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Relationship of Age at First Calving, First Lactation Milk Yield, Reproductive Performance and Diseases in Simmental Dairy Cows in Turkey

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ABSTRACT

The aim of this research was to determine the relationship between age at first calving (AFC) and first lactation milk yield [adjusted 305-day (MY_{305})], reproductive performance [days open (DO), calving interval (CI)] and diseases (lameness, mastitis, metritis and dystocia) in Simmental dairy cows bred under Turkey conditions. A total of 1110 Simmental cows (first calving to second calving) were assessed according to study criteria. While the relation between AFC and disease incidence and MY_{305} was not found significant, the relation between AFC and CI and DO was found significant and the optimum interval of AFC was determined 684≤ İBY≤730 d for minimum CI and DO. Even though relation between AFC and diseases was not significant, it can be said that the same interval is advantageous for low disease incidence in Simmental cows. Furthermore, it can be accepted that the same interval is optimum also for the best lactation milk yield since it was not found a significant relationship among the average milk yields according to AFC. In conclusion, it can be said that planning the reproductive management practices according to these results will be beneficial for the optimal balance between economic benefit, animal health and milk yield.

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Cow health, Reproduction, Milk yield, Dairy cow, Simmental

INTRODUCTION

Due to the rapid increase of intensive herd sizes in recent years, herd management strategies have become even more important for sustainable production. Animal health, reproductive condition and milk yield are considered important indicators for proper herd management (Okuyucu *et al*., 2018). On the other hand, some herd management practices, such as reducing the age at first calving aimed at reducing rearing costs may have a negative impact on animal health, reproductive performance and milk yield. Hence, it has been reported that calving at very early age may adversely affect milk performance and that heifers are more susceptible to certain health issues, especially dystocia, due to the fact that they are physically under-developed at the start of their first lactation (Hoffman and Funk, 1992). Although older age interval is being recommended for first calving for some breed and breeding systems, various research has shown that calving between 22-24 months in order to reduce breeding costs is suitable without any adverse effects on milk yield and animal health throughout the heifer's productive life (Hoffman, 1997; Nilforooshan and Edriss, 2004). In accordance, provide of the optimal balance between economic benefit, animal health and milk yield is mandatory.

The aim of this study was to determine the relationship between age at first calving (AFC) and milk yield adjusted 305 days (MY_{305}), reproductive performance and animal health in Simmental dairy herds in terms of providing the optimal balance between economic benefit, animal health and milk yield and increase the success of herd management practices accordingly.

MATERIALS AND METHODS

Selection of herd

Study was carried out in one commercial dairy farm (3,000 Simmental cows) which is one of the biggest dairy farms located in west central Bursa, Turkey because of elimination of some environmental factors like as climate or nutrition and management practice that will be able to effect on results.

Selection of cows

Lactations with milk yields outside the range 2,000

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to 12,000 L and DIM 260 to 400 days and cows that do not comply with the descriptive values of the calving age according to the calving order reported by Kumlu and Akman (1999) were excluded from the study. In accordance, a total of 1110 Simmental cows that born in 2016 completed their first lactation and gave their second calving were included in the study. The first calvings occurred between April 2018 and June 2019, and the second calvings February 2019 and August 2020. AFC (age at first calving, day), MY_{305} (milk yield adjusted 305 days, L), DO (days open), CI (calving interval, day) and health records (yes, no) were collected from the herd database.

Statistical analyses

For analyses, cows were divided into groups with mean ± 1 standard deviation width according to AFC and MY_{305} and the relation between these groups and disease incidence was investigated as used Chi-square tests. Also, ANOVA was used to investigate whether the difference between AFC groups in terms of CI, DO and MY_{305} or not and when necessary, Duncan's multiple range test was used. Means of cows with each health problem and healthy cows were compared with the t-test to determine whether the health problems had an effect on AFC, CI, DO and MY_{305} or not. SPSS Inc (2008) was used for statistical analysis.

RESULTS AND DISCUSSION

As descriptive statistics in this study, the average AFC, MY_{305}, and CI was found 706.89 ± 1.41 days, 6928.50 ± 33.51 L, 377.87 ± 1.44 days, respectively in the study herd. Lameness has been determined to be the most common health problem observed 32.2% in the study herd. Mastitis, metritis and dystocia followed with of 29.3%, 14% and 8%, respectively. In terms of first lactation MY_{305}, the result of this study was found higher than results reported by Cilek and Tekin (2005), Ozkan and Gunes (2011), Okuyucu *et al*. (2018) and lower than the result reported by Kucuk-Baykan and Ozcan (2017) while they have been observed to be coherent with results reported for various regions of Europe by Perišić *et al*. (2009). When the study results were evaluated for AFC, it is seen that AFC was earlier according to the national or international research's results (Akbulut, 1998; Kocak *et al*., 2008; Szewczuk *et al*., 2015; Fedorovych, 2017). This result is decisive for herd economics and sustainability and can be explained that the animal group constituting the study materials having reached early two-thirds of mature weight which is considered a physical indicator of suitable time for insemination as reported by Mourits *et al*. (1997). Moreover, this result also exhibits the success and the importance of herd management programme for animal tracking practised in this herd before, during and after inseminations. When the effect of AFC on MY_{305} and reproductive performance investigated, the results are as shown in Table I. Contrary to studies reporting importance of positive correlation between AFC and MY_{305} (Krpálková *et al*., 2014) or studies reporting of negative correlation (Curran *et al*., 2013), in this study, it was not found significant difference exists between mean milk yields of animals in AFC groups. The difference of the results in studies on the effect of optimum first calving age on milk yield for different breeds so far establishes the importance of the effect of factors such as the breed being studied, environment, practised herd management programme etc. Under the circumstances, every result obtained shall constitute data in terms of performance information pertaining to the studied breed.

On the other hand, it has been determined that the difference observed as a result of the study in terms of DO and CI as reproductive performance criteria for animals in different AFC groups was found significant (P<0.05). Under the circumstances, the first thing to consider is whether there is any difference between AFC groups in terms of first service interval (FSI) after calving. Average FSI was found 67.28 ± 0.42 days in this study and this value is favourable for good reproductive management (Esslemont and Kossaibati, 2000; Uygur, 2004). When AFC groups were evaluated for FSI, the difference between

Table I. Effects of AFC on CI, DO and MY_{305} in Simmental dairy cows in Turkey.

AFC (d)	N	CI*	DO*	MY_{305}
		Mean ± SE	Mean ± SE	Mean ± SE
< 684	437	377.67 ± 2.46 †‡	95.83 ± 2.09 †	6905.81 ± 55.99
684 – 730	417	373.88 ± 2.10 †	93.92 ± 1.86 †	6904.19 ± 54.10
731 – 777	159	382.95 ± 4.08 †‡	100.35 ± 3.40 †‡	6977.30 ± 84.47
> 777	97	387.64 ± 4.65 ‡	108.02 ± 4.76 ‡	7059.67 ± 101.42
General	1110	377.87 ± 1.44	96.82 ± 1.26	6928.89 ± 33.51

AFC, Age at first calving; CI, Calving interval; DO, Days open; MY_{305}, Milk yield adjusted 305-day; †,‡ Means in a column with no common superscript differ; *, denote statistical significance at the P<0.05.

groups was not found significant (Table II). This result is indicated that there is a problem regarding the conception rate in the first AI in the herd with a mean DO of 96.82 ± 1.26 days or in another point of view, there is a problem regarding service per conception. Accordingly, DO and in parallel with DO, CI has prolonged. While many factors such as AI technician (age, skills, serving internal or external) the season of AI, the semen used, etc. can be effective on DO (Bhave *et al*., 2021); there are also lots of studies reporting the effect of AFC on in AI. Hence, Ettema and Santos (2004) reported that the lowest DO occurred in the youngest group with AFC <23 months; Banos *et al*. (2007) reported longer DO and CI for the young group with AFC within 18-23 months interval, with 7% higher service per conception and 7.5% higher rate of return. Similarly, Krpálková *et al*. (2014) and Eastham *et al*. (2018) reported higher DO and CI in young group with AFC <26 months. According to the results of this study, the AFC interval suitable for the lowest DO and CI is found to be 684≤ AFC ≤730 days (22.5≤ AFC ≤24 months) (P<0.05). As reported by other researchers, the result obtained is important for rapid genetic improvement, increase productive life and for the decrease in herd renewal costs (Ettema and Santos, 2004; Nilforooshan and Edriss, 2004).

Table II. Mean ± SE of FSI in different AFC groups.

AFC (d)	N	FSI	
< 684	436	65.69 ± 0.64	NS
684 – 730	413	68.67 ± 0.70	
731 – 777	158	68.26 ± 1.15	
> 777	97	66.89 ± 1.51	
General	1110	67.28 ± 0.42	

AFC, Age at first calving; FSI, First service interval; *NS*, not significant.

When the relationship between AFC and diseases investigated, it was seen that disease incidence increases with increased AFC except for dystocia (Table III) but this relationship was not found significant. The reason for this result can be appropriate rearing, feeding and preventive veterinary practices in the postpartum period. Another possible reason can be the animal group constituting the study material was young. As a matter of fact, Dohoo *et al*. (1984) has reported a linear relationship between age and disease incidence. Still, it can be mentioned that the optimum AFC interval for minimum health problem is the optimum 684≤ AFC ≤730 days interval as determined for minimum DO and CI in this study. When the study material was assessed in terms of recorded health problems, the results as shown in Table IV. It was found that AFC is higher and MY_{305} is lower in cows with lameness (P<0.05). There are studies that reported a decrease in milk yield for cows with lameness (Amory *et al*., 2008; Charfeddine and Pérez-Cabal, 2017). As to high AFC in cows with lameness, study result is consistent with results as reported by Mason (2017). The researcher has reported that the incidence of lameness in cows calving at younger ages is lower than cows calving at later ages.

One reason for this can be that the changes in hoof structure and flexor tendons following the calving be causing fewer complications in younger animals as reported by Webster (2001). One other reason may be the body weight of the animals according to the age of first calving. Even though body weights were not evaluated in the study, Singh *et al*. (2012) reported that the percentage changes in body weight in animals were associated with the lameness incidence and that the incidence increased as the weight increased. Incidence of lameness is high in dairy cattle herds and arrangements are unfortunately limited for yield and in feeding program that supports the high milk yield that for decreasing this incidence. For this reason, it may be pointed out that for such type of herds; practises to strengthen and protect foot and leg health such as regular claw trimming, manure management, foot bath, proper bedding etc. are more of a necessity than choice. When compared the cows with dystocia and without, it was found that lower MY_{305} and AFC and higher DO and CI in cows with dystocia. However, the differences between groups were not found significant despite studies reporting otherwise. This result may be explained with dystocia score. Disease records that belong to cows were collected from herd records (yes, no) so, the dystocia score was evaluated as “unassisted” and “assisted” in the study performed by Johanson and Berger (2003). Although there is no common way of determining the level of calving difficulty, some other researchers suggested different scoring for more accurate assessment. Hansen *et al*. (2004) suggest a four-point scoring system of calving difficulty: (1) easy, (2) easy with assistance, (3) difficult but without veterinary assistance and (4) difficult with veterinary assistance. Ettema and Santos (2004) also distinguished four levels of calving difficulty but defined them differently: (0) no assistance with normal delivery of a live calf, (1) no assistance with normal delivery of a stillborn calf, (2) some assistance required for extraction of the calf and (3) difficult calving with forced extraction of the calf. Considering this information, the non-existence of difference between groups can be explained that dystocia records in the herd actually being non-assisted instances according to other evaluation systems.

Animals have completed involution periods after calving without any problems and their reproductive performance or milk yield being adversely non-affected.

While the milk yield was found to be low for animals with mastitis which is in concordance with many preceding studies (P<0.01), was not found a significant relation between mastitis and reproductive parameters. This result can be explained that the effect of efficient herd health management where early diagnosis and proper treatment protocols are performed in time and correctly as reported by Fourichon *et al*. (2000). When compared the cows with metritis and without, it was found that decreasing in MY_{305} and AFC and increasing DO and CI in cows with metritis. While the difference was not found significant in between groups in terms of MY_{305} and AFC was found significant for DO and CI (P<0.01). This result in terms of the relation between metritis and DO and CI corresponded with the results of current studies (Vieira-Neto *et al*., 2016; Dubuc and Denis-Robichaud, 2017). Postpartum uterus infections such as metritis effects increasing CI directly since they prolong the FSI and DO (Foldi *et al*., 2006).

In this study, the DO and CI in the group with metritis was observed to have prolonged for 11 and 13 days, respectively. According to these results, in view of heat occurs every two to three weeks on average (Kojima, 2003), the 13 days of difference for CI can also be explained as one heat has been missed on average due to metritis. The negative effects of uterus diseases on fertility reported by current studies (Pinedo *et al*., 2020; Pérez-Báez *et al*., 2020) support these results.

Table III. Relation between AFC and disease incidence.

AFC (d)	Mastitis				Metritis				Dystocia				Lameness			
	NO	O	%		NO	O	%		NO	O	%		NO	O	%	
< 684	311	126	28.8		372	65	14.8		396	41	9.4		284	153	35.1	
684 – 730	298	119	28.5	NS	356	61	14.6	NS	383	34	8.2	NS	293	124	29.7	NS
731 – 777	112	47	29.6		135	24	15.1		147	12	7.5		110	49	30.8	
> 777	58	39	40.2		81	16	16.5		91	6	6.2		54	43	44.3	

AFC, Age at first calving; NO, Non observed; O, Observed; *NS*, not significant.

Table IV. Relation between diseases and milk yield and reproductive parameters.

Diseases		N	MY_{305}		AFC		CI		DO	
			Mean ± SE		Mean ± SE		Mean ± SE			
Lameness	NO	753	6985.83 ± 40.58	*	704.40 ± 1.62	*	377.65 ± 1.85		95.76 ± 1.54	
	O	357	6808.78 ± 59.00		712.13 ± 2.72		378.35 ± 2.19		99.06 ± 2.20	
Dystocia	NO	1017	6943.62 ± 34.67		707.59 ± 1.49		374.73 ± 3.63		94.90 ± 3.60	
	O	93	6767.85 ±127.00		699.22 ± 4.10		378.16 ± 1.54		97.00 ± 1.34	
Mastitis	NO	785	7026.73 ± 38.45	**	706.07 ± 1.62		378.59 ± 1.80		97.06 ± 1.51	
	O	325	6692.57 ± 65.15		708.86 ± 2.82		376.15 ± 2.29		96.25 ± 2.29	
Metritis	NO	958	6942.05 ± 36.37		713.20 ± 4.41		376.14 ± 1.51	**	95.28 ± 1.33	**
	O	152	6845.92 ± 85.70		705.88 ± 1.48		388.82 ± 4.40		106.53 ± 3.68	

MY_{305}, Milk yield adjusted 305-day; AFC, Age at first calving; CI, Calving interval; DO, Days Open; **,* denote statistical significance at the P<0.01, P<0.05 respectively; *NO*, Non observed; *O*, Observed.

Table V. Relation between MY_{305} and diseases.

MY_{305} (L)	Mastitis			Metritis			Dystocia			Lameness		
	NO	O	%	NO	O	%	NO	O	%	NO	O	%
<5254.1	35	34	49.3	58	11	15.9	63	6	8.7	43	26	62.3
5254.1 – 6370.6	170	86	33.6	220	36	14.1	226	30	11.7	92	164	64.1
6370.7 – 7487.1	324	130	28.6	392	62	13.7	421	33	7.3	148	306	67.4
7487.2 – 8603.7	196	60	23.4	218	38	14.8	240	16	6.3	72	184	71.9
> 8603.7	60	15	20.0	70	5	6.7	67	8	10.7	19	56	74.7
			**									

MY_{305}, Milk yield adjusted 305-day; **, denote statistical significance at the P<0.01; NO, Non observed; O, Observed.

Therefore, accurate assessment of factors in after calving such as birth stress, negative energy balance and rapid body condition loss which increase the risk of uterus infection and reduce the immune system in this period is critical. Accordingly, it can be said that follow-up of animals and taking protective cautions until the 3rd and 4th week after calving when bacterial contamination significantly decreases (Williams *et al*., 2007) are important and priority in increasing the reproductive performance within the herd. Finally, the relationship between MY_{305} and diseases was investigated and the relation between MY_{305} and mastitis was found important in animals of different milk yield groups ($P<0.01$), (Table V). According to this result, it can be said that mastitis incidence is low in high milk yield groups. It would be more accurate to interpret this result as a milk yield has been increased because of a decrease in mastitis incidence. Results of similar studies on this subject both national and international are in support of this interpretation (Kocak, 2006; Dhakal *et al*., 2016; Grayaa *et al*., 2019).

CONCLUSION

As a conclusion, it can be said that for Simmental breed cows bred in intensive herd, for the purposes of establishing the optimal balance between economic benefit, yield and animal health in the herd, the most suitable interval of AFC for maximum reproductive performance is $684 \leq AFC \leq 730$ days. Since was not found a significant difference between lactation milk yields according to AFC groups, it could be accepted the same interval as optimum for the best lactation milk yield and the mean lactation milk yield was 6904.19 ± 54.10 L in this interval. Although there was no significant difference between in AFC groups in terms of diseases observed, it can be seen that the optimum interval of AFC is the same for the lower incidence of lameness and mastitis that affect MY_{305} and metritis that affect fertility. Age at first calving is an important factor in the cost of rearing replacements in all dairy herds and the results of this study are important in terms of length of the rearing period and decreasing rearing cost as a management factor in Simmental dairy herds. Nevertheless, to achieve clearer conclusions regarding about performance of Simmental cows, do more studies that involved more animals and also considering the effects of different environmental factors would be beneficial.

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Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Akbulut, Ö., 1998. Simental sığırların Türkiye'de verim performansı üzerine bir değerlendirme. *Atatürk Univ. J. Agric. Fac.*, **29**: 43-49.

Amory, J., Barker, Z.E., Wright, J., Mason, S., Blowey, R.W. and Green, L.E., 2008. Associations between sole ulcer, white line disease and digital dermatitis and the milk yield of 1824 dairy cows on 30 dairy cow farms in England and Wales from February 2003-November 2004. *Prev. Vet. Med.*, **83**: 381–391. https://doi.org/10.1016/j.prevetmed.2007.09.007

Banos, G., Brotherstone, S. and Coffey, M.P., 2007. Prenatal maternal effects on body condition score, female fertility, and milk yield of dairy cows. *J. Dairy Sci.*, **90**: 3490–3499. https://doi.org/10.3168/jds.2006-809

Bhave, K., Shirsath-Kalbhor, T., Potdar, V., Joshi, S., Guandare, Y. and Marimutthu, S., 2021. Study of effect of non-genetic factors on reproduction traits in Holstein Friesian crossbreed cows. *Indian J. Pure appl. Biosci.,* **9**: 359-366. https://doi.org/10.18782/2582-2845.8554

Charfeddine, N. and Pérez-Cabal, M.A., 2017. Effect of claw disorders on milk production, fertility, and longevity, and their economic impact in Spanish Holstein cows. *J. Dairy Sci.*, **100**: 653–665. https://doi.org/10.3168/jds.2016-11434

Cilek, S. and Tekin, M.E., 2005. Environmental factors affecting milk yield and fertility traits of Simmental cows raised at the Kazova state farm and phenotypic correlations between these traits. *Turk. J. Vet. Anim. Sci.*, **29**: 987-993.

Curran, R.D., Weigel, K.A., Hoffman, P.C., Marshall, J.A., Kuzdas, C.K. and Coblentz, W.K., 2013. Relationships between age at first calving; herd management criteria; and lifetime milk, fat, and protein production in Holstein cattle. *Prof. Anim. Sci.*, **29**: 1–9. https://doi.org/10.15232/S1080-7446(15)30188-1

Dhakal, K., Tiezzi, F., Clay, J. and Maltecca, C., 2016. Causal relationships between clinical mastitis events, milk yields and lactation persistency in US Holsteins. *Livest. Sci.*, **189**: 8-16. https://doi.org/10.1016/j.livsci.2016.04.015

Dohoo, I.R., Wayne Martin, S., McMillan, I. and Kennedy, B.W., 1984. Disease, production and culling in Holstein-Friesian cows II. Age, season and sire effects. *Prev. Vet. Med.*, **2**: 655-670. https://

doi.org/10.1016/0167-5877(84)90012-6

Dubuc, J. and Denis-Robichaud, J., 2017. A dairy herd-level study of postpartum diseases and their association with reproductive performance and culling, *J. Dairy Sci.*, **100**: 3068-3078. https://doi.org/10.3168/jds.2016-12144

Eastham, N.T., Coates, A., Cripps, P., Richardson, H., Smith, R. and Oikonomou, G., 2018. Associations between age at first calving and subsequent lactation performance in UK Holstein and Holstein-Friesian dairy cows. *PLoS One*, **13**: e0197764. https://doi.org/10.1371/journal.pone.0197764

Esslemont, R.J., and Kossaibati, M.A., 2000. The use of databases to manage fertility. *Anim. Reprod. Sci*., **60-61**: 725-741. https://doi.org/10.1016/S0378-4320(00)00081-6

Ettema, J.F. and Santos, J.E., 2004. Impact of age at calving on lactation, reproduction, health, and income in first-parity Holsteins on commercial farms. *J. Dairy Sci.,* **87**: 2730–2742. https://doi.org/10.3168/jds.S0022-0302(04)73400-1

Fedorovych, V.V., 2017. The impact of reproductive capacity indicators of simmental cattle on their milk productivity. *Sci. Messenger Lnuvmbt named S.Z. Gzhytskyj*, **19**: 52–56. https://doi.org/10.15421/nvlvet7412

Foldi, J., Kulcsar, M., Pecsi, A., Huyghe, B., de Sa, C., Lohuis, J.A.C.M., Cox, P. and Huszenicza, G.Y., 2006. Bacterial complications of postpartum uterine involution in cattle. *Anim. Reprod. Sci*., **96**: 265–281. https://doi.org/10.1016/j.anireprosci.2006.08.006

Fourichon, C., Seegers, H. and Malher, X., 2000. Effect of disease on reproduction in the dairy cow: A meta-analysis *Theriogenology*, **53**: 1729-1759. https://doi.org/10.1016/S0093-691X(00)00311-3

Grayaa, M., Vanderick, S., Rekik, B., Gara, A.B., Hanzen, C., Grayaa, S., Mota, R.R., Hammami, H. and Gengler, N., 2019. Linking first lactation survival to milk yield and components and lactation persistency in Tunisian Holstein cows. *Arch. Anim. Breed.*, **62**: 153-160. https://doi.org/10.5194/aab-62-153-2019

Hansen, M., Lund, M.S., Pedersen, J. and Christensen, L.G., 2004. Gestation length in Danish Holsteins has week genetic associations with stillbirths, calving difficulty, and calf size. *Livest. Prod. Sci.*, **91**: 23–33. https://doi.org/10.1016/j.livprodsci.2004.06.007

Hoffman, P.C. and Funk, D.A., 1992. Applied dynamics of dairy replacement growth and management. *J. Dairy Sci.*, **75**: 2504–2516. https://doi.org/10.3168/jds.S0022-0302(92)78012-6

Hoffman, P.C., 1997. Optimum body size of Holstein replacement heifers. *J. Anim. Sci.*, **75**: 836–845. https://doi.org/10.2527/1997.753836x

Johanson, J.M. and Berger, P.J., 2003. Birth weight as a predictor of calving ease and perinatal mortality in Holstein cattle. *J. Dairy Sci.*, **86**: 3745–3755. https://doi.org/10.3168/jds.S0022-0302(03)73981-2

Kocak, O., 2006. Influence of mastitis on milk yield in Holstein cows. *Acta Vet. Brno*, **75**: 507–513. https://doi.org/10.2754/avb200675040507

Kocak, S., Tekerli, M., Özbeyaz, C. and Demirhan, İ., 2008. Lalahan Merkez Hayvancılık Araştırma Enstitüsü'nde yetiştirilen Holştayn, Esmer ve Simental sığırlarda bazı verim özellikleri. *Lalahan Hay. Araşt. Enst. Derg.*, **48**: 51–57.

Kojima, F.N., 2003. The estrous cycle in cattle: Physiology, endocrinology, and follicular waves. *Prof. Anim. Sci*., **19**: 83–95. https://doi.org/10.15232/S1080-7446(15)31387-5

Krpálková, L., Cabrera, V.E., Kvapilík, J., Burdych, J. and Crump, P., 2014. Associations between age at first calving, rearing average daily weight gain, herd milk yield and dairy herd production, reproduction, and profitability. *J. Dairy Sci.*, **97**: 6573–6582. https://doi.org/10.3168/jds.2013-7497

Kucuk Baykan, Z., and Ozcan, M., 2017. Determination of reproduction and lactation parameters in the first production year of Brown Swiss and Simmental cows imported from Austria. *Istanbul Univ. Vet. Fak. Derg.*, **43**: 132-139. https://doi.org/10.16988/iuvfd.324052

Kumlu, S. and Akman, N., 1999. Türkiye damızlık Siyah Alaca sürülerinde süt ve döl verimi. *Lalahan Hay. Araşt. Enst. Derg.*, **39**: 1-16.

Mason, W., 2017. Association between age and time from calving and reported lameness in a dairy herd in the Waikato region of New Zealand. *N. Z. Vet. J*., **65**: 163-167. https://doi.org/10.1080/00480169.2017.1289864

Mourits, M.C.M, Dijkhuizen, A.A, Huirne, R.B.M. and Galligan, D.T., 1997. Technical and economic models to support heifer management decisions: Basic concepts. *J. Dairy Sci.,* **80**: 1406–1415. https://doi.org/10.3168/jds.S0022-0302(97)76070-3 https://doi.org/10.3168/jds.S0022-0302(97)76070-3

Nilforooshan, M.A. and Edriss, M.A., 2004. Effect of age at first calving on some productive and longevity traits in Iranian Holsteins of the Isfahan province. *J. Dairy Sci.,* **87**: 2130–2135. https://doi.org/10.3168/jds.S0022-0302(04)70032-6

Okuyucu, I.C., Erdem, H. and Atasever, S., 2018. Determination of herd management level by some reproduction and milk yield traits of Simmental cows at intensive conditions in Turkey. *Sci. Pap. Ser. D Anim. Sci.*, **61**: 135-139.

Ozkan, M., and Gunes, H., 2011. Kayseri'deki özel işletmelerde yetiştirilen Simmental sığırların süt verim özellikleri üzerinde bazı faktörlerin etkileri. *İstanbul Univ. Vet. Fak. Derg.,* **37**: 81-88.

Pérez-Báez, J., Silva, T.V., Risco, C.A., Chebel, R.C., Cunha, F., De Vries, A., Santos, J.E.P., Lima, F.S., Pinedo, P., Schuenemann, G.M., Bicalho, R.C., Gilbert, R.O., Rodrigez-Zas, S., Seabury, C.M., Rosa, G., Thatcher, W.W. and Galvão, K.N., 2020. The economic cost of metritis in dairy herds. *J. Dairy Sci*., **104**: 3158-3168. https://doi.org/10.3168/jds.2020-19125

Perišić, P., Skalicki, Z., Petrović, M.M., Bogdanović, V. and RužićMuslić, D., 2009. Simmental cattle breed in different production systems. *Biotechnol. Anim. Husb*., **25**: 315-326. https://doi.org/10.2298/BAH0906315P

Pinedo, P., Santos, J.E.P., Chebel, R.C., Galvão, K.N., Schuenemann, G.M., Bicalho, R.C., Gilbert, R.O., Rodriguez Zas, S., Sea-bury, C.M., Rosa, G. and Thatcher, W.W., 2020. Early-lactation diseases and fertility in 2 seasons of calving across US dairy herds. *J. Dairy Sci.,* **103**: 10560–10576. https://doi.org/10.3168/jds.2019-17951

Singh, M., Lathwal, S.S., Singh, Y., Kumar, A., Gupta, A.K., Mohanty, T.K., Vraja, T., Gupta, R.K., Sharma, V., Chandra, G. and Kumar, M., 2012. Association of lameness with per cent body weight distribution and shifting to individual limbs of static Karan Fries crossbred cows. *Indian J. Anim. Sci*., **82**: 962–970.

SPSS Inc., 2008. *SPSS Statistics for Windows, Version 17.0.* Chicago.

Szewczuk, M., Chocilowicz, E. and Bartosiewicz, R., 2015. Effect of age at first calving on the yield and composition of simmental cows milk. *Zeszyty Naukowe Uniwersytetu Przyrodniczego we Wrocławiu. Biologiai Hodowla Zwierząt,* **613**: 63–69.

Uygur, A.M., 2004. Süt sığırcılığı sürü yönetiminde döl verimi. *Hayvansal Üretim*, **45**: 23-27.

Vieira-Neto, A., Lima, F.S., Santos, J.E.P., Mingoti, R.D., Vasconcellos, G.S., Risco, C.A. and Galvao, K.N., 2016. Vulvovaginal laceration as a risk factor for uterine disease in postpartum dairy cows. *J. Dairy Sci*., **99**: 4629-4637. https://doi.org/10.3168/jds.2016-10872

Webster, A.J.F., 2001. Effects of housing and two forage diets on the development of claw horn lesions in dairy cows at first calving and in first lactation. *Vet. J*., **162**: 56–65. https://doi.org/10.1053/tvjl.2001.0569

Williams, E.J., Fischer, D.P., Noakes, D.E., England, G.C.W., Rycroft, A., Dobson, H. Sheldon, I.M., 2007. The relationship between uterine pathogen growth density and ovarian function in the postpartum dairy cow. *Theriogenology*, **68**: 549-559. https://doi.org/10.1016/j.theriogenology.2007.04.056