Available online at www.sciencedirect.com
ScienceDirect
Preventive Veterinary Medicine 85 (2008) 158–165
PREVENTIVE VETERINARY MEDICINE
www.elsevier.com/locate/prevetmed

Short communication

Study of reproductive performance and related factors in four dairy herds in Fars province (southern Iran) by Cox proportional-hazard model

Maryam Ansari-Lari *, Sepideh Abbasi

Department of Food Hygiene and Public Health, School of Veterinary Medicine, Shiraz University, Shiraz 71345, Iran

Received 21 August 2007; received in revised form 2 February 2008; accepted 7 February 2008

Abstract

Our objective was to characterize the current reproductive performance and factors which may be related to it in the Fars province dairy herds in southern Iran. We collected retrospective data from four commercial herds in the region. All 256 cows with history of calving between 21 March 2004 and 20 March 2005 were followed until subsequent pregnancy, culling or death. Effects of risk factors on days open were investigated in a Cox proportional-hazards model. The overall median calving interval, dry period and days open were 388, 68, and 120 days, respectively. First-service conception risk and overall-service conception risk were 45 and 42%, respectively. Average numbers of insemination per pregnant and all cows were 2 and 2.1, respectively. Cows without incidence of any disorder during the lactation (but before conception, and including metabolic disorders) had 2.1-times greater hazard of conception than cows with incidence of disease. No significant association between calving interval, dry period, parity of dam, and sex and weight of calves with days open was observed.

Keywords: Dairy cow; Days open; Cox model; Iran; Reproductive performance

1. Introduction

Reproductive performance of dairy cows is important in evaluating dairy management, because it influences profitability through milk production, reproductive culling risks and animal sales (Vargas et al., 1998). A regular analysis of reproductive performance is required to understand how it impacts on herd management, feeding policy and herd health. Measures for

* Corresponding author. Tel.: +98 711 2286950; fax: +98 711 2286940.
E-mail address: ansari@shirazu.ac.ir (M. Ansari-Lari).

0167-5877/$ – see front matter
doi:10.1016/j.prevetmed.2008.02.004

evaluation of reproductive performance are various and no single parameter can adequately summarize reproductive performance (Kanuya et al., 2000).

In Iran over the last decade, commercial dairy herds expanded continuously. In these herds, production and reproduction data are routinely collected. Fars province is one of the major dairy-production areas of the country. Our objectives were to determine current reproductive performance as well as factors related to it in Fars province daries in southern Iran. For evaluation of reproductive performance, a panel of reproductive parameters was determined and we used the event-time approach (a Cox proportional-hazards model) for analysis.

2. Materials and methods

Our retrospective cohort study was conducted in the central part of the Fars province, southern Iran. This part has relatively rainy mild winters and hot dry summers. The average temperature is 17 °C ranging between 5 and 30 °C. Study population consisted of 4 commercial herds in this part which were under registration of the national ‘‘Dairy herd improvement program’’ by the Agricultural Jahad Organization (AJO), Ministry of Agriculture. The commercial dairy herds in the province have different management practices; however, all of them are crossbreds (Holsteins-indigenous) or Holstein dairy herds with non-seasonal calving programs, and are artificially inseminated as a routine. We considered the four dairy herds in the present study to be cooperative, and to be nearly representative of other commercial dairy farms in the province with respect to reproductive performance. Comparison of reproductive values of these herds with what was reported for all province in 2005 (Ministry of Agriculture, Animal breeding Center website) is as follows, respectively: average calving interval, 416 vs. 426 days ($t = -1.43$, d.f. = 184, $P = 0.15$); average days open, 148 vs. 146 ($t = 0.55$, d.f. = 255, $P = 0.58$); and average parity, 2.72 vs. 2.77 ($t = -0.48$, d.f. = 255, $P = 0.64$). The median herd size for province is ~50, so we must acknowledge that our study herds were larger. The average 305-day milk production for 2004–2005 ranged from 7413.3 to 8284.2 kg per cow in the study herds. Comparing their average production with that of province (7193 kg) showed significant difference ($P < 0.05$). Therefore regarding production, it seems that the study herds are in a better situation than the province's herds generally.

In the study herds, artificial insemination (AI) was done by a trained herd owner or an AI technician. Estrous detection was conducted on a time-planned observation schedule and diagnosis of pregnancy was done by rectal palpation between 45 and 55 days post insemination. Cows were housed in open-shed barns, milked 3 times per day and the milk was used for manufacturing. Their rations were based primarily on corn silage, alfalfa hay and some concentrates with ground barley as the main energy source. They had veterinary consultants for disease management and nutrition. They had reliable manual (3 herds) or computerized (one herd) record keeping and data management was done by herd managers.

All cows with history of calving between 21 March 2004 and 20 March 2005 were included in the analysis. Each cow was followed until subsequent pregnancy, culling or death regardless of how long the time interval. If she was culled or died before pregnancy, she considered to be censored and the interval from calving to censoring was calculated. Data about date of dry-off, calving date, parity of the cow, sex and weight of calves at the parity initiating the study lactation, number of inseminations, date of last service which resulted in pregnancy, confirmation of pregnancy and date of culling or death were obtained from herd records.

There were 256 cows (comprising more than 50% of all cows in these herds) which had calving during the study period. Parity was categorized into the first, second, third, fourth, and

fifth or greater. In the study period, 38 total cases with various disorders after calving were recorded; the diagnoses included retained placenta, metritis, endometritis, cystic and inactive ovaries, and mastitis; and metabolic disease including ketosis and hypocalcemia. Only disease conditions which occurred before subsequent conception was recorded in this study. Because of the retrospective nature of our data, there was no way to know which criteria were used for diagnosis of each disease. Nevertheless, it is our experience with these herds that diagnoses were based on conventional clinical signs and symptoms. Due to low incidence of each disorder, these disorders were combined and then categorized as a dichotomous variable in the statistical analysis (Dohoo et al., 2003).

Reproductive parameters consisted of days open, first- and overall-service conception risk (the proportion of first and all services which result in pregnancy, respectively), and services per conception for pregnant and for all cows. These parameters were reported as percents or quartiles. For cows that were diagnosed to be pregnant, date of last service was considered the date of conception. Days open were calculated as the interval between date of last service and date of previous calving. Length of dry period and calving interval were calculated for multiparous cows with complete records for these measures.

To determine the effect of predictor variables on days open, we used Cox proportional-hazards regression with subsequent pregnancy defined as the failure event (outcome variable). Cows that did not have a failure event (i.e. that were culled or died) were considered as having censored records and the date of censoring had to be available. The longest censored observation in this study was 829 days. The predictor variables tested were parity of dam (five groups), sex of calves (two groups), disease status (two groups), and herd (four groups) as categorical variables; and weight of calves, length of dry period and calving interval as continuous variables. Multicollinearity amongst predictor variables was assessed using Spearman rank correlation coefficients, Wilcoxon's rank-sum test and Chi-square test. Correlation coefficients were <0.20 (absolute value), and all 2-sided P-values were ≥ 0.11, revealing lack of significant collinearity in the dataset. Initial screening for association of predictor variables with the outcome was conducted using rank-sum tests for categorical variables and Spearman correlation for continuous variables. Those variables with 2-sided P-values <0.2 in the initial screening were offered to the Cox model. Herd was forced to remain in the model to account for clustering effect. To construct the model, in the first step, all main effects and relevant two-way interactions (disease $\times$ sex, disease $\times$ parity and parity $\times$ calving interval) were included in the analysis. Our backward-elimination procedure progressively dropped nonsignificant effects using the likelihood ratio Chi-square. To check the proportional-hazards assumption, graphical methods were used: the log of the negative log of survival was plotted against days open with the significant independent variables as strata. No violation of the proportionality assumption was evident. All analysis was conducted by SPSS software (version 11.5). In the final model alpha was 0.05 (2-sided).

3. Results

Overall, 84% of cows (216 out of 256) became pregnant during the study period. First-service conception risk and overall-service conception risk were 45 and 42%, respectively. Average numbers of insemination per pregnant and all cows were 2 and 2.1, respectively. The overall median calving interval, days open, and days dry were 388, 120, and 68 days, respectively (Table 1).

The overall mean weight of calves was 39.9 ± 4.10 kg. Diseased cows had slightly heavier calves than healthy cows (41.5 vs. 39.8 kg, $P = 0.03$). There was no significant association

Table 1
Quartiles (Q_i) for reproductive parameters in 256 dairy cows from four herds in the Fars province, southern Iran during 2004–2005

Factor	Calving interval			Days open			Dry period		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
Herd[a]									
1	362	400	537	83	118	203	58	66	83
2	347	367	425	58	108	195	64	69	79
3	344	376	446	86	134	218	66	82	106
4	354	397	444	75	115	196	61	67	71
Parity[b]									
1				66	99	199			
2	348	377	442	80	115	198	61	67	75
3	355	393	469	81	121	215	63	71	88
4	350	393	480	118	162	203	64	69	89
≥5	355	397	442	80	113	198	61	68	93
Periparturient disorder[b]									
Yes	376	414	448	107	173	298	65	75	100
No	348	385	443	74	113	190	62	68	77
Sex of calf[a]									
Male	354	388	438	82	126	202	61	68	77
Female	348	382	459	77	107	199	63	68	79

[a] P-value >0.2 in initial screening analysis for association with days open.
[b] P-value <0.2 in initial screening analysis for association with days open.

between calving interval and dry period with disease status, parity, and sex and weight of calves ($P \geq 0.11$). Also, the association between parity of dam and disease status was not significant ($P = 0.26$).

The distribution of animals according to pregnancy status with regard to median days open is shown in Table 2. Forty nine percent of all cows (95% CI: 43, 55%) were open after 120 days and 38% (95% CI: 32, 44%) still were open after 150 days— but there were no differences in this between parity groups ($P = 0.93$).

Based on initial screening tests, disease, parity and calving interval had significant association with days open with $P < 0.2$ (Table 1), whereas no association between dry period and weight of calves with days open was observed. Results of the Cox regression model showed no significant association for calving interval and parity with the hazard of conception. The only factor retained was disease status of animal (Table 3; with herd forced into the model). No significant interaction was detected between covariates in the model. Fig. 1 shows the Kaplan–Meier survival curves for time to conception stratified by disease status. Cows without incidence of any disorder during the lactation had 2.1-times greater hazard of conception than cows with incidence of disease.

4. Discussion

The overall median calving interval was 388 days (12.9 mo). There are diverse reports about duration of calving interval because the genetics, housing, feeding and other management as well as environmental conditions is varied among countries. Nevertheless, producers all over the world are likely attempting to reach a suggested optimal value of around 12–13 months

Table 2
Distribution of 256 dairy cows from four herds in the Fars province, southern Iran according to pregnancy status and median days open (2004–2005)

Variable	Pregnant				Censored			
	≤120 days[a]		>120 days		≤120 days		>120 days	
	N	%	*N*	%	*N*	%	*N*	%
Herd								
1	14	42	13	39	3	9	3	9
2	24	51	12	26	4	8	7	15
3	29	40	34	47	2	3	7	10
4	51	49	38	36	4	4	11	11
Parity								
1	33	48	25	37	5	7	5	7
2	38	49	28	36	3	4	9	12
3	20	44	18	39	2	4	6	13
4	7	28	14	56	1	4	3	12
>5	19	50	12	32	2	5	5	13
Periparturient disorder								
Yes	7	18	20	53	3	8	8	21
No	111	51	78	36	9	4	20	9
Sex								
Male	52	41	52	41	6	5	16	13
Female	62	52	40	34	5	4	11	9

[a] 120 days is the median days open for study population.

Table 3
Estimates of hazard ratio for days open (days to conception) in 256 dairy cows from four herds in the Fars province, southern Iran during 2004–2005

Factor	Class	*b*	S.E.	Hazard ratio	95% CI	*P*-value
Herd	1	–	–	–	–	–
	2	0.14	0.18	1.15	0.80, 1.67	0.44
	3	−0.09	0.22	0.94	0.59, 1.40	0.68
	4	−0.04	0.19	0.95	0.64, 1.40	0.82
Disease						
	Yes	–	–	–	–	–
	No	0.72	0.24	2.05	1.27, 3.36	<0.01

(Radostites, 2001). Comparing the reported values might present the degree of successes of these efforts among different countries. De Vries and Risco (2005) in an attempt to describe the trends in reproductive measures from 1976 to 2002 in 1552 dairy herds in Florida and Georgia reported that average calving interval increased from 13.1 months in 1976 to 14.1 months in 2000. In another study, trends in reproductive performance in 1772 Ohio dairy herds from 1992 to 1998 revealed that herd average calving interval lengthened from 13.6 to 14.1 months (Rajala-Schultz and Frazer, 2003). It seems that considering the calving interval as one measure of reproductive performance, it is not so far from the suggested optimal value in this study. However, as indicated by other studies, first-lactation cows are excluded from the measure (they have not had two

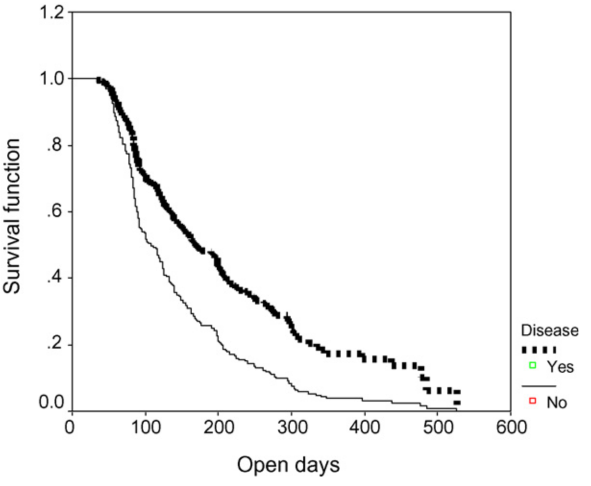

Fig. 1. Kaplan–Meier survival curves for time to conception stratified by disease status.

calving) and cows culled for reproductive failure also do not contribute to the measure; calving interval therefore should not be interpreted alone for evaluation of reproductive performance (Plaizier et al., 1998; Esselmont, 1992).

First-service conception risk (45%) and overall-service conception risk (42%) in the present work are comparable with reports from other studies (Rajala-Schultz and Frazer, 2003; Kinsel and Etherington, 1998; Gilbert et al., 2005; Heins et al., 2006). Kinsel and Etherington (1998) indicated that first-service conception risk and overall-service conception risk in Ontario dairy herds is 48.2 and 46.7%, respectively. A recommended goal for first-service conception risk is ~60% (Radostites, 2001). However, in the literature there are few studies which found this measure above 50%.

Dry period might be considered as an indirect measure of reproductive performance. In the present study, median days dry was 68 days. De Vries and Risco (2005) reported that average days dry remained nearly constant at 69 days from 1976 to 2002 in Florida and Georgia dairy herds. There is recent interest in shorter dry periods (Kuhn et al., 2006; Gumen et al., 2005; Grummer and Rastani, 2004). To determine effects of length of dry period on fertility in a retrospective study, Kuhn et al. (2006) suggested that short dry periods resulted in fewer days open in the subsequent lactation; however, when adjusted for milk yield, it actually resulted in reduced fertility. In contrast, Gumen et al. (2005) during an experimental study concluded that reducing or eliminating the dry period led to earlier postpartum ovulation. We found no effect of length of dry period on reproductive performance as measured by days open. However, our study might not have sufficient power to detect an association between number of days dry and reproductive performance in the subsequent lactation.

Median days open was 120 days. Variation in reported days open in various studies is large (Heins et al., 2006; Gilbert et al., 2005; De Vries and Risco, 2005; Asseged and Birhanu, 2004; Oseni et al., 2003; Rajala-Schultz and Frazer, 2003; Washburn et al., 2002). Based on records from about 1552 dairy herds, De Vries and Risco (2005) reported that average days to conception increased from a low of 121 in 1982 to a high of 167 days in 1998 in Florida and Georgia dairy herds. Etherington et al. (1996) found mean and median days to conception of 126 and 115 days, respectively, in 45 Ontario dairy herds.

We used the time-to-event approach to study the effect of suggested risk factors on days open. In our model, we forced herd into the model to adjust for its clustering effect. However, methods are now available for this purpose with random-effects model which falls under ‘‘frailty models’’. In a frailty model, an additional latent effect (i.e. the frailty) acts on the baseline hazard, and this model is analogous to a random-effects model of a grouping variable such a herd (Dohoo et al., 2003).

Disease had a significant negative effect on days open in this study. Due to low incidence of each disorder, we could not evaluate effect of individual disease on days open. However, the overall negative impact of disease is in agreement with several studies which showed the detrimental effect of various diseases on reproductive performance (Kim and Kang, 2003; Loeffler et al., 1999; Kinsel and Etherington, 1998; Esselmont, 1992). It should be mentioned that in our study, risks of various diseases are very low and there is great possibility for under-recording of disease events. This would have reduced the strength of the association between the presence of a disease event and days to conception.

No association was observed between parity of dam with reproductive performance, although there are conflicting results in the literature (Asseged and Birhanu, 2004; Kanuya et al., 2000; Esselmont, 1992; Silva et al., 1992). We suggested that sex and weight of calf might affect the health status of the dam and thereby influence the subsequent reproductive performance. Because this influence might be presented either as subclinical problems or as overt disease status, we tested their effects in the model separately from the effect of disease. However, we did not find any effect for those variables, consistent with the only other such study which we found (Silva et al., 1992).

The limitations of our study should not be ignored. Using retrospectively collected data cause some concern about validity. This is especially true for recording of disease status of the animals. We could not be confident that the criteria used for assigning diagnoses were uniform over time and across herds. Nonetheless, more efforts to identify responsible determinants and control the disease of dairy cows in the region are needed. Also, that we used only four herds may be criticized. Conducting more comprehensive research using larger sample size and considering other potential related variables is highly recommended. We hope our present study will provide a framework for such additional studies in the near future.

5. Conclusion

As in other parts of the world, breeding performance in these four commercial dairy herds in southern Iran is sub-optimal. The median days open and calving interval were 120 and 388 days, respectively. Cows without incidence of disease had 2.1-times greater hazard of conception than cows with incidence of disease.

Acknowledgements

We appreciate the cooperation of farmers for data collection. Assistance of Dr. Maryam Rezagholi also appreciated. This study was supported by Shiraz University.

References

Asseged, B., Birhanu, M., 2004. Survival analysis of calves and reproductive performance of cows in commercial dairy farms in and around Addis Ababa, Ethiopia. Trop. Anim. Health Prod. 36, 663–672.

De Vries, A., Risco, C.A., 2005. Trends and seasonality of reproductive performance in Florida and Georgia dairy herds from 1976 to 2002. J. Dairy Sci. 88, 3155–3165.

Dohoo, I., Martin, W., Stryhn, H., (1st), 2003. Veterinary Epidemiologic Research. Charlottown, Prince Edward Island, Canada. pp. 320; 427; 453.

Esselmont, R.J., 1992. Measuring dairy herd fertility. Vet. Rec. 131, 209–212.

Etherington, W.G., Kinsel, M.L., Marsh, W.E., 1996. Relationship of production to reproductive performance in Ontario dairy cows: herd level and individual animal descriptive statistics. Theriogenology 46, 935–959.

Gilbert, R.O., Shin, S.T., Guard, C.L., Erb, H.N., Frajblat, M., 2005. Prevalence of endometritis and its effect on reproductive performance of dairy cows. Theriogenology 64, 1879–1888.

Grummer, R.R., Rastani, R.R., 2004. Why reevaluate dry period length? J. Dairy Sci. 87 (e. Suppl.), E77–E85.

Gumen, A., Rastani, R.R., Grummer, R.R., Wiltbank, M.C., 2005. Reduced dry periods and varying prepartum diets alter postpartum ovulation and reproductive measures. J. Dairy Sci. 88, 2401–2411.

Heins, B.J., Hansen, L.B., Seykora, A.J., 2006. Fertility and survival of pure Holsteins versus crossbreds of Holstein with Normande, Mentbeliarde, and Scandinavian Red. J. Dairy Sci. 89, 4944–4951.

Kanuya, N.L., Kessy, B.M., Bittegeko, S.B.P., Mdoe, N.S.Y., Aboud, A.A.O., 2000. Suboptimal reproductive performance of dairy cattle kept in smallholder herds in a rural area of northern Tanzania. Prev. Vet. Med. 45, 183–192.

Kim, I.H., Kang, H.G., 2003. Risk factors for postpartum endometritis and the effect of endometritis on reproductive performance in dairy cows in Korea. J. Reprod. Develop. 9, 485–491.

Kinsel, M.L., Etherington, W.G., 1998. Factors affecting reproductive performance in Ontario dairy herds. Theriogenology 50, 1221–1238.

Kuhn, M.T., Hutchison, L., Norman, H.D., 2006. Effects of length of dry period on yields of milk fat and protein, fertility and milk somatic cell score in the subsequent lactation of dairy cows. J. Dairy Res. 73, 154–162.

Loeffler, S.H., de Vries, M.J., Schukkent, Y.H., 1999. The effects of time of disease occurrence, milk yield, and body condition on fertility of dairy cows. J. Dairy Sci. 82, 2589–2604.

Ministry of Agriculture, Animal Breeding Center, http://www.abc.org.ir.

Oseni, S., Misztal, I., Tsuruta, S., Rekaya, R., 2003. Seasonality of days open in US Holsteins. J. Dairy Sci. 86, 3718–3725.

Plaizier, J.C.B., Lissemore, K.D., Kelton, D., King, G.J., 1998. Evaluation of overall reproductive performance of dairy cows. J. Dairy Sci. 81, 1848–1854.

Radostites III, O.M., 2001. Herd Health: Food Animal Production Medicine. W.B. Saunders Company, pp: 276; 278.

Rajala-Schultz, P.J., Frazer, G.S., 2003. Reproductive performance in Ohio dairy herds in the 1990s. Anim. Reprod. Sci. 76, 127–142.

Silva, H.M., Wilcox, C.J., Thatcher, W.W., Becker, R.B., Morse, D., 1992. Factors affecting days open, gestation length, and calving interval in Florida dairy cattle. J. Dairy Sci. 75, 288–293.

Vargas, B., Van Der Lende, T., Baaijen, M., Van Arendonk, J.A.M., 1998. Event-time analysis of reproductive traits of dairy heifers. J. Dairy Sci. 81, 2881–2889.

Washburn, S.P., Silvia, W.J., Brown, C.H., Mcdaniel, B.T., McAllister, A.J., 2002. Trends in reproductive performance in southeastern Holstein and Jersey DHI herds. J. Dairy Sci. 85, 244–251.