry of Health, Dai Kim, Hoang Mai District, Ha Noi, Viet Nam
***Corresponding author:** nguyenhoainam@vnua.edu.vn

Article History: 24-517 Received: 28-May-24 Revised: 08-Jul-24 Accepted: 20-Jul-24 Online First: 24-Jul-24

ABSTRACT

This study investigated factors influencing the number of services per conception (NSC) in dairy cows, focusing on age at first calving (AFC), cow's age, parity, and days in milk (DIM) at first insemination. Data from 1014 lactating Holstein cows in a commercial farm in Denmark was collected. The effects of the studied factors on NSC were analyzed using the Kruskal-Wallis test with pairwise comparisons. The average NSC was 2.2±1.1. No significant effect of AFC on NSC at first AI was detected. However, significant associations between NSC and cow's age (P=0.005), parity (P=0.001), and DIM (P<0.05) were found. NSC in cows at the age of <3 years (2.2±1.2), and 3-4 years (2.1±1.2) was smaller than that in cows at the age of >5 years (2.6±1.2). Cows in parity 1 exhibited a lower NSC compared to those in parities 2, 3, 4, and ≥5 (2.0±1.1 *vs* 2.3±1.3, 2.3±1.3, 2.2±1.3, and 2.4±1.2, respectively). NSC levels in cows at ≥81 DIM were higher than those at 51-80 DIM (P<0.01). These findings highlight the necessity of incorporating cow's age, parity, and DIM into assessments of reproductive performance in dairy herds, with the potential for maximizing lifetime profit by reducing the optimal AFC to as early as 21 months.

Keywords: Conception, Dairy cows.

INTRODUCTION

The reproductive efficiency of lactating dairy cows is a critical component of dairy farm profit, as it directly impacts milk production and the sustainability of dairy operations (Wiltbank et al. 2011). Achieving and maintaining high pregnancy rates in dairy herds is essential for ensuring a steady supply of replacement animals, optimizing milk production, and maximizing economic returns (Consentini et al. 2021). However, several factors may influence the reproductive performance of lactating dairy cows.

Age at first calving (AFC) is particularly important as it influences the functional longevity and reproductive performance of dairy cows. Research has shown that cows calving at older ages tend to have shorter productive lives, lower fertility, and higher risks of premature culling compared to those calving at younger ages (Chirinos et al. 2007; M'hamdi et al. 2010). In contrast, some studies have not observed a significant correlation between AFC and productive life (Ojango et al. 2005). There is consensus that reducing AFC below certain thresholds, such as ≤24 months in Holsteins, optimizes lactation performance and minimizes rearing costs, ultimately improving the economic efficiency of dairy operations (Tozer and Heinrichs 2001).

The timing of the first AI postpartum also plays a crucial role in determining pregnancy rates in lactating dairy cows. Delayed initiation of breeding postpartum can result in longer calving intervals and reduced overall reproductive efficiency (Inchaisri et al. 2011), while early initiation may not allow sufficient postpartum recovery and uterine involution, leading to lower pregnancy rates (Stangaferro et al. 2019). Moreover, nutrition and metabolic changes during the early postpartum period can further affect reproductive performance, contributing to reduced first AI conception rates (Butler, 2000; Leroy et al. 2004; Wiltbank et al. 2006).

Parity is another significant factor affecting fertility in dairy cows. Research indicates that higher parity levels may correlate with diminished fertility compared to primiparous cows (Balendran et al. 2008). However, there is evidence suggesting higher conception rates in

Cite This Article as: Dung BV, Thanh MT and Nam NH, 2024. Effects of age at first calving, cow's age, parity, and days in milk at first service on the number of services per conception in Holstein cows. International Journal of Veterinary Science x(x): xxxx. https://doi.org/10.47278/journal.ijvs/2024.211

multiparous cows compared to primiparous ones (Barcellos et al. 1996), with a rising trend in conception rates from parity 2 to 6, followed by a decline at higher parities (Than et al. 2001). Higher parity positively correlates with cows ages and the number of inseminations was shown to increase as cows aged (Holodova et al. 2019).

Understanding the interplay between these factors and their effects on pregnancy rates in lactating dairy cows is essential for optimizing reproductive management strategies in dairy herds. Consequently, the primary objective of this investigation was to explore the effects of AFC, age, parity, and timing of first AI postpartum on the number of services per conception (NSC) in lactating dairy cows. By identifying key factors influencing reproductive performance, this research aims to contribute valuable insights to improve fertility management practices and enhance the overall reproductive efficiency of dairy herds.

MATERIALS AND METHODS

Animals

This research was conducted on a commercial dairy farm in the Southwest of Denmark from October 2022 to May 2023. The farm housed a total of about 2400 lactating Holstein cows with an average milk yield of 12,800kg/cow/lactation. Studied cows were in parities 1 to 10 with majority (≥90%) fell within parities 1 to 5. Cows were milked twice using the Delaval robot milking system. All management data were extracted from the Delpro Farm Manager software.

AI and pregnancy diagnosis

Estrus detection relied on the use of the DeLaval activity meter system (DelPro Farm Manager Software, version 5.9, DeLaval International AB). Cows in estrus were artificially inseminated using frozen-thawed semen from established Holstein Friesian sires once per estrus cycle. Cows not exhibiting estrus within 45 days post-insemination were considered pregnant.

Categorization of cows according to factors influencing the NSC

The cows were stratified into distinct groups based on various factors potentially influencing the NSC. These categories included cow's age at first calving (21-22, 23, 24, and 25-27 months), cow's age (≤3, 3-4, 4-5, 5-6, and ≥6 years), DIM at first AI (≤50, 51-80, and ≥81 DIM) and parity (1, 2, 3, 4 and ≥5).

All data were presented as mean±SD (standard deviation). The impact of cow's age at first calving, cow's age, DIM at first AI, and parity on NSC was analyzed by using Kruskal-Wallis test with pairwise comparison. Statistical significance was defined as probabilities less than 5% (P<0.05). All statistical analyses were conducted using IBM SPSS for Windows version 22 (IBM Corp., Armonk, New York, United States).

RESULTS

The average NSC in the studied cows was 2.2±1.2 varying from 1-4 services. The AFC was 23.4±1.0 months ranging from 21 to 27 months. There was no difference in NSC among 4 different AFC cow groups (Table 1).

Table 1: The association between cow's age at 1st calving (month) and the number of services per conception (Mean±SD)

Cow's age at 1st calving (month)	No. of animals	Number of services per conception
21-22	86	1.8±1.1[a]
23	168	1.9±1.1[a]
24	132	2.0±1.1[a]
25-27	55	1.9±1.2[a]
Total	441	1.9±1.1[a]

The superscript in the column means non-significant (P>0.05).

Table 2 presents the relationship between the age of cows and the NSC. The average NSC in different age groups varied between 2.1 and 2.6. Cows at the age of <4 years had a smaller NSC compared to cows at the age of >5 years. The association between NSC and age of the cow is presented by the equation y=0.107x+2.030 (Fig. 1) with the determination coefficient (R-square) of 0.012.

Table 2: The association between cow's age (year) and the number of services per conception (Mean±SD)

Group	Cow's age (year)	No. of animals	Number of services per conception
1	<3	715	2.2±1.2[a]
2	3-4	104	2.1±1.2[a]
3	4-5	69	2.3±1.2[a,b]
4	5-6	57	2.6±1.2[b]
5	>6	69	2.6±1.2[b]
	Total	1014	2.2±1.2

Different superscripts in the same column mean significant (P<0.05)

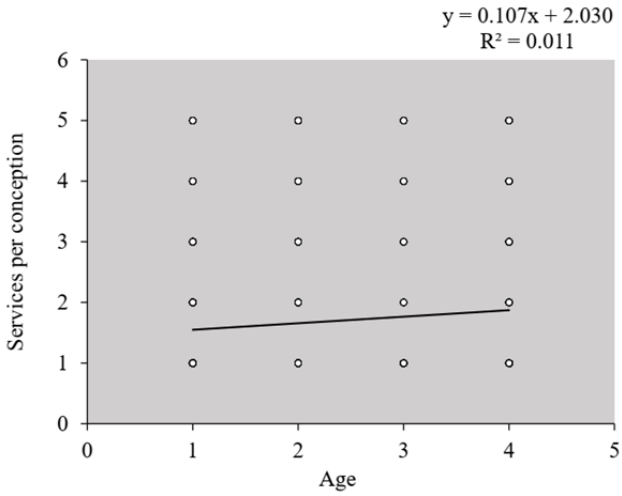

Fig. 1: Regression equation of services per conception based on age (years) as predictor in lactating Holstein cows

The effect of DIM on the NSC was demonstrated in Table 3. NSC level in cows at ≥81 DIM was higher than those in cows at 51-80 DIM (P=0.009). However, no difference in NSC was observed between cows at ≤50 DIM and cows at 51-80 DIM. The association between NSC and DIM of the cow is presented by the equation y=0.092x+2.020 (Fig. 2) with the determination coefficient (R-square) of 0.002.

Table 4 presents the correlation between parity and the NSC. The average NSC in different parity groups varied between 2.0 and 2.4. Specifically, cows in parity 1 exhibited a lower NSC compared to those in parities 2, 3, and ≥5 (P<0.05), and tended to be lower than that in cows

in parity 4 (P=0.08). The association between parity and the NSC is depicted by the equation y=0.091x+1.971 (Fig. 3) with the determination coefficients (R-Square) of 0.014.

Table 3: The association between days in milk (DIM) at first AI and the number of services per conception (Mean±SD)

DIM	No. of animals	Number of services per conception
≤50	155	2.3±1.2[a,b]
51-80	649	2.1±1.2[a]
≥81	210	2.4±1.3[b]
Total	1014	2.2±1.2

Different superscripts in the same column mean significant (P<0.05).

Table 4: The association between parity and the number of services per conception (Mean±SD)

Parity	No. of animals	Number of services per conception
1	311	2.0±1.1[a]
2	211	2.3±1.3[b]
3	201	2.3±1.3[b]
4	124	2.2±1.3[c]
≥5	167	2.4±1.2[b]
Total	1014	2.2±1.2

Different superscripts in the same column mean significant (P<0.05)

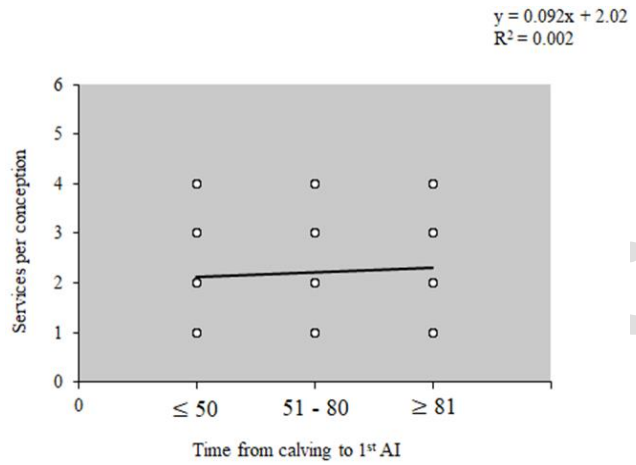

Fig. 2: Regression equation of services per conception based on time (DIM) from calving to 1st AI as predictor in lactating Holstein cows

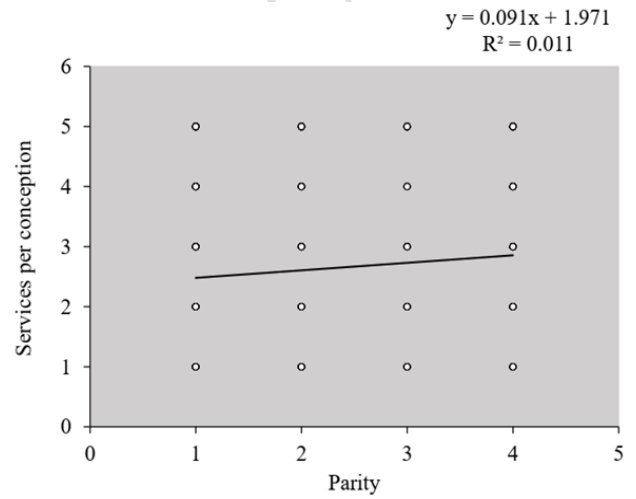

Fig. 3: Regression equation of services per conception based on parity as predictor in lactating Holstein cows

DISCUSSION

Studies have recommended that maintaining an average AFC of ≤24 months in Holsteins could optimize lactation performance and minimize rearing costs (Tozer and Heinrichs 2001). Additionally, a previous study found that the optimal AFC for maximum lifetime profit fell between 22.5 and 23.5 months (Do et al. 2013). These studies also noted a negative genetic correlation between the AFC and lifetime profit (Do et al. 2013). Cows with higher AFC were associated with shorter length of productive life and longer days open, days between calving and first service, and days between first service and conception in the first lactation, compared to cows with lower AFC (Zavadilová and Štípková 2013). The age of heifers at first AI did not correlate with conception rate, emphasizing the importance of promptly initiating breeding in heifers to enhance production efficiency (Irikura et al. 2018). Results of the present study indicate no significant difference in NSC across different AFCs, which suggest that the AFC can be reduced to as early as 21 months to maximize lifetime profit and mitigate the negative genetic correlation between first calving interval and lifetime profit.

The present study indicates that as the age of dairy cows increases, there is a corresponding rise in the NSC. This finding aligns with the findings of Ananda et al. (2019), which reported a positive correlation between age and NSC. Previous research has shown that cross-bred beef cows have the highest conception rates between 3.5 and 5 years, while cows older than 9 years have significantly lower conception rates compared to younger counterparts (Khan et al. 2015). Holodova et al. (2019) found a weak negative correlation (R=0.15) between the age of dairy cows and conception rate, with the number of inseminations increasing as cows aged. The decline in conception rate with increasing parity is potentially attributable to age-related decrease in reproductive performance (Irikura et al. 2018). Furthermore, an increase in parity is associated with a postponement in uterine involution (Izaike et al. 1989). In dairy cattle, older cows have been documented to face an increased susceptibility to periparturient problems known to influence fertility outcomes (Chebel et al. 2004). Collectively, these factors likely contribute to the superior reproductive performance observed in younger cows in the present study.

Various studies have investigated the impact of DIM on reproductive performance in dairy cows. Yusuf et al. (2011) observed that cows inseminated within 40 DIM tended to have a lower first AI conception rate compared to those inseminated after 40 DIM. Similarly, Dohoo (1983) reported an increase in first service conception rate when DIM increased from 40 to over 60 days. The decreased reproductive performance in cows inseminated early postpartum may be attributable to energy deficit in this period (Ospina et al. 2010; Ribeiro et al. 2011; Bisinotto et al. 2018). Therefore, cows inseminated before 50 DIM might suffer from the energy imbalance more than cows inseminated during 51-80 DIM. Additionally, subclinical endometritis was observed in cows approximately 35 to 40 days postpartum (Sheldon et al. 2006; de Boer et al. 2014) which was associated with reduced fertility (Kasimanickam et al. 2004; Gilbert et al. 2005). Therefore,

on the one hand, the NSC levels in cows at ≤ 50 DIM tended to be higher than those in cows at 51-80 DIM. On the other hand, the earlier restoration of reproductive activity depicted a more efficient hypothalamus/ hypophyseal/ovarian axis in the cows receiving first insemination during 51-80 DIM compared to cows with >80 DIM. These conditions may contribute to the higher NSC levels observed in cows at ≥81 DIM compared to those at 51-80 DIM in the present investigation.

Notably, the present NSC in parity 1 was lower than in parities 2, 3, 4 and ≥5. This result is consistent with previous findings indicating a significant effect of parity on pregnancy rates (Balendran et al. 2008; Mufti et al. 2010). Rearte et al. (2018) similarly demonstrated reduced odds of pregnancy in parity 3 and ≥4 compared to that in parity 1. Differences in follicular development (Walters et al. 2002), hormonal profile (Ferreira et al. 2021), and uterine environment (Izaike et al. 1989) are potential factors contributing to the difference in fertility observed among parities. Overall, our findings underscore the relationship between parity and NSC.

In conclusion, the findings of this study indicate that while AFC did not significantly influence the NSC, cow age, parity, and DIM did have a notable impact. Specifically, younger cows, cows in lower parity, and cows inseminated during 51-80 DIM tended to have a lower NSC compared to those in other groups. These results emphasize the importance of considering cow age, parity, and DIM when assessing reproductive performance in dairy herds. Further research is warranted to explore additional factors that could affect the NSC in dairy cows.

Acknowledgments

The authors would like to extend their appreciation to Dr. Tran Van Quyen for his assistance in data collection, and to the farmers for their consent regarding the use of data in the study.

Conflicts of interest

The authors have no conflicts of interest to disclose.

Author contributions

Bui Van Dung: Conceptualization, Methodology, Writing-original draft, Investigation, Visualization; Man Thi Thanh: Validation Writing-review & editing; Nguyen Hoai Nam: Supervision.

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REFERENCES

Ananda H, Wurlina HN, Hariadi M, Samik A and Restiadi T, 2019. Relationship between age with interval calving, days open, and service per conseption of Friesian Holstein (FH) cow. Ovozoa 8: 94-99. https://doi.org/10.20473/ovz.v8i2.2019.94-99

Balendran A, Gordon M, Pretheeban T, Singh R, Perera R and Rajamahedran R, 2008. Decreased fertility with increasing parity in lactating dairy cows. Canadian Journal of Animal Science 88(3): 425-428. https://doi.org/10.4141/CJAS07127

Barcellos JOJ, Silva MD and Silva JD, 1996. Effects of early weaning on conception rate in Santa Gertrudis cows. Economie et Sociologie Rurales (Toulouse) 96-110D: 30-44.

Bisinotto RS, Greco LF, Ribeiro ES, Martinez N, Lima FS, Staples CR, Thatcher WW and Santos JEP, 2018. Influences of nutrition and metabolism on fertility of dairy cows. Animal Reproduction 9(3): 260-272.

Butler WR, 2000. Nutritional interactions with reproductive performance in dairy cattle. Animal reproduction science, 60, 449-457. https://doi.org/10.1016/s0378-4320(00)00076-2

Consentini CEC, Wiltbank MC and Sartori R, 2021. Factors that optimize reproductive efficiency in dairy herds with an emphasis on timed artificial insemination programs. Animals 11(2): 301. https://doi.org/10.3390/ani11020301

Chebel RC, Santos JE, Reynolds JP, Cerri RL, Juchem SO and Overton M, 2004. Factors affecting conception rate after artificial insemination and pregnancy loss in lactating dairy cows. Animal Reproduction Science 84: 239-255. https://doi.org/10.1016/j.anireprosci.2003.12.012

Chirinos Z, Carabaño MJ and Hernández D, 2007. Genetic evaluation of length of productive life in the Spanish Holstein-Friesian population. Model validation and genetic parameters estimation. Livestock Science 106(2-3): 120-131. https://doi.org/10.1016/j.livsci.2006.07.006

de Boer MW, LeBlanc SJ, Dubuc J, Meier S, Heuwieser W, Arlt S, Gilbert RO and McDougall S, 2014. Invited review: Systematic review of diagnostic tests for reproductive-tract infection and inflammation in dairy cows. Journal of Dairy Science 97(7): 3983-3999. https://doi.org/10.3168/jds.2013-7450

Do C, Wasana N, Cho K, Choi Y, Choi T, Park B and Lee D, 2013. The effect of age at first calving and calving interval on productive life and lifetime profit in Korean Holsteins. Asian-Australasian Journal of Animal Sciences 26(11): 1511-7. https://doi.org/10.5713/ajas.2013.13105

Dohoo IR, 1983. The effects of calving to first service interval on reproductive performance in normal cows and cows with postpartal disease. The Canadian Veterinary Journal 24(11): 343-6.

Ferreira MFL, Rennó LN, Rodrigues II, Detmann E, Paulino MF, de Campos Valadares Filho S, Martins HC, Moreira SS and de Lana DS, 2021. Effects of parity order on performance, metabolic, and hormonal parameters of grazing beef cows during pre-calving and lactation periods. BMC Veterinary Research 17 (1): 311. https://doi.org/10.1186/s12917-021-03019-0

Gilbert RO, Shin ST, Guard CL, Erb HN and Frajblat M, 2005. Prevalence of endometritis and its effects on reproductive performance of dairy cows. Theriogenology 64(9): 1879-1888. https://doi.org/10.1016/j.theriogenology.2005.04.022

Holodova LV, Novoselova KS, Mikhalev EV, Onegov AV and Chirgin ED, 2019. The effect of age on milk productivity and reproductive qualities of dairy cows. IOP Conference Series: Earth and Environment Science 315: 022087. https://doi.org/10.1088/1755-1315/315/2/022087

Inchaisri C, Jorritsma R, Vos PL, van der Weijden GC and Hogeveen H, 2011. Analysis of the economically optimal voluntary waiting period for first insemination. Journal of Dairy Science 94(8): 3811-3823. https://doi.org/10.3168/jds.2010-3790

Irikura N, Uematsu M, Kitahara G, Osawa T and Sasaki Y, 2018. Effects of service number on conception rate in Japanese Black cattle. Reproduction in Domestic Animals 53(1): 34-39. https://doi.org/10.1111/rda.13049

Izaike Y, Suzuki O, Okano A, Shimada K, Oishi T and Kosugiyama M, 1989. Influences of parity, milk yield and suckling stimulation on uterine involution in beef cows. Japanese Journal of Animal Reproduction 35, 45-49.

Kasimanickam R, Duffield TF, Foster RA, Gartley CJ, Leslie KE, Walton JS and Johnson WH, 2004. Endometrial cytology and ultrasonography for the detection of subclinical endometritis in postpartum dairy cows. Theriogenology 62(1-2): 9-23. https://doi.org/10.1016/j.theriogenology.2003.03.001

Khan MRK, Uddin J and Gofur MR, 2015. Effect of age, parity and breed on conception rate and number of service per conception in artificially inseminated cows. Bangladesh Livestock Journal 1: 1-4.

Leroy JL, Vanholder T, Delanghe JR, Opsomer G, Van Soom A, Bols PE, Dewulf J and de Kruif A, 2004. Metabolic changes in follicular fluid of the dominant follicle in high-yielding dairy cows early postpartum. Theriogenology 62(6): 1131-1143. https://doi.org/10.1016/j.theriogenology.2003.12.017

M'hamdi N, Aloulou R, Bouallegue M, Brar SK and Hamouda MB, 2010. Study on functional longevity of Tunisian Holstein dairy cattle using a Weibull proportional hazard model. Livestock Science 132(1-3): 173-176. https://doi.org/10.1016/j.livsci.2010.05.011

Mufti MMR, Alam MK, Sarker MS, Bostami ABMR and Das NG, 2010. Study on factors affecting the conception rate in Red Chittagong cows. Bangladesh Journal of Animal Science 39(1-2): 52-57.

Ojango JMK, Ducrocq V and Pollott GE, 2005. Survival analysis of factors affecting culling early in the productive life of Holstein-Friesian cattle in Kenya. Livestock Production Science 92(3): 317-322. https://doi.org/10.1016/j.livprodsci.2004.08.011

Ospina PA, Nydam DV, Stokol T and Overton TR, 2010. Associations of elevated nonesterified fatty acids and β-hydroxybutyrate concentrations with early lactation reproductive performance and milk production in transition dairy cattle in the northeastern United States. Journal of Dairy Science 93(4): 1596-1603. https://doi.org/10.3168/jds.2009-2852

Rearte R, LeBlanc SJ, Corva SG, de la Sota RL, Lacau-Mengido IM and Giuliodori MJ, 2018. Effect of milk production on reproductive performance in dairy herds. Journal of Dairy Science 101(8): 7575-7584. https://doi.org/10.3168/jds.2017-13796

Ribeiro ES, Lima FS, Ayres H, Greco LF, Bisinotto RS, Favoreto M and Santos JEP, 2011. Effect of postpartum diseases on reproduction of grazing dairy cows. Journal of Dairy Science 94(1): 63.

Sheldon IM, Lewis GS, LeBlanc S and Gilbert RO, 2006. Defining postpartum uterine disease in cattle. Theriogenology 65(8): 1516-1530. https://doi.org/10.1016/j.theriogenology.2005.08.021

Stangaferro ML, Wijma RW and Giordano JO, 2019. Profitability of dairy cows submitted to the first service with the Presynch-Ovsynch or Double-Ovsynch protocol and different duration of the voluntary waiting period. Journal of Dairy Science 102(5): 4546-4562. https://doi.org/10.3168/jds.2018-15567

Than H, Aung M, Daw SSK and Ye HW, 2001. Improvement of cattle production in Myanmar through the use of progesterone RIA to increase efficiency and quality of artificial insemination services (No. IAEA-TECDOC-1220). International Atomic Energy Agency: 45-50

Tozer PR and Heinrichs AJ, 2001. What affects the costs of raising replacement dairy heifers: A multiple-component analysis. Journal of Dairy Science 84(8): 1836-1844. https://doi.org/10.3168/jds.S0022-0302(01)74623-1

Walters AH, Bailey TL, Pearson RE and Gwazdauskas FC, 2002. Parity-related changes in bovine follicle and oocyte populations, oocyte quality, and hormones to 90 days postpartum. Journal of Dairy Science 85(4): 824-832. https://doi.org/10.3168/jds.S0022-0302(02)74142-8

Wiltbank M, Lopez H, Sartori R, Sangsritavong S and Gümen A, 2006. Changes in reproductive physiology of lactating dairy cows due to elevated steroid metabolism. Theriogenology 65(1): 17-29. https://doi.org/10.1016/j.theriogenology.2005.10.003

Wiltbank MC, Sartori R, Herlihy MM, Vasconcelos JL, Nascimento AB, Souza AH, Ayres H, Cunha AP, Keskin A, Guenther JN and Gumen A, 2011. Managing the dominant follicle in lactating dairy cows. Theriogenology 76(9): 1568-1582. https://doi.org/10.1016/j.theriogenology.2011.08.012

Yusuf M, Nakao T, Yoshida C, Long ST, Gautam G, Ranasinghe RM, Koike K and Hayashi A, 2011. Days in milk at first AI in dairy cows; its effect on subsequent reproductive performance and some factors influencing it. Journal of Reproduction and Development 57(5): 643-649. https://doi.org/10.1262/jrd.10-097t

Zavadilová L and Štípková M, 2013. Effect of age at first calving on longevity and fertility traits for Holstein cattle. Czech Journal of Animal Science 58(2): 47-57.