A Comparative Study of Reproductive Performance in Organic and Conventional Dairy Husbandry

O. REKSEN,[1], A. TVERDAL,[2] and E. ROPSTAD[1]
Norwegian School of Veterinary Science,
PO Box 8146, N-0033 Oslo, Norway

ABSTRACT

A comparative cohort study of reproductive performance in organic and conventional dairy husbandry was conducted using longitudinal data from the Norwegian National Board of Animal Production Recording from January 1, 1994 to December 31, 1996. The present study is the first study comparing reproductive efficiency in organic and conventional husbandry in which characteristics such as herd size, breeding season, milk yield, parity, breed, use of artificial insemination (AI), and geographical distribution were taken into account. The organically managed cohort comprised 998 lactation periods, and the conventionally managed cohort comprised 3016 lactation periods. Both groups were similar in herd size and geographical distribution. The following reproduction variables were studied: days open, calving interval, calving to first AI interval, calving to last AI interval, and AI per cow. No consistent difference in reproductive performance was found between the cohorts before adjustments were made for milk yield, breeding season, service, and parity. After inclusion of these independent variables in the repeated measures, mixed-model analyses, reproductive efficiency of organically managed dairy cows was impaired compared with those under conventional management. In organic dairy farming, breeding efficiency was difficult to maintain in cows bred during winter. Organic husbandry proved more efficient than did conventional husbandry in converting roughage into milk. Furthermore, the average multiparity percentage was higher in organically managed cows.

(**Key words:** cow, dairy, organic, reproduction)

Abbreviation key: FEM = feed unit (6900 KJ), **EA305** = energy-adjusted 305-d milk yield.

INTRODUCTION

Organic husbandry and the sustainability of conventional agricultural production have received increasing attention in recent years. Sustainable agriculture can be defined as agriculture that does not necessarily require subsidies of exogenous energy from finite resources, such as fossil fuels, or environmentally sensitive resources, such as fertilizers and pesticides (11, 20). In organic husbandry the ratio of energy output to energy input is kept as high as possible.

The Norwegian regulations for organic production are controlled by Debio (6). Norwegian organic dairy production is characterized by a low fraction of concentrate in feed rations, because under the Debio regulations, only 30% of the energy requirement of a cow can be met by concentrate. Of this percentage, only two-thirds can be grown nonorganically. As organic grain production is limited in Norway, most organic farms feed less than 20% of the energy requirement of a cow by concentrate (23). The remaining 80% is mainly from pasture, grass silage, root crops, and hay (18). Cattle must be able to graze outdoors during summer. Fertilizers and pesticides are not used in organic feed production. Organic husbandry prohibits the use of embryo transfer or hormone therapy for treatment of reproductive disorders. Mating with bulls is preferred over AI (6).

Comparative studies of reproductive performance in organic and conventional dairy farms have been limited and, at least in part, inadequate. Some investigations have indicated good reproductive performance in organic dairy husbandry (12, 18, 25). In these studies, reproductive data from groups of organic dairy farms have been directly related to the mean reproductive performance in a given area or country. Offerhaus et al. (22) found higher conception rates and less AI per pregnancy in organic herds compared with a reference group of conventional herds, although comparison of organic and conventional husbandry was not the primary objective of that investigation.

The aim of the present study was to compare the reproductive performance between selected groups of organic and conventional dairy farms and to take into account characteristics such as herd size, breeding season, milk yield, parity, breed, AI, and geographical distribution. Herd reproductive performance may change from year to year, depending on factors such as drift toward summer calving, quality and availability of feed,

Received March 8, 1999.
Accepted July 22, 1999.
[1]Department of Reproduction and Forensic Medicine.
[2]Department of Morphology, Genetics and Aquatic Biology.

climatic variations, and farmers developing better skills in organic management as time passes. To correct for this time factor, data for the period January 1, 1994 to December 31, 1996 were taken from the reproduction files of the Norwegian National Board of Animal Production Recording. We determined this study to be the first longitudinal, epidemiological study of cohort design comparing reproductive performance in organic and conventional dairy husbandry.

MATERIALS AND METHODS

A cohort study of reproductive performance was carried out using data from dairy farms of which 29 were organically managed and 87 were conventionally managed. Data were from a 3-yr period extending from January 1, 1994 to December 31, 1996. All herds were enrolled in the Norwegian National Board of Animal Production Recording (Ås, Norway). Consultation of agronomists of the board assisted in planning the feeding regimens. Once a month, the daily ration of concentrate and the daily milk yield per cow were recorded.

The unit of the study was the cow over one lactation period. To adjust for geographical distribution and herd size, the conventional cohort was derived from farms of the same size and geographic distribution as the organic cohort. Norway is divided into nine administrative veterinary regions. In each region, each dairy farm was assigned to one of the following size categories: 5 to 10 cows, 11 to 15 cows, 16 to 20 cows, or 21 to 45 cows. For each organic farm included in the study, three conventional farms in the same region and size category were selected at random. This strategy resulted in an organically managed cohort of 998 lactation periods and a conventionally managed cohort of 3016 lactation periods.

Information from the reproduction files of the Norwegian National Board of Animal Production Recording was used for the comparison. The following reproduction variables were used: days open, calving interval, calving to first AI interval, calving to last AI interval, and AI per cow. Days open were calculated for all cows included in the study (4014 lactation periods). The calving interval was estimated for cows that delivered within 550 d after the previous calving (3178 lactation periods). Cows serviced naturally or bred by AI were included in the analysis when days open and calving interval were assessed. Calving to first and last AI intervals and AI per cow were calculated for cows bred only by AI, regardless of whether they subsequently calved or were culled (3664 lactation periods).

The daily use of concentrate in the 305-d period after calving was estimated, and the energy uptake was given in feed units (**FEM**). One FEM was 6900 KJ of net energy. Energy-adjusted 305-d milk yield (**EA305**) was defined as (8) 305-d milk yield × (0.01 + 0.122 × mean fat percentage + 0.077 × mean protein percentage) = kilograms of EA305. In accordance with Norwegian standards, net energy required for EA305 was calculated as FEM (6.9 MJ) = 0.44 × EA305 + 0.0007293 × $EA305^2$ (8). Breed was included in the models as a binary variable with Norwegian Red Cattle and other breeds as its two categories. Distribution of breed, parity, FEM, EA305, service, and culling practices were calculated for all lactation periods included in the study.

Statistical Analyses

The effects of the management factors were studied both univariately and in repeated-measures, mixed-model analyses. Two-sided *t*-tests (1) were used in the univariate analyses to assess differences between organic and conventional husbandry regarding the reproductive traits, FEM, EA305, parity, breeding management, and culling practices.

In the mixed-model analyses PROC MIXED of SAS was used (16). The dependent variables were days open, calving interval, calving to first AI interval, calving to last AI interval, and AI per cow. The independent variables in the models were breeding season (winter or summer), management system (conventional or organic), parity (primiparous or multiparous), EA305, and service (artificial or natural) as fixed effects. An interaction term between breeding season and management was included in the model to assess whether seasonal effect in reproductive traits differed between the management systems. The effect on the dependent variables was calculated for each level of season and management. Year (1994, 1995, or 1996) was the repeated time points variable, and cows nested within herd was the repeated measurement (random variance) variable. The unstructured correlation matrix was used. Breed was initially included in all models but was omitted as it was not significantly related to any of the dependent variables when the other independent variables were taken into account. Statistical significance was assessed by the type III *F*-test, and $P < 0.05$ was considered statistically significant. The analyses were run separately for complete data sets and for subsets of cows within the 25th to 75th percentile of EA305.

RESULTS

Breeding and Culling Practices

Natural breeding resulted in 19 to 27% of the pregnancies in organic husbandry and in 3 to 5% in conventional husbandry (Table 1). Annual replacement was 23% in organic and 35% in conventional husbandry (*P*

TABLE 1. Mean calving interval, mean days open, mean interval from calving to first AI, mean interval from calving to last AI, mean AI per cow, mean energy-adjusted 305-d milk yield (EA305), mean feed units (FEM) per day from concentrate, FEM from concentrate/100 kg of energy-adjusted (EA) milk, mean multiparity percentage, mean percentage of cows in the second lactation, mean percentage of cows bred during summer, and mean percentage of cows bred by natural service, distributed by class of husbandry systems and year.

	1994		1995		1996	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Calving interval	378.4	377.8	376.4	375.1	369.0*	374.1*
Days open	115.3*	130.5*	111.2*	126.5*	112.8*	130.5*
Calving to first AI interval	77.7	80.0	82.2*	76.3*	78.7	80.9
Calving to last AI interval	95.6	99.7	100.3	96.9	98.7	98.4
AI per cow	1.6	1.7	1.6	1.7	1.6	1.6
EA305, kg	4854*	6212*	4791*	6014*	4554*	6040*
FEM/day from concentrate	2.6*	5.3*	2.4*	5.1*	2.4*	5.3*
FEM from concentrate/100 kg of energy-adjusted milk	16.2*	26.1*	14.9*	26*	18.1*	27.1*
Multiparity, %	70*	60*	71*	58*	68*	62*
Second parity, %	22*	27*	24*	26*	23*	30*
Breeding in summer, %	58*	38*	59*	42*	52*	36*
Natural breeding, %	25	3	27	5	19	4

*Significant within year difference between organic and conventional husbandry systems ($P < 0.05$).

< 0.01). Thus, significantly more multiparous cows and fewer cows in their second lactation existed under organic husbandry than under conventional husbandry (Table 1). Norwegian Red Cattle comprised 85% of organically managed dairy cows and 97% of conventionally managed dairy cows. Winter was the main breeding period for conventional husbandry; summer was the major breeding period for organic husbandry (Table 1).

FEM and EA305

Mean EA305 was significantly lower for organic husbandry than for conventional husbandry (Table 1). Conventionally managed farms used approximately twice as much FEM from concentrate per cow as did organic farms (Table 1). Energy consumption, calculated as FEM (from concentrate) per 100 kg of EA305, was 33 to 43% greater in conventional husbandry compared with organic husbandry (Table 1). After adjustments were made for breeding season, management system, parity, and service in the repeated measures model, increased EA305 was associated with impaired reproductive efficiency (Table 2).

Reproductive Traits

No consistent difference in calving interval, interval from calving to first and last AI, or AI per cow were found in the univariate analyses of the two types of husbandry, whereas cows under organic management experienced significantly fewer days open for all 3 yr studied (Table 1). Calving interval was significantly less in 1996, and the interval from calving to first AI was significantly greater in 1995 for cows on organic husbandry compared with cows on conventional husbandry (Table 1).

In the mixed-model analyses, parity and interaction between season and management were significantly related to days open, calving interval (Table 3), calving to first and last AI, and AI per cow (Table 4). The model predicted shorter calving interval (Table 3) and shorter intervals from calving to first and last AI (Table 4) for cows under conventional management compared with cows under organic management. Significantly more days open were found in cows artificially inseminated compared with cows bred naturally (Table 3). All results were similar when cows under the 25th and over the 75th percentiles of EA305 were omitted from the analyses.

The effect of the significant interaction terms between season and management on the reproductive traits (Tables 3 and 4) revealed that conventionally managed cows bred during winter showed better breeding performance. Impaired performance was observed in organically managed cows that were bred during the same period.

DISCUSSION

Cows under organic management experienced fewer days open compared with cows under conventional management, whereas there was no distinct pattern regarding calving interval, interval from calving to first and last AI, and AI per cow across the management systems in the univariate analyses. Few days open for cows on organic husbandry was, most likely, due to a

TABLE 2. Least squares estimates of days open, calving interval, calving to first and last AI interval, and AI per cow per 1000 kg of energy-adjusted 305-d milk yield (EA305) as predicted by repeated measurement models.

	1000 kg of EA305		
	LS Estimate	SE	*P*
Days open (n = 4014)	10.6	1.1	<0.01
Calving interval (n = 3178)	7.3	0.5	<0.01
Calving to first AI interval (n = 3664)	4.0	0.4	<0.01
Calving to last AI interval (n = 3664)	8.0	0.5	<0.01
AI per cow (n = 3664)	0.1	0.01	<0.01

TABLE 3. Least squares means of days open and calving interval as predicted by the repeated measurement models.

	Days open (n = 4014)			Calving interval (n = 3178)		
	LS Mean	SE	*P*	LS Mean	SE	*P*
Breeding season						
Winter	118.8	3.1	0.59	379.0	1.4	0.38
Summer	117.1	2.8		377.7	1.3	
Management						
Conventional	116.7	2.8	0.47	374.1	1.3	<0.01
Organic	119.2	3.4		382.7	1.6	
Parity						
Primiparous	121.3	3.2	0.02	383.3	1.5	<0.01
Multiparous	114.6	2.6		373.4	1.2	
Service						
Artificially	132.1	1.8	<0.01	379.3	0.9	0.41
Naturally	103.8	4.7		377.4	2.1	
Season × management						
Winter and conventional husbandry	112.8	3.1	<0.01	371.4	1.5	
Winter and organic husbandry	124.8	4.6		386.6	2.2	<0.01
Summer and conventional husbandry	120.5	3.2		376.7	1.5	
Summer and organic husbandry	113.7	4.0		378.7	1.9	

TABLE 4. Least squares means of calving to first AI interval, calving to last AI interval, and AI per cow as predicted by the repeated measurement models (n = 3664).

	Calving to first AI interval			Calving to last AI interval			AI per cow		
	LS Mean	SE	*P*	LS Mean	SE	*P*	LS Mean	SE	*P*
Breeding season									
Winter	81.8	0.81	0.67	105.7	1.2	<0.01	1.82	0.03	<0.01
Summer	81.3	0.82		100.6	1.2		1.62	0.03	
Management									
Conventional	79.3	0.5	<0.01	98.6	0.8	<0.01	1.68	0.02	0.12
Organic	83.8	1.1		107.7	1.6		1.76	0.04	
Parity									
Primiparous	84.4	0.9	<0.01	109.0	1.2	<0.01	1.79	0.03	<0.01
Multiparous	78.7	0.7		97.4	1.0		1.64	0.02	
Season × management									
Winter and conventional husbandry	78.3	0.6		96.8	0.9		1.70	0.02	
Winter and organic husbandry	85.3	1.5	0.03	114.6	2.2	<0.01	1.93	0.05	<0.01
Summer and conventional husbandry	80.3	0.8		100.3	1.2		1.66	0.03	
Summer and organic husbandry	82.4	1.42		100.9	2.1		1.57	0.05	

high proportion of cows in this group being serviced naturally. Furthermore, high culling rates for conventional herds were probably the reason that calving intervals were shorter for organically managed herds compared with conventionally managed herds for 1996 but not for 1994 or 1995. In accordance with these findings, univariate analyses without correction for milk yield, parity, service, or season revealed better reproductive performance for organic compared with conventional dairy husbandry in a Dutch study (22).

The mixed-model analyses demonstrated an inverse relationship between milk yield and reproduction for both organic and conventional husbandry. Similar findings have been reported previously (14, 15), but other researchers have found no relationship (9). In organic husbandry an attempt is made to keep the energy output to input ratio as high as possible. In the present study equal quantities of milk were produced with considerably reduced amounts of concentrate fed to cows on organic husbandry compared with cows on conventional husbandry. Milk yield has been found (3, 4) to be directly related to energy balance. Villa-Godoy et al. (28) demonstrated that most of the variation in energy balance was due to energy intake rather than milk yield. The EA305 was significantly less for organic than for conventional husbandry. Thus, one would expect reproductive performance under organic husbandry to have been favorably influenced by low milk yield. In contrast, the mixed-model analyses predicted impaired reproductive performance in organic herds compared with conventional herds. Hence, low milk yield in organic husbandry might, at least in part, be a consequence of negative energy balance postpartum (19).

In the present study, reproductive performance of cows on organic husbandry was significantly reduced after adjustment for EA305, season, parity, and service compared with cows on conventional husbandry, which suggested that cows on conventional husbandry had greater success in meeting the energy requirements of increasing milk yields. The analyses of cows on EA305 between the 25th and 75th percentile demonstrated, however, that these characteristics were apparent even for cows with moderate milk yields. Prolonged calving intervals under organic compared with conventional husbandry were also found in another investigation (24).

Under organic husbandry, the figures for days open, calving interval, calving to first and last AI interval, and AI per cow were all impaired in cows bred during winter compared with those bred during summer. This finding cannot solely be explained by the minimal seasonal differences in the interval from calving to first AI. The energy requirements might not have been fully met during winter, because the cows could not benefit from fresh pasture during peak lactation. Strøm and Olesen (25) found that the energy requirements during winter were not adequately met in individual organic herds in a Norwegian survey. In another Norwegian study (27), two groups of dairy cows were fed normal (6 FEM/d) and low (3 FEM /d) levels of concentrate. Weight loss and acetoacetate level in blood were greater in postpartum cows that were fed at low compared with normal levels. Dry matter intake decreased and blood acetoacetate increased during autumn. Hayes et al. (10) reported a multiparity percentage of almost 80 in a pasture-based system, in which essentially no concentrate was used, with 45% of cows being Frisian dairy cows (10). Hence, breeding in summer might be essential to balance genetic capacity for milk yield and energy needs in organic dairy husbandry in Norway. The upper limit of the energy requirement provided by concentrate for most organic dairy herds in Norwegian has been 20%. This limit exists because not more than 20% of the feed can be of nonorganic origin, and production of organic grain has traditionally been limited in Norway. In our opinion, this restriction should be eased to ensure optimal feeding of all cows in accordance with their individual needs, at least until other energy-rich, organically grown alternatives become available. This method would be a better way to proceed than to select for low-producing cows as suggested by Sundrum (26). In contrast, others (18, 29) have reported low frequencies of ketosis and have suggested that the energy composition and forage quality of the rations on organic dairy farms are generally adequate.

Primiparous cows tend to have more negative energy balance postpartum than do multiparous cows (19). This phenomenon could explain the impaired reproductive performance among primiparous cows compared with multiparous cows in this study. Negative energy balance may influence reproduction through modulation of pulsatile LH secretion, alteration of ovarian responsiveness to LH (5), and impaired progesterone secretion (17, 28). The latter affects expression of estrus and support of the conceptus during early pregnancy (21). The replacement rate was significantly higher in conventional dairy herds than in organic dairy herds. Thus, reproductive traits in conventional herds have probably been favorably influenced by culling of cows that were slow to become pregnant. Longevity has been an important characteristic of organic dairy herds (2, 13, 18, 25), as long productive life has both an ethical aspect and is cost effective (7). The overall breeding performance was greater in multiparous cows than in primiparous cows. Hence, reproductive performance in organic herds might have been favorably influenced by

the differences in age composition, as organic herds had more multiparous cows than conventional herds did.

In conclusion, reproductive performances of cows on organic husbandry were comparable with those of cows under conventional management. However, breeding during winter decreased the reproductive success in organic dairy herds. Strong indications existed that energy requirements had not been adequately met to ensure optimal reproduction for all organically managed cows included in our study. Because breeding in winter would be necessary for year-round delivery of organic dairy products, and some organically managed cows inevitably will attain high milk yields, an improvement of the feeding regimens should be sought. Allowance of a higher percentage of the energy demands to be provided by concentrate could increase reproduction performance both during winter and in high yielding, organically managed dairy cows.

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