J. Dairy Sci. 84:2673–2679

Mastitis, Ketosis, and Milk Fever in 31 Organic and 93 Conventional Norwegian Dairy Herds

F. Hardeng* and V. L. Edge†
*Department of Large Animal Clinical Sciences,
Norwegian School of Veterinary Science,
PO Box 8146, N-0033 Oslo, Norway
†Department of Population Medicine,
Ontario Veterinary College, University of Guelph,
Ontario, Canada

ABSTRACT

The aim of this study was to investigate differences in disease incidence between organic and conventional herds. The study was based on data from the Norwegian Dairy Herd Recording, which includes the Norwegian Cattle Health Recording System. All herds certified for organic farming in 1994 with a herd size of more than five cow-years were included. Conventional herds were matched on size and region, and from these, three herds were randomly selected for each organic herd. This resulted in a study group of 31 organic and 93 conventional herds with data from 1994 through 1997. The study unit was the cow within a lactation. Factors influencing disease incidence were studied by means of a generalized linear model approach. Management system had a highly significant effect on disease incidence. Odds ratios for organic compared with conventional herds were as follows: mastitis, 0.38; ketosis, 0.33; and milk fever, 0.60. Other significant factors that emerged in modeling the three diseases were year and lactation category for mastitis; lactation category, maximum milk yield, and season for ketosis; and lactation category and milk yield for milk fever. There was no marked difference in milk somatic cell count (SCC) between organic and conventional herds. However, cows in organic herds had lower SCC in lactation two and greater counts in lactations six and higher.
(**Key words:** cow, dairy, organic, disease)

Abbreviation key: FUm = feed unit in milk production (6900KJ), **EA305** = energy-adjusted 305-d milk yield, **NDHR** = Norwegian Dairy Herd Recording.

INTRODUCTION

Previous research projects in Norway (Ebbesvik, 1993; Strøm and Olesen, 1997) have investigated production diseases such as mastitis, ketosis, and milk fever in a number of organic dairy herds. Compared with the rates of disease found in the annual reports from the Norwegian Dairy Herd Recording (**NDHR**), the organic dairy herds in these projects appeared to have fewer occurrences of mastitis, ketosis, and milk fever.

Organic milk production differs from conventional in several ways, some of which may influence the health of the herd. One of the main objectives in organic agriculture is to employ as many of the local natural resources as possible, which, among other restrictions, precludes the use of chemical fertilizers and pesticides. In Norway, certified organic milk producers are allowed a maximum of 30% total energy intake per year from concentrates. Low-intensity production, an accentuated spring calving period, a generally older herd, and a more complex breed composition than is found in the conventional herd are all characteristics of the organic dairy herd.

The aim of this study was to investigate whether or not there were differences in production disease incidence between organic and conventional herds. The reproductive performance in these herds was published by Reksen et al. (1999).

Norwegian cows are seldom treated with antibiotic at dry-off time, this includes conventional as well as organic herds. A selective dry cow therapy is recommended using SCC at cow level and additional bacteriology information as selection criteria. This is in contrast to North American practices, where virtually 80 to 90% of the cows are treated at drying off.

MATERIALS AND METHODS

Inclusion of Herds

Debio (1994) is the Norwegian control and certification body for organic agricultural production. All organic dairy farms registered in both the NDHR and the Norwegian Cattle Health Recording System, and

Received November 14, 2000.
Accepted July 16, 2001.
Corresponding author: F. Hardeng; e-mail: froydis.hardeng@veths.no.

certified for milk production by Debio in 1994, formed the sampling frame for this study. Herds with less than five cow-years were excluded from the study. The remaining 31 organic herds were categorized based on size (5 to 10, 11 to 15, 16 to 20, and 21 to 45 cow-years) and region (nine regions based on counties). After exclusion of conventional NDHR herds with incomplete feeding records, the conventional herds were similarly categorized on size and region, and then matched on this basis to the organic herds. Three conventional herds were then randomly selected for each organic herd. The final study group consisted of 31 organic and 93 conventional herds.

Data from NDHR

Production and health data were extracted from the NDHR database. The individual register provided information on breed, date of birth, and date of culling. The calving register contained the date of each calving, lactation number, milk production information, and the use of concentrates during the first 305 d of lactation. A code identified how the first 305 d of the lactation period ended: by culling, by the next calving, or by the completion of a 305-d lactation. The 305-d milk production value was transformed to an energy-adjusted 305-d milk yield (**EA305**) using the formula: 0.297 * 305-d milk yield + 11.8 * [(mean fat percentage * 305-d milk yield)/100] + 7 * [(mean protein percentage * 305-d milk yield)/100].

The milk register usually has 11 records per year on a cow's daily milk yield and daily ration of concentrates in feed units containing 6900 KJ of net energy for milk production (**FUm**). From this register, the record with the highest milk yield and highest amount of concentrates per lactation was used. Milk samples from individual cows were obtained for SCC every second month, with the first test taken more than 5 d after calving. SCC were log-transformed for the purpose of normalizing the distribution as recommended by the International Dairy Federation (1997). All existing SCC in the lactation were used to calculate a mean SCC.

By dichotomizing the SCC values as either >200,000 cells/ml or ≤200,000 cells/ml, the proportion of high SCC values out of the total number of SCC values per lactation, was then obtained:

$$\frac{\text{HIGH\_SCC}}{\text{TOTAL\_SCC}} = \frac{\text{number with SCC exceeding 200,000}}{\text{total number of counts}}.$$

A unique observation was created by combining the lactation number with the herd and cow identifier. Lactations with calving dates from the years 1994 to 1997 were included if the period had a complete record, which meant having either a minimum length of 305 d, or ending with culling or a calving. The unit of study was one lactation period; this selection strategy resulted in 5488 lactation periods in conventionally managed herds and 1785 lactations in organic herds.

Each time a disease case is diagnosed by a veterinarian, it must be recorded on the cow's individual health card, after which the information is transferred to the health register. In this study, only the first occurrence of each disease in a specific lactation was considered; different denominators were used for mastitis, ketosis, and milk fever. The following definitions/formulas for disease risk where used:

MASTITIS

$$= \frac{\text{no. of lactations with mastitis 14 d prior to calving until 14 d prior to next calving}}{\text{total no. of lactations}}$$

KETOSIS

$$= \frac{\text{no. of lactations with ketosis in the first 60 d of lactation}}{\text{no. of lactations with a duration of at least 60 d}}$$

MILK FEVER

$$= \frac{\text{no. of lactations with milk fever from 2 d before to 7 d after calving, after 3rd calf}}{\text{total no. of calvings, after 3rd calf}}$$

The disease observations were restricted to certain lactation periods to minimize the problem of censored data. Additionally, accumulated cumulative risk rates of mastitis, ketosis, and milk fever for all first cases within a lactation were calculated as a survival function on a daily basis (Rothman and Greenland, 1998).

Statistical Analysis

The unit of statistical analysis was the cow within one lactation. Herds were classified as organic or not. All analyses were performed using Version 6.12 of SAS. Descriptive statistics and tests of significance were done using PROC MEANS, PROC TTEST, and PROC FREQ (with the chi-square option). To determine correlation between variables, PROC CORR was employed. Because many factors influencing the results are common within the herd (in particular, herd management), it is essential to adjust for this 'cluster' effect. Under the assumption that responses from different herds would be independent, and whereas responses within herds would be correlated, a generalized linear model approach was taken (Nelder and Wedderburn, 1972;

McCullagh and Nelder, 1989) using PROC GENMOD to fit the data. In this study, measurements were recorded repeatedly over time within the herd. Thus, the modeling procedure involved deciding on the best method to deal with these repeated (correlated) measures. In assessing different combinations of variables, interactions, and covariance structures, the exchangeable covariance structure produced the best fit within the GENMOD procedure.

Explanatory or independent variables were described as HERD, BREED (Norwegian Red Cattle/other breeds), ORGANIC (conventional/organic), SEASON (spring = March–May, summer = June–August, autumn = September–November, winter = December–February), YEAR (1994 to 1997), and LACT_NO (first, second, and greater than second lactation). The diseases MASTITIS, KETOSIS, and MILK_FEVER together with the proportion HIGH_SCC/TOTAL_SCC were modeled as response (dependent) variables. Because these variables were all of a binomial nature, the logit link function was used in the modeling procedure.

The full model included all the fixed effect variables described, with HERD as a random effect, and in addition, the highest milk yield or highest amounts of concentrates for all records in the lactation from the milk register. The models were reduced by stepwise removal of the least significant variable (by backward elimination), retaining variables at a significance level of 5%. A number of interactions were also tested in the modeling process.

RESULTS

The mean lactation number in Table 1 shows that on average, cows are older in organically managed herds (mean lactation number was 2.97 in organic and 2.35 in conventional herds). Average culling age also differed between the two management systems. Cows from organic herds were culled at a mean age of 5 yr and 4 mo, compared with 4 yr and 6 mo for conventional herds. The EA305 for cows that had completed 305 d of lactation was 22% lower in organic than in conventional herds. When this comparison was done by lactation, organic herds were consistently lower. Differences ranged from 19 (in the fourth lactation) to 28% (in the first lactation). All these differences were significant at a P value less than 0.01.

The use of concentrates was much lower in organic herds; 15.6 FUm per 100 kg of milk compared with 23.6 FUm in conventional herds. The same trend was seen in the use of concentrates as related to the highest milk yield. A strong correlation was found between milk production per lactation and the corresponding use of concentrates (Pearson correlation coefficient = 0.825; $P < 0.0001$). Organic management was also found to be closely associated with low milk production and reduced use of concentrates. This implied that one could not use variables related to milk yield and use of concentrates simultaneously in the statistical models.

The overall geometric mean SCC was slightly higher in the organic than the conventional herds; the difference between the two means (Table 1) was found to be significant ($P = 0.016$). However, when this analysis was done separately for each lactation (Table 2), it was found that organic cows had lower mean SCC in first and second lactations, this difference being significant in the second lactation ($P = 0.007$). Above sixth lactation, the mean SCC was significantly higher in the organic group ($P = 0.0015$).

Conventional herds had higher proportions of treated cows for all three diseases (mastitis, ketosis, and milk fever) as seen in Table 1. This is illustrated in Figures

Table 1. Summary statistics from 31 organic and 93 conventional dairy herds 1994 through 1997.

	Conventional			Organic			Level of significance
	n	Mean	SD	n	Mean	SD	
Lactation number	5488	2.35	1.54	1785	2.97	2.02	0.0000[3]
Culling age (d)	2256	1642	652	577	1955	868	0.0000[3]
Energy adjusted 305-d milk yield[1]	3888	6129	1297	1384	4784	1406	0.0000[3]
Feed units of concentrate in 305-d lactation[1]	3888	1620	478	1385	747	401	0.0000[3]
Highest milk yield (kg/d)	5447	27.71	6.18	1770	23.07	6.10	0.0001[3]
Highest amount of concentrate (feed units/d)	5457	7.92	2.06	1742	4.31	1.97	0.0000[3]
Mean ln of SCC (in 1.000) in lactation[1]	3886	4.30	0.96	1355	4.37	1.04	0.0161[3]
Mastitis cases, <305 d in lactation	5488	0.29	0.45	1785	0.14	0.35	0.001[4]
Ketosis cases, <60 d in lactation	5256	0.078	0.268	1736	0.028	0.166	0.001[4]
Milk fever cases, <8 d in lactation[2]	1968	0.123	0.328	876	0.073	0.260	0.001[4]

[1]Lactations with cows culled before d 305 were excluded.

[2]Only lactations number 3 or higher were included.

[3]T-test value by comparison of means.

[4]Chi-square value by comparison of means.

Table 2. Mean ln of SCC per lactation in 31 organic and 93 conventional dairy herds 1994 through 1997.

	Conventional				Organic				
Lactation no.	n	Mean (ln scale)	SD (ln scale)	Geometric mean[1]	n	Mean (ln scale)	SD (ln scale)	Geometric mean[1]	Level of significance[2]
1	1589	4.01	0.91	55,000	413	3.99	0.95	54,000	NS
2	1080	4.39	0.93	80,600	318	4.23	0.95	68,700	0.007
3	588	4.52	0.93	91,800	229	4.53	1.02	92,700	NS
4	329	4.62	0.90	101,500	156	4.53	1.06	92,700	NS
5	160	4.69	0.95	108,900	103	4.76	0.98	116,800	NS
6+	140	4.76	0.91	116,700	136	5.13	0.97	169,000	0.0015

[1]Calculated from mean ln scale.

[2]*T*-test values by comparison of means.

1 through 3, which show a cumulative risk related to calving. In Figure 2, one can see that the majority of ketosis cases appeared within 9 wk of lactation, thus the choice of 60 d for ketosis monitoring was justified.

PROC GENMOD results are shown in Tables 3 through 5. Only significant independent variables are shown in the tables displaying estimates, odds ratios calculated from the estimates, and their corresponding 95% confidence intervals. The adjusted odds ratio for mastitis in organic management was 0.38 (0.25 to 0.56) compared with conventional, for ketosis 0.33 (0.18 to 0.58), and milk fever 0.60 (0.38 to 0.94). For mastitis, year and lactation category also had significant effects. There was an increasing risk of mastitis with increasing lactation number. The trend of less mastitis treatments, which was observed in this study, is also found in the NDHR.

For ketosis, the following factors (in addition to management system) had significant effects: lactation category (lowest risk in first lactation), maximum milk (increasing risk with increasing yield), and season (lowest risk during summer).

The relative rate of calvings in relation to season was 14% higher for organic herds in spring, equal in summer, 11% lower in autumn, and 3% lower in winter. This gave a larger proportion of the cows in organic herds with peak milk production in the grazing season.

Lactation number and highest milk yield were found to be significant factors for milk fever; however, because milk fever is very rare in first and second lactations (Østerås and Spanne, 1999), these were not included in our analyses, resulting in a reduced dataset. None of the tested interactions were found to be of significance. The proportion HIGH_SCC/TOTAL_SCC was not significantly different between organic and conventional management, showing that the occurrence of subclinical mastitis was at a fairly equal level.

DISCUSSION

Comprehensive information on production and disease are collected for every cow individually in the NDHR database. Because this is field-based registration information, the data are likely to be burdened to some extent by faults and lack of completeness (Solbu, 1983). However, this would be an effect common to all the information, and thus this paper is based on the assumption that the registration data quality in the

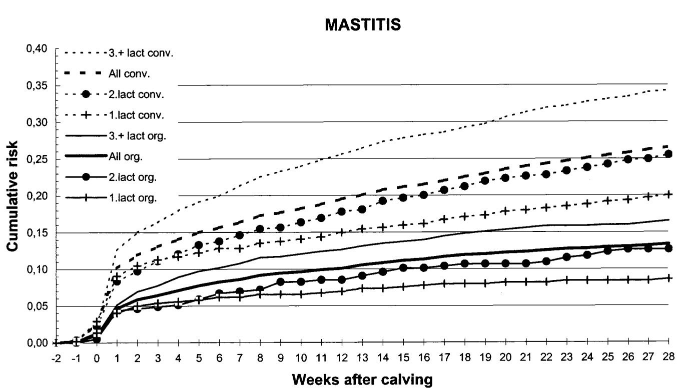

Figure 1. Cumulative risk rate of mastitis in 31 organic and 93 conventional dairy herds 1994 through 1997.

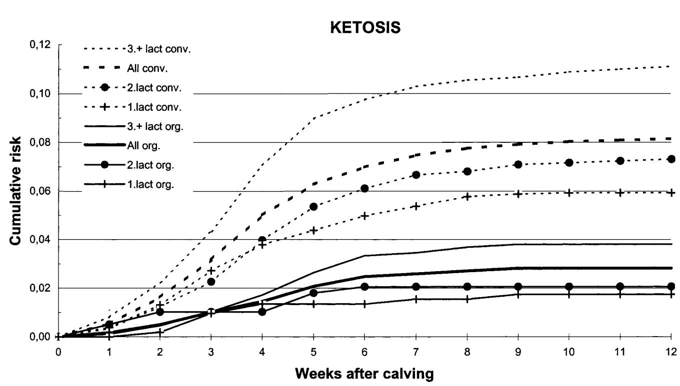

Figure 2. Cumulative risk rate of ketosis in 31 organic and 93 conventional dairy herds 1994 through 1997.

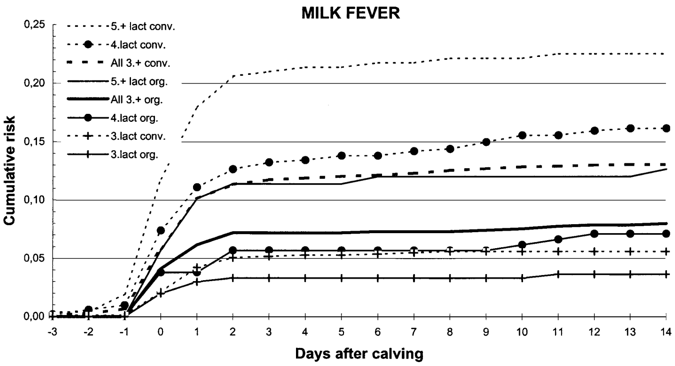

Figure 3. Cumulative risk rate of milk fever in 31 organic and 93 conventional dairy herds 1994 through 1997.

selected herds is essentially the same, and will be balanced by random selection of herds within the NDHR.

Organic farms tended to have older cows than conventional herds, and in the statistical models, the lactation category was a significant explanatory variable for all three diseases studied. As shown in Figures 1 through 3 (cumulative risk rates), and Tables 2 through 5 (relative odds ratios), the risk of disease increased with lactation number. This observation is valid for both organic and conventional dairy husbandry, and is in agreement with results from the Norwegian population (Østerås and Spanne, 1999).

The treatment rate of mastitis was much lower in organic compared with conventional herds. In organic farming, the withdrawal time for milk delivery after antibiotic therapy lasts longer than in conventional farming. Furthermore, medication with any kind of artificially produced drug (like antibiotics and hormones) is inconsistent with the idea of organic farming, as this system urges the use of natural resources whenever possible. This being the case, mastitis occurrences would not necessarily be treated by veterinarians, and hence there would be fewer cases recorded in the database used in this survey. Given this lower treatment rate, the concern might be that the udder health is worse in the organic herds. To assess this, the proportion of high SCC was used as an objective measure of subclinical mastitis. No marked difference was found between organic and conventional herds, which implies that the lower veterinary treatment rate did not lead to more chronic subclinical mastitis. It is possible that some of the mastitis cases in organic herds are handled by frequent hand milking rather than conventional antibiotic therapy and thus may not have been recorded.

The occurrence of ketosis was also markedly different between organic and conventional farms, with organic farm cows being only one third as likely as conventional farm cows to have a ketotic event. The difference in maximum milk production does account for some of the difference and is included in the model. Also, one might expect more ketosis because of the limited use of concentrates in organic farming, where the maximum limit for concentrates is 30% of the feed ration. But, because of the high correlation between milk production and use of concentrates, both factors could not be in the model simultaneously. As has been previously discussed (Hardeng, 1998), the feeding regime was found to differ in the two herd-management categories. Conventional husbandry was dominated by use of concentrates and silage; these two components represented about 75% of the feed ration based on energy. The corresponding percentage for organic husbandry was about 50; hay, pasture, and root crops were used more extensively. Strøm and Olesen (1997) proposed that a low risk of ketosis in the organic herds could be the result of more variation in the composition of the forage. A decrease in treatment rates with an increase in the number of different feedstuffs was also shown by Riemann et al. (1985). The basis for this is suggested to be a more tasty diet and consequently a higher feed consumption. Organic husbandry also differs from conventional in that cows spend more of their time outdoors. It is common practice for the cows to be let outside daily for at least 30 min of open air year round. This

Table 3. Odds ratios and confidence intervals (CI) for mastitis in 31 organic and 93 conventional dairy herds 1994 through 1997.

		Estimate	Odds ratio	95% CI	Pr>|Z|
Intercept		–1.7118			0.0000
Management system	Organic	0.9768	0.38	0.25 to 0.56	0.0000
	Conventional	0.0000	1.00		
Lactation category	First	–0.7040	0.49	0.43 to 0.56	0.0000
	Second	–0.3943	0.67	0.59 to 0.77	0.0000
	Third+	0.0000	1.00		
Year	1994	0.3507	1.42	1.19 to 1.69	0.0001
	1995	0.3118	1.37	1.14 to 1.63	0.0006
	1996	0.0894	1.09	0.94 to 1.28	0.2624
	1997	0.0000	1.00		

Table 4. Odds ratios and confidence intervals (CI) for ketosis in 31 organic and 93 conventional dairy herds 1994 through 1997.

		Estimate	Odds ratio	95% CI	PR>|Z|
Intercept		–3.4226			0.0000
Management system	Organic	1.1218	0.33	0.18 to 0.58	0.0001
	Conventional	0.0000	1.00		
Lactation category	First	–0.4801	0.62	0.46 to 0.83	0.0016
	Second	–0.4083	0.66	0.54 to 0.82	0.0002
	Third+	0.0000	1.00		
Calving season	Autumn	–0.6208	0.54	0.40 to 0.73	0.0001
	Spring	–0.2999	0.74	0.58 to 0.95	0.0186
	Summer	–0.9381	0.39	0.28 to 0.54	0.0000
	Winter	0.0000	1.00		
Maximum milk	Per kg	0.0263	1.03	1.01 to 1.05	0.0097

practice could well be a discerning factor in the health of the herd (Ekesbo, 1966).

Because organic farms have more cows in higher lactations, we would expect to find a higher risk of milk fever compared with the conventional farms. However, the opposite was true. Part of the explanation is shown in Table 5, where for each kilogram increase in peak milk production, the risk of milk fever increased by 5%. In organic herds, the mean maximum milk yield was 4.6 kg lower than in conventional herds (Table 1), so calcium depletion through milking would be much reduced. Harris (1981) reported a higher incidence of milk fever when pastures were fertilized with potash and super phosphate, a practice that is not employed in organic agriculture. Lately, the focus has been on dietary management before calving, emphasizing the cation-anion balance as an important element in the prevention of milk fever (Horst et al., 1997).

This study clearly demonstrated a comparatively better health performance in organic husbandry, particularly with respect to ketosis and mastitis, but also for milk fever. Other studies have also reported low disease incidences in organic herds (Ebbesvik, 1993; Vaarst et al., 1993; Vaarst and Enevoldsen, 1997; Weller and Cooper, 1996; Strøm and Olesen, 1997; Weller and Bowling, 2000), but no others have designed their study to specifically compare organic and conventional management in relation to production disease incidence.

In the present study, we attempted to incorporate different elements of husbandry practices as potential factors in the disease outcomes. Our results showed that organic herds had less disease treatment than conventionally managed herds. Some of this could be explained by the different attitude and choice of disease management, resulting in less reported disease in organic husbandry. Another explanation could simply be that better skills and performance are exhibited among organic farmers, but it is also possible that the principles applied in organic agriculture can contribute to better health management in general. This study clearly demonstrated the importance of parity when production diseases in organic and conventional dairy husbandry are compared.

ACKNOWLEDGMENTS

This study was financed by funds from the Norwegian Research Council. The Norwegian Centre for Ecological Agriculture, Tingvoll also provided financial support. The access to the database was given by the NDHR

Table 5. Odds ratios and confidence intervals (CI) for milk fever in 31 organic and 93 conventional dairy herds 1994 through 1997.

		Estimate	Odds ratio	95% CI	Pr>|Z|
Intercept		–3.1653			
Management system	Organic	0.5109	0.60	0.38 to 0.94	0.0249
	Conventional	0.0000	1.00		
Maximum milk	Per kg	0.0478	1.05	1.02 to 1.08	0.0005
Lactation number	3	–1.6048	0.20	0.13 to 0.32	0.0000
	4	–0.5019	0.61	0.39 to 0.93	0.0219
	5	–0.0300	0.97	0.62 to 1.51	0.8938
	6	0.2490	1.28	0.74 to 2.22	0.3754
	7+	0.0000	1.00		

and the Norwegian Cattle Health Services (for health data) in agreement number 001/1995.

REFERENCES

Debio. 1994. Økologisk landbruk. Driftsregler for merkegodkjenning og omleggingstilskudd. (Organic farming. Rules for system approval and conversion subsidy.) Debio, Oslo, Norway.

Ebbesvik, M. 1993. Melkeproduksjon i økologisk landbruk. Fôr, fôring, helse og avdrått. Resultater fra 30 bruks-prosjektet. (Milk production in organic agriculture. Feeds, feeding, health and production. Results from the 30-farm project). Statens fagtjeneste for landbruket. Report No22 Ås, Norway.

Ekesbo, I. 1966. Disease incidence in tied and loose housed dairy cattle. Thesis. Acta Agric. Scand. Suppl. 15.

Hardeng, F. 1998. Pages 347–351 *in* Husdyrforsøksmøtet. Helsemessige forhold ved økologisk mjølkeproduksjon sammenlignet med konvensjonell drift. (Health of dairy cows in organic farming compared with conventional management). Forskningsparken i Ås, Ås, Norway.

Harris, D. J. 1981. Factors predisposing to parturient paresis. Aust. Vet. J. 57:357–361.

Horst, R. L., J. P. Goff, T. A. Reinhardt, and D. R. Buxton. 1997. Strategies for preventing milk fever in dairy cattle. J. Dairy Sci. 80:1269–1280.

International Dairy Federation. 1997. Recommendations for presentation of mastitis-related data. O. Østerås, K. Leslie, Y. H. Schukken, U. Emmanuelson, K. Plym Forshell, and J. Booth. Bull. Int. Dairy Fed. No. 321/1997.

McCullaugh, P., and J. A. Nelder. 1989. Generalized Linear Models. 2nd ed. Chapman and Hall, London.

Nelder, J. A., and R. W. M. Wedderburn. 1972. Generalized Linear Models. J. R. Statist. Soc. A 135:370–384.

Reksen, O., A. Tverdal, and E. Ropstad. 1999. A comparative study of reproductive performance in organic and conventional dairy husbandry. J. Dairy Sci. 82:2605–2610.

Riemann, H. P., R. Bjerke Larssen, and E. Simensen. 1985. Ketosis in Norwegian dairy herds—some epidemiological associations. Acta Vet. Scand. 26:482–492.

Rothman, K. J., and S. Greenland. 1998. Measures of Disease Frequency. Page 29 *in* Modern Epidemiology. 2nd ed. Rothman, K. J. and S. Greenland, eds. Lippincott-Raven Publishers, Philadelphia, PA.

Solbu, H. 1983. Disease recording in Norwegian dairy cattle I. Disease incidences and non-genetic effects on mastitis, ketosis and milk fever. Z. Tierz. Züechtungsbiol. 100:139–157.

Strøm, T., and I. Olesen. 1997. Mjølkekvalitet, helse og holdbarhet på kyrne ved omlegging til økologisk mjølkeproduksjon. (Milk quality, health and durability in conversion to ecological milk production) Norwegian Centre for Ecological Agriculture. Tingvoll, Norway.

Vaarst, M., C. Enevoldsen, and P. Jakobsen. 1993. Reports on diseases in 14 organic farms in Denmark. Acta Vet. Scand. Suppl. 89:143–145.

Vaarst, M., and C. Enevoldsen. 1997. Patterns of clinical mastitis manifestations in Danish organic dairy herds. J. Dairy Res. 64:23–37.

Weller, R. F., and P. J. Bowling. 2000. Health status of dairy herds in organic farming. Vet. Rec. 146:80–81.

Weller, R. F., and A. Cooper. 1996. Health status of dairy herds converting from conventional to organic dairy farming. Vet. Rec. 139:141–142.

Østerås, O., and T. Spanne. 1999. Helsekortordninga 1998. (Health recordings during 1998) Nor. Vet. Tidsskr. 111:321–332.