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Disease Occurrence and Risk Factor Analysis in Finnish Ayrshire Cows

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Rajala PJ, Gröhn YT: Disease occurrence and risk factor analysis in Finnish Ayrshire cows. Acta vet. scand. 1998, 39, 1-13. – Disease occurrences and risk factors for the most common diseases among 39,727 Finnish Ayrshire dairy cows belonging to 2338 herds were studied. All the cows calved during 1993 and were followed until the next calving or culling.

Lactational incidence risks, recurrence of, and number of treatments required for one episode of a disease are described for 17 different veterinary diagnoses. The 5 most common diseases and their lactational incidence risks were: acute mastitis (17.0%), anestrus (8.1%), ovarian cysts (7.3%), milk fever (5.4%), and ketosis (4.9%). The highest recurrence probability (14.2%) was observed for acute mastitis, followed by fertility disorders. Milk fever was the one disease that required the most repeated treatments, i.e., almost 30% of the cows were treated at least twice, whereas for most of the other diseases about 10% of the cows required more than one treatment per first episode of the disease.

Logistic regression models were fitted to study the effect of milk yield and other risk factors on the occurrence of the 5 most common diseases. Increasing milk yield was found to be a risk factor for acute mastitis, ovarian cysts, and for anestrus among older cows (parity>2), and for milk fever among younger cows (parity = 2). Several diseases were found to be risk factors for other diseases.

dairy; milk yield; logistic regression.

Introduction

The effect of milk yield on the occurrence of dairy cow diseases has been under much debate and the literature gives controversial results on the subject. In her literature review, *Erb* (1987) concluded that cows producing more than their herdmates are not at increased risk of any disorders other than perhaps milk fever. In studies done in Canada and the United States among Holstein-Friesians, *Dohoo et al.* (1984) found that out of 17 diseases only milk fever was associated with high milk yield, and *Gröhn et al.* (1995) found that higher milk yield was a risk factor only for mastitis and ovarian cysts out of the 7 diseases studied. However, in studies on Finnish Ayrshire cows, high milk yield was found to be a risk factor for several diseases, including retained placenta, early metritis, ovarian cysts, silent estrus, milk fever, ketosis, and mastitis (*Gröhn et al.* 1989, *Gröhn et al.* 1990a, *Gröhn et al.* 1990b). In a German study, increasing milk yield of cows was found to lead to an increase in the frequencies of ketosis, milk fever, and ovarian cysts (*Distl et al.* 1989); cows with low peak daily yields suffered less frequently from silent estrus, cystic ovaries, and metritis in a Norwegian study (*Solbu* 1984). These discrepancies may be partly due to the different management styles and also different data recording systems in North America and Europe: e.g., in Finland all the disease diagnoses are made and treatments are given by a veterinarian, whereas in the United States farmers diagnose and treat a majority of the diseases. The Finnish studies were conducted using data from the Finnish dairy herd health recording system from the early 1980's. The system was introduced at the beginning of the 1980's. It may not yet have established its place when these first studies were carried out using those early data; the disease recording may consequently not have been very accurate and consistent at the time.

The purpose of this study was to investigate the effect of milk yield and other risk factors on the occurrence of the 5 most common diseases (anestrus, ovarian cysts, milk fever, ketosis, and acute mastitis) among Finnish Ayrshire cows in the 1990's. By that time, both veterinarians and farmers in Finland had realized the benefits of the nationwide disease surveillance program and were utilizing it to its full extent. This study will also give a more detailed description on disease occurrence than has been given before, including second occurrences of the same disease and number of treatments given per episode of a disease.

Materials and methods

The data

The data for this study are from 39,727 Finnish Ayrshire dairy cows that calved during 1993 and were followed until the next calving or culling. The cows were in 2338 herds that belong to the milk registry and the national health recording system. The herds were in the area of 19 different agricultural centers which cover almost the whole country. The Finnish dairy cow health data recording system has been described earlier (*Gröhn et al.* 1984). Herds with at least 10 calvings/year that were still in business in summer 1996, and belonged to communities where the health registration percentage was at least 80%, were included in the study.

Finnish farmers do not have access to veterinary drugs without supervision of a veterinarian, so virtually all diseases are diagnosed and treated by a veterinarian during farm visits. Consequently, the reliability of the data is high. Seventeen different veterinary diagnoses that were made during the study lactation (starting 5 days before the calving and ending at the following calving or culling) were considered. The diseases included: dystocia, retained placenta, metritis (early and late metritis combined into one diagnosis), anestrus, ovarian cysts, other infertility problems, milk fever, non-parturient paresis, ketosis, hypomagnesemia (indoor and outdoor combined), disorders of the abomasum, rumen disorders (e.g., bloat, rumen acidosis combined), traumatic reticuloperitonitis (also referred to as hardware), acute mastitis, teat injuries, chronic mastitis, and lameness. Diagnoses were made by veterinarians according to ordinary clinical methods under field conditions. Mastitis treatments given by phone prescription during the lactation were included in the acute mastitis diagnosis.

Some general information (production data, calving interval) about the data is given in Table 1. For comparison, some values from the same data base from 1983 (*Gröhn et al.* 1986) are presented. Cows in the first parity consisted of 33.5% of the cows in the study population, and there were 23.8% parity 2 cows, and 17.1% parity 3 cows. The rest (25.6%) of the cows were in their fourth or higher parity. The mean number of calvings per year in a herd in this data set was 17. More than one-third of the herds (38.5%) in the study had 10 to 14 calvings, 34.8% had 15-19 calvings, 17.5% had 20-

Table 1. Production information from the current and earlier study[1] in Finnish Ayrshire cows. The current study consisted of 39,727 cows calving in 1993 and the earlier study consisted of 73,368 cows calving in 1983.

	Year -93		Year -83[1]	
	x̄	sd	x̄	sd
305-day milk, kg	6715	1350	5487	1121
305-day fat, kg	300	61	244	51
305-day protein, kg	220	43	180	37
Calving interval, days	389	50	379	41

[1] *Gröhn et al.* 1986.

24 calvings and 9.3% of the herds had 25 or more calvings during the year 1993.

Lactational incidence risk, recurrence of, and repeated treatments for diseases are described. An occurrence of a disease was considered to be a new episode if at least 3 weeks had passed between consecutive treatments, otherwise the treatments were considered to have been given for the same disease episode.

We examined risk factors for the 5 most common diseases in the data set. Parity, calving season and previous lactation milk yield were considered as risk factors in addition to all other health disorders during the study lactation. Parity had 4 classes: 1, 2, 3, and 4 or higher. Calving season had 4 classes: winter (December-February), spring (March-May), summer (June-August), and fall (September-November).

The effect of milk yield on disease occurrence was the primary interest in the risk factor analyses and previous lactation 305-day milk yield was used for that purpose. Multiparous cows with a missing value for previous lactation milk yield (2283 cows) were excluded from the analyses. The 305-day milk yield was standardized for fat and protein content for the analyses by using the following formula (*Van Arendonk et al.* 1989):

$$\text{fpmilk} = 0.349*\text{milk} + 10.7*\text{fat} + 6.7*\text{prot}$$

where fpmilk = the fat-protein-corrected 305-day milk yield, milk = "crude" 305-day milk yield, fat = 305-day fat yield, and prot = 305-day protein yield.

Cow's milk yield was classified into 4 categories based on the herd milk yield level. That is, each cow was placed in the lowest, second lowest, second highest or highest milk yield category based on how much she had produced in relation to her herdmates. Cows in first parity formed a fifth, separate class, because they did not, naturally, have any previous milk yield. Consequently, parity and milk yield were combined into 13 different categories. Cows in first parity formed the reference category; otherwise each parity group was divided into 4 categories based on cow's milk yield. E.g., PARMY21 refers to a cow in parity 2 and in the lowest milk yield category within her herd, and PARMY44 refers to a cow in fourth or higher parity and in the highest milk yield category.

In these analyses, only the first diagnoses of the diseases were considered. The data were checked for any illogical values in disease treatment dates; if any were found, those records were removed from the data set. E.g., the first treatment of parturient paresis was only allowed to occur within the period 5 days before to 7 days after calving. Diagnoses that had been made within 5 days before the next calving, and thus were clearly associated with the next calving, were not considered in these analyses. All diseases occurring before the outcome disease were considered as potential risk factors. A putative risk-factor disease was coded as 1 (= "present") if it had occurred before the outcome disease and 0 (= "absent") if the cow had not experienced that disease or if it had been diagnosed on the same day as or after the outcome disease. However, a potential bias existed for those records that had not had the outcome disease ("controls"); they did not have a diagnosis date for that disease with which to compare the date of occurrence of a risk-factor disease. If the entire lactation had been considered "at risk" for the occurrence of risk-factor diseases, then the "controls" would have a longer follow-up period than the "cases". This would then have biased the odds ratio towards the null. Therefore, for cows who had not had the outcome disease, "an average diagnosis date for the outcome disease" was assigned: their calving date + median days in milk after calving for that particular disease in the whole data set. The date of the risk factor disease was then compared to that date and if it had occurred before the assigned date the disease was coded 1, otherwise it was coded 0. This procedure was repeated for each of the 5 diseases of interest (anestrus, ovarian cyst, milk fever, ketosis, and acute mastitis).

Statistical analyses

All data editing and statistical analyses were carried out using the Statistical Analysis System (*SAS Institute Inc.* 1994) in the Cornell Theory Center Supercomputer. The first occurrence of disease was expressed as lactational incidence risk (*Gröhn et al.* 1990a), which was calculated as the number of cows with at least one occurrence of the disease divided by the number of cows at risk times 100 (as it was presented as percentage). The recurrence of any disease was expressed as a percentage of the cows who had already experienced one episode of that same disease. Number of treatments needed per episode of a disease was expressed as a percentage of cows with the disease who needed one, 2, and 3 or more treatments.

A 3-stage process was used to model and evaluate the risk factors for the 5 most common diseases. In the first stage, 2×2 Chi-square tests were conducted to relate each outcome disease with the potential risk factors. Risk factors associated with the outcome at significance level $\alpha = 0.05$ were included in the second stage.

In the second stage, a multiple logistic regression was run (using PROC LOGISTIC in SAS) with all the factors which passed the first screening. From the full model the least significant covariate was dropped and the reduced model was compared to the full model by means of likelihood ratio tests. The procedure was repeated until all the remaining variables were significant at the $\alpha = 0.01$ level (with the exception that for the variables parity-milk yield and season all the categories were kept in the model even if only some of them were significant). After this, some diseases which had not been included for further analysis, but were known to be associated with the outcome disease based on earlier studies, were tested in the model with all other significant factors. If they were significant at the $\alpha = 0.01$ level they were kept in the model.

In the third stage, agricultural center was added to each model acquired in Stage 2. This was done to account for any possible variation due to the geographical areas within the country.

The probability of finding an erroneous significant result on a single test (type I error) is traditionally set to the level $\alpha = 0.05$ (comparisonwise error rate). The probability of erroneously claiming at least one significant result when doing several separate screening tests (experimentwise error rate), however, gets higher than the α-level set for an individual test (*Snedecor*

& Cochran 1989). The validity of our screening method was tested with the model for acute mastitis: the preliminary screening, i.e., 2×2 Chi-square tests were run using a randomly picked subset from the original data set (60% of the original observations) and the modeling was done using the complement of this subset (the remaining 40 % of the data). These results were then compared to the original final model (based on the whole data set).

The effect of each risk factor in any one of the models was determined by the odds ratio and its 95% confidence interval. The odds ratio (OR) for a factor is a measure of the cow's risk of having the outcome disease, given that the cow had that factor, compared to a situation in which she did not have the factor. An odds ratio greater than 1 indicates an increased risk and an odds ratio smaller than 1 indicates a protective effect. The reference category for each factor had an odds ratio equal to 1. The 95% confidence interval for an odds ratio implies that the true parameter value lies between the 2 end points 95% of the time.

Results

Occurrence of the diseases

The lactational incidence risks (LIR) and the median days in milk until the first diagnosis of 17 different veterinary diagnoses are presented in Table 2. The 5 most common diseases were: acute mastitis (LIR = 17.0%), anestrus (8.1%), ovarian cysts (7.3%), milk fever (5.4%), and ketosis (4.9%).

The highest recurrence probability was observed for acute mastitis, followed by fertility disorders (Table 2). Over 14% of cows with one episode of acute mastitis contracted the disease again later on during the lactation. About 12% of cows who had previously been diagnosed with silent heat or ovarian cysts were treated for the same disorder later in the same lactation.

If the treatments were given less than 3 weeks apart, they were considered to have been given for the same episode of the disease. Table 3 presents the percentage of cows who were treated once, twice, and 3 or more times for the same episode. Milk fever was the one disease that clearly required the most repeated treatments; almost 30% of the cows were treated at least twice, whereas for most of the other diseases about 10% of the cows required more than one treatment.

Risk factors for the diseases

The odd ratios and their 95% confidence intervals for the risk factors of the 5 most common diseases are presented in Table 4.

A n e s t r u s – Cows in first parity had the highest risk of being treated for anestrus. Among older cows (parity > 2), a slightly increasing risk was observed with increasing milk yield. Cows that calved during winter had a 2.5 times higher risk of being diagnosed with anestrus than had cows calving in spring. Also, summer and fall calvers were at higher risk.

Ovarian cysts, other fertility disorders, and metritis were risk factors for anestrus (OR's 2.0, 2.6, and 1.6, respectively), as well as dystocia and foot and leg disorders.

O v a r i a n c y s t s – The occurrence of ovarian cysts was not associated with parity, except for high producing cows; among the highest producing cows the risk of being treated for ovarian cysts was higher the older the cow was. Within each parity, an increasing risk with increasing milk yield could be observed, i.e., the lowest producing cows had the lowest risk and the highest producing cows had the highest risk of ovarian cysts. Cows calving in fall were at 2.5 times higher risk for ovarian cysts than those calving in spring. As was found with anestrus, all the other reproductive disorders were also risk factors for ovarian cysts.

M i l k f e v e r – Increasing age was a strong risk factor for milk fever. In this study the associa-

Table 2. Lactational incidence risks (%) of the most common diseases among 39,727 Finnish Ayrshire cows calving in 1993.

Diagnosis	LIR1[1]	n[2]	dim1[3]	LIR2[4]	n[2]
Dystocia	2.1	833	0	na	
Retained placenta	3.1	1225	2	na	
Metritis	3.2	1259	21	7.6	96
Anestrus	8.1	3200	85	11.9	381
Ovarian cysts	7.3	2890	94	12.2	353
Other fertility disorder	1.9	763	131	6.7	51
Milk fever	5.4	2161	1	na	
Non-part. paresis	1.0	382	27	2.6	10
Ketosis	4.9	1966	28	8.5	168
Hypomagnesemia	0.5	199	47	1.0	2
Displaced abomasum	0.7	295	16	4.4	13
Rumen disorders	1.6	654	38	2.1	14
Hardware	0.8	307	80	0.7	2
Acute mastitis	17.0	6738	47	14.2	958
Teat injury	3.4	1334	100	6.1	81
Chronic mastitis	4.1	1631	135	8.2	134
Lameness	2.3	931	52	5.4	47

[1] LIR1 = (# of cows with at least one occurrence of the disease divided by the total number of cows at risk) *100.
[2] n = number of cows experiencing the disease.
[3] dim1 = median time in days from calving to the first diagnosis.
[4] LIR2 = percentage of cows with a disease who have a second episode of that same disease; second episode occurs at least 3 weeks later than the preceding treatment
na = not applicable.

Table 3. Percentage of cows requiring one, two, or 3 or more treatments for the first episode of the most common diseases among 39,727 Finnish Ayrshire cows, n = number of cows experiencing the disease.

Disease	1	2	≥ 3	n
Retained placenta	97.2	2.6	0.2	1225
Metritis	86.7	11.7	1.6	1259
Anestrus	92.6	6.7	0.7	3200
Ovarian cysts	90.3	8.7	1.0	2890
Other fertility disorder	94.1	5.5	0.4	763
Milk fever	70.2	22.1	7.7	2161
Non-part. paresis	84.8	11.5	3.7	382
Ketosis	91.4	7.7	0.9	1966
Hypomagnesemia	88.9	9.5	1.6	199
Displaced abomasum	88.1	9.5	2.4	295
Rumen disorders	91.6	7.0	1.4	654
Hardware	94.5	4.5	1.0	307
Acute mastitis	86.3	11.9	1.8	6738
Teat injury	88.8	10.1	1.1	1334
Chronic mastitis	93.9	5.6	0.5	1631
Lameness	90.8	8.1	1.1	931

Table 4. Odds ratios and their 95% confidence intervals (CI) for risk factors of the 5 most common diseases among Finnish Ayrshire cows.

	Anestrus OR (95% CI)	Ovarian cysts OR (95% CI)	Milk fever OR (95% CI)	Ketosis OR (95% CI)	Acute mastitis OR (95% CI)
Parity-milk yield[1]					
Parity1	1	1	1	1	1
Parmy21	0.5 (0.4-0.6)	1.1 (09-1.3)	1.3 (0.8-2.0)	1.0 (0.8-1.2)	1 (0.9-1.1)
Parmy22	0.7 (0.6-0.8)	1.2 (1.0-1.4)	1.3 (0.8-2.1)	1.0 (0.8-1.3)	1.4 (1.2-1.5)
Parmy23	0.8 (0.7-1.0)	1.4 (1.1-1.7)	2.8 (1.8-4.6)	1.1 (0.8-1.4)	1.3 (1.2-1.5)
Parmy24	0.6 (0.5-0.9)	1.5 (1.2-2.0)	3.1 (1.7-5.7)	1.3 (0.9-1.9)	1.3 (1.1-1.6)
Parmy31	0.6 (0.4-0.7)	1.1 (0.8-1.4)	9.0 (6.2-13.0)	1.3 (0.9-1.8)	1.1 (0.9-1.4)
Parmy32	0.6 (0.5-0.8)	1.4 (1.1-1.7)	8.5 (6.1-11.7)	1.5 (1.2-1.9)	1.1 (1.0-1.3)
Parmy33	0.7 (0.6-0.8)	1.6 (1.3-1.9)	8.7 (6.4-11.9)	1.6 (1.3-2.0)	1.2 (1.0-1.3)
Parmy34	0.8 (0.7-1.0)	1.6 (1.4-1.9)	9.9 (7.3-13.4)	1.5 (1.2-1.9)	1.4 (1.3-1.6)
Parmy41	0.3 (0.2-0.5)	0.8 (0.6-1.2)	23.4 (17.1-31.8)	1.5 (1.1-2.1)	1.2 (1.0-1.5)
Parmy42	0.5 (0.4-0.6)	1.3 (1.1-1.6)	24.8 (19.1-32.5)	1.6 (1.3-2.0)	1.3 (1.1-1.4)
Parmy43	0.6 (0.5-0.7)	1.4 (1.2-1.6)	32.2 (25.1-41.4)	1.6 (1.3-2.0)	1.3 (1.2-1.5)
Parmy44	0.8 (0.7-0.9)	1.8 (1.6-2.1)	29.4 (23.1-37.5)	1.5 (1.2-1.7)	1.7 (1.5-1.8)
Season					
Spring	1	1	–	3.6 (3.0-4.3)	–
Summer	1.3 (1.1-1.5)	1.8 (1.6-2.0)	–	13.6 (2.2-.1)	–
Fall	2.4 (2.2-2.7)	2.5 (2.2-2.8)	–	2.6 (2.2-3.1)	–
Winter	2.5 (2.2-2.9)	2.0 (1.7-2.2)	–	4.3 (3.6-5.2)	–
Diseases					
Dystocia	1.4 (1.1-1.8)	–	–	–	–
Ret. placenta	–	–	–	–	2.0 (1.7-2.3)
Metritis	1.6 (1.3-1.9)	1.9 (1.5-2.3)	–	1.5 (1.1-2.1)	–
Anestrus	–	1.8 (1.6-2.1)	–	5.8 (2.7-12.5)	10.6 (8.5-13.2)
Ovarian cyst	2.0 (1.7-2.4)	–	–	4.1 (2.1-8.2)	6.2 (5.1-7.7)
Other fertility disor.	2.6 (1.8-3.8)	2.7 (1.8-3.9)	–	–	7.4 (4.6-12.0)
Milk fever	–	–	–	1.3 (1.1-1.6)	–
Non-part. paresis	–	–	–	3.5 (2.3-5.3)	–
Hypomg	–	–	–	2.4 (1.1-5.1)	–
Teat injury	0.6 (0.4-0.9)	–	–	–	7.8 (6.6-9.3)
Lameness	1.7 (1.3-2.2)	–	–	–	–

[1] E.g., parmy21 refers to a cow in second parity and lowest milk yield category; parmy44 refers to a cow in parity 4 or higher and in the highest milk yield category.

tion between milk yield and milk fever was not very clear; only among younger cows (parity = 2) did risk of milk fever increase with increasing milk production.

Ketosis – Previous lactation milk yield was not a risk factor for ketosis in this study. Cows that calved during winter were at 4.3 times higher risk of ketosis than those calving in summer. Also, cows calving in spring and fall had a higher risk of ketosis than those calving in summer (OR's 3.6 and 2.6 respectively). Risk of ketosis was higher for older cows (parity > 2) than for cows in first parity regardless of the milk production level, but there was no significant difference between first and second parity cows. Anestrus, ovarian cysts, and metritis increased the risk of ketosis (OR's 5.8, 4.1, and 1.5, respectively). Cows who had had milk fever had a slightly increased risk of contracting ketosis (OR = 1.3). Non-parturient paresis and hypomagnesemia also increased ketosis risk.

Acute mastitis – This study did not find any clear increasing or decreasing trend in mastitis risk with parity; only among the high producers did mastitis risk rise as the cow got older (OR = 1.3 in second parity, 1.4 in third parity and 1.7 in fourth or higher parity). However, cows in all the parity-milk yield categories, except for the lowest producing categories, had a significantly higher risk of contracting mastitis than cows in first parity. The highest producing cows had a higher risk of mastitis than the cows in the lowest milk yield category. Teat injuries were a strong and significant risk factor for acute mastitis (OR = 7.8). Infertility disorders (anestrus, cystic ovaries, and other infertility disorders) were also strong risk factors for acute mastitis (OR's 10.6, 6.2, and 7.4, respectively).

In all of the models, adding agricultural center to the model did not significantly change the coefficients of the other variables, so it can be concluded that geographical area was not a confounder in the data and it was not necessary to keep it in the models.

The validity of our screening procedure was tested by using a random sample from the original data set for screening tests and the complement of this for the actual modeling for the mastitis model. The results from this validation were in agreement with the original mastitis model, so we can be confident that the probability of spurious associations was no higher than the pre-set value.

Discussion

Occurrence of the diseases

Disease incidences in the present study are consistent with the results of other similar studies (*Cobo-Abreu et al.* 1979, *Erb & Martin* 1980, *Dohoo et al.* 1983, *Gröhn et al.* 1989, *Bigras-Poulin et al.* 1990b). The most noticeable difference compared to the earlier (data from 1983) studies on Finnish Ayrshire cows is the big increase in the lactational incidence risk of acute mastitis (from 7.0% to 17.0%) (*Gröhn et al.* 1990a).

The median days in milk at first treatment are very similar to the results from other studies. When compared to previous Finnish studies, the first treatments of digestive disorders and lameness took place earlier in this study. This might simply indicate a change in farmers' attitude towards treating the disorders as soon as possible.

Our study found highest recurrence percentage (14%) for acute mastitis, which is consistent with the results of *Bigras-Poulin et al.* (1990b); most other studies have concentrated only on the first occurrence of diseases and have not reported recurring cases during the same lactation.

Risk factors for the diseases

The youngest cows were at the highest risk for anestrus which finding has also been reported by *Gröhn et al.* (1990b), and is also consistent with results of *Solbu* (1984) and *Distl et al.* (1989). Increasing risk of being treated for ovarian cysts and a slightly higher risk of being treated for anestrus among older cows (parity >2) was associated with increasing milk yield in this study. *Gröhn et al.* (1990b, 1994) reported that the risk of silent heat and cystic ovaries increased with increasing milk yield and that the risk of cystic ovaries also increased with higher parity. Also, *Erb & Martin* (1980) and *Dohoo & Martin* (1984) reported age to be a significant factor in occurrence of cystic follicles, but they did not find these disorders to be associated with milk yield. Seasonal pattern with silent heat and cystic ovaries has been reported previously (*Erb & Martin* 1980, *Dohoo & Martin* 1984, *Gröhn et al.* 1990b, *Gröhn et al.* 1994).

Higher age was a risk factor for milk fever as has been established in earlier studies (*Dohoo & Martin* 1984, *Gröhn et al.* 1989, *Bigras-Poulin et al.* 1990b). The association between milk yield and milk fever was not very clear in this study and literature also gives contradictory results. In the studies of *Dohoo et al.* (1984) and *Bendixen et al.* (1987), milk fever was significantly associated with the level of milk production; also *Bigras-Poulin et al.* (1990a) found an association between milk fever and previous milk production. However, *Gröhn et al.* (1995) did not find any association between milk yield and milk fever among New York Holsteins, but there was a tendency to increased risk with increasing milk yield among Finnish Ayrshire cows (*Gröhn et al.* 1989).

Previous milk yield was not a risk factor for ketosis, which finding is in agreement with the results of *Dohoo et al.* (1984) and *Gröhn et al.* (1995), but in contrast to earlier studies among Finnish Ayrshire cows which found that cows with higher previous milk yield and in higher producing herds were at increased risk of ketosis (*Gröhn et al.* 1989). The seasonal variation of ketosis occurrence was consistent with previous results (*Dohoo & Martin* 1984, *Gröhn et al.* 1984, *Gröhn et al.* 1989). *Bigras-Poulin et al.* (1990b) found an association between age and ketosis implying that older animals were at a higher risk of experiencing the health problem which was also our finding. *Dohoo & Martin* (1984) found the peak occurrence to be approximately at nine years of age and *Gröhn et al.* (1989) during parities 3 and 4.

Increasing milk yield was found to be a risk factor for acute mastitis in this study. *Bigras-Poulin et al.* (1990a) and *Gröhn et al.* (1995) found that increasing milk yield increased the risk of mastitis; *Dohoo et al.* (1984), however, reported no association between mastitis and milk yield. The results of this study, in contrast to several other studies (*Cobo-Abreu et al.* 1979, *Dohoo & Martin* 1984, *Gröhn et al.* 1990a), did not indicate a clear increasing mastitis risk with increasing parity.

Several other studies (*Saloniemi & Roine* 1981, *Dohoo et al.* 1984, *Bigras-Poulin et al.* 1990b, *Gröhn et al.* 1990a) have also found teat injuries to be strong risk factors for acute mastitis. The association between mastitis and cystic ovaries and retained placenta has also been found in other studies (*Dohoo et al.* 1984, *Gröhn et al.* 1990a, *Gröhn et al.* 1995).

General discussion

The Finnish dairy herd health recording system currently provides probably one of the most comprehensive and most reliable sources of data for this kind of research, because it comprises dairy herds in the whole country (large data base) and virtually all the diagnoses are made by veterinarians. Despite this, the accuracy of recorded diseases may not be perfect and there are also differences between veterinarians. It is also worth emphasizing that incidences presented in this study are based on veterinary treatments of the diseases, which might not be exactly the same as the occurrence of diseases. Some disease occurrences might not be recorded and this will underestimate the true incidence. E.g., lameness could be one of the diseases which is underreported, because farmers might often call a professional hoof-trimmer instead of a veterinarian to take care of some hoof problems and these treatments might not be recorded. Surveys of lameness in dairy cattle have revealed an average incidence ranging from 2.7% to about 60%, with part of the variation being explained by whether treatments given only by veterinarians or also by farmers were recorded (*Greenough et al.* 1997). In a Scandinavian study, the incidence of foul in the foot was found to be very low (0.6%) (*Alban et al.* 1995), whereas in the US, infectious diseases of the digits have reached nearly epidemic proportions in certain regions (*Greenough et al.* 1997), accounting for the high incidence of lameness. In a Swedish study, 94% of primiparous cows and 66% of multiparous cows had haemorrhages of the sole at trimming 2 to 4 months after calving (*Bergsten & Herlin* 1996), but it was not indicated how these findings related to clinical lameness.

Another problem faced in large studies like this using field data is the fact that all diagnoses are not as specific as might be desirable. In field conditions, often no blood samples are taken to confirm the diagnosis (e.g., hypomagnesemia) and also, several veterinarians are making the diagnoses. Therefore, it is difficult to know which particular criteria each veterinarian has used for a diagnosis (e.g. chronic mastitis).

Because of our inclusion criteria (i.e., only herds with at least 10 calvings/year and in communities with high health registration percentage), herds in our study might not represent the average herd in Finland at the moment, and this restricts the ability to generalize the results to all dairy cows in Finland. However, our inclusion criteria were implemented in order to improve the quality of the data; we believe that the herds included in our study represent typical Finnish herds of the near future. Also, the data recording system has been in use for over 10 years and farmers and veterinarians have realized the advantages it brings. Also, a significance level of 0.01 was applied before a factor was said to be significantly associated with the disease.

The average 305-d milk yield in 1983 was 5487 kg and in 1993 it was 6715 kg, so the increase in average milk yield per cow over the 10-year period was over 20%. In 1983 the 5 most common diseases were ovarian cysts (7.5% lactational incidence risk), acute mastitis (7.0%), ketosis (6.6%), parturient paresis (milk fever) (5.3%), and retained placenta (5.3%). In the current study acute mastitis was found to be the most common disease among Finnish Ayrshire cows (lactational incidence risk 17.0%), followed by fertility disorders (silent heat, 8.1%; ovarian cysts, 7.5%). After those came milk fever (5.4%) and ketosis (4.9%).

The most noticeable difference between the current and earlier studies conducted on Finnish Ayrshire cows is the big increase in the lactational incidence risk of acute mastitis. This is probably due to changes in treatment practices in Finland and in the recording of the diseases. In the 1980's a large percentage of acute mastitis cases was treated with intramammary antibiotics prescribed by the veterinarian by phone without his/her visiting the farm. It is very likely that not all of those treatments were marked on the cow's health card by the farmer and the actual incidence was underestimated. Also, the earlier studies purposely excluded all phone prescription treatments from the analyses. Today, however, most acute mastitis cases are treated with systemic antibiotic therapy; the veterinarian thus visits the farm to treat the cow. Therefore, the incidence risk from the current study is likely to be closer to reality. So, the large apparent increase probably does not reflect any true increase in mastitis incidence, but instead indicates a change in treatment and recording practices. In fact, *Honkanen-Buzalski et al.* (1996) reported that prevalence of mastitis (mastitis defined as somatic cell count being > 300,000/ml) had decreased in Finland from 1988 to 1995. Because the milk price in Finland has been based partly on somatic cell count in milk since 1988, it is likely that farmers actually treat cows for mastitis and cull chronically mastitic cows more readily now than earlier, in order to keep the milk quality and premiums as high as possible.

Incidence of retained placenta was higher in

1983 than in 1993. This change is most likely also due to different treatment practices between these 2 years; during the last few years the tendency has been to leave retained placenta untreated unless the cow has systemic symptoms (high fever, loss of appetite, etc.).

The overall variation in disease occurrences and their interrelationships can depend on many factors. First, there is the biological variation between individual cows. Secondly, cows are clustered in herds, which presents another level of variation. Farmers differ in their ability to recognize disease symptoms and in their willingness to call the veterinarian to treat the diseased cows. Also, their overall management skills differ. *Distl et al.* (1989) found the herd effect to have the most important systematic influence on the disease frequencies, and also *Emanuelson et al.* (1993) concluded that herd represents an important source of variation for most diseases. Also, veterinarians can differ in their readiness of making farm visits and in their ways of treating animals and recording the treatments.

One of the reasons for the differing results between the current and earlier Finnish studies might be the way in which the herd effect was accounted for in the analyses. Because the number of herds in this data set was so large and herd could not be included in the model as a random effect (with PROC LOGISTIC in SAS), cow's previous milk yield was categorized based on the herd milk yield level in order to indirectly account for the herd effect. Due to this method of classification our results reflect more the decisions as to whether high producing cows are treated more than low producing cows within a herd, regardless of the herd production level, rather than the effect of absolute amount of milk production on the disease frequencies.

High yielding cows could be more susceptible to production diseases, but in high yielding herds, good management with proper feeding could counterbalance the possible negative effect of high milk production on disease occurrences. Therefore, cows producing the same amount of milk, but in different herds, might not be comparable in their production disease frequencies. *Gröhn et al.* (1995) showed, however, that using deviations from herd average or cow's actual milk yield as a milk measure gives the same results if herd is included in the model with the absolute milk yield. The effect of herd on the results and different ways of adjusting for it needs to be investigated further in the future.

We categorized milk yield within parity groups. It is well recognized that milk yield increases as parity increases, and with respect to their effects on disease occurrences, the interaction between milk yield and parity should also be considered. The effect of milk yield might be different among young cows than among old cows. Also, parity might have a different effect among high producers than among low producers. Our results showed this, as among the highest producing cows increasing parity increased the risk of mastitis, but had no effect among the "average or low producers". This might partly explain the differences found between this study and other studies with respect to the effect of parity on mastitis occurrence. Also, the risk of milk fever increased with increasing milk yield only among younger cows (parity = 2), but milk yield did not have a clear effect on the risk among older cows. In general, literature gives controversial results on the association between milk yield and risk of diseases and failure to consider the interactions between parity and milk yield in their effects on disease occurrence might partly explain that.

Management decisions on culling and treatment of cows might introduce some bias into the observed associations. Diseased cows with low milk production are more likely to be culled than their higher producing herdmates, leaving more high producing cows with diseases to attribute to the association. High producing cows may also be more likely to be treated for certain diseases than their low producing herdmates.

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Sammanfatting

Sjukdomsförekomst och riskfaktoranalys hos finska Ayrshire kor.

Sjukdomsförekomsten och riskfaktorer för de vanligaste sjukdomarna, hos 39,727 Finska Ayrshire mjölk kor på 2338 gådar, undersöktes. Alla korna kalvade under 1993 och de följdes upp fram till nästa kalvning eller tills de slaktades.

Incidensrisken under laktationsperioden, antal behandlingar för och upprepning av en episod av en viss sjukdom beskrivs för 17 olika, av veterinär ställda, diagnoser. De fem vanligaste diagnoserna och deras insidensrisk under laktationsperioden var: akut mastit (17.0%), anestrus (8.1%), ovarie cystor (7.3%), kalvnings förlamning (5.4%) och acetonemi (4.9%). Akut mastit hade den största sannolikheten för upprepning av sjukdomsepisoden (i 14.2% av fallen), följd av fertilitetsstörningar. Kalvningsförlamning var den sjukdom som krävde det högsta antalet behandlingar för en episod av sjukdomen. Nästan 30% av korna med kalvningsförlamning behandlades åtminstone 2 gånger. Mer än en behandling krävdes vid ca. 10% av fallen av de andra undersökta sjukdomarna.

För undersökning av riskfaktorerna för de fem vanligaste sjukdomarna gjordes en logistisk regressions modell upp. Högre produktionsnivå visade sig vara en riskfaktor för akut mastit, ovarie cystor, för anestrus hos äldre kor (>2 kalvningar) och för kalvningsförlamning hos yngre kor (vid andra kalvningen). Det visade sig att flera av sjukdomarna var riskfaktorer för andra sjukdomar.

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