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The influence of farm and herd factors on the health status of organic dairy cattle under low concentrate feeding considering an assessment-tool for site-related breeding

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Abstract

The objectives of this study were to examine influences of farm and herd factors on the health status of Swiss organic dairy cattle and to evaluate if an existing estimation tool is suitable to express impacts of not-site-related breeding on herd health and reproduction indicators in 72 organic dairy farms with low concentrate feeding. Farm and herd factors were body condition scores, milk recording data, and farm management characteristics. Data from an existing estimation tool to describe farm and cow 'types' and the site-relatedness of breeding was also included. Health status was assesses by herd means of calving interval, fat-to-protein ratio, somatic cell score, veterinary treatments, culling rate, and number of lactation. A relation between the site-relatedness of cow type and calving interval was found. Further factors influencing the herd health status were mainly related to feeding. Also cow type factors had an effect, which is why strategies for improving animal health should include both feeding and breeding practices and consider sight-relatedness of breeding.

Key words: dairy cow, fertility, site-relatedness, breeding

Introduction

Ruminants do not depend on concentrates as they are experts in digesting forage (Hofmann 1991). Given that the use of food crops for livestock drives up world food prices due to competition (Bruinsma, 2003) utilizing grass for ruminant production is vital in the context of food security (Hopkins and Holz 2006). Re-linking ruminant production to grassland resources can improve animal health (Winsten et al. 2010) and is a basic component of organic farming (Rosset et al. 1997).

With only 10% of all dairy cattle having been selected under grazing conditions (Steinfeld and Mäki-Hokkonen 1995), most genotypes may not be well suited to organic systems. The objective of this study was to examine influences of farm and herd factors on the health status of organic dairy cattle in low-concentrate systems, which can be used for developing site-relatedness criteria needed to define breeding goals and management tools for different farm and cow types under low-concentrate conditions in organic farming.

Material and methodology

A total of 72 organic dairy farms were assessed, ranging from 0% to 10% concentrates with respect to the total yearly dry matter intake of their herds. Participation depended on farmers' willingness to participate and availability of milk recording data. This study observed the 12 months period from November 2009 till October 2010. The range of farms included in the project is not fully representative for Swiss organic dairy farms, but it was emphasized that in regard to several factors the whole bandwidth was portrayed. Farms from the mountainous and lower regions of Switzerland were taking part in the study as well as five German farms near the Swiss border. As a consequence of farmers' voluntary participation in the "Feed no Food" project abundant information was available. Body condition score (BCS) of all cows had been assessed during four farm visits. Farm and herd factors were assessed by means of an estimation tool established and evaluated in a previous FiBL project (Spengler et al., 2010) between January and March 2010. The estimation tool consisted of two fact sheets. The first fact sheet covered farm factors, such as farm size, concentrate use, and grazing management (Table 1). The second fact sheet covered overall herd data (Table 2), like the estimation of size, weight, muscling, and temperament of cows related to the herd average. The fact sheets were filled in by one of five researchers in the Feed no Food project, who had been trained in assessing these data in collaboration with the farmers. Further data, such as basic farm information, treatments and milk recording data were retrieved from the project database (which is based on data of the breeding companies and of the national statistics office BfS). Wherever possible, data assessed by the estimation tool were replaced by more detailed farm data from the project (including milk recording data, body condition score, and farm statistics).

Table 1. Farm factors and variable values

Farm factor[2]	Variable values[1]
Farm area (ha)	numeric
Livestock units dairy cows	numeric
Dairy cow livestock units on all roughage feeding livestock units (%)	numeric
Feed purchase	no feed purchase, ≥ 5% of ration, ≥ 10% of ration, ≥ 15% of ration
Cadastral zone	mountain zone II-IV, mountain zone I, pre-alpine hill zone, valley zone
Frequency of use of main forage area	1 to 2, 2 to 3, 3 to 4, > 4
Precipitation per year (mm)	1800 - 2100, 1400 - 1790, 1000 - 1390, 700 - 990, < 700 mm
Irrigation	no, yes
Percentage of ley	0 - 9%, 10 - 39%, 40 - 79%, 80 - 100%
Hay conservation	ground drying, ground drying and ventilation, ventilation of all hay, hot air ventilation
Protein based roughage (winter)	≤10%, >10% medium-quality, 10-40% high-quality, >40% high-quality
Additional energy based roughage	none, partly / little, in winter, all year
Feeding management	all cows alike (roughage), dry cows, concentrate, roughage, concentrate
Concentrate per cow and year (kg)	numeric
Concentrate per kg ECM (g)	numeric
Dimensions of housing	narrow spacing, partially generous spacing, generous spacing
Lightness of housing	dark, light
Spring and autumn grazing system	continuous grazing, rotational grazing, strip grazing
Spring and autumn grazing quantity	< 50%, 50% - 75%, > 75%
Summer grazing system	continuous grazing or alpine pasture, rotational grazing, strip grazing
Summer grazing quantity	< 50%, 50% - 75%, > 75%
Labour units per 25 livestock units	< 0.7 or frequent change, 0.7 - 1, 1.1 - 1.5, 1.6 - 2
Quality of farm labour	no special interest, great interest in cows
Percentage of natural mating	numeric
Seasonal calving	no, partly, yes

[1] all variable values are listed in ascending order
[2] ECM: energy-corrected milk

The estimation tool calculated a farm score and a herd score for each farm by summing up values attributed to the answers and comparing the achieved net score with the total achievable points. The comparison of farm and herd score, expressed as percentage, allows a rating of the analogy between cow and farm type. Differences between both scores lower than 6 percentage points are regarded as site-related, which means that cow and farm type fit to each other (Spengler Neff et al. 2007). If the farm score is more than 10 percentage points higher than the cow score, it is assumed that the full potential of the farm is not tapped. If the cow score is more than 5 percentage points higher than the farm score, the cow demand is regarded as exceeding the possibilities of the farm environment. In this case, cows may not be well adapted to their environment and thus likely to be in stress and prone to disease. The difference between both scores was included in the statistical analysis as an explanatory variable.

Health status was assesses by means of eight health and reproduction indicators. These were herd means of calving interval (CI), risk of acidosis, risk of ketosis, somatic cell score (SCS), veterinary treatments (udder treatments and all treatments), culling rate, and number of lactations. Risk of acidosis was determined by a fat-to protein ratio < 1.1 whilst risk of ketosis was determined by a fat-to protein ratio > 1.5, according to Čejna and Chládek (2005).

Herd and farm factors were reduced by univariate analyses as recommended by Dohoo et al. (1996). Relationships between explanatory variables were examined by nonparametric rank correlations (Spearman's rho). Independent variables strongly correlating with $r_s > 0.6$ (Brosius, 2008) or overlapping with regard to their meaning were not simultaneously included in one model. Scale and ordinal independent variables were tested for associations with the dependent variable via rank correlations. ANOVA was used to find relationships between one nominal independent variable (breed) and the dependent variables. Explanatory variables univariably associated with $p < 0.2$ with the dependent variable were included into initial models of multivariable analyses as described by Dohoo et al. (1996). After pre-selection, multivariate linear regression models with stepwise backwards selection were used to explore effects on health and reproduction indicators. The acceptance and rejection criteria 'probability of F-to-enter' (PIN) at 0.05 and 'probability of F-to-remove' (POUT) at 0.1 were applied.

Table 2. Herd factors and variable values

Herd factor[2]	Variable values[1]
Age at first calving (months)	numeric
ECM per day (kg)	numeric
ECM per kg live weight (kg)	numeric
Mean minimum BCS of all cows	numeric
Difference between BCS minimums and maximums of all cows	numeric
Percentage of horned cows	numeric
Height at withers (cm)	< 135, 135 - 140, 140 - 145, > 145
Weight (kg)	< 600, > 600
Feet and legs	rather big-boned, rather fine-boned
Muscling	rather heavy, rather light
Temperament	rather calm, rather spirited
Breed	Fleckvieh, Holstein-Friesian, Braunvieh (BV), BV and Original Braunvieh, mixed breeds

[1] all variable values are listed in ascending order; factors without variable values were interval-scaled
[2] ECM: energy-corrected milk; BCS: body condition score

Results

Factors influencing CI are presented in Table 3. CI was longer when BCS range was higher in the course of lactation. The difference between farm and herd score was negatively associated with calving interval. Age of first calving showed a trend to be higher for herds with longer CI.

Factors influencing the risk of acidosis are presented in Table 4. Lower minimum BCS values were associated with less cows showing a risk of acidosis. Where cattle housing was lighter more cows showed a risk of acidosis. Higher grazing quantities in spring and autumn were associated by tendency with a higher risk of acidosis, as was strip grazing in summer as opposed to continuous and alpine grazing.

Table 3. Regressions of influences on the calving interval ($R^2 = 0.190$; adj.$R^2 = 0.154$; $F = 5.315$; $p = 0.002$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	305.550	36.003	8.487	<0.001
DiffBCS	73.580	22.662	3.247	0.002
DiffScore	−0.919	0.330	−2.707	0.009
AFC	1.875	1.069	1.755	0.084

[1]DiffBCS: difference between minimum and maximum BCS; DiffScore: difference between farm and herd score; AFC: age at first calving

Table 4. Regressions of influences on the risk of acidosis ($R^2 = 0.203$; adj.$R^2 = 0.155$; $F = 4.206$; $p = 0.004$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	−82.275	33.191	−2.479	0.016
MinBCS	31.971	12.227	2.615	0.011
LigHous	6.633	2.844	2.332	0.023
GrazSAqu	3.438	1.899	1.810	0.075
GrazSUsy	2.803	1.651	1.698	0.094

[1]MinBCS: minimum BCS; LigHous: lightness of housing; GrazSAqu: spring and autumn grazing quantity; GrazSUsy: summer grazing system

Table 5: Regressions of influences on the risk of ketosis ($R^2 = 0.166$; adj.$R^2 = 0.141$; $F = 6.671$; $p = 0.002$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	4.787	4.045	1.183	0.241
PctCows	0.130	0.048	2.729	0.008
GrazSAqu	−2.495	0.957	−2.606	0.011

[1]PctCows: percentage of cows of all roughage feeders, GrazSAqu: spring and autumn grazing quantity

Factors with an effect on SCS are presented in Table 6. Herds characterized by high BCS fluctuations showed higher SCS. Lighter housing showed a trend to be associated with higher SCS. Herds kept by farm labour interested in cows had lower SCS by tendency.

Table 6. Regressions of influences on the Somatic Cell Score ($R^2 = 0.125$; adj.$R^2 = 0.087$; $F = 3.251$; $p = 0.027$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	1.965	0.335	5.859	<0.001
DiffBCS	0.907	0.437	2.078	0.042
LigHous	0.261	0.145	1.794	0.077
FLqual	−0.287	0.165	−1.740	0.086

[1]DiffBCS: difference between minimum and maximum BCS; LigHous: lightness of housing; Flqual: quality of farm labour

Factors influencing the risk of ketosis are presented in Table 5. In herds with more roughage feeders other than dairy cows risk of ketosis was lower. If higher quantities were grazed in spring and autumn this was associated with a lower risk of ketosis.

Table 7 presents factors influencing the categorized number of udder treatments. On farms where more concentrate was used to produce 1 kg of energy-corrected milk (ECM) significantly more udder treatments were done. More intensive grazing in summer was associated with fewer treatments. Braunvieh (BV) cows received more udder treatments than other breeds. The number of udder treatments was lower in herds where feeding management was more advanced. More precipitation was related to more treatments.

Table 7. Regressions of influences on udder treatments ($R^2 = 0.387$; adj.$R^2 = 0.338$; $F = 7.938$; $p < 0.001$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	4.389	1.174	3.737	<0.001
ConcECM	0.017	0.006	2.881	0.005
GrazSUsy	−0.805	0.288	−2.796	0.007
Breed (BV)	1.179	0.438	2.694	0.009
FeedMgt	−0.596	0.280	−2.132	0.037
Precip	0.411	0.198	2.069	0.043

[1]ConcECM: concentrate per kg ECM; GrazSUsy: summer grazing system; BV: Braunvieh; FeedMgt: feeding management; Precip: precipitation

Table 8. Regressions of influences on all treatments ($R^2 = 0.36$; adj.$R^2 = 0.30$; $F = 5.80$; $p < 0.001$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	0.203	0.071	2.873	0.006
FeedPch	0.037	0.012	3.060	0.003
FL25	0.030	0.014	2.196	0.032
EnergBas	0.024	0.011	2.199	0.032
GrazSUsy	−0.032	0.015	−2.166	0.034
ProtBas	−0.032	0.015	−2.090	0.041
DimHous	−0.024	0.013	−1.883	0.064

[1]FeedPch: feed purchase; FL25: farm labour per 25 livestock units; EnergBas: additional energy based roughage; GrazSUsy: summer grazing system; ProtBas: protein based roughage in winter; DimHous: dimensions of housing

Table 9. Regressions of influences on culling rate ($R^2 = 0.62$; adj.$R^2 = 0.57$; $F = 12.15$; $p < 0.001$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	58.968	8.149	7.236	<0.001
GrazSUqu	−8.689	1.363	−6.373	<0.001
FeedPch	5.299	1.156	4.584	<0.001
ProtBas	5.178	1.455	3.558	0.001
Area	−0.094	0.034	−2.740	0.008
FeedMgt	−3.541	1.352	−2.620	0.011
Tempmt	−5.955	2.296	−2.594	0.012
GrazSAsy	−4.384	1.869	−2.346	0.022
LigHous	−4.561	2.422	−1.883	0.065

[1]GrazSUqu: summer grazing quantity; FeedPch: feed purchase; ProtBas: protein based roughage in winter; Area: farm area; FeedMgt: feeding management; Tempmt: temperament; GrazSAsy: spring and autumn grazing system; LigHous: lightness of housing

Factors influencing the logarithmized number of all treatments are presented in Table 8. Feed purchase had the most significant effect, followed by farm labour and additional energy based roughage. All those factors had a positive influence on treatments. Animals grazing continuously and alpine pastures in summer received more treatments than animals in intensive grazing systems. Herds having been fed more protein based roughage in winter were treated less. More spacious housing was associated with fewer treatments.

Factors associated with the culling rate are presented in Table 9. On farms with higher grazing quantities in summer the culling rate was lower. Higher feed purchase was associated with a higher culling rate. Where more protein based roughage was fed in winter, more animals were culled. Larger farms and farms with a more advanced feeding management had lower culling rates. The same accounted for herds of more spirited cows and herds that grazed in more intensive systems throughout spring and autumn. By trend herds with lighter housing showed lower culling rates.

Factors influencing the number of lactations are presented in Table 10. Cows grazing in more intensive systems during spring and autumn had more lactations. If more concentrate was fed per kg ECM fewer lactations completed. Herds with lower minimum BCS values had less lactations. There was a tendency of taller cows having fewer lactations.

Table 10. Regressions of influences on number of lactations ($R^2 = 0.280$; adj.$R^2 = 0.237$; $F = 6.507$; $p < 0.001$)

Variable[1]	Estimate	Standard error	t	p
(Constant)	−0.004	1.632	−0.002	0.998
GrazSAsy	0.337	0.110	3.054	0.003
ConcECM	−0.004	0.002	−2.222	0.030
MinBCS	1.320	0.600	2.201	0.031
Height	−0.172	0.099	−1.731	0.088

[1]GrazSAsy: spring and autumn grazing system; ConcECM: concentrate per kg ECM, MinBCS: minimum BCS; Height: height at withers

Discussion

The results presented indicate that dairy cattle characterized by stable BCS values might be better suited for grazing systems with low to zero concentrate supplementation than cows with highly fluctuating BCS. This supports findings of Thomet and Steiger Burgos (2007), Coleman et al. (2010) and Piccand et al. (2011b) that angular, high genetic merit cattle might be less suitable. No pronounced breed impacts could be determined, but suitability of individuals for zero concentrate supplementation seems to vary within breeds. The current study confirms a major influence of feeding and feeding management on the health status of dairy cattle. The importance of feed and feeding management is higher with higher performance (Clark and Kanneganti 1998). Site-relatedness was strongly associated with fertility, confirming a previous study (Spengler Neff 2010). Low fertility is one of the main reasons for culling (Burren 2011) and can be directly linked to dairy cow nutrition. The estimation tool can be regarded as a useful tool for improving the compatibility between cow and system.

Suggestions to tackle the future challenges of organic animal husbandry

Site-relatedness can be achieved by two measures: the adjustment of the cow type, for example by breeding for robustness, or the adjustment of the environment, for example by improving feed quality and management. Since changing the environment in organic systems is limited farmers, breeders, farm advisors and veterinary surgeons may use site-relatedness parameters to improve and maintain health and reproduction in organic dairy cows.

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