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Health disorders and their association with production and functional traits in Holstein Friesian cows

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ABSTRACT

Logistic regression models were used for studying the relationships between milk yield, body condition score (BCS), somatic cell score and some disorders of periparturient cows (mammary edema and retained placenta) with the occurrence of ovarian cysts, clinical mastitis and lameness. Data from milk recording (milk yield and somatic cell content) collected at nearly monthly intervals (time period: 35 ± 3 d) were merged with BCS recorded on the same dates of milk recording on periparturient heifers, lactating and dry cows, and with health disorders data (retained placenta, severe mammary edema, ovarian cysts and clinical mastitis and lameness) collected during regular herd activities over nearly 3.5 years. Data were from one commercial herd consisting of over 200 lactating dairy cows and exhibiting an average 305-d milk yield of nearly 10,000 kg. A total of 5,315 records from 728 lactations and 429 cows were used in the analyses. The time period incidence rate was 11.9%, 6.6% and 4.6% for ovarian cysts, lameness and mastitis, respectively, and the lactational incidence rate was 44.1%, 33.4% and 28.1% for ovarian cysts, lameness and mastitis, respectively. Occurrence of both ovarian cysts and mastitis was more common in the early lactation than afterwards, whereas lameness tended to occur erratically during lactation. The risk of occurrence of mastitis and lameness was lower in primiparous when compared to multiparous cows. The increase of milk yield increased the risk of occurrence of ovarian cysts (odds ratio: 1.32, $P < 0.01$) and of mastitis (odds ratio: 1.12, $P < 0.10$), whereas no significant relationship was found between milk yield and lameness. An increase of somatic cell score was found to be a risk factor for mastitis (odds ratio: 1.36, $P < 0.01$) and for the occurrence of lameness (odds ratio: 1.06, $P < 0.05$). The occurrence of relative risk of disorders was not related to BCS at calving, and monthly variation of BCS was related to the onset of mastitis only. Retained placenta did not appear to present a risk factor for the occurrence of diseases of concern, whereas the presence of severe mammary edema at calving increased the risk of mastitis occurrence by nearly 50%. Regular recording of herd health data seems advisable for a better understanding of the relationships between production and functional traits and the occurrence of health disorders.

Key words: Dairy cows, Health traits, Functional traits, Milk yield.

RIASSUNTO

RELAZIONI TRA ALCUNI DISORDINI SANITARI E CARATTERI PRODUTTIVI E FUNZIONALI IN VACCHE DI RAZZA FRISONA ITALIANA

La presente ricerca era finalizzata ad indagare le relazioni tra produzione del latte, punteggio di condizione corporea, contenuto di cellule somatiche del latte, disordini sanitari delle vacche al parto (edema mammario e ritenzione di placenta) e il rischio di insorgenza di cisti ovariche, mastite clinica e zoppia tramite analisi di regressione multipla logistica. A tale fine sono stati utilizzati i dati provenienti dai controlli funzionali (produzione individuale di latte al controllo e contenuto del latte in cellule somatiche), raccolti con una periodicità circa mensile (35 ± 3 d), le valutazioni di BCS effettuate nello stesso giorno del controllo funzionale su tutte le manze prossime al parto e le vacche in lattazione e in asciutta e le registrazioni sanitarie relative all'edema mammario, alla ritenzione di placenta, alle cisti ovariche, alla mastite clinica e alla zoppia. Tutti i dati provenivano da un unico allevamento che presentava una consistenza media di circa 200 vacche in lattazione ed una produzione media nei 305 d di circa 10,000 kg di latte, e facevano riferimento ad un arco temporale di circa 3.5 anni. Complessivamente, si sono resi disponibili per l'analisi 5315 records completi provenienti da 728 lattazioni e 429 vacche. L'incidenza di cisti ovariche, zoppie e mastite è risultata pari a 11.9%, 6.6% e 4.6%, rispettivamente, quando riferita alla durata dell'intercontrollo, e a 44.1%, 33.4% e 28.1%, rispettivamente, quando riferita alla lattazione. L'insorgenza di cisti ovariche e mastiti è risultata più frequente nella prima fase di lattazione, mentre quella delle zoppie si è distribuita in modo più casuale lungo l'intera lattazione. Il rischio relativo di insorgenza delle patologie considerate è apparso significativamente inferiore nelle primipare rispetto alle pluripare. Un aumento della produzione di latte è risultato associato ad un significativo aumento del rischio relativo di insorgenza delle cisti ovariche (odds ratio: 1.32, $P < 0.01$) e delle mastiti (odds ratio: 1.12, $P < 0.10$), ma non delle zoppie. Un aumento del punteggio di cellule somatiche è risultato essere un fattore di rischio per l'insorgenza di mastiti (odds ratio: 1.36, $P < 0.01$) e di zoppie (odds ratio: 1.06, $P < 0.05$). Non è emersa una significativa associazione tra rischio relativo di insorgenza delle patologie considerate e BCS al parto, mentre la variazione di BCS tra due controlli contigui è apparsa significativamente associata all'insorgenza di mastite. La ritenzione di placenta non è mai apparsa essere un significativo fattore di rischio per la comparsa delle patologie considerate, mentre la presenza di edema mammario evidente ha aumentato di circa il 50% il rischio di insorgenza della mastite clinica. Sembra necessario approfondire le conoscenze in merito alle relazioni tra caratteri produttivi e funzionali ed insorgenza di eventi patologici nella vacca da latte, e a questo fine è necessario incoraggiare la regolare registrazione degli eventi sanitari a livello aziendale.

Parole chiave: Vacche da latte, Caratteri sanitari, Caratteri funzionali, Produzione di latte.

Introduction

Maximisation of income in dairy cattle has been pursued mostly through management, feeding and selection strategies aimed to improve yield traits. However, economic efficiency could be further enhanced by placing greater emphasis on functional and health traits, which directly or indirectly affect both income and production costs.

Economic losses due to the occurrence of diseases are mainly caused by reduced milk yield, prolonged calving intervals, additional veterinary costs, labour and treatments (Enting *et al.*, 1997), and several diseases have an important impact on the culling of cows (Gröhn *et al.*, 1998).

According to Kelton *et al.*, (1998), recording diseases of economic significance is needed for monitoring health status of cows, for developing

management strategies able to promote health and for investigating genetic aspects of the occurrence of diseases and resistance. Interest in recording the occurrence of diseases in dairy cattle is further prompted by the concern for possible positive associations between milk production and risk of disease outbreak. In long-term studies comparing lines of different genetic merit for milk yield, Hansen (2000) and Kelm *et al.* (2000) found that cows of high genetic merit for milk yield incurred greater health costs, mainly for mammary treatment. Likewise, Simianer *et al.* (1991), Pryce *et al.* (1998) and Hooijer *et al.* (2001) found positive genetic relationships between milk yield traits and the occurrence of some diseases. Conversely, other studies failed in highlighting relationships between milk yield and disease incidence in Holstein cows (Erb, 1987; Gröhn *et al.*,

1995). Because milk yield can not be considered the only risk factor for diseases (Fleischer *et al.*, 2001), it seems relevant to take into account the effects of other factors potentially associated with the occurrence of diseases, in the view of proposing tools useful in predicting cows at risk for the onset of specific diseases.

The aim of the present study was to investigate the relationship between milk yield in the current lactation, body condition score, somatic cell score and disorders of the periparturient cow (mammary edema and retained placenta) and the occurrence of ovarian cysts, mastitis and lameness in Holstein Friesian cows.

Material and methods

Data collection

This study was carried out from January 1998 to August 2001 in one large dairy herd located in the province of Venice. The herd consisted of over 200 lactating Holstein Friesian cows housed in free stall barns and milked twice daily. Cows were fed ad libitum different total mixed rations (TMR) according to their stage of lactation and milk yield level. Based on farm data, TMR for fresh group (cows until 50 days in milk) provided 1.02 ± 0.01 UFI/kg DM, $16.6 \pm 0.3\%$ and $32.0 \pm 2.0\%$ of CP and NDF on a DM basis, respectively; TMR for the high yielding cows group provided 1.00 ± 0.02 UFI/kg DM, $16.3 \pm 0.2\%$ and $33.0 \pm 2.0\%$ of CP and NDF on a DM basis, respectively; and TMR for the low yielding cows group provided 0.93 ± 0.03 UFI/kg DM, $15.1 \pm 0.4\%$ and $34.0 \pm 2.6\%$ of CP and NDF on a DM basis.

Individual milk yield and somatic cell count (SCC), together with test dates, date of calving and lactation number, were provided by the official milk recording agency at monthly intervals. At the same dates of milk recording, all periparturient heifers (from 75 d prior to the expected calving date onward), lactating and dry cows were scored for body condition score (BCS) by a skilled operator according to the method proposed by Edmonson *et al.* (1989) and based on a five-point scale with a 0.25-unit increment scoring system.

Occurrence of the following disorders was recorded by farm personnel or by the farm veteri-

narian along with the date of the event: i) retained placenta (RP), defined as retention of foetal membranes later than 24 h after calving; ii) severe mammary edema (ME), defined as edema covering more than half of the udder; iii) clinical mastitis (CM), defined as visual abnormal milk secretion from one or more quarters followed by microbiological confirmation; iv) lameness (LA), defined as an episode of abnormal gait attributable to either foot or leg, followed by clinical diagnosis by the farm veterinarian; v) ovarian cysts (OC), defined as the presence of cysts larger than 20 mm in diameter diagnosed by the veterinarian in non pregnant cows. Disorders were recorded in binary form, i.e. 0 for absence of a disease and 1 for one or more observations of a disease in the time period between two consecutive milk recording dates (TP: 35 (3 d), and the date of event occurrence was referred to the closest date of milk testing.

Data editing and statistical analysis

A total of 9269 records from 1034 lactations and 535 cows were collected during the study. Altogether, 2094 events (804 OC, 608 LA, 426 CM, 136 RP and 120 ME) were recorded and used for computing the following incidence measures (Kelton *et al.*, 1998): i) time period incidence rate, expressed as number of first cases of the disease per 100 cows at risk during TP, computed for the diseases likely to occur at any stage of lactation (OC, LA, CM); ii) lactational incidence risk, expressed as number of lactations affected per 100 lactations at risk (including open lactations), computed for all disorders taken into account.

Only complete records with test day milk yield, SCC and BCS data were retained for statistical analysis, resulting in a total of 5315 records from 728 lactations and 429 cows when LA and CM were taken into account; in analysing data concerning OC only records from non pregnant cows were used, and 3195 records were available.

Statistical analysis was performed using a logistic regression procedure, in order to express the influence of a set of independent variables (continuous or discrete) on the frequency of a disorder complex (binomial). Categorical independent variables of concern were treated as follows:

Table 1. Descriptive statistics for test-day milk yield (MY), somatic cell score (SCS) and BCS at calving (CBCS).

	All			Heifers			Cows		
	N.	Mean	S.D.	N.	Mean	S.D.	N.	Mean	S.D.
MY (kg/d)	5315	34.7	9.11	1857	31.5	5.9	3458	36.3	10.0
SCS	5315	2.52	2.02	1857	2.38	1.73	3458	2.59	2.16
CBCS	728	3.47	0.48	255	3.72	0.41	473	3.34	0.47

- year effect (RY): 3 dummy variables were created and year 1999 was used as reference year (intercept of the model);
- season of calving (SC) effect: modeled as fall (September to November), winter (December to February), spring (March to May) and summer (June to August). Three dummy variables were created and winter was used as reference calving season (intercept of the model);
- parity (P): modeled as first and later parity. One dummy variable was created and later parity was used as reference parity (intercept of the model);
- stage of lactation (SL): modeled as 12 monthly classes, ranging from 1-30 days in milk (class 1) to more than 330 days in milk (class 12). Eleven dummy variables were created and class 1 (1-30 days in milk) was used as reference stage of lactation class (intercept of the model);
- BCS at calving (CBCS): the score for preparturient heifers and cows closest to the date of calving was used and was modeled as 3 classes (low CBCS: 3.00 or lower; intermediate CBCS: between 3.25 and 3.75; high CBCS: 4.00 or higher). Two dummy variables were created and intermediate CBCS was used as reference CBCS (intercept of the model);
- ME and RP occurrence were categorised as dummy variables, being the absence of disorders the reference event included in the intercept of the model;
- other concomitant disorders (OD) were categorised as dummy variables when the presence of additional disorders (OC and/or LA and/or CM) occurred in the same TP of concern; the

absence of OD was the designated reference event included in the intercept of the model.

Continuous independent variables were:

- cumulated milk yield (CMY), modelled as cumulated milk (103 kg) yielded from calving to the date of event observation;
- average somatic cell score (ASCS), computed as the average between SCS [$SCS = \log_2 (SCC/100000)+3$] recorded in the milk test date of concern and the SCS recorded in the preceding test date;
- the change of BCS (Δ BCS), computed as the difference between the BCS recorded in the milk test date of concern and the BCS recorded in the preceding test date.

In the present study the risk of occurrence of diseases due to selected explanatory variables has been evaluated through odds ratios (OR), a multiplicative measure of risk that ranges from 0 to infinity. The null value of an OR of 1 is assigned to levels of explanatory variables included in the intercept of the logistic regression model, thus representing the "reference condition" for comparisons. An OR > 1 means an increased risk of disease occurrence and implies that a given level of explanatory traits is predisposing to the occurrence of the disorder when compared to the reference condition. Conversely, an OR < 1 means a decreased risk of occurrence and implies that a given level of explanatory variable is preventive to the occurrence of the disorder with respect to the reference condition.

In order to provide odds ratio, logistic regression analysis was performed using the LOGISTIC procedure of SAS (SAS/STAT, 1990) according to the following model:

$$\ln \left[\frac{\pi(X)}{1-\pi(X)} \right] = \mu + \sum_{i=1}^3 b_{1i} RY_{iz} + \sum_{j=1}^3 b_{2j} SC_{jz} + b_3 P_z + \sum_{k=1}^{11} b_{4k} SL_{kz} + b_5 ASCS_z + b_6 ME_z + b_7 RP_z + b_8 CMY_z + b_9 OD_z + \sum_{l=1}^2 b_{10l} CBCS_{lz} + b_{11} \Delta BCS_z$$

where:

$$\ln \left[\frac{\pi(X)}{1-\pi(X)} \right]$$

is the logit of Y (Y=1 for presence of OC, CM, LA, Y=0 otherwise) and $\pi(x)$ is the probability that Y = 1; μ is the intercept, expressing the "reference" animal (multiparous cow, calving in winter with intermediate CBCS, with no ME and RP, in the first stage of lactation and showing no other concomitant disorder in the TP of concern);

RY, SC, P, SL, ASCS, ME, RP, CMY, OD, CBCS and Δ BCS are covariates as defined previously.

Results and discussion

Descriptive statistics and incidence measures

Descriptive statistics for milk yield, SCS and CBCS are given in Table 1.

Average test day milk yield was 35 kg/d, and was somewhat higher than 31 kg/d and 36 kg/d in heifers and cows, respectively. On average, 305 d milk yield slightly exceeded 9000 kg in heifers and 10,500 in cows (data not shown in table), which is markedly higher than the average lactation yield

reported by AIA (2000) for registered primiparous and multiparous Italian Friesian cows.

The average somatic cell score was 2.52; it appeared higher in cows than in heifers and exhibited a large variation in both groups, with a variability coefficient ranging between 72% and 83%.

The average CBCS was very close to 3.5 and appeared, as expected, higher in heifers than in cows. Nearly 65% of heifers and 55% of cows calved with a BCS ranging between 3.25 and 3.75. The body condition score at calving was 4 or higher in 29% of heifers and 11% of cows and was 3.00 or lower in 5% of heifers and 33% of cows (data not shown in table).

Time period and lactational incidence risk for disorders of concern are reported in Table 2. Ovarian cysts appeared the most frequent disorder, exhibiting an incidence of nearly 12% on a monthly basis and of more than 40% on a lactational basis. Time period incidence values were close to 7% and 5% for LA and CM, respectively, leading to a lactational incidence rate close to or higher than 30% for both diseases. Considering the disorders closely associated with parturition, RP and ME exhibited lactation incidence values of 17 and 15%, respectively. Incidences were higher

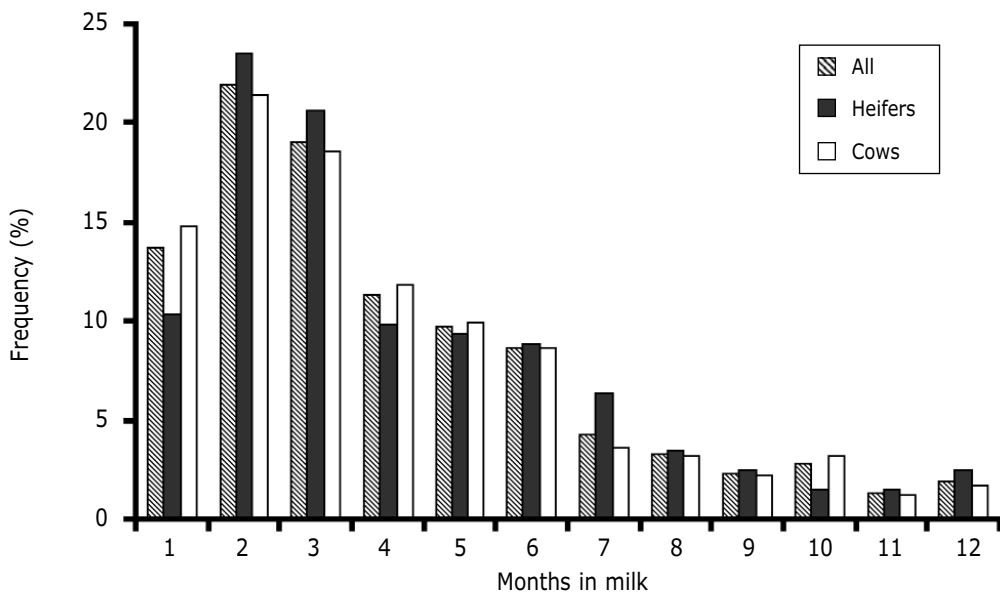
Table 2. Time period incidence rate¹ and lactational incidence risk² for disorders taken into account (9269 records).

	Time period incidence rate (%)			Lactational incidence risk (%)		
	all	heifers	cows	all	heifers	cows
Retained placenta	-	-	-	17.0	9.3	21.3
Mammary edema	-	-	-	15.0	12.8	16.2
Ovarian cysts	8.7	6.4	9.8	45.4	35.1	51.0
Clinical mastitis	4.6	3.2	5.3	28.1	19.7	32.6
Clinical lameness	6.6	3.7	8.1	33.4	23.0	39.0

¹ Time period incidence rate: number of first cases per 100 cows at risk during the recording time period.

² Lactational incidence risk: number of affected lactations (first case) per 100 lactations at risk (including open lactations)

Figure 1. Distribution of the occurrence of ovarian cysts during lactation.



for multiparous than for primiparous cows, which generally agrees with results from other studies (Østergaard and Gröhn, 1999; Fleischer *et al.*, 2001). Unlike the results reported by Dentine and McDaniel (1983), in the present study multiparous cows exhibited a higher incidence rate of severe mammary edema than primiparous heifers.

The incidence rates of the occurrence of diseases found in the present study tended to be higher than those generally reported in recent papers (Gröhn *et al.*, 1998; Heuer *et al.*, 1999; Østergaard and Gröhn, 1999; Rajala-Schultz *et al.*, 1999; Fleischer *et al.*, 2001; Hooijer *et al.*, 2001; Warnick *et al.*, 2001). For most diseases, incidence rates found in the present study fall within the range reported by Kelton *et al.* (1998), who reviewed incidence values of eight diseases considered of economic importance. Large variability is a constant feature of such traits, and herd effects play an important role in affecting the magnitude of the occurrence of diseases (Fourichon *et al.*, 2001) due to both management practices and methodology and accuracy of disease diagnosis and recording.

The distribution of OC, CM and LA during lactation is reported in Figures 1, 2 and 3, respec-

tively. Nearly 60% of first cases of detection of ovarian cysts occurred in the first 3 months of lactation in both heifers and cows, and the incidence of such disorder progressively decreased thereafter (Figure 1). Garverick (1997) reported that most cysts occur early postpartum and mainly prior to the first insemination. Also, the occurrence of mastitis (Figure 2) was more common in early lactation than afterwards: in the present study nearly one third of all first cases of CM in heifers occurred in the first month of lactation and this is in agreement with the findings of Heuer *et al.* (1999) and Rajala-Schultz *et al.* (1999).

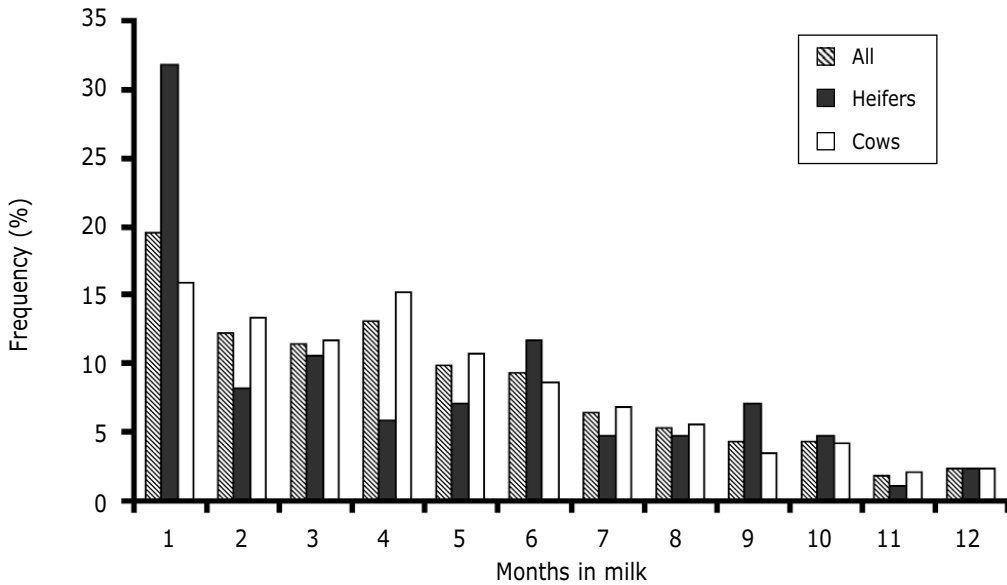
Conversely, in this study lameness occurred erratically during lactation (Figure 3), which is in disagreement with Warnick *et al.* (2001), who found lameness to be more common in early lactation.

Relative risk of occurrence for diseases of concern

Odds ratios for the 2nd to the 12th months in milk are reported in Figures 4, 5 and 6 for OC, CM and LA, respectively.

When compared to the first month in milk, stages of lactation from the 4th month since calving onwards appeared to be significant protective factors for OC occurrence (Figure 4), and OR

Figure 2. Distribution of the occurrence of clinical mastitis during lactation.



ranged between 0.39 in the 4th to 0.03 in the 12th stage of lactation ($P < 0.01$). Also for mastitis occurrence, months in milk belonging to the last third of lactation were significant protective factors ($P < 0.05$), and OR ranged between 0.266 for the 7th month to 0.079 for the 12th month since calving (Figure 5), which means a reduction in the risk of clinical mastitis occurrence with respect to the 1st month in milk ranging from nearly 4 times to nearly 13 times, respectively. Conversely, the risk of lameness occurrence tended to increase at increasing stages of lactation (figure 6), being significantly higher than that of the early 30 days in milk for months 2 to 5 and for months 9 to 12 since calving.

Generally, indications from OR fit well with distribution of the occurrence of diseases during lactation reported by Garverick (1997), Heuer *et al.* (1999) and Rajala-Schultz *et al.* (1999) for mastitis and ovarian cysts, whereas the occurrence of lameness has been found in some studies to be more frequent in early lactation (Barkema *et al.*, 1994; Warnick *et al.*, 2001).

Odds ratios of the other covariates considered in the logistic regression models for OC, CM and LA are shown in Tables 3, 4 and 5, respectively.

The first parity appeared to be a protective factor against the onset of most disorders, and the relative risk of occurrence of CM and LA was 1.90 and 2.00 times lower, respectively, in heifers than in cows. This is fully in agreement with findings of Fleischer *et al.* (2001), who reported that the risk of occurrence of mastitis and claw disease increased with the increasing of lactation number, whereas a non significant relationship between lactation number and the risk of occurrence of ovarian cysts was observed in that study.

Season of calving inconsistently affected the risk of occurrence of the selected disorders. Spring calvings were characterised by a 1.24-fold increase in the risk of OC occurrence (table 3) when compared to winter calvings ($P < 0.10$). The risk of the occurrence of lameness appeared higher for cows having their calving during summer than for cows calving in winter, whereas the risk appeared 1.6 times lower for cows calving during the spring when compared to those calving during the winter (Table 5). Conversely, the season of calving did not significantly affect the relative risk of clinical mastitis occurrence (Table 4). Gröhn *et al.* (1995) found that the risk of occurrence of ovarian cysts and mastitis was significantly affected by calving sea-

Figure 3. Distribution of the occurrence of clinical lameness during lactation.

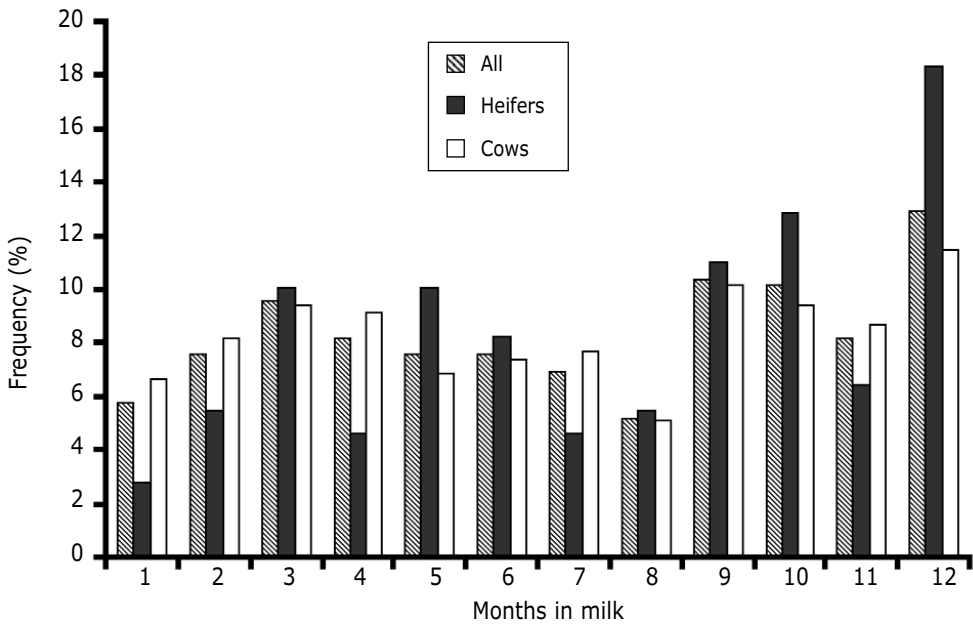


Table 3. Relative risk for occurrence of ovarian cysts.

	Odds ratio:			P value
	point estimate	95% confidence interval		
Parity:				
- heifers	0.84	0.66	1.07	n.s.
- cows	1.00	-	-	-
Calving season:				
- spring	1.24	0.96	1.60	0.10
- summer	1.21	0.93	1.56	n.s.
- fall	1.01	0.79	1.29	n.s.
- winter	1.00	-	-	-
CMY ¹	1.32	1.18	1.48	< 0.01
ASCS ²	0.91	0.87	0.96	< 0.01
BCS at calving:				
- ≤ 3.00	1.03	0.82	1.29	n.s.
- ≥ 4.00	1.01	0.78	1.29	n.s.
3.25 – 3.75	1.00	-	-	-
ΔBCS ³	0.85	0.68	1.07	n.s.
Retained placenta	0.91	0.72	1.15	n.s.
Mammary edema	1.03	0.81	1.32	n.s.
Other diseases:				
- mastitis	1.29	0.91	1.84	n.s.
- lameness	1.15	0.81	1.63	n.s.

¹ Cumulated milk yield; logistic regression coefficient: 0.281/103 kg.

² Average somatic cell score; logistic regression coefficient: - 0.093.

³ Change of BCS between the test date of diagnosis and the preceding test date.

son, and Enevoldsen *et al.* (1991) found for sole ulcer that calving in May to June or September to October was associated with an increased risk of occurrence.

The relative risk of both OC and CM occurrence (Tables 3 and 4, respectively) increased with the increase of cumulated milk yield (OR: 1.32, $P < 0.01$ and 1.12, $P < 0.10$, respectively), whereas no significant association between higher yielding cows and higher risk of the occurrence of lameness was found (Table 5).

Even though the association between increased milk production and greater risk of certain diseases is frequently taken for granted, contradictory assertions to this regard are found in the literature (Fleischer *et al.*, 2001). In the present study the occurrence of selected diseases in a monthly time period has been related to the cumulative milk yielded from parity to the milk testing date of concern, with the aim of accounting for the

metabolic load burdening a cow when a disease was diagnosed. A clear association between milk yield in the current lactation and risk of OC occurrence was found in this study: for example, logistic regression results indicated that an increase in milk yield from 8000 to 10,000 or 12,000 kg led to a 2.0 and 4.1 higher risk of OC occurrence, respectively (data not shown in table). These results are in agreement with the findings of Fleischer *et al.* (2001), who found that the estimated probability of appearance of OC in multiparous cows yielding 12,000 kg was 3.1 times as high as for cows producing 6000 kg. Likewise, increased milk yield has been associated with increased OC occurrence by other authors (Erb *et al.*, 1985; Heuer *et al.*, 1999), and Van Dorp *et al.* (1998) and Hooijer *et al.* (2001) found genetic correlations between milk yield and OC ranging between 0.23 and 0.35, respectively.

Results from the present study also suggest possible relationships between milk yield in the

Table 4. Relative risk for occurrence of clinical mastitis.

	Odds ratio:			P value
	point estimate	95% confidence interval		
Parity:				
- heifers	0.53	0.37	0.76	<0.01
- cows	1.00	-	-	-
Calving season:				
- spring	1.34	0.93	1.91	n.s.
- summer	1.27	0.89	1.82	n.s.
- fall	0.94	0.66	1.33	n.s.
- winter	1.00	-	-	-
CMY ¹	1.12	0.98	1.29	< 0.10
ASCS ²	1.36	1.28	1.44	< 0.01
BCS at calving:				
- ≤ 3.00	1.15	0.85	1.55	n.s.
- ≥ 4.00	1.10	0.77	1.59	n.s.
3.25 – 3.75	1.00	-	-	-
ΔBCS ³	0.72	0.52	1.00	0.05
Retained placenta	0.83	0.59	1.18	n.s.
Mammary edema	1.48	1.08	2.03	0.01
Other diseases:				
- ovarian cysts	1.24	0.88	1.74	n.s.
- lameness	0.80	0.49	1.32	n.s.

¹ Cumulated milk yield; logistic regression coefficient: 0.115/10³ kg.

² Average somatic cell score; logistic regression coefficient: 0.304/point.

³ Change of BCS between the test date of diagnosis and the preceding test date; logistic regression coefficient: -0.332/point.

Table 5. Relative risk for occurrence of clinical lameness.

	Odds ratio:		P value	
	point estimate	95% confidence interval		
Parity:				
- heifers	0.49	0.37	0.66	<0.01
- cows	1.00	-	-	-
Calving season:				
- spring	0.61	0.43	0.86	<0.01
- summer	1.28	0.97	1.69	<0.10
- fall	0.88	0.66	1.16	n.s.
- winter	1.00	-	-	-
CMY ¹	0.98	0.89	1.08	n.s.
ASCS ²	1.06	1.00	1.12	0.05
BCS at calving:				
- ≤ 3.00	1.00	0.77	1.23	n.s.
- ≥ 4.00	1.20	0.89	1.62	n.s.
3.25 – 3.75	1.00	-	-	-
ΔBCS ³	0.82	0.61	1.09	n.s.
Retained placenta	0.89	0.67	1.19	n.s.
Mammary edema	1.16	0.86	1.57	n.s.
Other diseases:				
- ovarian cysts	1.08	0.78	1.51	n.s.
- mastitis	0.83	0.51	1.36	n.s.

¹ Cumulated milk yield.

² Average somatic cell score; logistic regression coefficient: 0.059/point.

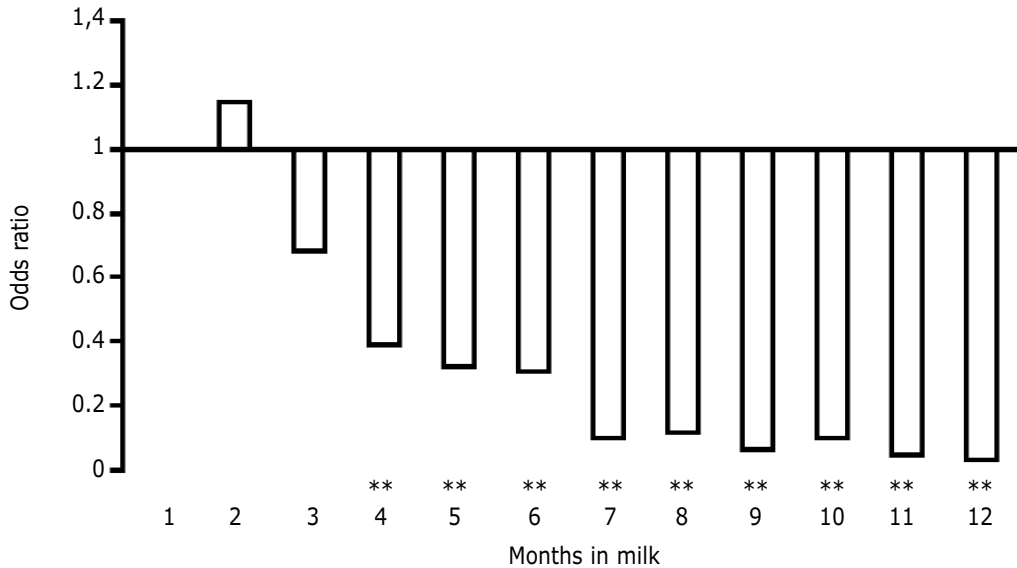
³ Change of BCS between the test date of diagnosis and the preceding test date.

current lactation and risk of occurrence of mastitis: as an example, logistic regressions indicated that an increase in milk yield from 8000 to 10,000 or 12,000 kg led to a 1.3 and 1.6 higher risk of CM occurrence, respectively (data not shown in table). Data from the literature are rather contradictory in this regard: Simianer *et al.* (1991), Pryce *et al.* (1998) and Van Dorp *et al.* (1998) found positive genetic correlations between 305-d milk yield and clinical mastitis, but the magnitude of these correlations was rather different. Erb (1987) and Deluyker *et al.* (1991) did not report a higher risk of mastitis for high-yielding cows. Fleischer *et al.* (2001) found a positive association between milk yield in the preceding lactation and risk of mastitis occurrence, but significant relationships between mastitis and milk yield in the current lactation were not proven. It must be pointed out that

the lack of correlation between CM and milk yield during the current lactation found in some studies can be at least partly due to the decreased milk secretion caused by the infection (Fleischer *et al.*, 2001), whereas in our study the occurrence of mastitis has been related to the cumulated milk yield up to the time preceding the diagnosis of mastitis.

This study evidenced a lack of association between milk yield in the current lactation and the risk of the occurrence of lameness. Both Lyons *et al.* (1991) and Van Dorp *et al.* (1998) reported no significant phenotypic correlations between lameness and 305-d milk yield. Conversely, Fleischer *et al.* (2001) found that the occurrence of claw disease was positively related to milk yield in the current lactation and Heuer *et al.* (1999) found a significant relationship between milk yield recorded in the first test day and the occurrence of lameness.

Figure 4. Relative risk of ovarian cysts occurrence during lactation with respect to the first month in milk (**: $P < 0.01$).



Average SCS appeared significantly related to the occurrence of all diseases of concern, and resulted a protective factor for OC occurrence (Table 3, OR: 0.91, $P < 0.01$) and a risk factor for mastitis (Table 4, OR: 1.36, $P < 0.01$) and the occurrence of lameness (Table 5, OR: 1.06, $P = 0.05$). Significant relationships do not necessarily mean causal relations between the traits, and a biological interpretation of these results is not always easily achievable, especially when experimental data are from one herd only and a limited number of cows. From a practical point of view, the monitoring of somatic cell content of milk could be regarded as a herd health management tool also for disorders other than udder diseases; however, a larger data set and further analyses are needed to support these speculations.

The relative risk of the occurrence of disorders did not appear to be related to differences in BCS at calving or in Δ BCS (Tables 3, 4, 5), with the only exception of clinical mastitis, for which a significant relationship with Δ BCS was found (OR: 0.72, $P < 0.05$). As the logistic regression coefficient of CM on Δ BCS was negative (Table 4), the relative risk of CM occurrence increased for cows mobilising body reserves, i.e., losing BCS since the preceding test date, and decreased for cows gaining

body reserves with respect to the preceding test date: for example, logistic regressions indicated that, when compared with a steady condition, a -0.5 or -1.0-point variation in BCS between the test date of diagnosis and the preceding test date led to a 1.06 or 1.13 higher risk of CM occurrence, respectively, whereas a variation in BCS of 0.5 or 1 points led to a 0.94 and 0.89 decreased risk of CM occurrence, respectively (data not shown in table). Results from the literature give conflicting indications about the association between BCS close to calving or BCS loss during lactation and disease occurrence: Heuer *et al.* (1999) failed to prove any significant relationship between these aspects, and Ruegg and Milton (1995) reported that BCS at calving was not related to OC, CM and LA occurrence, and that the relationships between BCS loss from calving and diseases were very limited. Conversely, Markusfeld *et al.* (1997) and Gillund *et al.* (2001) found BCS to be related to health traits, particularly ketosis.

Retained placenta was not significantly related to the relative risk of occurrence of disorders (Table 3 to 5), whereas the presence of severe mammary edema near calving increased the risk of mastitis occurrence by nearly 50% (Table 4). Previous studies (Gröhn *et al.*, 1990) also found

udder edema to be associated with an increased risk of clinical mastitis, and Waage *et al.* (2001) reported that primiparous heifers exhibiting severe edema at parturition were 1.7 times more likely to display mastitis than those that had no signs or a limited degree of edema. Therefore,

monitoring cows at parturition for mammary edema can be regarded as a useful tool aimed at controlling clinical mastitis at the herd level.

As reported in Tables 3, 4 and 5, other disorders occurring in the same time period did not affect the risk of occurrence of the disease of concern.

Figure 5. Relative risk of occurrence of clinical mastitis during lactation with respect to the first month in milk (*: P < 0.05).

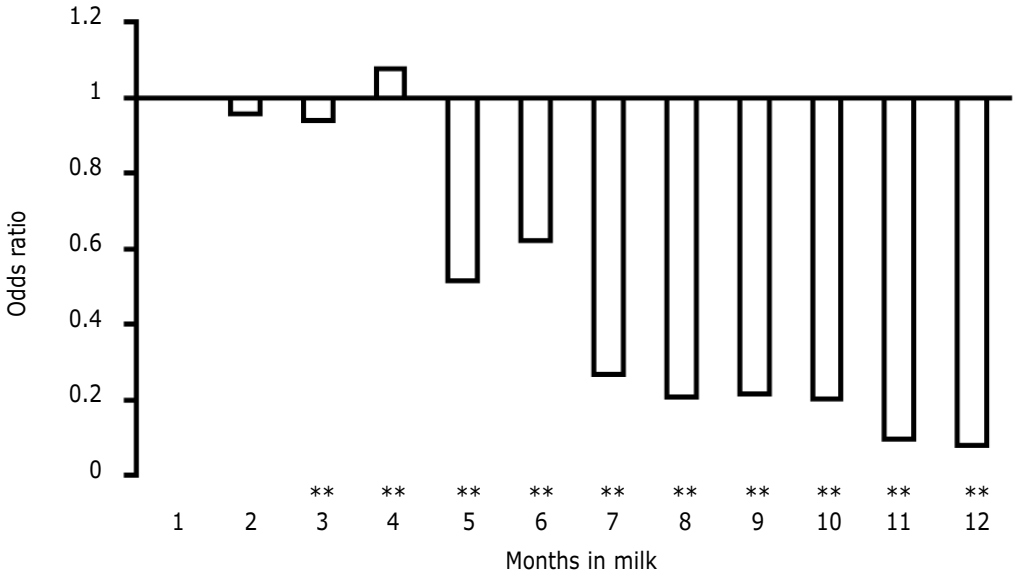
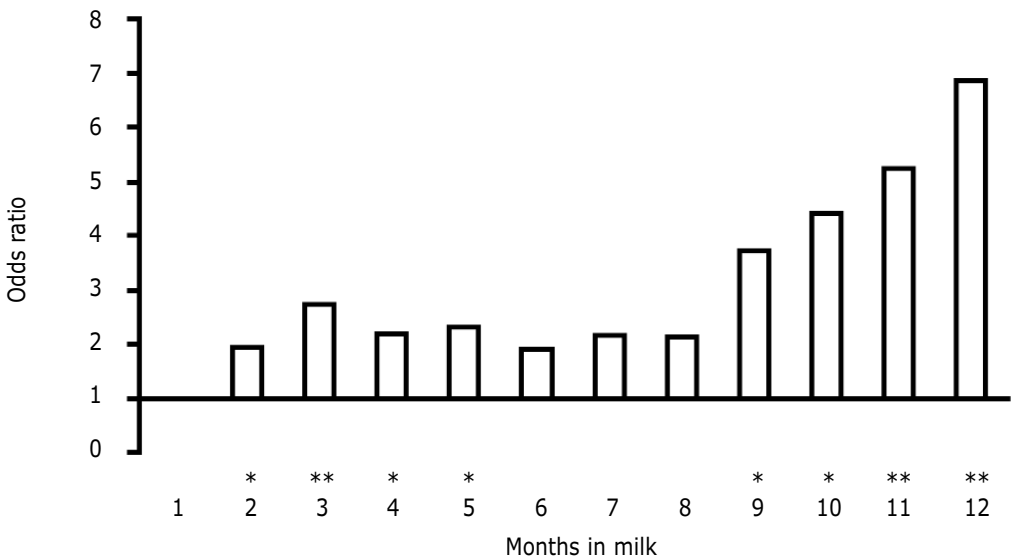


Figure 6. Relative risk of occurrence of clinical lameness during lactation with respect to the first month in milk (*: P < 0.05; **: P < 0.01).



Conclusions

The herd enrolled in this study exhibited an appreciable incidence of all health disorders taken into account, in spite of a good management strategy and a high production level.

Herd health data merged with milk testing information evidenced significant relationships between milk yield and risk of occurrence of disorders such as mastitis and ovarian cysts. Moreover, the monitoring of somatic cell content of milk and the regular control of udder edema after parturition seem to be useful tools in the prediction of the occurrence of some disorders, especially clinical mastitis.

Results from this study were derived from only one herd and need to be validated by studies on larger samples, including herds representative of the current Italian dairy management strategies. This would also make it possible to acquire information on the occurrence of major diseases, which is currently lacking for Italian dairy herds, and to properly investigate the relationships between health disorders, production and reproduction traits, and culling policy.

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