Relationships between the incidence of health disorders and the reproduction traits of Holstein cows in the Czech Republic

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ABSTRACT: The objective of this study was to evaluate the relationships between several health disorders: milk fever (MF; hypocalcaemia and parturient paresis), retained placenta (RP; retained foetal membranes), metritis (ME; endometritis and pyometra), ovarian cysts (OC; follicular and luteal cysts), clinical mastitis (CM), and lameness (LS; foot and leg problems) as affecting the reproductive performance of dairy cows. The dataset of 1 432 Holstein cows calving between January 2000 and April 2004 from 4 commercial dairy herds was analyzed by the linear regression model which included the effects of herd-year-season of calving, parity, FCM yield level, incidences of studied fertility and health disorders, and regression on the first calving age within parity. It was proved that fertility disorders relating to parturition, such as RP and ME, had a significant influence ($P < 0.01$ to $P < 0.0001$) on the evaluated reproduction parameters, i.e. days from calving to the first AI service (DAI), open days (OD), and the number of inseminations needed for conception (NAI). A significant effect ($P < 0.0001$) of OC on all reproduction parameters was also found. Mastitis and lameness occurring during lactation had significant effects on OD and NAI ($P < 0.05$ to $P < 0.0001$). The milk fever occurrence was related significantly only to a longer period to the 1st AI ($P < 0.01$). In general, cows with health disorders are inseminated later and they conceived later after their previous calving compared to healthy cows, and need more inseminations for conception.

Keywords: health; fertility; parameters; dairy cows

The increase in milk production due to genetic and management improvements over recent decades has been accompanied by an increase in health problems and, subsequently, by a decline in fertility. In addition to a decrease in production, health and fertility as well as herd replacement costs have increased.

Milk production, reproduction, and health are the principal factors affecting the profitability of a dairy herd. In recent years, the dairy industry agenda in many countries has been dominated by health-related problems. One prerequisite for effective health management is the accurate knowledge of factors that affect the health status of a cow, such as parity, season, or health history, and of the relationship between health problems and other economically important traits, such as milk production, reproduction, and length of productive life. The parameters required for health management are population- and time-specific and need to be estimated periodically (Emanuelson and Oltenacu, 1998).

However, the large datasets needed for epidemiological studies often come from general databases on production and diseases, and information regarding herd management is most often missing in these databases. Field data concerning the incidence of health disorders are not systematically recorded and collected in the Czech Republic, unlike the other European countries. Therefore, other options for the evaluation of herd management have

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to be investigated. One alternative is to use indicator variables as proxies, such as milk production or measures of reproductive performance.

Analyses of large datasets, however, have shown that a relatively large part of the variation cannot be explained by systematic environmental effects (Weller and Ron, 1992; Hoekstra et al., 1994). These studies did not include information on fertility disorders, probably due to a lack of recorded information. Poor fertility at the farm level is generally regarded as a result of poor management. Nevertheless, more detailed experiments show that there are differences between cows in the occurrence of the first heat (Azzam et al., 1991) and oestrus cycles (Larson and Ball, 1992). These differences can be affected by fertility problems, but the effects of fertility or health disorders on subsequent fertility and their interrelationships are not well qualified. The analysis and evaluation of farm management can be improved if the results are corrected for important environmental effects. Furthermore, farm management decisions can be improved if the effects of health disorders on fertility are known.

Reproductive losses caused by diseases have been analyzed from different aspects, such as parturition-to-conception interval, days open, days from calving to successful insemination, conception rate, and calving interval (Østergaard and Sørensen, 1998).

The objective of this study was to evaluate the effects of several health disorders on the reproductive performance of dairy cows.

MATERIAL AND METHODS

The data for this study are from 4 commercial dairy herds and they were acquired from 1 432 Holstein cows that calved during the period from January 2000 to April 2004 and were monitored until the next calving or culling. For this study, six different veterinary diagnoses (milk fever, retained placenta, metritis, ovarian cysts, mastitis, and lameness) made during the studied lactations were considered. The diagnoses were made by a veterinarian according to routine clinical methods under normal field conditions and were collected from the herd personnel records or the herd veterinarian's farm treatment records.

Six diseases of interest were identified: milk fever (MF; hypocalcaemia and parturient paresis), retained placenta (RP; retained foetal membranes), metritis (ME; endometritis and pyometra), ovarian cysts (OC; follicular and luteal cysts), clinical mastitis (CM), and lameness (LS; foot and leg problems).

The consequences of diseases on the days from calving to the first AI (DAI), open days (OD; interval from calving to successful insemination), and the number of inseminations needed for conception (NAI) were studied.

Data on fertility parameters, i.e. calving day, and dates of all AI services were collected from AI records. Milk production, fat and protein percentage in 305 days of lactation were collected from milk recording reports. The milk yield for each cow with a closed lactation period in a herd was adjusted to kilograms of 4% fat-corrected milk production (FCM) for the 305 days of lactation.

The dataset was analysed by ANOVA (Rasch and Mašata, 2006) through the statistical program SAS STAT 8.0 – GLM (SAS, 2001). The following linear regression model was used to estimate the effects of health disorders on fertility parameters:

$$Y_{ijklmn} = \mu + HYS_i + P_j + D_k + M_l + b_m A + e_{ijklmn}$$

Table 1. Descriptive statistics of production and reproduction traits of cows' groups according to herds in the trial

Variable	Herd 1 (*n* = 525)		Herd 2 (*n* = 548)		Herd 3 (*n* = 159)		Herd 4 (*n* = 200)	
	mean	SD	mean	SD	mean	SD	mean	SD
Milk kg in 305 days of lactation	8 588	2 638.4	8 952	2 017.6	8 415	1 825.8	7 164	1 596.9
Fat percentages in 305 days of lactation	3.99	0.478	3.93	0.32	4.02	0.453	3.83	0.454
Protein percentages in 305 days of lactation	3.25	0.222	3.31	0.151	3.38	0.164	3.23	0.236
FCM in 305 days of lactation	8 589	2 455.9	8 829	1 904.8	8 405	1 758.4	6 950	1 508.6
Days to the first service	79.5	32.39	90.8	36.51	77.8	31.63	71.3	34.31
Open days	132.1	70.62	158.2	78.6	166	95.74	125.8	81.2
Number of services per conception	1.77	1.291	2.52	1.584	2.96	1.824	2.62	1.563

where:

Y_{ijklmn} = observed value of the fertility parameter as a dependent variable (interval from calving to the first service, open days, number of inseminations per conception)

μ = average value of dependent variable

HYS_i = fixed effect of i-herd-year-season of calving (five years, 2000 to 2004, and four calving seasons, January to March, April to June, July to September, and October to December, were considered)

P_j = fixed effect of j-parity, i.e. lactation number of the cow (j = 1 to 5)

D_k = fixed alternative effect of k-occurrence of health disorders (alternatively according to the evaluated disorder), where k = 1 (no occurrence), 2 (one occurrence) in the case of MF, RP, and ME, or k = 1 (no occurrence), 2 (one occurrence), 3 (more than one occurrence) in OC, CM, and LS

M_l = fixed effect of l-milk yield class up to FCM production for 305 days of lactation (l = 1 to 3) where $< x -0.5s$; $x \pm 0.5s$; $> x + 0.5s$

$b_m A$ = regression on the age at the first calving within the class of parity

e_{ijklmn} = residual effects (random error)

The effect of each individual health disorder was evaluated separately using an alternative equation.

Differences between estimated variables were tested by the t-test on the levels of significance $P < 0.05$ (+), $P < 0.01$ (++), $P < 0.001$ (+++), and $P < 0.0001$ (++++).

RESULTS

Table 1 presents basic descriptive statistics of the production and reproduction traits of the groups of cows according to herds in the trial. The average yields of FCM in 305-day lactations were in the range of 6 950 to 8 829 kg. The average number of days between calving and the first AI service ranged from 71.3 to 90.8 days, open days from 125.8 to 166.0, and the average number of AI servi-ces needed per conception ranged between 1.77 and 2.96.

Statistical significances of individual effects in the particular models tested by the F-test are presented in Table 2. The results in Table 2 illustrate that the effect of herd-year-season was significant in all model variants ($P < 0.0001$), whereas the effect of cow parity was not significant in any variants of the model. The regression on the age at first calving within parity class has no general significance, but it was significant in the class of first-calved heifers and in other individual classes of parity according to the type of health disorders in variants of the model. The effect of the milk yield class according to FCM in 305-day lactations was significant on the various levels of significance ($P < 0.05$ till $P < 0.0001$). The highest significance of this effect was found in the case of open days as a dependent variable for all health disorders in the model. Lower but still significant was the effect of the milk yield class on the number of services per conception and the effect of the number of days to the 1st AI when the fertility disorders MF, RP, and ME were included in the model. The milk production class of cows had a significant effect on OD and NAI. In the case of DAI, milk yield was significant only with regard to OC, CM, and LS occurrence.

The effects of health disorders occurring in the periparturient period and related to fertility are demonstrated in Table 3. It was proved that fertility disorders relating to parturition, i.e. retained placenta and metritis, had a significant influence on the evaluated reproduction parameters. According to our results, there were significant differences in days to the first AI service, open days, and in the number of services for conception between cows with the incidence of these disorders and cows without these problems. Cows with retained placenta had a longer period of open days by +36.2 days, and cows with metritis by +40.4 days compared to cows without these diseases. Healthy cows had a lower number of services per conception by –0.63 and by –0.34, respectively. The milk fever occurrence had a similar significant effect only on days to the 1st AI service, when cows without this problem were inseminated for the first time by 28.2 days earlier after calving ($P < 0.01$). Cows without MF had a longer period of days open by 36.2 days, but the difference was not significant, while cows with MF did not have a significantly lower number of services per conception (–0.36 AI).

The effects of health disorders occurring during lactation on the reproduction parameters of cows are shown in Table 4. The results document that health disorders such as ovarian cysts, mastitis, and lameness resulted in the later 1st AI, longer OD and more NAI, although not all differences in evaluated parameters between the groups of cows according to the incidence of disease were significant. In

Table 2. Statistical significance of effects in the particular models

Dependent variable	Days to 1st service		Open days		Number of services	
Value of	*F*-test	*P*	*F*-test	*P*	*F*-test	*P*
Effect	*n* = 806		*n* = 814		*n* = 858	
HYS*	5.12	<.0001	2.62	0.0002	3.72	<.0001
Parity of cows	0.15	0.9637	1.37	0.2422	1.90	0.1078
Milk fever occurrence	9.12	0.0026	3.55	0.0601	0.94	0.3317
FCM 305	3.26	0.0388	15.04	<.0001	5.49	0.0043
1st calving age (parity)	0.67	0.6425	1.25	0.2843	2.13	0.0598
	n = 1 168		*n* = 1 173		*n* = 1 210	
HYS	4.24	<.0001	3.10	<.0001	3.04	<.0001
Parity	0.53	0.7132	1.63	0.164	1.30	0.2698
Retained placenta	11.55	0.0007	25.57	<.0001	23.73	<.0001
FCM 305	3.55	0.0291	17.45	<.0001	6.05	0.0024
1st calving age (parity)	0.79	0.5605	1.39	0.2255	1.72	0.1275
	n = 1 413		*n* = 1 418		*n* = 1 305	
HYS	4.53	<.0001	3.25	<.0001	4.31	<.0001
Parity	0.88	0.4731	0.66	0.6196	0.94	0.4379
Metritis occurrence	51.24	<.0001	56.74	<.0001	9.73	0.0019
FCM 305	4.00	0.0186	25.29	<.0001	7.02	0.0009
1st calving age (parity)	1.17	0.3220	0.51	0.769	1.45	0.2026
	n = 1 413		*n* = 1 418		*n* = 1 306	
HYS	3.52	<.0001	3.56	<.0001	4.82	<.0001
Parity	1.09	0.3609	0.48	0.7527	0.82	0.5122
Ovarian cyst occurrence	44.24	<.0001	130.08	<.0001	34.20	<.0001
FCM 305 days	1.32	0.2668	14.36	<.0001	2.85	0.0584
1st calving age (parity)	1.43	0.2104	0.36	0.875	1.26	0.2769
	n = 1 400		*n* = 1 405		*n* = 1 293	
HYS	4.30	<.0001	3.06	<.0001	4.43	<.0001
Parity	1.26	0.283	0.76	0.549	0.94	0.4371
Mastitis occurrence	2.93	0.0537	8.68	0.0002	3.34	0.0358
FCM 305	3.3	0.0371	22.42	<.0001	6.45	0.0016
1st calving age (parity)	1.36	0.2386	0.64	0.669	1.58	0.1624
	n = 1 147		*n* = 1 148		*n* = 1 022	
HYS	4.13	<.0001	3.00	<.0001	4.37	<.0001
Parity	0.62	0.6491	1.14	0.3359	1.69	0.1511
Lameness occurrence	4.07	0.0173	14.06	<.0001	10.65	<.0001
FCM 305	1.49	0.2249	15.04	<.0001	5.83	0.0031
1st calving age (parity)	1.21	0.3040	0.90	0.4771	1.78	0.1148

*HYS = Herd-Year-Season

FCH 305 = 4%fat-converted milk production for the 305 days of lactation

the case of ovarian cyst incidence, all differences between groups of healthy cows, cows with one recorded incidence, and cows with two or more records were statistically significant ($P < 0.001$). A similar effect was also found for the occurrence of lameness. Cows with two or more reported lameness incidences had a significantly longer period of days open than healthy cows by 31.9 days, and a higher number of services per conception by 0.51 AI ($P < 0.0001$). Cows with only one occur-

Table 3. Effects of health disorders occurrence during periparturient period on the reproduction parameters of cows

Health disorder	Incidence	Days to 1st service			Open days			Number of services		
		μ + α	SE	P	μ + α	SE	P	μ + α	SE	P
Milk fever	no	86.0	3.63	++	131.3	7.45		2.03	0.144	
	yes	114.2	9.65		167.5	19.94		1.67	0.392	
Retained placenta	no	80.7	2.66	+++	139.6	5.92	++++	2.43	0.115	++++
	yes	90.9	3.56		173.2	7.90		3.06	0.154	
Metritis	no	77.6	2.13	++++	133.8	4.85	++++	2.25	0.098	++
	yes	94.4	2.65		174.2	6.04		2.59	0.124	

P = levels of statistical significances of differences between groups: $P < 0.05$ (+); $P < 0.01$ (++); $P < 0.001$ (+++); and $P < 0.0001$ (++++)

rence of lameness had longer OD by 8.9 days and NAI by 0.4 ($P < 0.001$). Differences in NAI were significant only between healthy cows and cows with two or more incidences of lameness ($P < 0.01$). Cows with two or more such incidences had a longer interval from calving to the 1st AI than cows with only one reported incidence of this disease ($P < 0.05$). The relationships between clinical mastitis occurrence and fertility parameters were not so explicit. Most significant was an increase in OD, when this parameter associated with the udder disease was +15.1 and +31.9 days, respectively. Mastitis occurring in the whole lactation period had a negative effect only on DAI in cows with one reported incidence in comparison with healthy cows (+4.0) ($P < 0.05$) and on NAI in cows with two or more incidences during lactation (+0.29) ($P < 0.01$).

DISCUSSION

The linear model included the fixed effect of herd-year-season of calving, the effect of parity, and the fixed effect of health disorders. Consideration of the milk yield level and the age of cows at calving were used to estimate the effects of health disorders on fertility parameters in dairy cows. Herd-year-season, health disorders, and in most cases the milk yield level in FCM were evaluated as significant effects. A similar model with these significant effects was also used by Ouweltjes et al. (1996), who studied the effects of fertility disorders on the reproduction performance of dairy cows. Klaas et al. (2004) reported that the mean interval from calving to the first insemination was significantly influenced by herd vs. season, parity, milk yield, and reproductive and metabolic disorders. Factors with

Table 4. Effects of health disorders occurrence during lactation on the reproduction parameters of cows

Health disorder	Incidence	Days to 1st service			Open days			Number of services		
		μ + α	SE	P	μ + α	SE	P	μ + α	SE	P
Ovarian cyst	1. no	76.1	2.12	++++	125.1	4.57	++++	2.15	0.096	++++
	2. once	88.5	2.59	1:2, 3	155.7	5.59	1:2, 3	2.42	0.118	1:2, 3
	3. more than once	99.5	2.96	+++ 2:3	217.0	6.41	2:3	3.19	0.139	2:3
Mastitis	1. no	81.2	2.15	+	138.9	4.90	++	2.29	0.098	++
	2. once	86.2	2.47	1:2	155.0	5.62	1:2	2.37	0.114	1:3
	3. more than once	84.9	2.65		158.6	6.05	+++ 1:3	2.58	0.132	
Lameness	1. no	81.9	2.60	++	130.4	5.78	++++	1.94	0.118	++++
	2. once	82.5	3.04	1:3	139.5	6.76	1:3	2.34	0.139	1:3
	3. more than once	89.4	3.19	+ 2:3	162.3	7.10	+++ 1:2	2.45	0.146	+++ 1:2

P = levels of statistical significances of differences between groups: $P < 0.05$ (+); $P < 0.01$ (++); $P < 0.001$ (+++); and $P < 0.0001$ (++++)

a significant influence on days open were herd-season and milk yield, as well as reproductive and metabolic disorders. Emanuelson and Oltenacu (1998) recommended to consider the relationships between herd management and incidences of treated diseases when treatment records are used in herd health programs. Assessments of the health status of herds based on treatment records may be valuable for internal comparisons (i.e. comparisons of the herd development over time). However, assessments based on treatment records should be used with caution for external comparisons (i.e. comparisons of different herds).

The milk yield class of cows had a significant effect on OD and NAI. In the case of DAI, milk yield was significant only in relation to OC, CM, and LS occurrence. This could be explained by the fact that the day of the first service (DAI) is affected to a larger extent by management decisions than by the oestrous activity of cows. We could also expect a closer relationship between fertility traits and milk production in the first months of lactation than during the whole lactation period. Similarly, Vaněk (2004) reported significant correlations between milk production and days open or calving interval, but not with days to the first service.

The results of our study showing days to the first AI, days open, and the number of AI services per conception as standard measures of reproductive performance were affected by the occurrence of fertility and health disorders (MF, RP, ME, OC, CM, and LS). Reproductive losses caused by diseases have been analyzed in several studies from different aspects, such as the parturition-to-conception interval, days open, days from calving to successful insemination, conception rate, and calving interval. A common feature is that the reproductive loss is due to the performance of the cow. Generally, the reproductive loss has been found to be a result of reproductive disorders. According to Oltenacu et al. (1990), diseases known to affect reproductive performance are retained placenta, metritis, ovarian cysts, and silent oestrus. These authors reported an increase in days open associated with these four diseases for low-production herds, and that these negative effects diminished as the herd production increased. This diminishing negative effect further supports the argument that there are differences attributable to the herd health management between herds stratified according to production. Possible explanations for a smaller detrimental effect on the performance of cows in herds under good management are that health problems are identified earlier and have a better prognosis, and that the better follow-up is pursued after treatment (Emanuelson and Oltenacu, 1998).

The inclusion of retained placenta and endometritis in regression models to explain variation in fertility, however, does not result in considerable improvement (Ouweltjes et al., 1996). Estimates of the effects of fertility disorders on DAI and NAI, calculated without the requirement of the next calving, agreed very well with the results reported in Table 3. The effects of fertility disorders on fertility parameters found in this study are similar to and comparable to the effects found by Borsberry and Dobson (1989). Holt et al. (1989) reported lower conception rates and more days open (134 vs. 97) for cows with retained placenta compared with control cows. Lee et al. (1989) concluded that retained placenta, metritis, and ovarian cysts all had a negative influence on conception rates and days open, but the effect of retained placenta was relatively low (5 extra days open) compared to metritis (15 extra days open) and ovarian cysts (22 extra days open). Ouweltjes et al. (1996) found that endometritis prolonged the calving interval by 10 to 20 days. In their study no significant effect of retained placenta on fertility was found, whereas endometritis was related to longer calving intervals (10–20 days) and more inseminations (0.2 to 0.5 per pregnancy). Van Werven et al. (1992) found no influence of retained placenta on days open for heifers and 26 additional days open for older cows. Markusfeld and Ezra (1993) found no influence of metritis on future fertility.

As reported in Table 4, the incidence of ovarian cysts is another fertility disorder significantly affecting reproduction parameters. Erb et al. (1981) found a longer calving interval from metritis, cystic follicle, and luteal cyst. The negative effect of metritis and ovarian cyst occurrence on fertility parameters was also described by Bartlett et al. (1986), Lee et al. (1989), Markusfeld (1993) and Eicker et al. (1996).

Our results do not indicate that there is a strong relationship between the incidence of mastitis and all fertility disorders. For disorders such as mastitis this is not surprising because this is not directly related to fertility in cows. There are a lot of studies analyzing the relationship between clinical mastitis occurrence and milk yield in dairy cows, but the effect of mastitis on fertility traits has not been studied very often. Klaas et al. (2004) found that in cows with subclinical mastitis the interval was prolonged by 11.7 days ($P < 0.01$), whereas clinical mastitis had no effect. Clinical and subclinical mastitis did not increase days open. Subclinical mastitis during early lactation prolonged the interval to the first insemination, whereas clinical mastitis had no significant effect on reproductive performance. Loeffler et al. (1999) pointed out the importance of the time of disease occurrence for its effect on fertility. In their study, mastitis reduced the conception rate significantly if it occurred after the first insemination, which is in agreement with the results of Barker et al. (1998). In primiparous cows, Oltenacu et al. (1990) observed a significant influence of mastitis on DFS but, similarly to the present results, with no effect on DO. The study of Oltenacu et al. (1990) included cases of clinical mastitis until the first insemination, which means a different number of days at risk for each cow.

In the category of feeding-related diseases, the occurrence of lameness influenced OD and NAI significantly, but the effect on DAI was insignificant. In the study of Melendez et al. (2003) there was no difference in the interval from calving to the first service between lame and control cows. More days open due to clinical lameness were found in the study of Lee et al. (1989). These latter findings might indicate the effect of a negative energy balance. Some results indicate that disorders which occur later after calving have a higher effect than disorders that occur around calving. The small percentages of variation explained by retained placenta and endometritis in several analyses and their relatively small effects indicate that these disorders can be treated effectively. Unfortunately, our dataset does not include necessary information on the dates of all health disorders occurrence and treatment and therefore we could not analyze these relationships. It is possible that lameness can also decrease fertility due to less oestrus symptoms, as Berka et al. (2004) mentioned. Moreover, it is known that lameness can be caused by other factors not related to the health and metabolic profile of animals (Dembele et al., 2006).

Some of the reproductive disorders included in our studies were found in other studies not to decrease reproductive performance. However, there seems to be an evidence that reproductive disorders lead to a decrease in reproductive performance, whereas the effect of other disorders is primarily indirect. This is supported by Oetzel (1995) as cited by Østergaard and Sørensen (1998), suggesting that milk fever indirectly decreases fertility because milk fever is a risk factor for other diseases (dystocia, retained placenta, cystic ovaries, metritis, and any periparturient health problems) which directly cause a decrease in fertility.

Another problem is that the definitions of some fertility disorders can be different. Therefore, it is not surprising that the effects of these different disorders on fertility are also different. This illustrates the importance of clear and uniform definitions of health and fertility disorders. Systematic recording and calculating of the incidence of clinical diseases in dairy cattle was also recommended by Kelton et al. (1998). The problem remains that in practice even with clear definitions cases will differ in severity, with differences in the effects on fertility (Ouweltjes et al., 1996). This also explains why substantial average effects of some disorders on fertility parameters were found but much of the variation was not explained.

CONCLUSIONS

Our hypothesis is that incidences of diseases affect the reproduction performance of cows. The results of this study indicate that there is a significant relationship between fertility or health disorders and reproduction parameters. Significant effects of retained placenta, metritis, and ovarian cysts on all reproduction parameters were found. Mastitis and lameness occurring during lactation also had significant effects on open days and the number of AI per conception. Milk fever occurrence was significantly related only to a longer period between calving and the 1st AI. The milk production of cows had a significant effect on open days and the number of AI per conception. In the case of days to the first service, milk yield was related only to ovarian cysts, clinical mastitis, and lameness occurrence. In general, animals with fertility disorders are first serviced later after calving compared to healthy cows, and need more inseminations to conceive. Comparisons of the results indicate that clear and uniform definitions of traits are essential for the estimation of the effects on fertility. In the Czech Republic a national health recording system should be introduced to collect data for important analyses.

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